AWUTU SENYA EAST MUNICIPALITY

STATE OF ENERGY REPORT
2014




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SAMSET
Supporting Africa's Municipalities in Sustainable Energy Transitions

ISSER
Knowledge for Development

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STATE OF ENERGY REPORT 2014

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2015

This document is an output from a project (SAMSET) co-funded by UK Aid from the UK Department for International Development (DFID), the Engineering & Physical Science Research Council (EPSRC) and the Department for Energy & Climate Change (DECC), for the benefit of developing countries. The views expressed are not necessarily those of DFID, EPSRC or DECC, or any institution partner of the project

SAMSET Project Information:

Supporting Sub-Saharan Africa's 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 frameworks" 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
ASEM	Awutu Senya East Municipality
ASEMA	Awutu Senya East Municipal Assembly
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
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

Acknowledgements

This State of Energy (SoE) report for Awutu Senya East Municipality (ASEM) is a product of a knowledge exchange collaborative project among six municipalities in three Sub-Saharan African countries – Ghana, Uganda and South Africa - known as "Supporting Sub-Saharan Africa's Municipalities with Sustainable Energy Transitions (SAMSET)''. The support provided by all SAMSET project partners, especially the immense contributions by Sustainable Energy Africa (SEA) and the University of Cape Town's Energy Research Centre (ERC), which have shaped the final output of this report are deeply appreciated.

The Ghana SAMSET team also appreciates the support of ASEM's top officials; the municipal Chief Executive (MCE), Hon. Nuhu Adam, the Municipal Co-OrdinatingDirector (MCD), Mr. Armed-Rufai Ibrahim and others who exhibited keen enthusiasm in the project from the beginning and offered resources, office space and conference facilities at ASEM's premises willingly for SAMSET's activities. A special thank you also goes to ASEMA focal persons (partners) on the SAMSET project, Mr. Isaac Tettey(MPO) and Mr. Rahim Abdul-Musah who have been very supportive since the start of the project and have played key roles in the preparation of this SoE report.

Finally, the Ghana SAMSET team wishes to extend gratitude to all institutions (like the Ghana Statistical Services - GSS) and individuals including Assembly members from the Electoral Areas in ASEM who gave diverse support towards the preparation of this SoE report.

Executive Summary

ES 1: Background Information

The state of energy report for the Awutu Senya East Municipal Assembly is the first of its kind ever produced in Ghana. The existing energy outlooks and statistics only focus on national level energy situations with little being known of the holistic state of energy at the regional or metropolis/municipalities/districts level. In the absence of such specific baseline information, effective planning for sustainable issues becomes highly impossible. Against this backdrop, the project "Supporting Sub-Saharan African 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. Awutu Senya East Municipality (ASEM) is one of the two municipal partners SAMSET project is collaborating with in Ghana.

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 (at the Akosombo, Kpong and Bui hydro-power plants) and thermal (mainly from oil/diesel?) which together generated a total of 12,024GWh in 2012, an 18.3% increase over 2010 total generation of 12,870GWh. In 2013, there was an increase of 7% 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, 2012). This was however not consumed domestically, hence Ghana still depends on crude oil imports through the Ghana National Petroleum Corporation (GNPC).

Bioenergy (biomass) in the form of fuelwood and charcoal make up 75% or more of the national energy consumption (Ghana Statistical Services, 2013). The biomass consumption pattern in Ghana however indicates a shift from wood for firewood source to charcoal energy for more urban households. Liquefied petroleum gas (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 e.g. solar, hydro, wind etc.?. 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 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 energy demand sectors of the economy are the residential, non-residential (comprising of commercial and services, agriculture, transport and industrial sub-sectors)and the industrial sectors. Rural and urban communities make up the residential demand side of energy. The 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. Energy in the residential sector ismainly used for lighting and cooking, with biomass being the main energy source for most households especially in the rural communities. 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 the education sub-sector (more than 5%).

The road transport subsector accounted for about 93% of total 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 a solvent. The industrial sector, excluding the Volta Aluminium Company Limited (VALCO), accounted for nearly 22% of total national energy consumptionevery year since 2000.However, with the inclusion of VALCO, the industrial sector's total energy share increased slightly to about 23% per annum (Energy Commission, 2014).

ES 2.2: Energy Picture of the Central Region

Various forms of energy are consumed in Ghana's Central Region for different purposes. About 70% of the population in the region has access to the national grid for their power needs as at 2012 (GSS, 2012/ EC???). Electricity is mainly used for lighting purposes in the region accounting for 66.1%. Other lighting sources include kerosene lamp (20.7%), flashlight (11.2%), electricity from private generators (0.7%), and candles (0.5%). The proportion of households using electricity in Central region is the third highest in Ghana, after the Greater Accra and

Ashanti Regions. The use of private generators is a recent phenomenon that has ensured as a result of the frequent power outages and load shedding that have gripped the country. There are rural-urban variations in the sources of domestic lighting. Over three quarters (78.4%) of households in urban areas make use electricity from the national grid for lighting purposes, compared to 54.5% in rural areas. One-quarter (25.5%) of households in rural areas make use kerosene lamps as their main source of lighting compared to 15.7% in urban areas. In rural areas 18% of rural dwelling units use flashlights as their main source of light compared with only 3.9% in urban areas.

The three main sources of energy for cooking in households in the Central Region, as at 2010, are firewood (44.2%), charcoal (36.9%), and LPG (12.5%). The use of LPG is becoming more common with 12.5% of the households using LPG. In rural areas, because wood is locally available, it remains the main source of cooking fuel for 67% of households compared with 20% in urban areas. In contrast, charcoal, which is often produced for urban dwellers, is used by 52.9% of urban households, and 21.8% in rural areas.

ES 3: Awutu Senya East Municipality Energy Picture and Energy Breakdown by Sectors

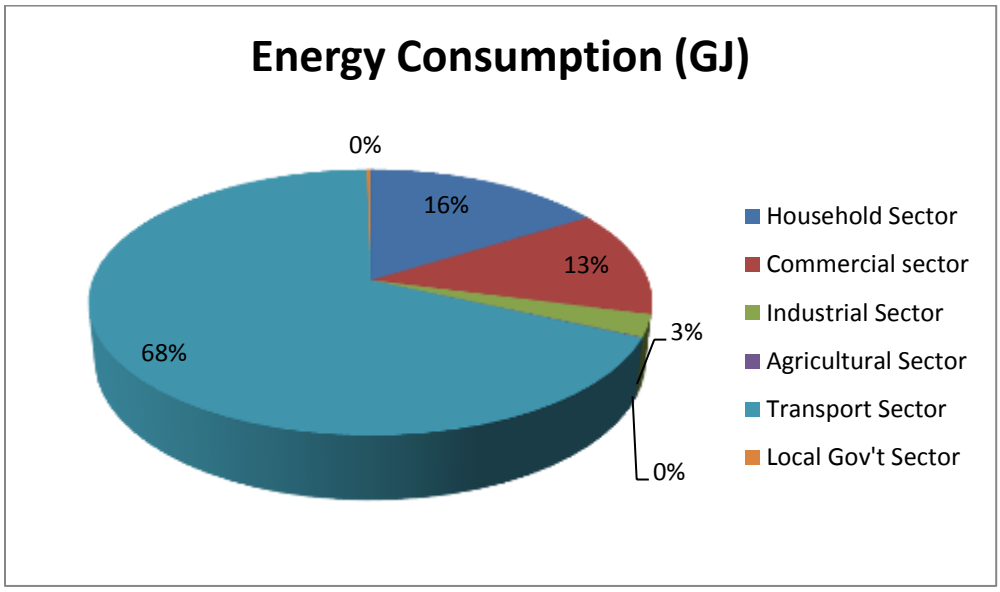
ES 3.1: ASEM Energy Picture

The municipality depends solely on fuels generated at the national level or from other parts of the country. Electricity consumed in the municipality is primarily generated by the Volta River Authority (VRA) through its hydro and thermal power plants around the country, distributed and sold to the demand sectors of the municipality by the Electricity Company of Ghana (ECG). About 20.1MWof electricity, in 20…?,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 the Bulk Oil Storage and Transport Limited (BOST) which stores and transports refined petroleum products to consumers after they have either been refined at the Tema Oil Refinery or imported already processed. Neither charcoal nor wood fuels are generated directly in the municipality but are imported from neighboring districts and sometimes from other regions. The production of charcoal moved further up north into areas such as Bole by 2012 as a result of the receding forest cover due to excessive cutting of trees (deforestation).

With reference to the total number of households, commercial, industrial and agricultural activities in the municipality, the total energy consumed is estimated around 4,965,445.85 Gigajoules. The transport sector constitutes the largest share in the total energy consumed in the municipality, 3,372,729.5 GJ (representing 68% of total energy consumed). The transport sector is followed by the residential sector which consumes about 16% of the total energy consumed in the municipality. The commercial sector is the third largest energy consuming sector in the municipality, consuming about 13% of the total energy while the industrial sector consumes

about 3% of the total energy in the municipality. The total energy consumed by both the local government and agricultural sectors is less than 1% of the total energy consumed by the municipality (Figure ES 1).

Figure ES 1: Total energy consumption in Awutu Senya East Municipality



Source:ISSER,2014

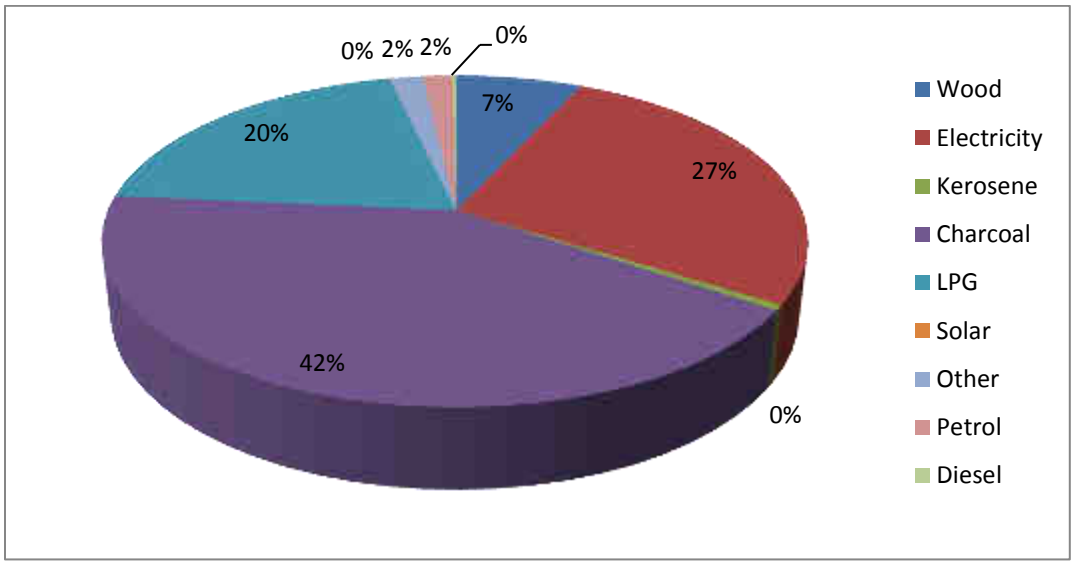
ES 3.2:Energy picture of the Household/Residential Sector in ASEM

The residential sector in ASEM is composed of 43% Third Class households followed by Second Class (34%) and First Class (23%). About 83% of the total households in the ASEM are electrified. Most electrified households in ASEM are separate (stand-alone) dwellings and the predominant window types in these dwellings are the louvre blades. The majority of non-electrified households in ASEM are stand-alone dwellings with louvre blades (…%) and wooden windows (…%)as the predominant window types.

Third class households consume about 42% of the total energy consumed by the residential sector in the municipality, while second and first class households consume 33% and 25% of the energy respectively. It is apparent from the survey results that, though households in ASEM consume quite a substantial amount of biomass energy, there is also evidence of massive

consumption of modern forms of energy (electricity and LPG fuels) in the municipality. Charcoal fuel constitutes the largest share (42%) of the total energy consumed by the residential sector in ASEMA. This is followed by electricity (27%), LPG (20%) and firewood (7%) (Figure ES 2).The energy consumption patterns observed in all three classes of settlements depict that of the residential sector. 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. Charcoal and LPG are the predominant fuel types used for cooking (…%) and water heating (…%) in the municipality while some electrified households use electricity as a supplementary source. Electricity is the main energy source for lighting in electrified households while non-electrified households depend on dry cell batteries and candles.

Figure ES 2: Percentage share of total energy consumption per energy carriers in ASEM



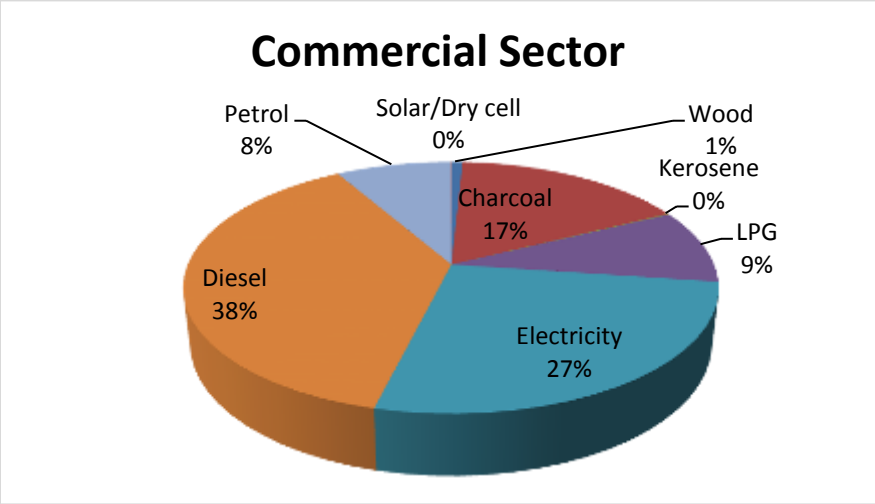
Source:ISSER, 2014

ES 3.3: Energy Consumption in the Commercial Sector in ASEM

About 38% of the total energy consumed by the commercial sector is diesel fuel while 27% is electricity. The remaining 35% is shared between charcoal, wood, LPG and petrol fuels with charcoal constituting about 17%. Kerosene and solar energy are consumed in small quantities in the municipality (Figure ES 3). Formal commercial activities (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)) depend largely on diesel fuel as it constitutes about 53% of the total energy consumed by formal commercial activities in the municipality. Informal commercial activities (hair salons and barbershops, 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) depend more on charcoal followed by electricity and LPG. Transportation consumes the most energy, about 28% of the total energy, while cooking/water heating and other activities such as welding, baking, smithing, soldering and spraying, use about 20% and 16% respectively of the total energy consumed by the commercial sector. Within the formal commercial activities, transportation accounts for the largest (43%) consumption of energy. About 19% of energy is consumed by cooking/water heatingactivities, especially in schools (school feeding programmes), hospitals and hotels/guest houses. Machine operations such as the use of computers, printers, photocopy machines and others consume about 9% of the total energy consumed in the formal commercial sector, while lighting uses about 8%. Refrigeration and entertainment account for 4% and 3% respectively of the total energy used in the formal commercial sector. Other commercial activities such as welding, baking, smithing, soldering and spraying are the most energy intensive activities in the informal commercial sector consuming about 40% of the total energy of the informal commercial sector followed by cooking/water heating which consumes about 21% of the total energy of the informal commercial sector.

Figure ES 3: Share of energy consumed in ASEM among various carriers in 2013



Source:ISSER, 2014

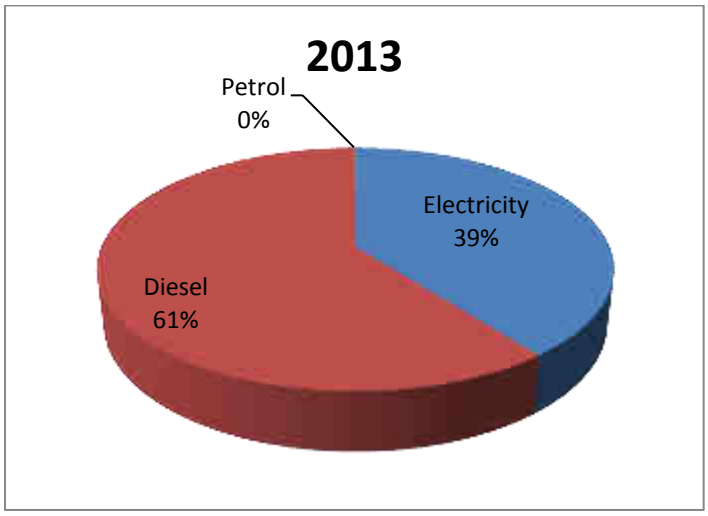
ES 3.4: Energy Picture of the Industrial Sector in ASEM

Industrial activities are heavily dependent on petroleum fuels (diesel, heavy furnace oils, etc.) to power their industrial power plants for electric power generation. In 2010 and 2011 over 80% of the total energy consumed in the industrial sector came from diesel, with electricity contributing a little over 10% of the total energy consumed by the industrial sector in the municipality. In 2012, 70% of the total energy consumed by the industrial sector came from diesel while 30%?.Similarly in 2013, diesel constituted about 61% of the total energy consumed by the

industrial sector in ASEM while electricity only constituted of about 39% (Figure ES 4). The increasing trend of electricity consumption in ASEM since 2010 despite the shortfall in the national supply of electricity to the municipality is attributed to the emergence of new industrial players whooften sought to be connected to the national grid.

Mining and quarrying is the most energy intensive sub-sector of the industrial sector in ASEMA, constituting about 88% of the total energy consumption in the industrial sector in 2013. The construction sub-sector follows as the second largest energy consuming sub-sector, consuming about 9% of the total energy consumed by the industrial sector while the manufacturing sub-sector constitutes the least energy intensive sub-sector in 2013. About 48% of the total energy consumed in the industrial sector is used on machinery, while lighting, other machine drives and cooling systems account for about 28%, 19% and 5% respectively of the total industrial energy consumption.

Figure ES 4: Percentage share of energy sources consumed by industrial sector in ASEM (2013)

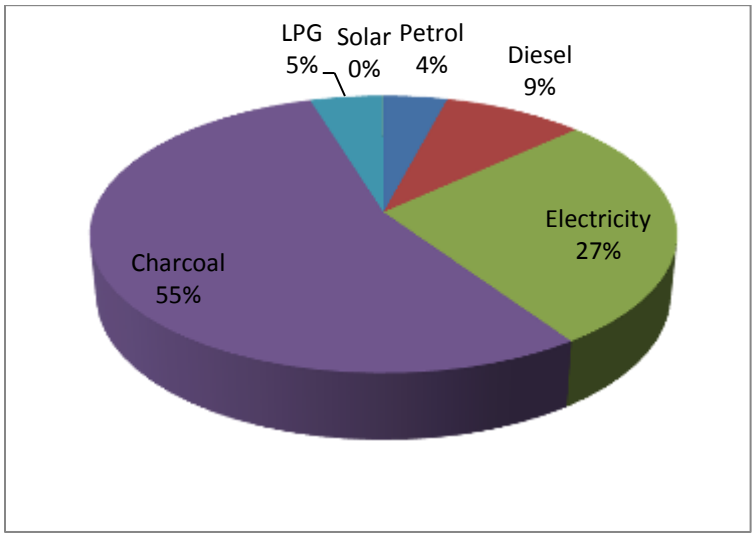


Source:ISSER, 2014

ES 3.5: Energy Consumption in the Agricultural Sectorof ASEM

Charcoal constitutes the largest energy source (55%) of all energy consumed in the agricultural sector within ASEM, followed by electricity (27%) (Figure ES 5). The remaining 18% is from diesel (9%), LPG (5%) and petrol (4%) fuels. Heating in the agricultural sector is the process or activity that consumes most of the energy (69%) in this sector. Transportation is the second most energy consuming agricultural activity, using about 12% of the total energy consumed by this sector. Processing of agricultural products, drying and lighting consume about 10%, 8% and 1% respectively of the total energy consumed by the sector.

Figure ES 5: Percentage share of Energy sources consumed by agricultural sector in ASEM



Source:ISSER, 2014

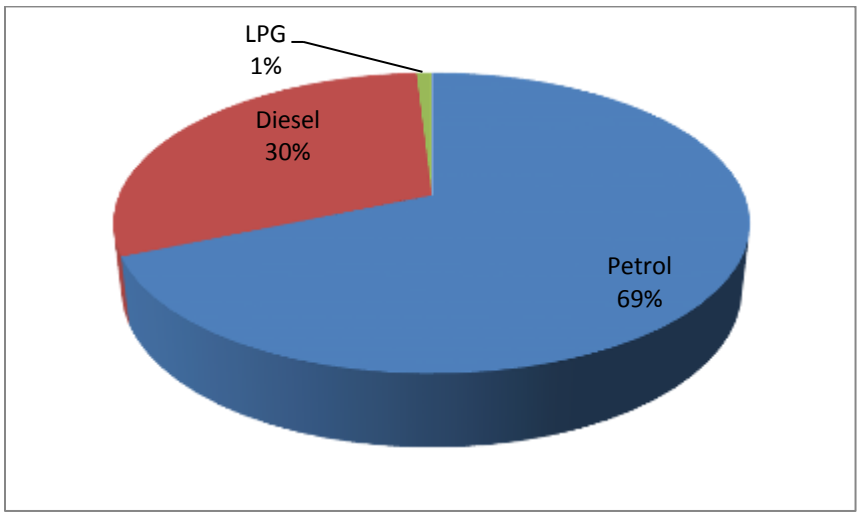
ES 3.6: Energy picture of the Transport Sector in ASEM

The total number of vehicles in the municipality in 2013 consisted of 15 public vehicles (Metro Mass Transit buses), 22,203 private vehicles and 7292 commercial vehicles. In 2013 the MMT buses transported about 43,200 people per week from various locations in the municipality while light passenger vehicles, which are often private cars, transported about 394,164 people per week in the municipality in the same year. Mini-buses (‘*trotros’*) transport about 7,380,000 people per week in the municipality while taxis transport about 336,000 people per week.

Commercial vehicles consume about 76% of the total energy consumed in the transport sector within the municipality. This is followed by private vehicles which consume about 24% of the

total energy used in the transport sector. Public vehicles (MMT buses) consume less than 1% of the total energy used in the transport sector in ASEMA. About 69% of the total energy consumed by the transport sector in ASEMA is in the form of petrol. Diesel fuel constitutes about 30% of the total energy used by the transport sector while 1% of LPG is consumed (Figure ES 6). LPG is consumed mainly by taxis, which have converted onto the LPG fue=-l from either petrol or diesel fuels because it is considered to be more economical than petrol and diesel. Mini buses (trotros) consume the most energy in the transport sector in the municipality, about 68%, followed by light passenger vehicles (mostly private cars) which consume about 21% of the total fuel used in the transport sector. Taxis consume about 7% of the total energy of the transport sector while all the trucks (light, medium and heavy) together consume about 4% of the total energy in the transport sector of the municipality. Tricycles and heavy passenger vehicles (MMT busses) account for less than 1% of the total energy consumed in the transport sector in ASEM.

Figure ES 6: Percentage share of fuel type consumed by the transport sector in ASEM

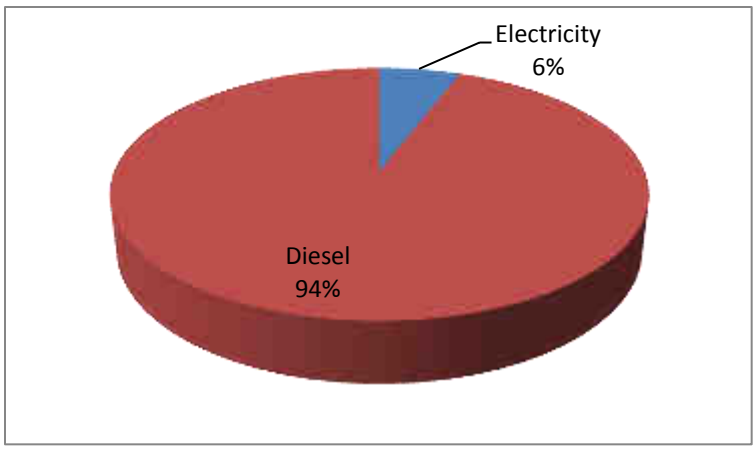


Source:ISSER, 2014

ES 3.7: Energy Picture of ASEMA

Diesel fuel constitutes about 94% of the total energy consumed by ASEMA in 2013 (Figure ES 7). This fuel type is used mainly by the Assembly's vehicles since the Assembly does not have any back-up generators. Electricity consumption from the national grid constitutes only about 6% of the total energy consumed by ASEMA in 2013. The electricity energy is mainly used on office machines, ventilation, refrigeration and lighting.

Figure ES 7: Share of total energy consumed by carriers in ASEMA



Source:ISSER, 2014

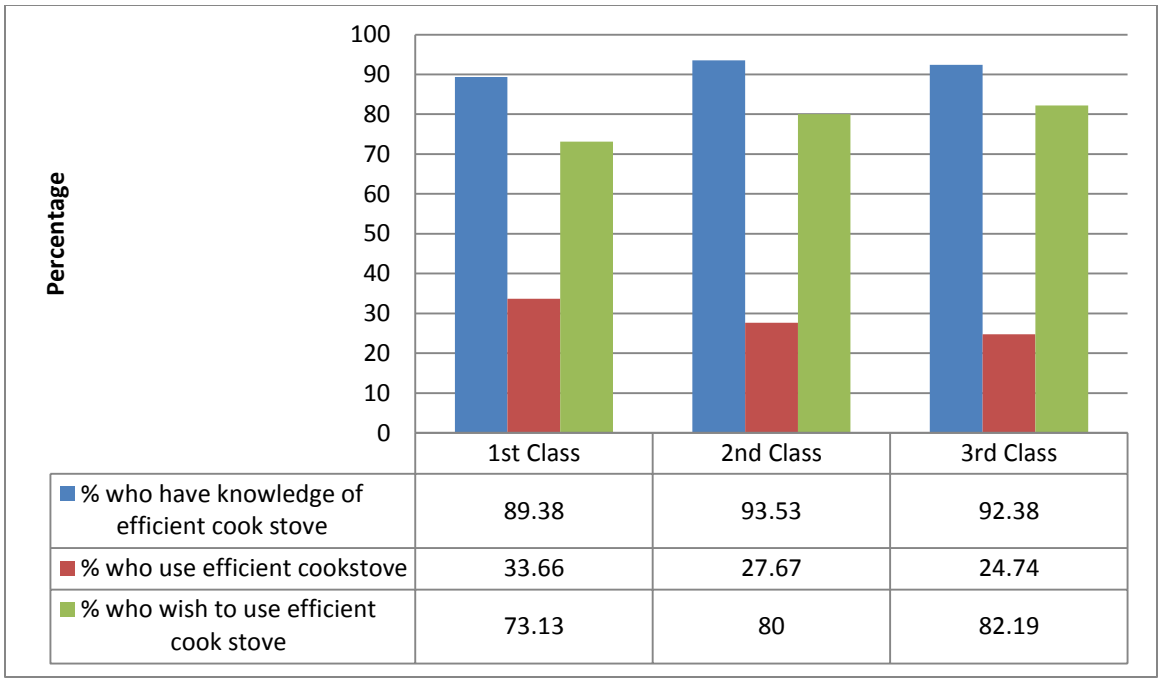
ES 4: Energy Efficiency Programmes: Knowledge-Based Evidence at the Municipal level

ES 4.1: Energy Efficient Cook stoves and light bulbs

More than 85% of electrified households across all three classes of settlements indicated their awareness of the energy efficient cook stoves. However, only 34%, 28% and 25% of First, Second and Third Class electrified households have ever used the energy efficient cook stoves. The percentage of electrified households who wish to use energy efficient cook stoves is high (over 70%) for all three classes of households (Figure ES 8). Among non-electrified households, more than 70% of households indicated their awareness of energy efficient cook stoves. Conversely, less than 35% of these households have used these efficient cook stoves despite the high level of awareness. Over 85% though, expressed willingness to use these energy efficient cook stoves (Figure ES 9).

From the survey, 100% of all First class households use energy efficient bulbs for lighting, while 99% all of Second and Third class households each use efficient lighting bulbs. Those who still depend on the old fluorescent and incandescent bulbs (less than 1%) expressed the views that the old fluorescent and incandescent bulbs are brighter than the energy efficient CFLs and that, the bulb holders have never been replaced as they are only made to suit incandescent or fluorescent bulbs.

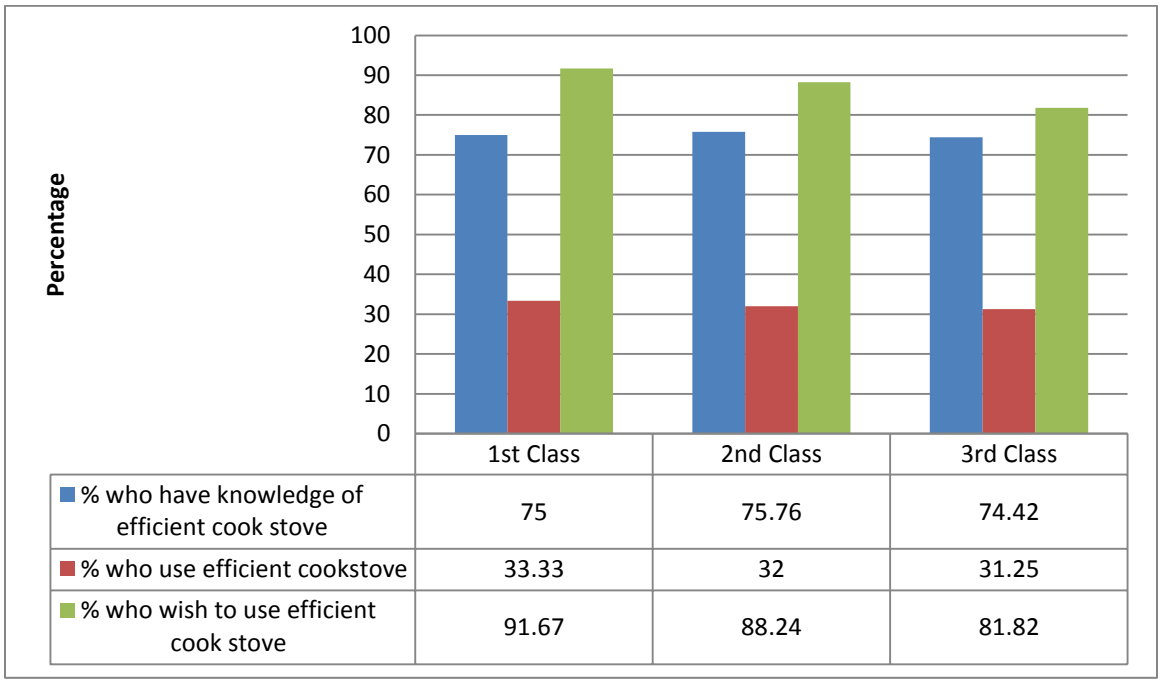
Figure ES 8: Percentage of electrified households who have knowledge, are using or wish to use efficient cook stoves in ASEM



	1st Class	2nd Class	3rd Class
% who have knowledge of efficient cook stove	89.38	93.53	92.38
% who use efficient cookstove	33.66	27.67	24.74
% who wish to use efficient cook stove	73.13	80	82.19

Source:ISSER, 2014

Figure ES 9: Percentage of non-electrified households who have knowledge, are using or wish to use efficient cook stoves in ASEM



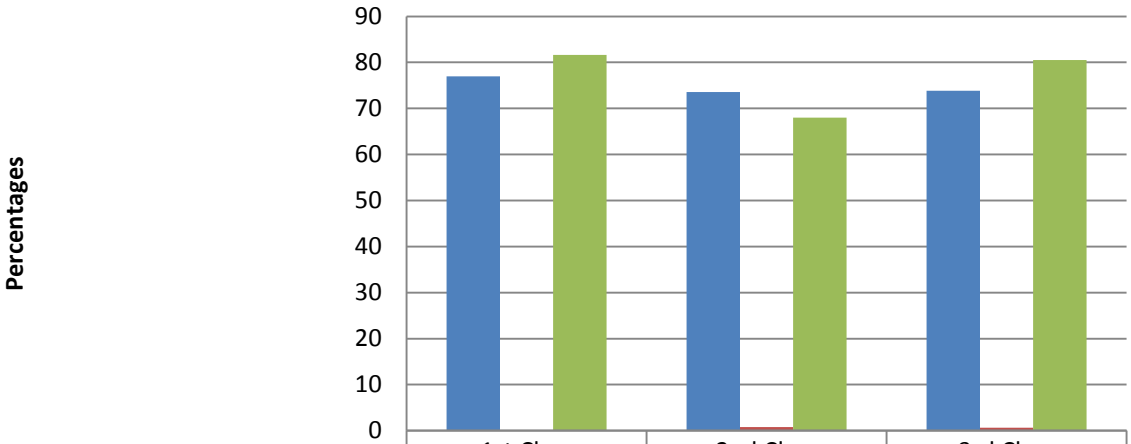
	1st Class	2nd Class	3rd Class
% who have knowledge of efficient cook stove	75	75.76	74.42
% who use efficient cookstove	33.33	32	31.25
% who wish to use efficient cook stove	91.67	88.24	81.82

Source:ISSER, 2014

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

a. Over 70% of households across all three settlement classes have knowledge of the programme. Regardless of the high awareness, patronage of the programme is rather abysmal. None of the households in the electrified First Class participated in the programme, while 0.8% and 0.65% of the Second and Third class electrified households benefited from the program. 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 10).

Figure ES 10: EC's fridge replacement programme: knowledge and accessibility



	1st Class	2nd Class	3rd Class
% who have knowledge on EC's fridge replacement program	76.99	73.53	73.81
% who benefited from EC's fridge replacement program	0	0.8	0.65
% who wish to benefit from EC's fridge replacement program	81.61	68	80.52

Source:ISSER, 2014

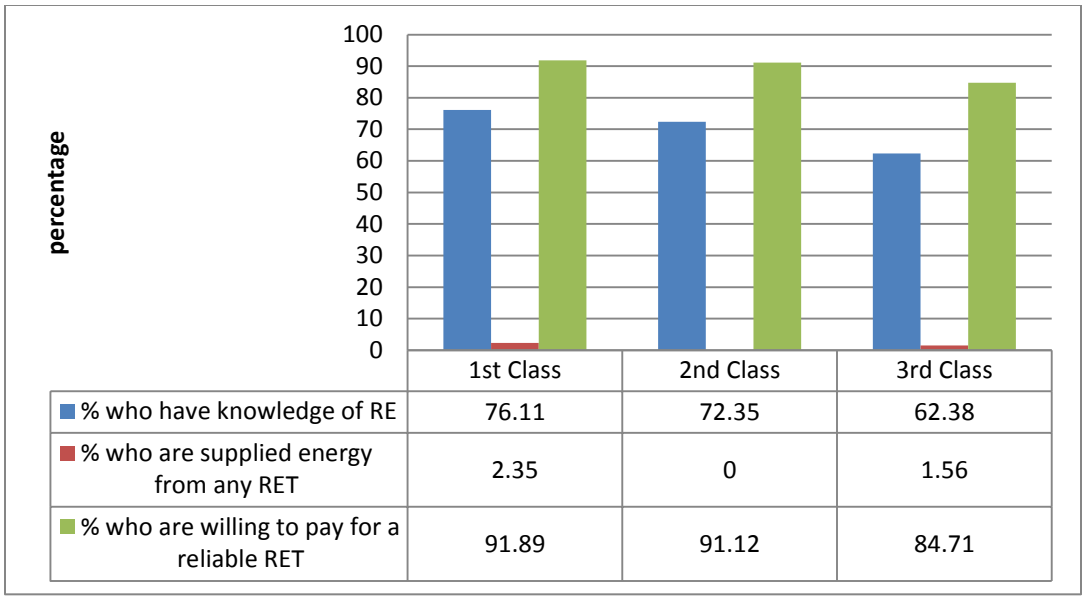
ES 4.3: Energy Commission's (EC) Appliance Energy Efficiency Labels

For electrified households who use air conditioners (ACs), -- in first class households— about 75% of them bought the ACs with the EC's efficiency labels on them while 25% of them bought new ACs without the efficiency labels. For refrigerators users in electrified households, about 49% of first class households bought new refrigerators with the EC's efficiency labels displayed on them. About 48% and 50% of second and third class refrigerator users bought new refrigerators with the efficiency labels displayed on them while 48% each of second and third class electrified households who use refrigerators also bought new refrigerators without the EC's efficiency labels displayed on them.

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

Information gathered from the 2014 Energy Survey reveals that public knowledge on RETs is quite encouraging in ASEM. About 76% and 46% of first class electrified and non-electrified households respectively have knowledge on renewable energy. About 72% and 53% of second class electrified and non-electrified households have knowledge on renewable energy while 62% and 37% of third class electrified and non-electrified households respectively, are also aware of renewable energy (Figures ES 11 and ES 12). The most common RETs known to these household members are solar photovoltaics (PVs)and wind. Despite the awareness level, more than 90% of these households across all the household classes are not supplied energy from these RETs. Meanwhile, there is high willingness to pay (over 70% of households across all three classes of settlements have expressed willingness to pay) for these RETs as long as they are reliable.

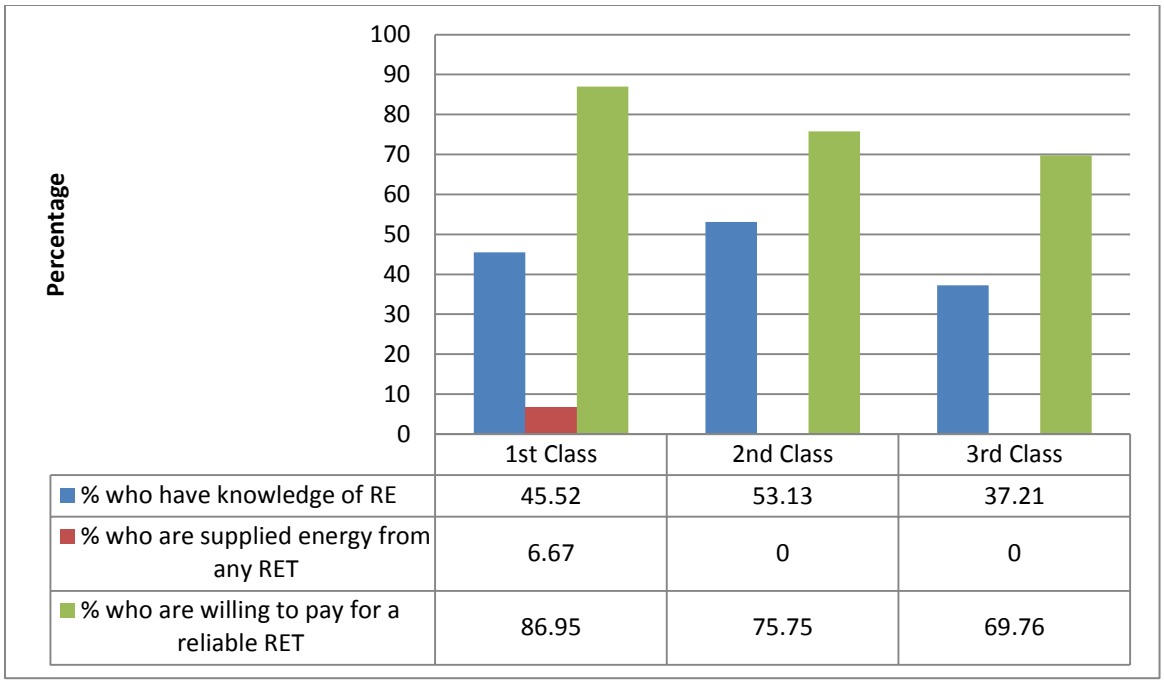
Figure ES 11: Percentage of electrified households who have knowledge of RE, supplied energy from RETs and willingness to pay for RET



	1st Class	2nd Class	3rd Class
% who have knowledge of RE	76.11	72.35	62.38
% who are supplied energy from any RET	2.35	0	1.56
% who are willing to pay for a reliable RET	91.89	91.12	84.71

Source:ISSER, 2014

Figure ES 12: Percentage of non-electrified households who have knowledge of RE, supplied energy from RETs and willingness to pay for RET



	1st Class	2nd Class	3rd Class
% who have knowledge of RE	45.52	53.13	37.21
% who are supplied energy from any RET	6.67	0	0
% who are willing to pay for a reliable RET	86.95	75.75	69.76

Source:ISSER, 2014

ES 5: Municipal Strategic Energy Issues

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

The municipal authority, ASEMA, 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 sectors in the municipality including the Assembly itself are supplied by national institutions. In the area of renewable energy technologies (RETs), there are some street lights in the municipality that are powered through solar photovoltaic (PV) systems.

ASEMA 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 wish to put up residential buildings, office structures, warehouses or other structures.

In terms of transport management, there are 56 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.

ES 5.2: The control of ASEMA over new developments in ASEM

Electricity extension to new communities and also to new residential buildings and other structures, in already connected communities, is an ongoing activity. The Assembly has no direct control over such connections, but indirectly provides information regarding such communities. ASEMA has full control over spatial layouts of the municipality and building structures. In 2013, about 277 permits were issued for permanent structures in the municipality. This includes 245 residential structures, 30 commercial structures (such as office structures, stores and warehouses) and 2 churches. No permits were given for temporal structures such as container and kiosk placements. It is however common 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 Assembly has no control over construction and maintenance of roads in the municipality (which are mandates of the national Urban Roads Department). Though not playing a major implementation role, ASEMA is keenly facilitating an on-going World Bank and Brazilian-funded 160 million USD Kasoa Interchange project with a 20km stretch of alternative town roads, bridges and flyovers which are supposed to distribute traffic in the municipality. The Assembly, however, supervised the setting up of some new bus terminals in the municipality and also the upgrading of some existing ones in the past year.

SECTION ONE

BACKGROUND TO THE STUDY OF THE STATE OF ENERGY IN ASEM

1.0 Introduction

Energy is pivotal for the socio-economic development of all societies, hence, the need to plan properly to ensure not only adequate supply to meet demand, but the supply and use of the appropriate types of energy for sustainable development. Population growth and rapid urbanization of most African countries are currently weighing heavily on the existing energy supply sources, because of increased demand. Ghana in particular has been experiencing numerous challenges within the energy sector, especially regarding power supply, in the past three years, because demand has outstripped supply. As an urbanized country[1], a greater percentage of the electricity supply and other energy sources are consumed in cities and other urban areas. 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 onthe existingstate 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 beingknown of the holisticstate of energy at the regional or metropolis/municipalities/districts. In the absence of such specific baseline information, effective planning for sustainable issues becomes impossible.

Against the backdrop of the issues outlined above, the project "Supporting Sub-African Municipalities with Sustainable Energy Transitions (SAMSET)[3]" has among its objectives, the

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[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;

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. Awutu Senya East Municipality (ASEM) is one of the two municipal partners[4]the SAMSET project is collaborating with in Ghana.

The report is structured as follows. Section onecovers the overview of the energy outlookin Ghana and the CentralRegion supported with national and local policy frameworks and regulatory arrangements. Also captured in the first section are national climate change issues. Section two captures the methodological approach used in data collectionand the compilation of the report. In section three, the energy picture of Awutu Senya East Municipality based on data from the survey is discussed together with other relevant demographic features of the municipality. Section four discusses the breakdown of energy dynamicswithin various sectors of Awutu Senya East Municipality (ASEM). 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 ASEM while the last section summarises the major findings of the survey with relevant policy implications.

1.1 The Macro Picture: Ghana and Central Regional Energy Picture

1.1.1 Ghana's Energy Picture

The growth rate of the total final energy consumedin Ghana stood at 8.3% 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 (in Akosombo,Kpong and Bui hydro-power plants) 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

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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/

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

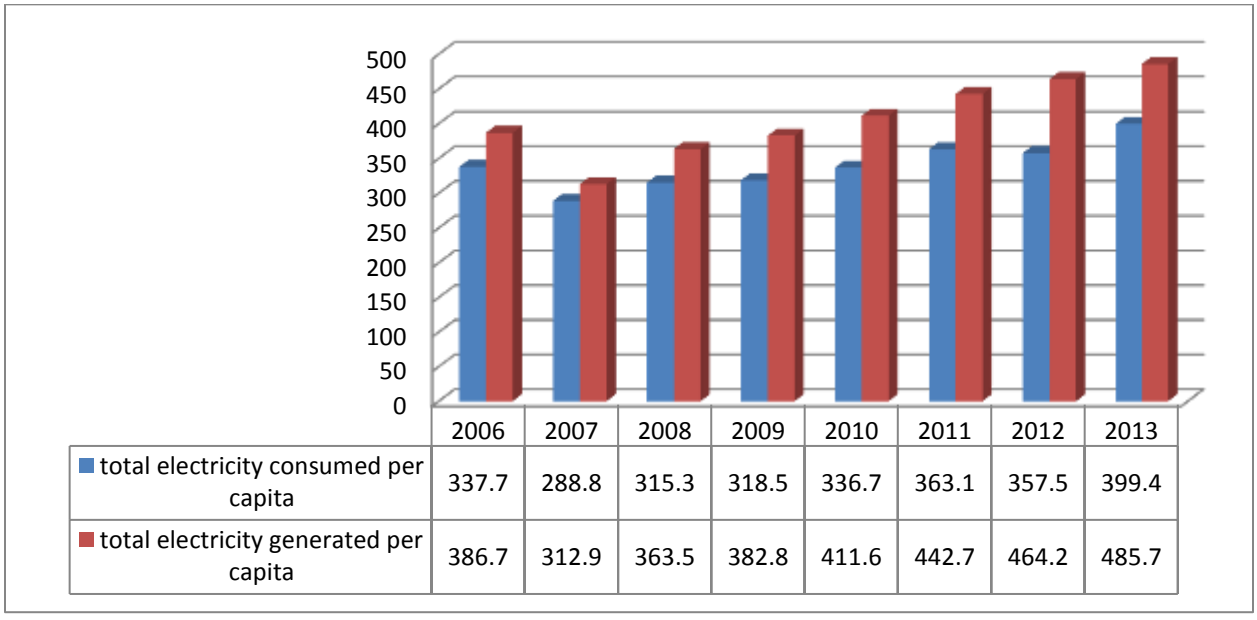
sources (Table 1).Total electricity consumed per GDP had a negative growth rate of 28.9% between 2006 and 2012. This, however, upturned in 2013 by 6.4% to a value of 327.4 kWh/GHS 1,000 of GDP (Energy Commission, 2014). A direct relationship has been observed between electricity generation and consumption per capita where an increase in consumption per capita always results in an increase in generation per capita (see Figure 1).

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



Source: Energy Commission, 2014

Commercial oil production officially commenced in December 2010 and by the end of 2012, about 4,133.8 kilotonnesof crude oil was produced in Ghana (Energy Commission, 2012). 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 fellto about 891kilotonnes in 2006, 946.4 kilotonnes in 2010, 454 kilotonnes in 2012 and 424 kilotonnes in 2013 when the total imported crude oil fellin those years (Table 2). Low production of petroleum products has led to an increased importation of these products in Ghana totaling 2,477.6 kilotonnes in 2012 from 1037.8 kilotonnes and 1589.9 kilotonnesin 2008 and 2010 respectively.

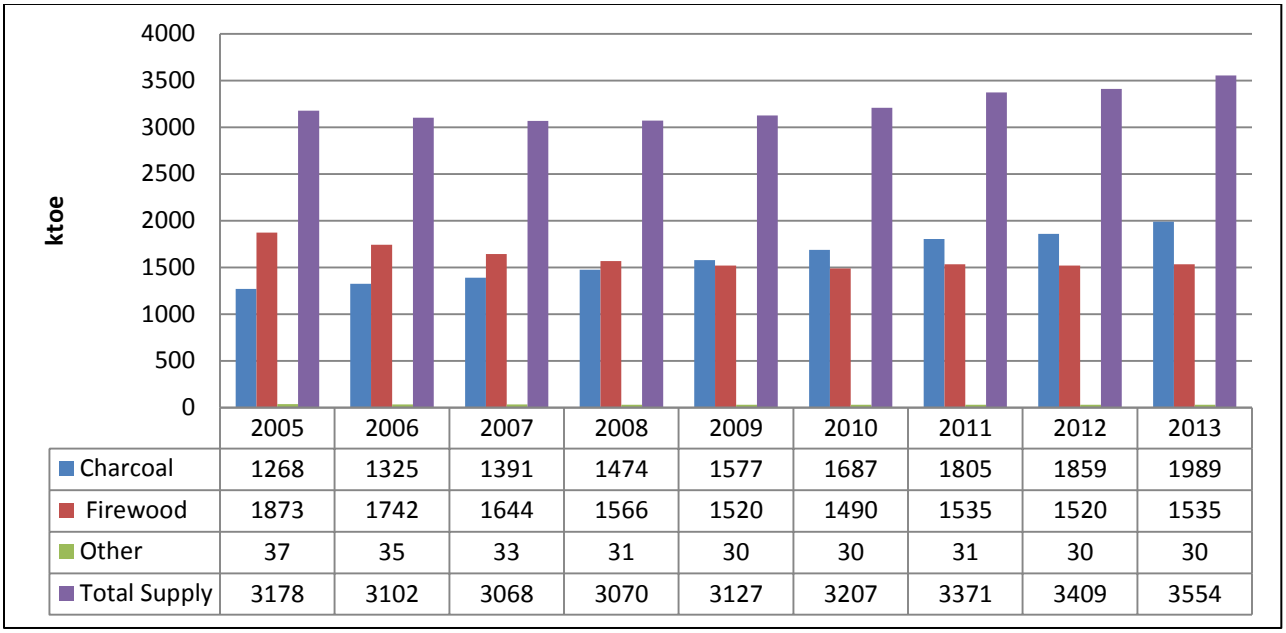
Consumption of petroleum products per capita was 0.09 ToE/capita in 2006, increasing to 0.13ToE/capita in 2013, representing a growth rate of 44.44%.The biomasss component of bioenergy, in the form of fuelwood and charcoal, make up 75% or more of the national energy consumption (Ghana Statistical Service, 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), 2005-2013

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: Biomass Supply in Ghana (ktoe)



	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 countryvaries 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 apotential generation of between 5.6MW – 24.5MW (Ministry of Energy, 2010).

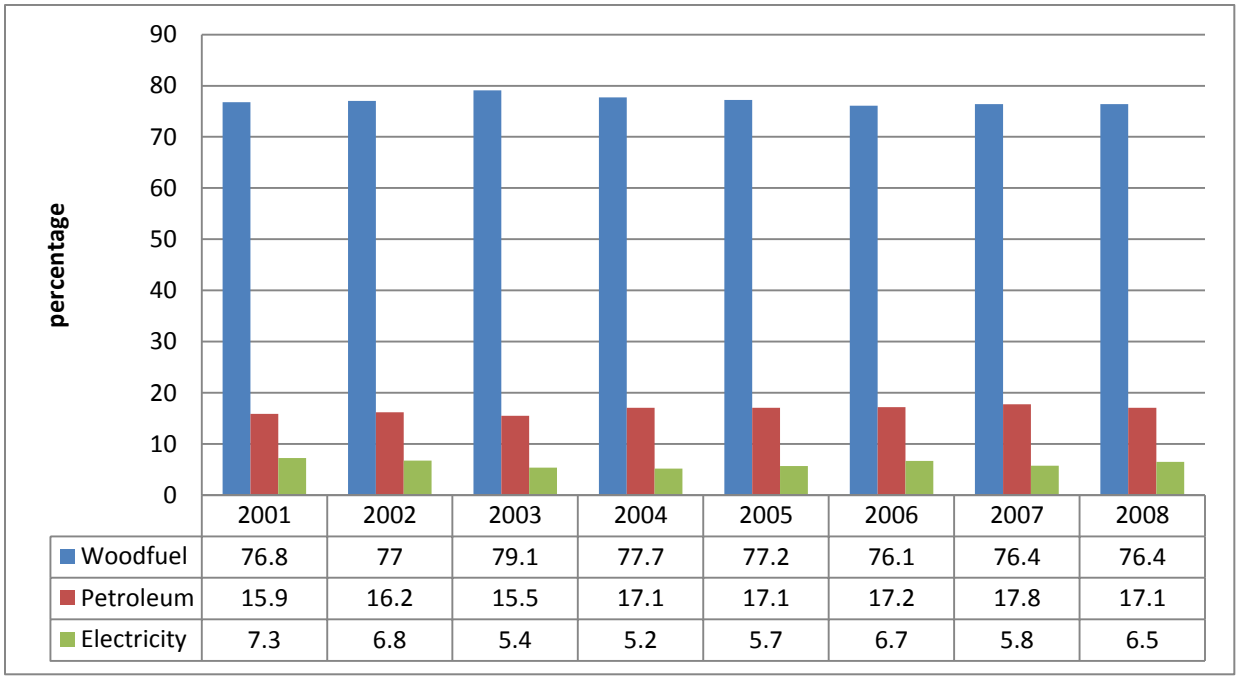
The major energy demand sectors of the economy are the residential, non-residential and the industrial sectors. The rural and urban communities make up the residential demand side of energy. Total number of households in Ghana was about 4 million in 2000, 5,467,136 in 2010 and is expected to reach between 5 – 6 million by 2020 (GSS, 2013). The main energy end-use applications in households are lighting and cooking,biomass is the main energy source usedbymost 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 the informalsector comes 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 bypetroleum and then electricity as depicted in Figure 3. According to the Ghana Statistical Service (GSS, 2013) electricityis the dominant modern energy form used in the industrial and service sectors, accounting for 69% of modern energy used in thetwo 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, 2013the results of the 2010 Population and Housing Census (PHC)showed thatmore than sixty percent (64.2%) of households use electricity (mains) as their main source of lighting (Figure 4).

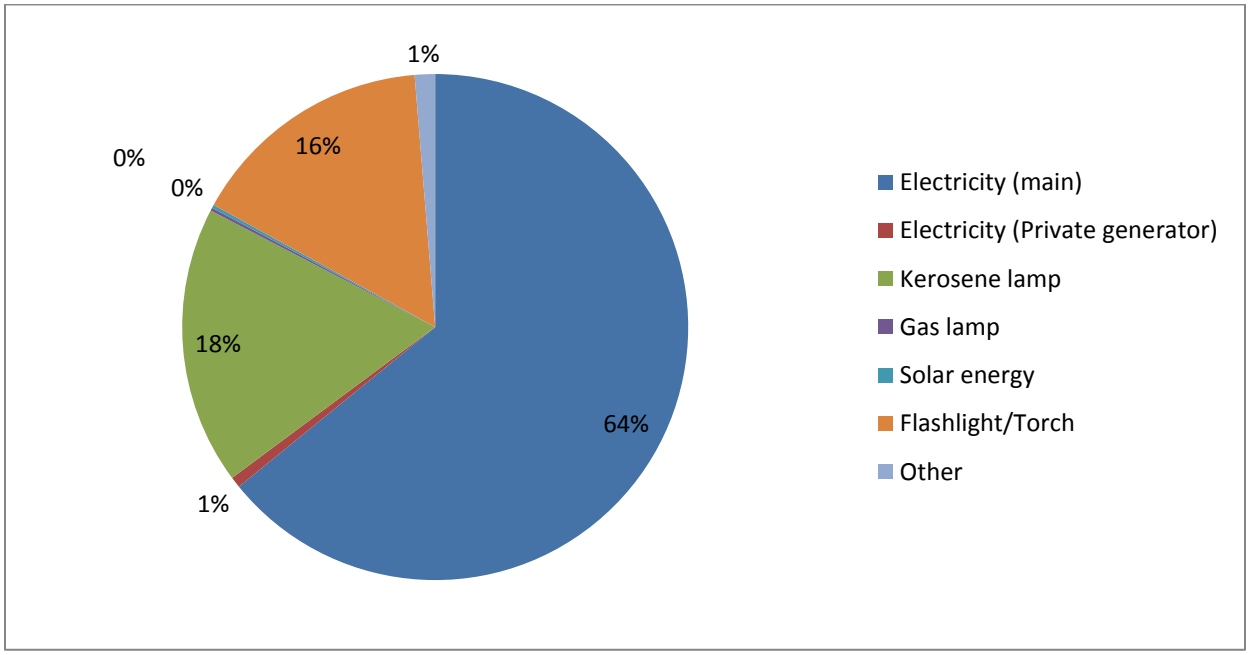
Figure 3: Trends in share of total energy consumed



	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

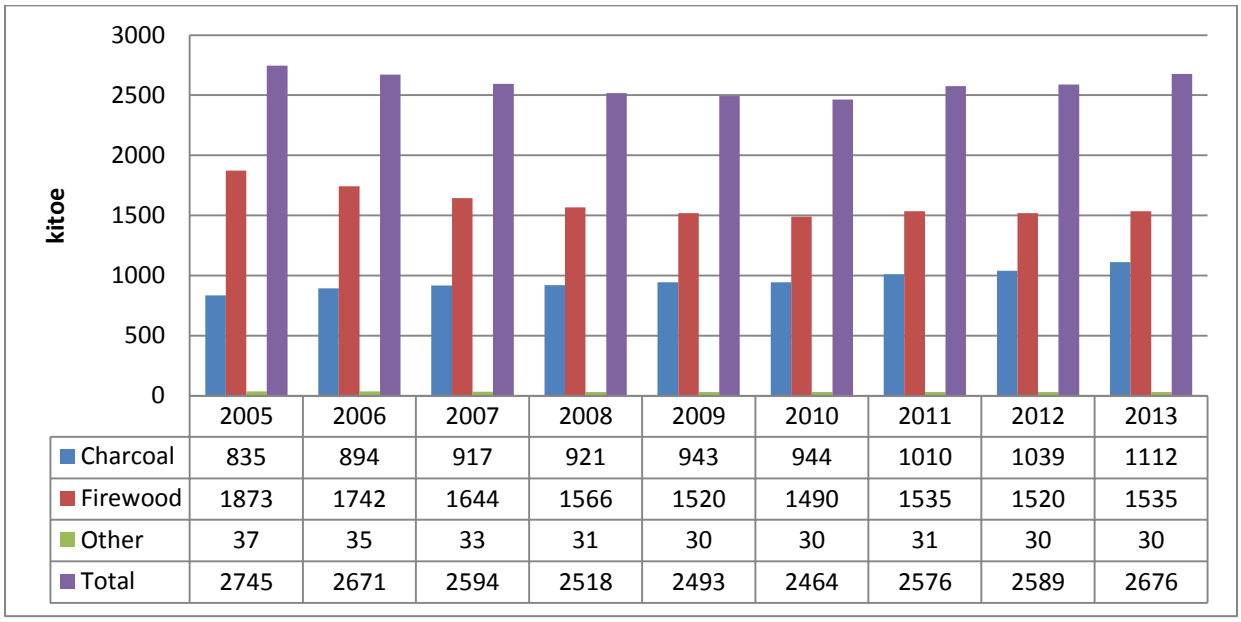
Figure 4: Energy sources for lighting



Source:GSS, 2013

Wood fuel consumption in the form of charcoal has seen an increased consumption rate since 2005 as compared to firewood which declined in consumption from about 1,873ktoe in 2005 to about 1,535ktoe in 2013 (Figure 5). Other biomass fuels such as saw dust, sawmill and crop residues are consumed in minute quantity. The biomass consumption pattern indicates a shift from wood use, in its unprocessed form, as firewood to charcoal for more urban households. LPG usage in Ghana increased significantly from 6.2% in 2000 to 18.2% in 2010 (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: Biomass Consumption (ktoe)



	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, 2014

Table 3: Energy for Household Cooking in 2000 and 2010

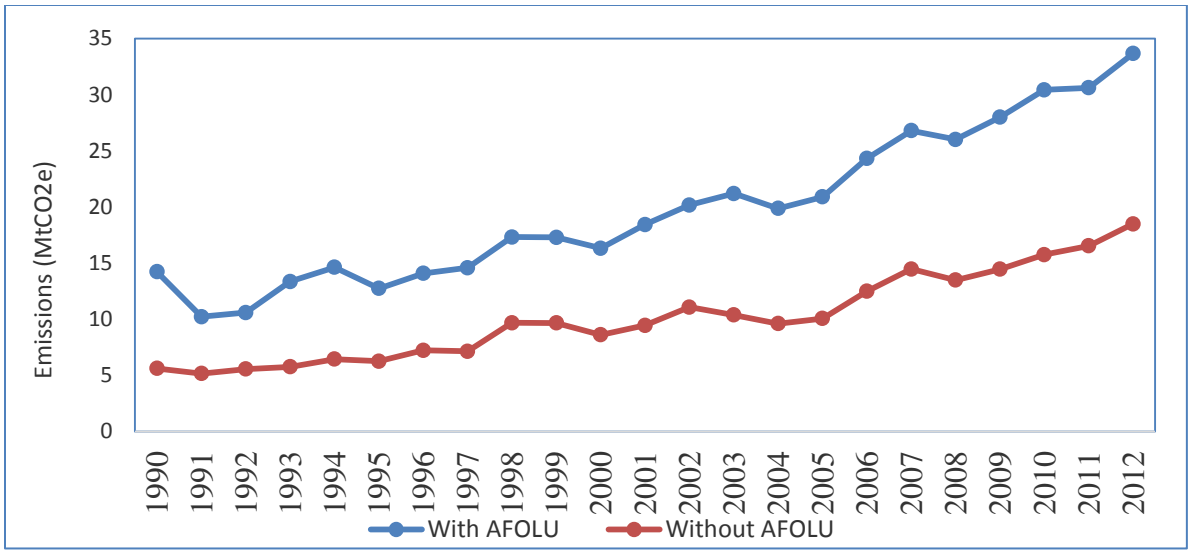
Energy Source	2000			2010		
	National	**Urban**	**Rural**	**National**	**Urban**	**Rural**
Percentage penetration (%)						
LPG	6.2	11.8	1.1	18.2	41.5	4.8
Charcoal	30.0	54.3	8.2	33.7	74.6	15.9
Firewood	55.8	22.9	85.2	40.2	26.7	73.4
Kerosene	2.0	2.6	1.4	0.5	1.1	0.3
Electricity	1.1	2.0	0.4	0.5	1.1	0.3

Source: GSS, 2002and 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).

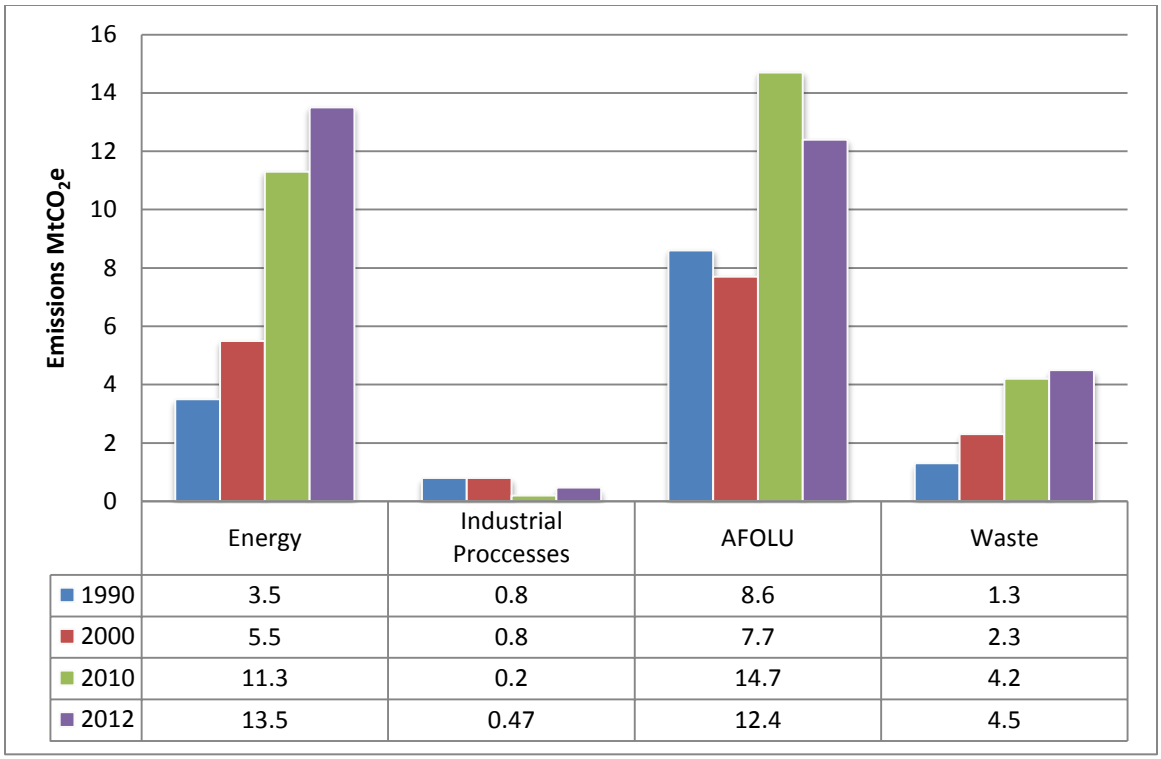
Figure 6: National emission trends with and without AFOLU



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 a 222.9% increment) and 13.5 MtCO2e in 2012 representing a 285.7% increase (Figure 7). Within the energy sector, the largest emissions came from the transport sub-sector followed by the 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 ($MtCO_2e$)



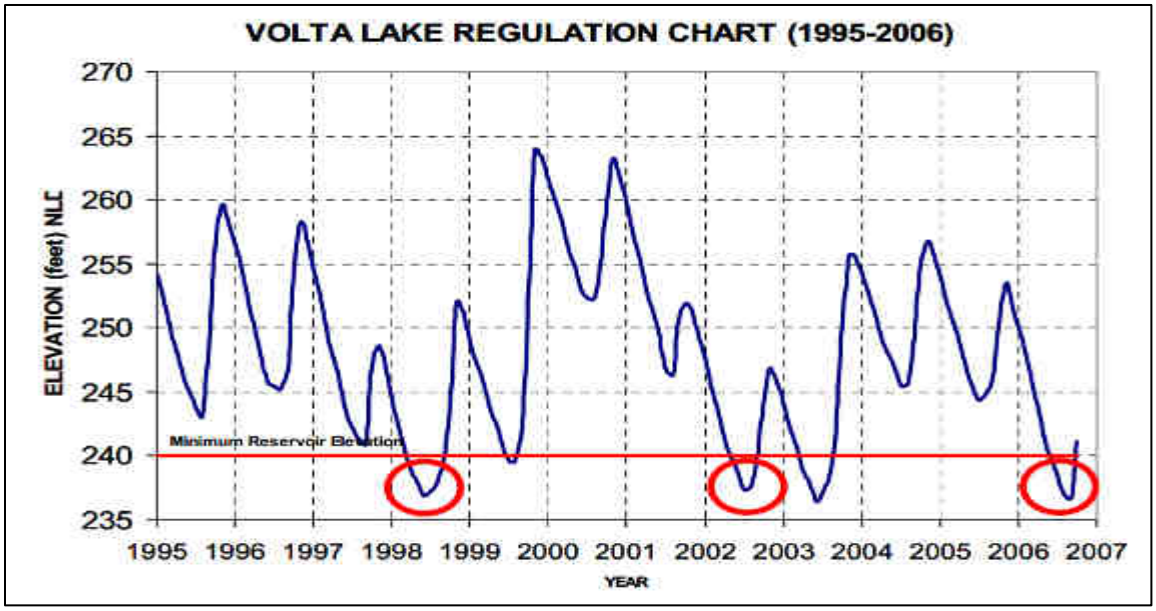
	Energy	Industrial Proccesses	AFOLU	Waste
1990	3.5	0.8	8.6	1.3
2000	5.5	0.8	7.7	2.3
2010	11.3	0.2	14.7	4.2
2012	13.5	0.47	12.4	4.5

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 rises. This is attributable to the fact that with low hydro-electricity production in those years, thermal power plants' production had to be ramped up 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 developedin 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, thekey one being the National Electrification Scheme, which aimedat extending electricity to all parts of the country by 2020. Other important energy policies are summarisedin 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

Asexplained in the workbyBawakyillenuo 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 within Ghana 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 somethermal 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 Powerin 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 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 formulation, implementation, monitoring and evaluation of energy sector policies.
• **Ministry of Power**	• 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 the electricity sector in Ghana

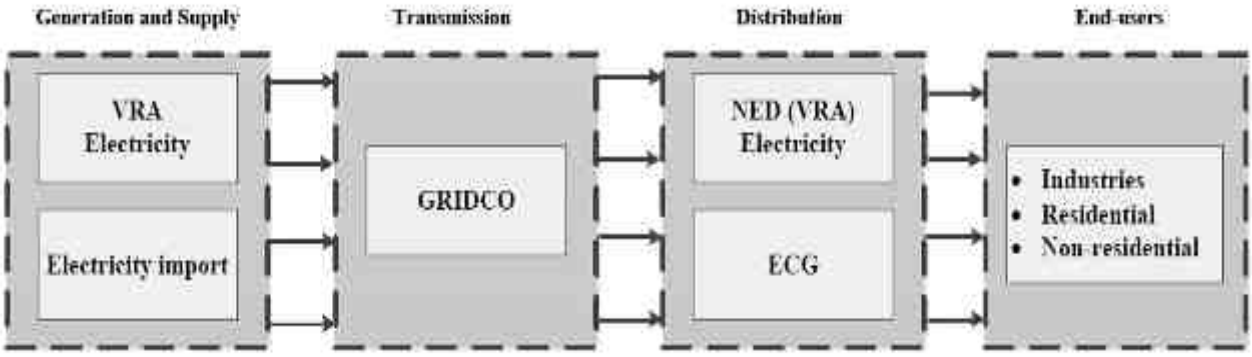
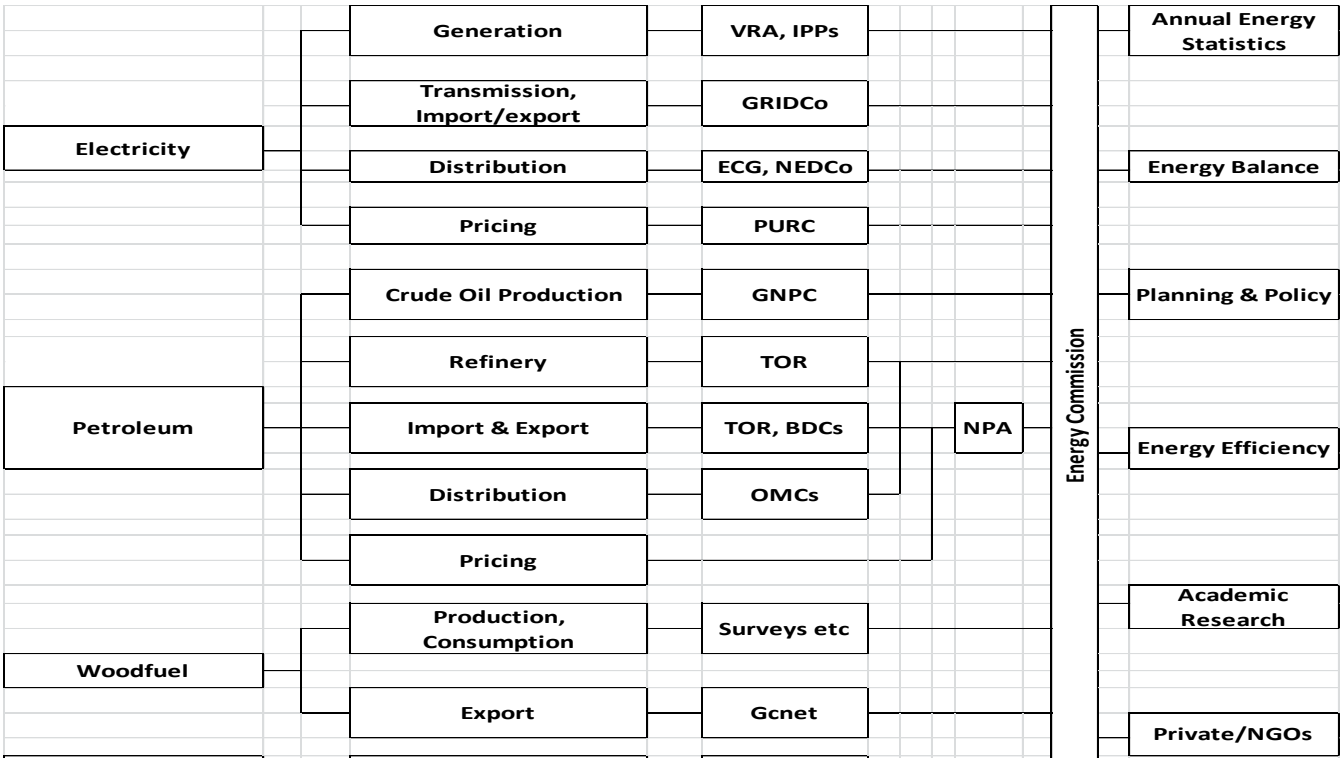


Figure 10: Organogram of the Energy Sector



Source: Ministry of Energy 2010

1.1.2 Energy Picture of the Central Region

The Central Region was created in 1970, with Cape Coast as the regional/administrative capital, threedistricts and eighteen local authorities. At the end of 2012, the region had twenty Metropolitan, Municipal and District Assemblies (MMDAs): one metropolis, seven municipal assemblies and twelve district assemblies (GSS, 2013). The region has the highest of tourist attraction sites in the country, ranging from historical castles and forts to national parks. The existence of these tourist facilities has underpinned the development of numerous economic activities including hospitality services. Close to 43% of the economically active population are into agriculture, forestry or fishing while 17.3%, 11.6% are into wholesale and retail and manufacturing respectively (GSS, 2013).

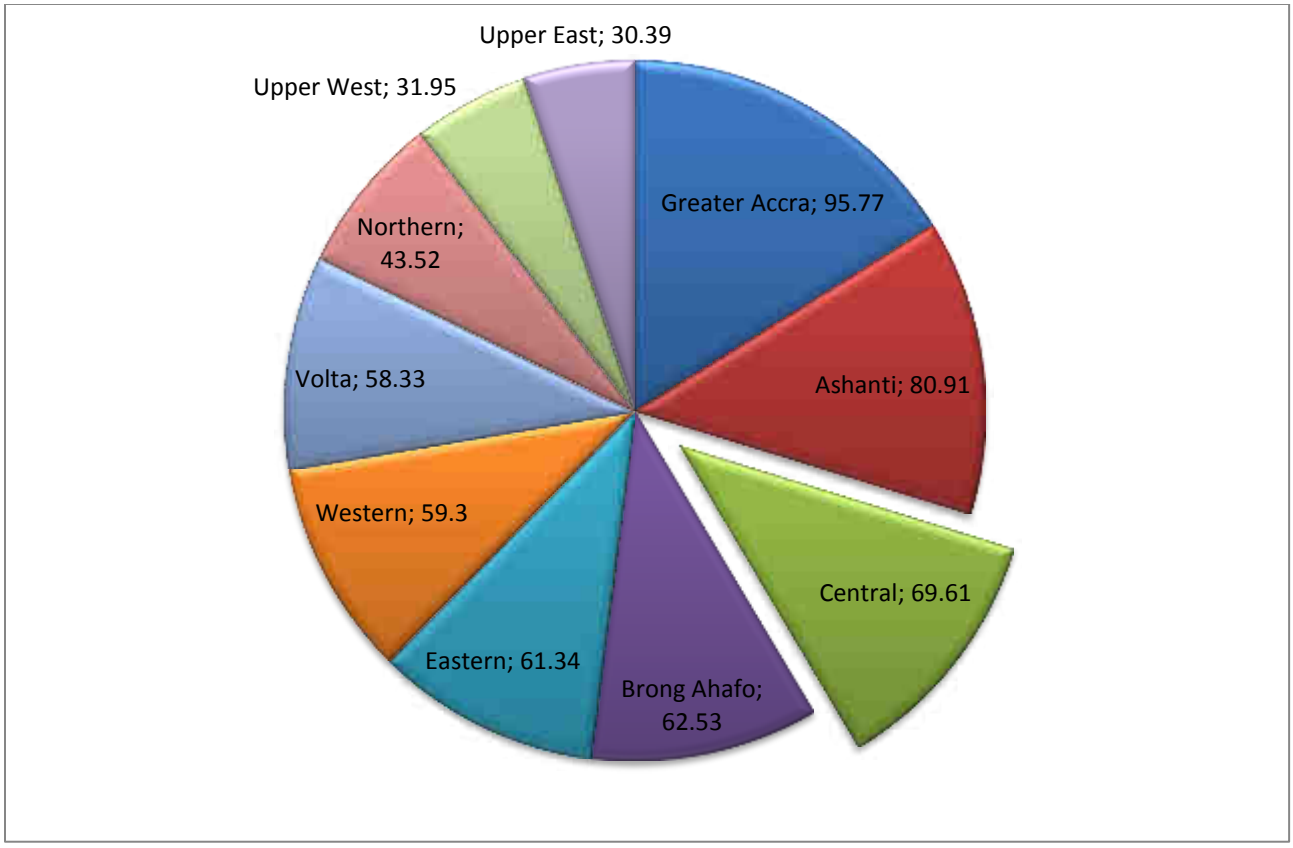
The 2010 PHCfound that about 2,201,863 people live in the region,comprising about 8.9% of the total population of Ghana and, ranking seventh among the ten regions in terms of population size. About 47.7% of this populationlives in urban areas, however there are marked variations in the proportion of urban dwellers inthe various districts within the region. There are 526,764 households in the region out of which 255,365, representing 48.5% of total households, are

located in urban areas (GSS, 2010).The 2010 PHC results also revealed that the region had the highest annual average inter-censal growth rate of 3.1% in Ghana.

Various forms of energy are consumed in the region for different purposes. About 70% of the population in the region has access to the national grid for their power needs as at 2012 (Figure 11). The proportion of households using electricity (from the national grid) for lighting in the region is about 66.1%. This is the third highest in Ghana, after Greater Accra Region and Ashanti Region. Other lighting sources include kerosene lamp (20.7%), flashlight (11.2%) and candles (0.5) (GSS, 2013). The proportion of households using electricity generators as the main source of lighting is under one percent (0.7%)(GSS, 2013). The use of private generators is a recent phenomenon,that has ensued as a result of the frequent power outages and load shedding that have gripped the country.There are rural-urban variations in the sources of domestic lighting. Over three quarters of households in urban areas (78.4%) obtain light from electricity (national grid), compared to54.5 percent in rural areas. One-quarter of households in rural areas (25.5%) use kerosene lamp as the main source of light compared to 15.7 percent in urban areas. Eighteen percent of rural dwelling units use flashlight as main source of light compared with only 3.9 percent in urban areas (GSS, 2013).

The three main sources of energy for cooking in households in the Central Region as at 2010 are firewood (44.2%), charcoal (36.9%), and LPG (12.5%)(GSS, 2013). The use of LPG is becoming more common in the region with several LPG service operators operating at different locations in the region (GSS, 2013). The proportion of dwelling units where no cooking is done is 5.1% which may be a reflection on the increase in single-member households (GSS, 2013). In rural areas, because wood is locally available, it is the main source of cooking fuel for 67.0% of households compared with 20.0% in urban areas. In contrast, charcoal,which is often produced for urban dwellers, is used by 52.9% of households in urban areas, and 21.8% in rural areas (GSS, 2013). The heavy reliance on wood and charcoal as the main sources of energy has implications for the rapid deforestation in the region.

Figure 11: 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 ASEMwere gathered in two phases, with each embodying different collection tools. Phase one scoping and desk review of existing energy data onASEM. Phase two involvedthe 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 discussions. Details of the two phases that led to the generation of data for the ASEM 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 ASEM 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 consultedinclude the National Energy Statistics(2014), the 2014 Energy (Supply and Demand) Outlook for Ghana, Central Region Analytical Report for the 2010 Population and Housing Census and the Awutu Senya 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 ASEM[5] was produced using the data gathered from the phase one activities. Appendix 1 contains the first draft of the SoE report for the ASEM, which was informed mainly by the data that were gathered from the phase one. The draft is less informative, based on its scanty nature and, thereforecan'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.

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

2.2 Phase Two: Conduction of Primary Data Collection (Energy Survey)

After identifying from phase one that, the existing energy data on ASEM was 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 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:

- Questionnaire (face-to-face) interviews; 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, a 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 ASEM 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)and the Energy Research Centre (ERC) madeinsightful 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 ASEMA's three broad settlement classes - First Class; Second Class and Third Class. These classifications were 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 research team adopted the settlement classifications used by ASEMA for levying and revenue collection purposes as proxies for income levels – First Class, Second Class and Third Class settlements. Sampling for the survey was done along these settlement classifications.

With the help of the municipal partners in the ASEMA, Assembly Members from various Electoral Areas (EAs) in ASEM were contracted to assist in a headcount exercise of the total households in the municipality along the various settlement classes defined by the ASEMA. Through this exercise, 43,795 households were counted as the total household population in the municipality. The breakdown of the total households into the respective settlement classes guided by the list of settlements made available by ASEMA is shown in Table 6.

Table 6: Total Number of HouseholdsSettlement Classes in ASEM

HOUSEHOLD CLASS	AWUTU SENYA EAST MUNICIPALITY
TOTAL NUMBER OF HOUSEHOLD	**43,795**
1ST CLASS HOUSEHOLDS	10,161
2ND CLASS HOUSEHOLDS	15,057
3RD CLASS HOUSEHOLDS	18,577

Sample size determination

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

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

[6] Details of these classifications are provided in section three.
[7] Available at surveysystem.com

where ‘Z’ is the 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 593 households were sampled for the household survey in ASEM. 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 sampling tool.

Table 7: Sampled householdsper class in ASEM

SECTOR	AWUTU SENYA EAST MUNICIPALITY	
	Population	**Sample**
TOTAL NUMBER OF HOUSEHOLD	**43,795**	**593**
1st Class Households	10,161	137
2nd Class Households	15,057	204
3rd Class Households	18,577	252

The household survey was designed to capture the state of energy among electrified andnon-electrified households. Therationale 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 sampledhouseholds 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**
ASEM	113	24	**137**	170	34	**204**	210	42	**252**

The relative sample proportionsof electrified and non-electrified households were premised on the yardstick that 83% of households are electrified as against 17% non-electrified in ASEM. 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**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

The commercial sector employs the majority of the people in ASEM. Commercial activities undertaken in ASEM vary across formal and informal sub-sectors. In order to understand the energy situation within the commercial sector of ASEM including the quantity of energy supplied to commercial activities as well as the quantity of fuel type consumed by these activities, a structured questionnaire was designed and administered to sampled formal and informal commercial activities. The SAMSET team obtained a list of commercial activities in the municipality from ASEMA, consisting of 1,854 commercial activities. A total of 435 commercial activities were sampled out of the 1,854 commercial activities using the online sampling tool. Of the 435 sampled commercial activities, about 20% were formal commercial activitiesincluding 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) while 80% were informal commercial 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 ASEM 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 structured questionnaire was designed to capture energy issues within ASEM's industrial sector as a whole and within the various sub sectors including mining and quarrying, manufacturing, water and sewerage and construction sectors. ASEMA provided the Ghana SAMSET team with a list of industrial activities in the municipality. The industrial survey covered all 33 activities across the various sub-sectors as provided by ASEMA. The enumerators carried out face-to-face interviews across all the industrial sub-sectors to gather information on energy usewithin these industrial activities.

2.2.1.4 Agricultural Sector

Some commercial agricultural activities are undertaken in ASEMA. Some large scale agricultural activities include pineapple farms and poultry farms in the municipality. In order to gain insight into energy issues around these agricultural activities, a structured questionnaire was designed by the Ghana SAMSET team to be used to capture energy issues within such activities. The Ghana SAMSET team obtained a list consisting of 16 agricultural activities from ASEMA. All the 16 agricultural activities were surveyed and the enumerators carried out face-to-face interviews guided by the structured questionnaire.

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 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 ASEM 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 ASEM 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 ASEMA on the 13th October, 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 ASEMA. ASEMA 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 best by the Ghana SAMSET team was to organize stakeholders from different departments of ASEMA 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 ASEMA on the 8th October, 2014. Participants were drawn from the following departments of ASEMA.

- Transport
- Works and Housing
- Electricity
- Planning

2.2.2.3 Energy Resources in ASEM

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 imported into ASEM. To obtain reliable quantities of different energy resources available in ASEM 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 resources availability issues in ASEM. The FGD was undertaken at the premises of ASEMA on the 13th October, 2014. Participants in this Energy Resources FGD in ASEM 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
- Awutu Senya East Municipal Assembly

2.2.2.4 Fuel Generation in ASEM

With respect to the different fuel types that are generated in ASEM, 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 8th October, 2014 at the ASEMA premises. Key stakeholders from the following groups were engaged in theFuel Generation Sector FGD.

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

Other national documents such as the 2014 National 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 ASEMA. 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. At least six participants were present during all the FGDs with some stakeholders having participated in more than one FGD due to their perceived experiences and wealth of knowledge they had to offer.

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 adapt, 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 Awutu Senya East Municipal Assembly (ASEMA) to discuss the essence of the survey, the strategies and methods to adapt 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 programmeso as to get them 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 ASEMAand ISSER, and the questionnaires themselves.

2.2.3.3 Piloting of survey instrument

After the training, the enumerators embarked on a 1-day pilot test of the survey instrument. 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 3rd September, 2014 and ended on the 18th September, 2014. 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 hours (KWh). Firewood is measured in kilograms 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 kilograms. LPG is usually stored in metal cylinders that come in different sizes starting from 3kgs. Candles and dry cell batteries are measured in their numbers, biogas is measured in British Thermal Unit (BTU) and natural gas is measured in million BTU per Gigajoules.

Table 9: Unit of measurement for the various fuel types

FUEL TYPE	UNIT OF MEASUREMENT
Electricity	kWh
Wood	Kilograms (kg)
Charcoal	Mini or Maxi Bag(converted to kg)
Kerosene	Litres
LPG	kg(*by cylinder*) 3kg, 6kg, 9kg, 15kg…
Petrol	Litres
Diesel	Litres
Biogas	BTU
Dry Cell Batteries	Numbers per Unit
Candles	Numbers per unit
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 training of the enumeratorsoffered 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 usingtwo statistical softwares, SPSS and STATA andanalyses 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 ASEM.

SECTION THREE

AWUTU SENYA EAST MUNICIPALITY ENERGY PICTURE

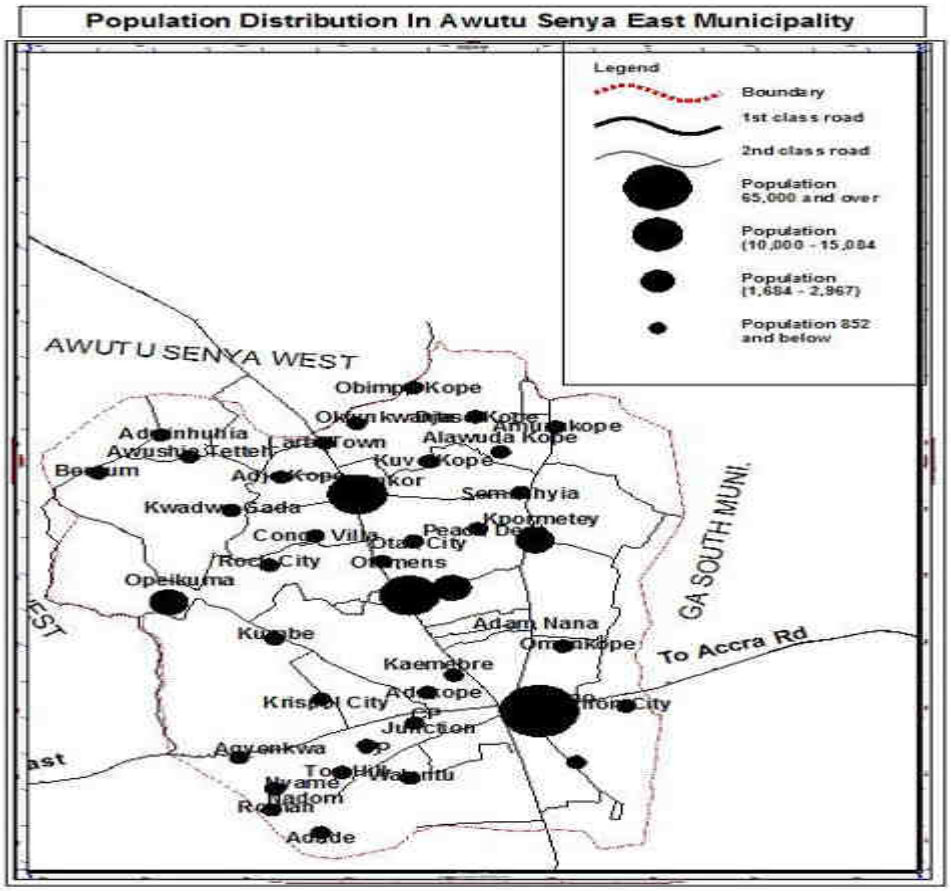
3.1 Profile of Municipality

3.1.1 Population and structure

The Awutu Senya East Municipal Assembly (ASEMA) is one of the newly created municipalities in the Central Region. It was carved out of the former Awutu Senya District in 2012 and established as a Municipality by Legislative Instrument (L.I) 2025, with Kasoa as its capital. The rationale was to facilitate government's decentralization programs and local governance system in the country.Statistics from the 2010 PHC peg the total population of the municipality around108,422,with an annual growth rate of 3.0% (GSS, 2014). This is about 4.9% of the Central region's population.The male population is 48.1%as against 51.9%female population.ASEM is highly urbanized due to its proximity to the capital city of Ghana, Accra. Only 15% of the population lives in rural areas in the municipality (GSS, 2014). Due to its strategic location, rural-urban and urban-urban migration is a common phenomenon in the municipality. The major settlements of the municipality, with high population densities, are Kasoa, Opeikuma, Adam Nana, Kpormertey, Ofaakor, Akweley, Walantu and Zongo (Figure 12).

The high migration and urbanization rate coupled with poverty, inadequate/insufficient housing and land speculations have led to the development of KasoaZongo and Adakope slums in the municipality. These slum areas are often characterized byincreased vulnerability to environmental health problems, environmental, and natural disasters; illegal electricity connection; intermittent fire outbreaks; and increased vulnerability among women, children and youth (GSS, 2014).

Figure 12:Map of population distribution in ASEM



Source: ASEMA, 2014

The results of a recent GPS survey undertaken in 2015 by officials of ASEMA wasused to map out urbanization in ASEM (Figure 13). Due to the locational factor vis-à-vis other economic factors, migrants from near and afar are attracted to the municipality. The survey revealed that the top three migrants' origins areAccra, AssimFosu and Gomoa/Fetteh (Figure 14). Upon arrival in the municipality, the majority of the people lookout for low cost and third class communities

like Walantu, Zongo, Opeikuma and CP to settle (Figure 14) and some of them could only afford and dwell in temporal structures like uncompleted buildings, kiosks and containers in the municipality. The existence of such habitation without any form of control from the local authorities has often resulted in the development of slums in the municipality. These Migrants often get access to public utilities like electricity and water but some gain such accessibilities through illegal connections.

Figure 13: Map of urbanisation in ASEM

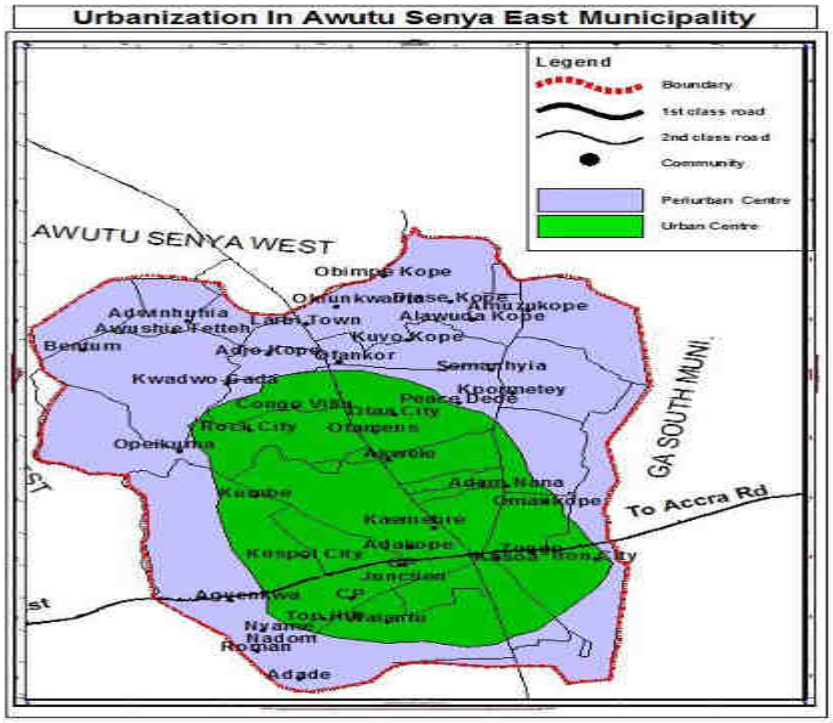
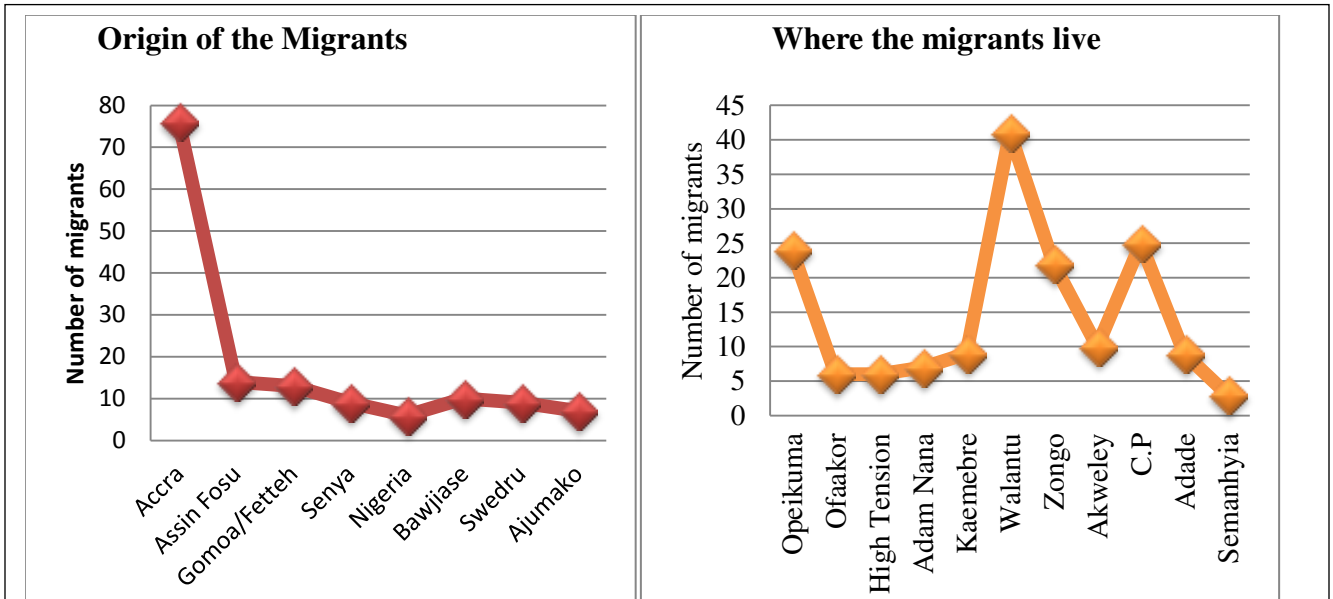


Figure 14: Origin and Destination of migrants to ASEM



Source: ASEMA, 2014

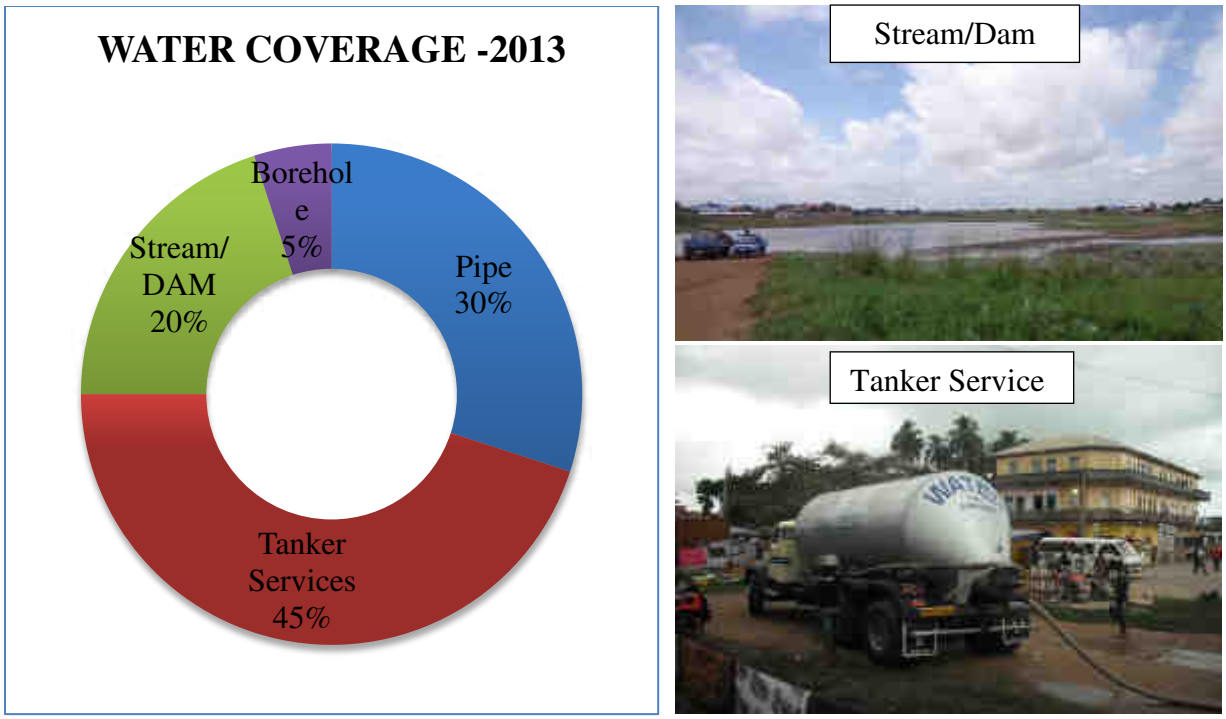
3.1.2 Land Tenure System

Land in the municipality is owned by chiefs, clans or family heads who hold them in trust for their subjects. Landcan be acquired through direct purchase, rent, leasehold and share cropping. The fact that these parcels of land canbe 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 farmlands to residential developments in the municipality (GSS, 2014).

3.1.3 Water and Sanitation

Lack of potable drinking water is a major challenge confrontingthe municipality. About 45% of households, commercial and industrial activities that demand water depend on water tanker services while 30% have access to piped water. About 20% depend on streams or dams while 5% use the borehole system (GSS, 2014) (Figure 15).

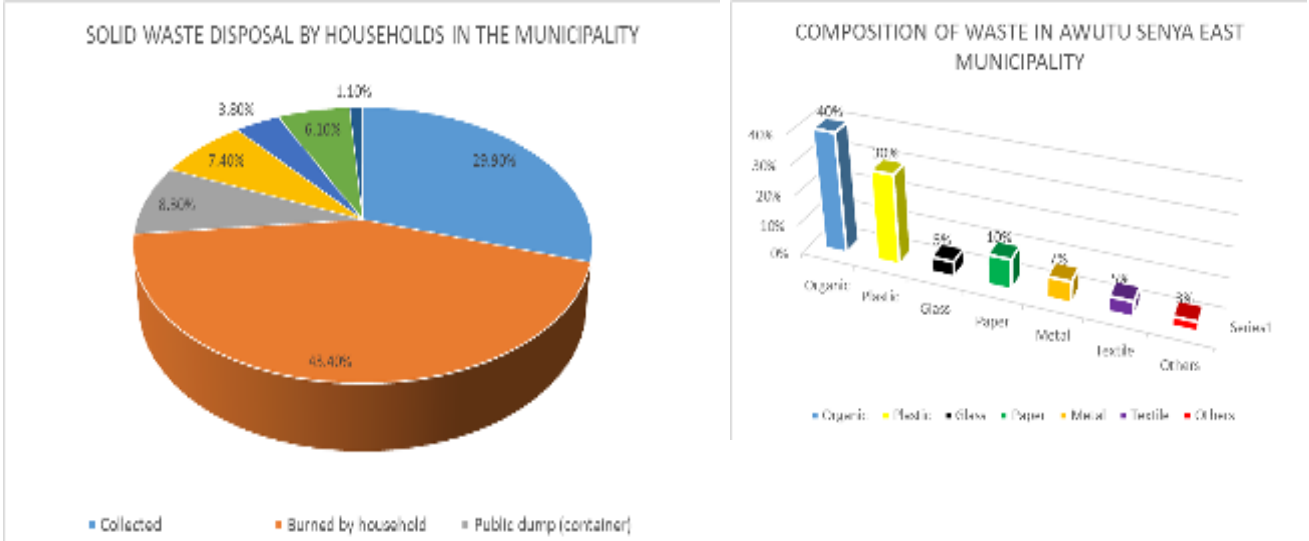
Figure 15: Water Coverage in ASEM

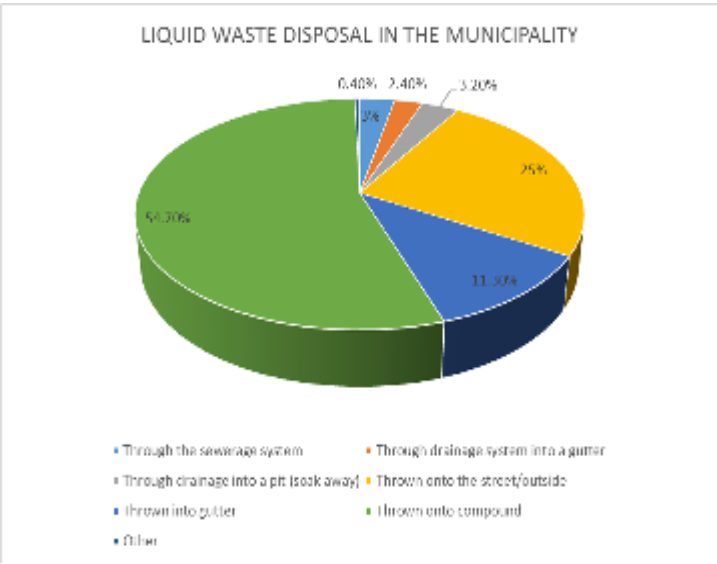


Source: ASEMA, 2014

Sanitation services within the municipality are poor. Significant quantities of solid and liquid waste isgenerated in the municipality due to the extensive trading activities coupled with the large central market located at Kasoa. About 1,414tonnes of solid waste is generated monthly in the municipality (Zoomlion Ghana Limited, 2013). Only 31% of households have their waste collected and sent to formal disposal sites. About 44.7% of households burn their waste, 8.6% dump their waste in public containers, while 8.4% dump the waste in open spaces indiscriminately (GSS, 2014). About 53% of households throw liquid waste in their compounds, 25.6% of households throw liquid waste on the streets/outside while 11.3% throw the liquid waste in gutters. Only 3% and 2.4% of households dispose liquid waste through the sewerage system and drainage into gutters respectively in the municipality (GSS, 2014) (Figure 16).

Figure 16: Solid and Liquid Waste disposal in ASEM





Source: ASEMA, 2014

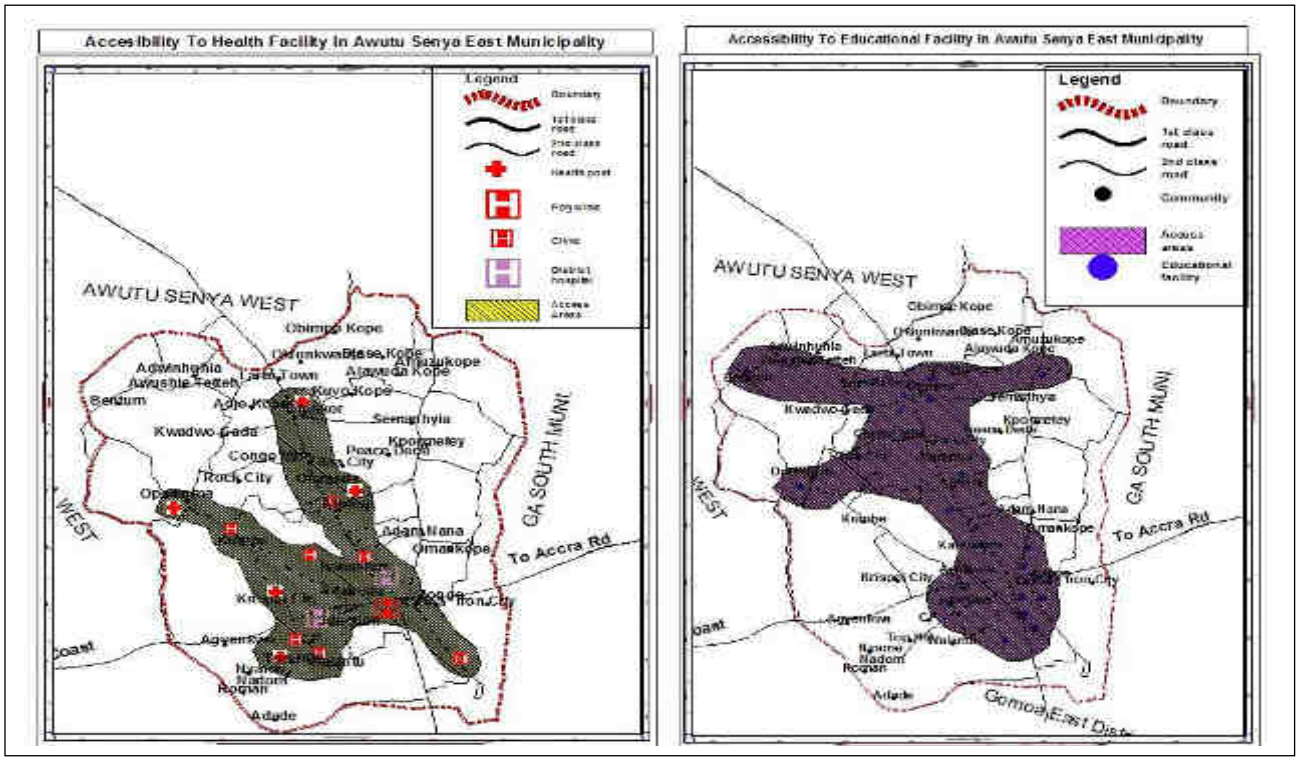
3.1.4 Health Service delivery and Education

There are 5 public hospitals including 1 polyclinic in the municipality which are located in 5 sub districts, Akwelley, Central Kasoa, Kasoa, OdupongKpehe and Opeikuma. The Out-Patient Department (OPD) attendance in these hospitals in the five sub districts ranged from 4,778 to 80,971 in 2013. There are also 2 private hospitalsin the municipality coupled with other care providers such as chemical shop dealers, maternity homes, traditional healers etc. (GSS, 2014).Malaria, acute respiratory & tract infections and rheumatism & other joint pains are the top three most suffered diseases in ASEM.

The municipality houses several educational institutions, both public and private. As at 2013, there were about 54 public educational institutions in the municipality out of which, 16 were kindergarten, 21 were primary and 17 were junior high schools (GSS, 2014). There are no public senior high schools, tech/vocational or tertiary schools in the municipality. There are however 10 private senior high schools, 2 private tech/vocational and 4 private tertiary institutions in the

municipality coupled with 53 private kindergarten, 147 private basic schools and 100 private junior high schools (GSS, 2014). Figure 17 Shows accessibility to health and education facilities in the municipality.

Figure 17: Maps of accessibility to health and education facilities in ASEM



Source: ASEMA, 2014

3.1.5 Economic Activities

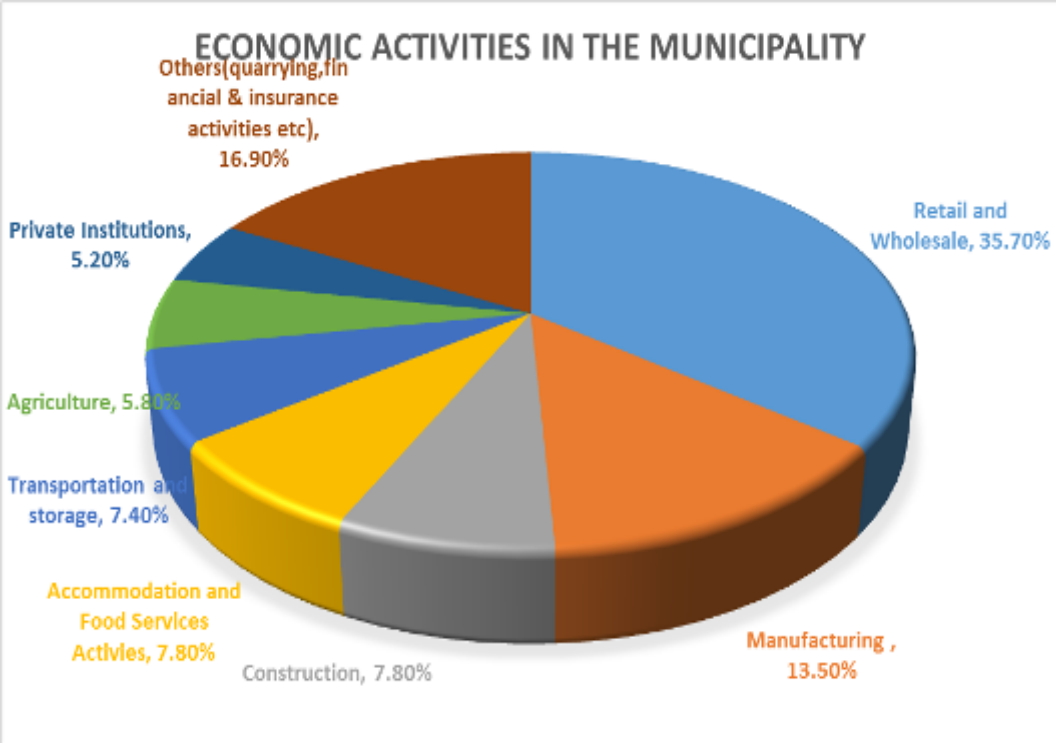
All kinds of economic activities across the agriculture, industry, service and commercial sectors exist in the municipality. The main economic activities in the municipalityinclude trading (wholesale/retail), agro-processing, informal sector service and commerce. Trading and its related activities - commercial activities-are the leading economic ventures which, according to statistics in the 2010 PHC, employ about 35.7% of the working population in the municipalityand contributes about 35.7% of the total economic activities in the municipality (GSS, 2013). The private informal sector's contribution is enormous (GSS, 2014) (Figure 18). The sector employs about 81.9% of the working population in the municipality but needs to be integrated with the formal commercial sectoractivities such as the education and health services (schools, hospitals and 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 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 ASEMA, hence, the assembly is unable to keep record of the total commercial activities in the municipality

Livestock production, crop and cash crop productionas well as retailing of agricultural products arepracticedin the municipality,but on a smaller scale. Approximately 61% of the population is into crop farming while 36% is into livestock farming (GSS, 2014). There are, however, few mechanised agricultural activities in the municipality including, poultry and pineapple farms that operate on large commercial scales for agro-processing and exports.

Other economic activities in the municipality include manufacturing, construction and mining and quarrying under the industrial sector. Due to the 'dormitory' nature of the municipality as a result of its proximity to the capital city, Accra, real estate business and construction works are very common in the municipality with large tracts of undeveloped lands being developed at a fast pace ahead of planning. Sand mining and quarrying are very common in the municipality to satisfy the high construction demands (GSS, 2014). Sachet water and fruit juice production are some of the manufacturing activities in the municipality. These activities employ both indigenous and non-indigenous workers in the municipality.

Figure 18: Economic activities in ASEM



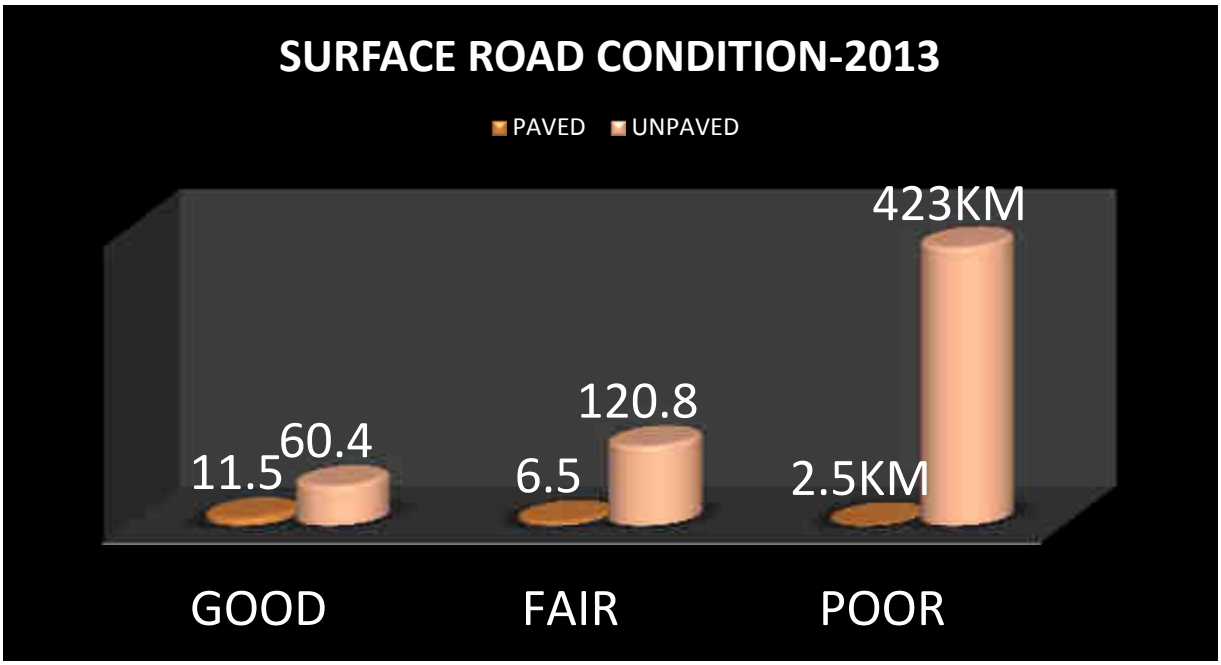
Source: ASEMA, 2014

3.1.6 Road Network and Transportation

The municipality has a total of 625 km road network, of which 59 km is within the urban centers. Close to 20.6 km of the total road network in the municipality has received flexible pavement finishing(GSS, 2014).About 11.5km of the 20.6km is in good condition while 6.5 km isin a fairly good condition.The rest (604.4km) constitute gravel/earth roads located within various deprived communities in the municipality. About 60.44km of the unpaved roads are in good shape, 120.8km are fairly goodwhile 423km are in poor condition (GSS, 2014) (Figure 19).

The proportion of good roads in the municipality is inadequate and, therefore, does not meet the demands of the people especially in the low income areas. However, an unknown length of road is yet to be assessed by the urban roads authority to assess the full length of roads in the municipality (GSS, 2014).

Figure 19: Surface road condition in ASEM as at 2013



Source: GSS, 2014

3.1.7 Settlement classifications by ASEMA

The Awutu Senya East Municipal Assembly 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 settlementswithin 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. Withthe availability of these infrastructures, first class settlements are often dominated by high income households who live invery expensiveresidential structures and mansions. By virtue of their location, these structures attract high property rates, per ASEMA'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 ASEM includeIron City, New Town, Adam Nana, American Town, Blue Rose Estate, Little Rock Area and Windy Hills.

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 oneswithin thesesettlements. A few schools and

health facilities also exist. Second class settlements in ASEMA are dominated by middle income households that livein medium size residential structures. Properties in the second class settlements attract medium rates compared to the first class, but higher than thethird 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 Akweley Township, Semenshia, Down Town, Krispol City, Ofaakor Newtown and Adom City.

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 pupilspopulation. Health facilities are also few or non-existentin 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 ASEMA include,Opeikuma, Rock City, KasoaZongo, Dokutsekope, Adakope, Mount Zion Area, Christian Hill and Ayigbe Town.All the communities in ASEM per ASEMA's settlement classification means are attached in Appendix 1

3.2 Overview of ASEM Energy Supply and Demand

3.2.1 Energy Generation and Supply in the Awutu Senya East Municipality

There is noknown major fuel that is being generated in the ASEM. It therefore implies that the municipality depends solely 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 sources 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, ASEMA sometimes procures and installs electricity poles in non-electrified areas before ECG installs the cables on them. Information gathered from the focus group discussions reveals that, the stock of electricity power available for importation to the ASEM was about 2,631 MW by 2013. Out of this stock, about 20.1MW 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 ASEM 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 ASEM

Products	Quantity available for importation	Quantity imported to ASEM
Kerosene	27.8 kilotonnes (kt)	300000 lit (0.24kt)
LPG	251.8 kilotonnes (kt)	40218480 kg (40.21848 kt)
Diesel	1722.6 kilotonnes (kt)	17442000 lit(14.78 kt)
Petrol	1080.6 kilotonnes (kt)	17100000 lit(12.76 kt)

Source: GSS, 2014 and 2014 Energy Survey

Neither charcoal nor wood fuels are generated directly in the municipality, but are imported from neighboring districts and sometimes from other regions. As of 2013, the quantity of wood fuel and charcoal available for importation toASEMwas 1,535 ktoe and 1,989 ktoe respectively (Energy Commission, 2014). In 2013, about 90,000kg(0.0324 ktoe) of wood fuel and 468,000kg(0.41184ktoe) of charcoal were 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 producingareas in Ghana included,Kintampo, Wenchi, Atebubu, Mampong and Techiman (2014 Energy Survey). By 2013, the production of charcoal moved further up north into areas such as Bole where charcoal consumed in ASEM was transported from (ISSER, 2014). 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 ASEM. This has increased transportation cost of charcoal over the years.

3.2.2 Energy Consumption in ASEM

Based on the survey results, the total energy consumed in 2013by the sampled households, commercial and industrial activities, agricultural activities, transportation and the local

[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].

government sectors in the municipality is about 3,425,300.7 Gigajoules. With reference to the total number of households, commercial, industrial and agricultural activities, in the municipality, the total energy consumedis estimated around 4,965,445.85 Gigajoules (Table 11).

Table 11: Total aggregate energy demand by sector in 2013

Sector	Energy demand (GJ)*	Energy demand (GJ)**
Household Sector	10,863.6	802,324.4
Commercial Sector	18,591.9	641,100
Industrial Sector	8,789.9	133,180.3
Agricultural Sector	840.4	2,626.25
Transport Sector	3,372,729.5	3,372,729.5
Local Government Sector	13,485.4	13,485.4
TOTAL	**3,425,300.7**	**4,965,445.85**

Source: 2014 Energy Survey

*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 3,372,729.5 GJ (representing 68% of total energy consumed). The energy carriers mainly consumed in this sector are diesel, petrol and LPG fuels. Petrol constitutes about 69% of the fuels consumed within the transport sector; followed by diesel (30%) and LPG (1%). The household sector is the second largest energy consuming sector in the municipality, constituting about 16%. This is followed by the commercial sector, 13%. The industrial sector consumes about 3% of the total energy in the municipality, while the agricultural and local government sectors constitute less than 1% of the total energy consumed in ASEM (Figure 20). These energy consumption levels by the sectors are based on the actual population estimates of all the sectors.

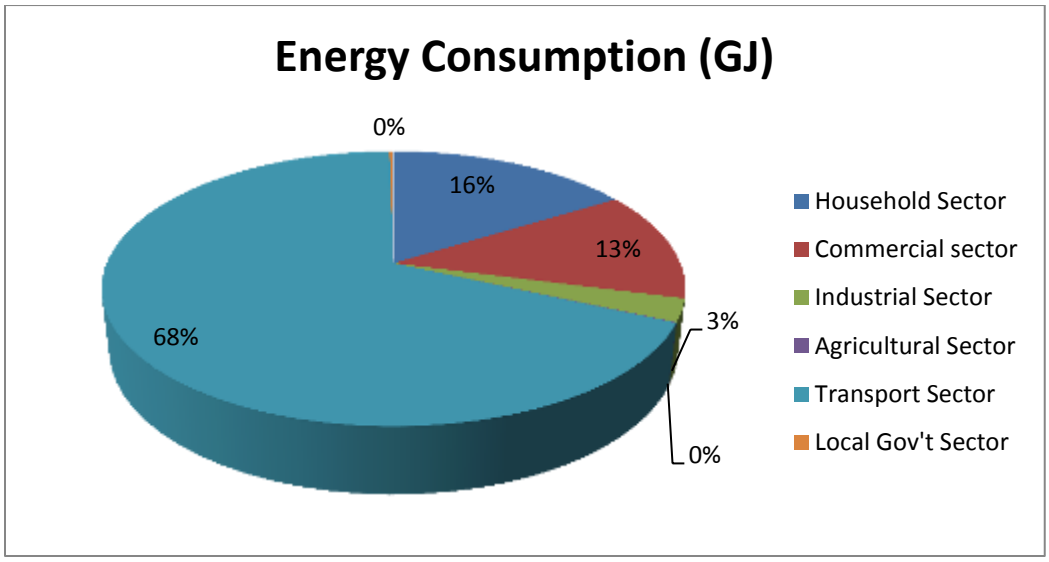
Energy Balance 2013 (GJ/year)

	Petrol	**Diesel**	**Charcoal**	**Wood**	**Electricity**	**Paraffin**	**LPG**
Households							
Commerce							
Industry							
Agriculture							
Transport							
Local govt							
TOTAL							

Energy Balance 2013 (original units)

	Petrol (litres)	Diesel (litres)	Charcoal (kg)	Wood (kg)	Electricity (kWh)	Paraffin (litres)	LPG (kg)
Households							
Commerce							
Industry							
Agriculture							
Transport							
Local govt							
TOTAL							

Figure 20: Energy consumption by sectors in GJ at ASEM (Actual population estimation)



Source: 2014 Energy Survey

SECTION FOUR

SECTORAL PERSPECTIVES OF ENERGY IN ASEM

4.0 Introduction

The sectoral energy supply and demand dimensions of ASEMare analysedin this section of the SoE report. These sectors includethe residential sector, commercial sector, industrial sector, agricultural sector, transport sector and local government sector (the municipal assembly).

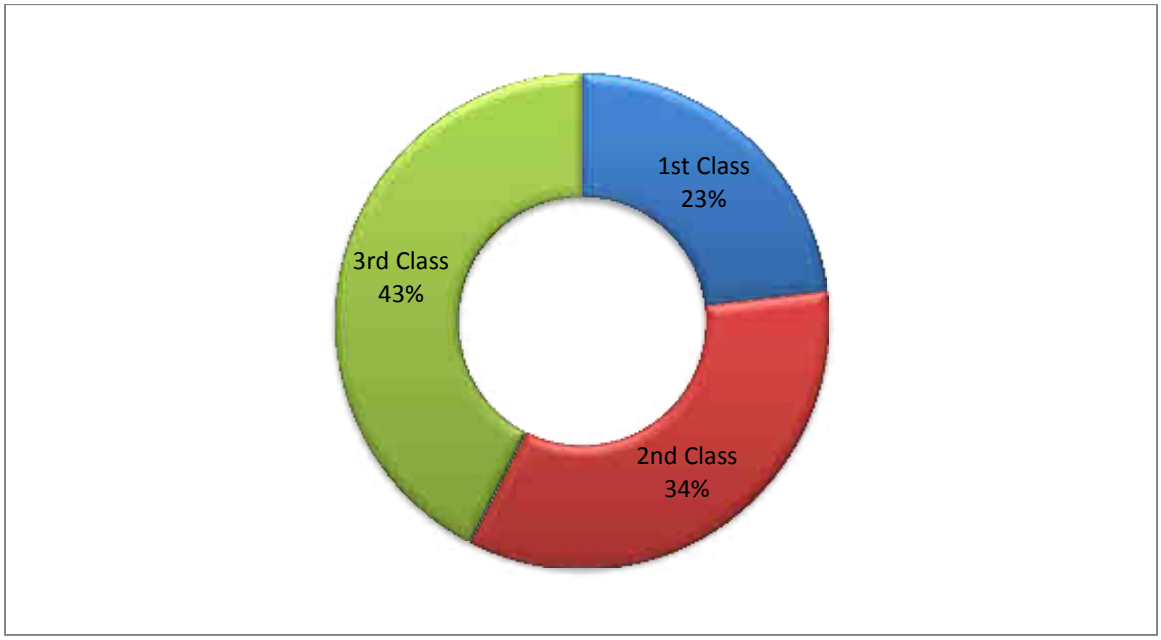
4.1 Residential Sector

Of the total number of 43,795 households[9]in the municipality, 593 were sampled for the household 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 versus non-electrified households The essence of doing the discussion around these two units of analysis is geared towards understandingthe energy consumption patterns among these different classes of settlements as well as, among electrified and non-electrified households in the municipality.

[9] The total household was obtained through headcount system in ASEM

The ASEMA demarcated the entire municipality into three classifications – First, Second and Third Classes – (see section three for attributes of these classes). Regarding their sizes, third class households are the largest, constituting 43% of all settlements, followed by second class (34%) and first class (23%) in the municipality (Figure 21).About 83% of the total households in the municipality are electrified.

Figure 21: Settlement classifications and sizesin ASEM

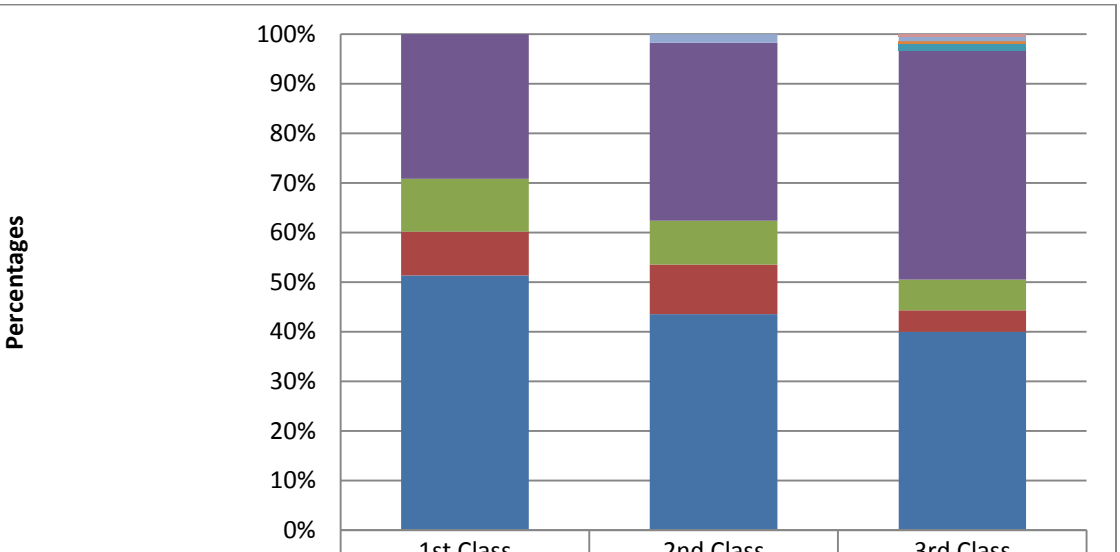


Source: 2014 Energy Survey

Figure 22 encapsulates the dwelling characteristics of electrified households in ASEM. Most first class electrified households dwell in stand-alone (51%), compound houses (29%) and flats/ apartments (10.6%). Similar to the first class settlements, the majority of second class electrified households reside in separate houses (44%), compound houses (36%), semi-detached (10%) and flats (9%). In the third class settlements, about 46% of electrified households live in compound

houses, 40% live in separate houses, while 6% and 4% live in flats and semi-detached housesrespectively. A little less than 1% of third class households live in traditional huts, uncompleted buildings, quarters attached to offices; while a little less than 2% dwell in kiosks/containers. 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 22: Dwelling units of electrified households in ASEM

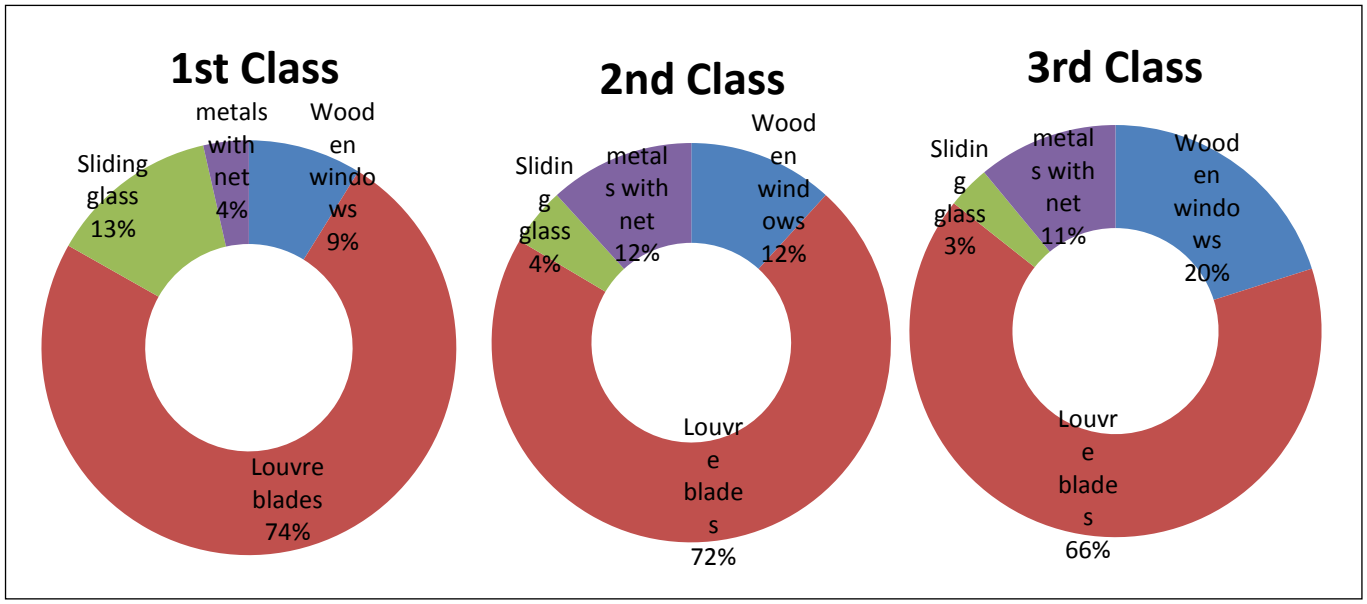


	1st Class	2nd Class	3rd Class
Huts	0	0	0.48
Uncompleted building	0	1.76	0.95
Quarters attached to office	0	0	0.48
Kiosk/Container	0	0	1.43
Compound house	29.2	35.88	46.19
Flat/Apartment	10.62	8.82	6.19
Semi-detached	8.85	10	4.29
Separate House	51.33	43.53	40

Source: 2014 Energy Survey

The predominant window types in most electrified households in the ASEM are the louvre blades(glass and wood) (see pictures in Figure24). About 74% of first class electrified households use louvre blades, 9% wooden windows, 13% sliding glazed windows and 4% metals with net windows in their dwelling units. On the other hand, 72% of second class electrified households use louvre blades, 12% wooden windows and metals with net windows while 4% use sliding glazed windows in their dwelling units. Meanwhile, in the third class 66% of electrified households use louver blades, 20% wooden windows, 11% metals with net,with 3% usingsliding glazed windows (Figure 23).

Figure 23: Window types within dwelling units in electrified households in ASEM



Source: 2014 Energy Survey

Figure 24: Different Window types used in ASEM

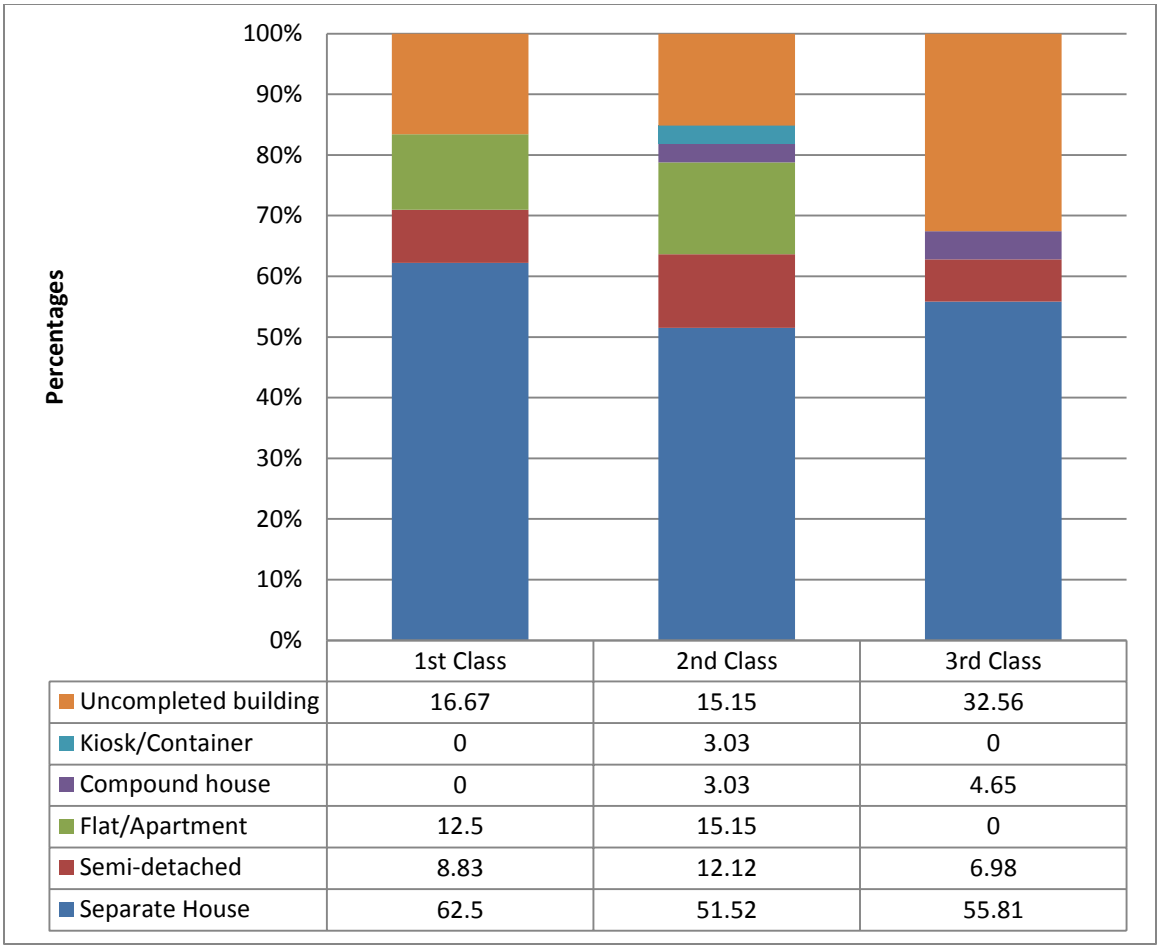
Metal with net windows

Traditional wooden windows

Louvre blade Windows

The majority of non-electrified households in first class settlements live in separate stand-alone houses (63%); about 17% in uncompleted buildings, 13% in flats, while 8% live in semi-detached houses (Figure 25). Within the second class non-electrified, majority of households (about 52%) in the municipality live in separate houses, about 16% each in uncompleted buildings and flats, while 12% live in semi-detached houses. In the third class communities, most households that are not connected to the national power grid live in separate houses (56%) while 33% live in uncompleted buildings. In addition, 7% live in semi-detached houses, while 5% reside in compound houses in the municipality.

Figure 25: Dwelling units of non-electrified households in ASEM

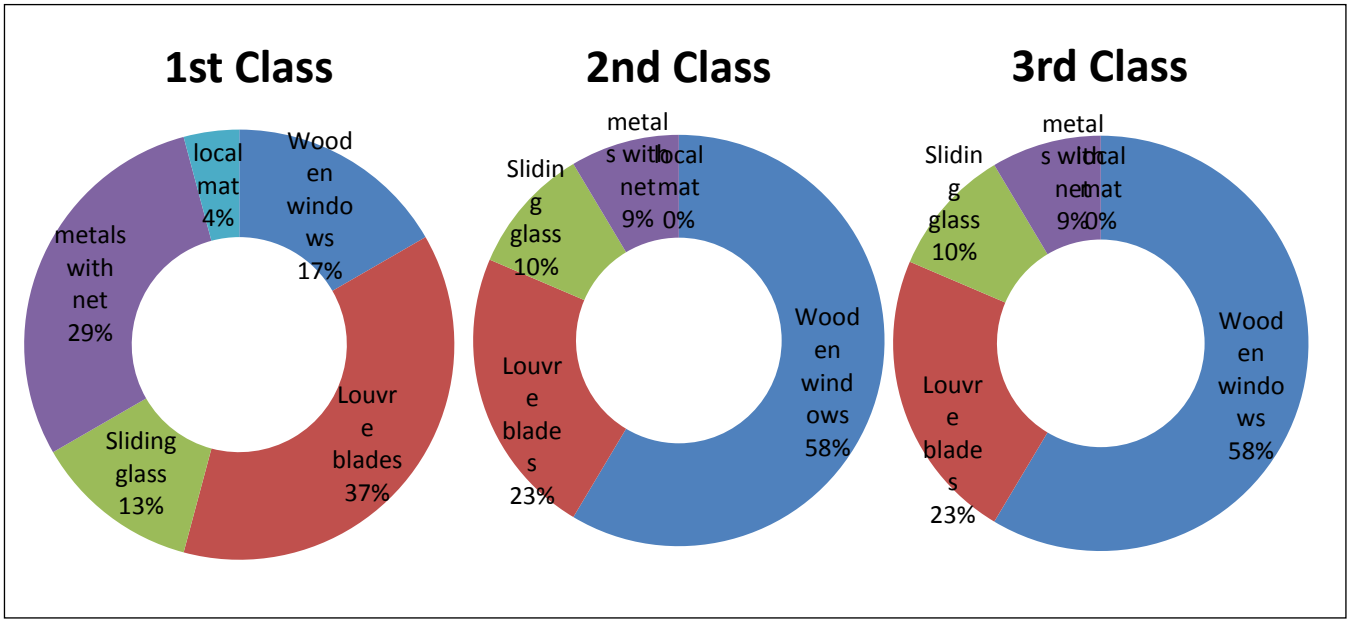


	1st Class	2nd Class	3rd Class
Uncompleted building	16.67	15.15	32.56
Kiosk/Container	0	3.03	0
Compound house	0	3.03	4.65
Flat/Apartment	12.5	15.15	0
Semi-detached	8.83	12.12	6.98
Separate House	62.5	51.52	55.81

Source: 2014 Energy Survey

The predominant window type among first class non-electrified households in ASEM is the louvre blade window type. About 37% of first class non-electrified households use louvre blades, 29% metals with net, 17% wooden windows, 13% sliding glazed windows and 4% local woven mats in their dwelling units. Within the second class non-electrified households, about 59% use wooden windows, 23% louvre blades, 10% sliding glazed windows, while 8% use metals with net in dwelling units. In the third class settlements, 59% use wooden windows, 23% louvre blades, while 10% and 8% use sliding glass windows and metals with nets respectively in their dwelling units (Figure 26).

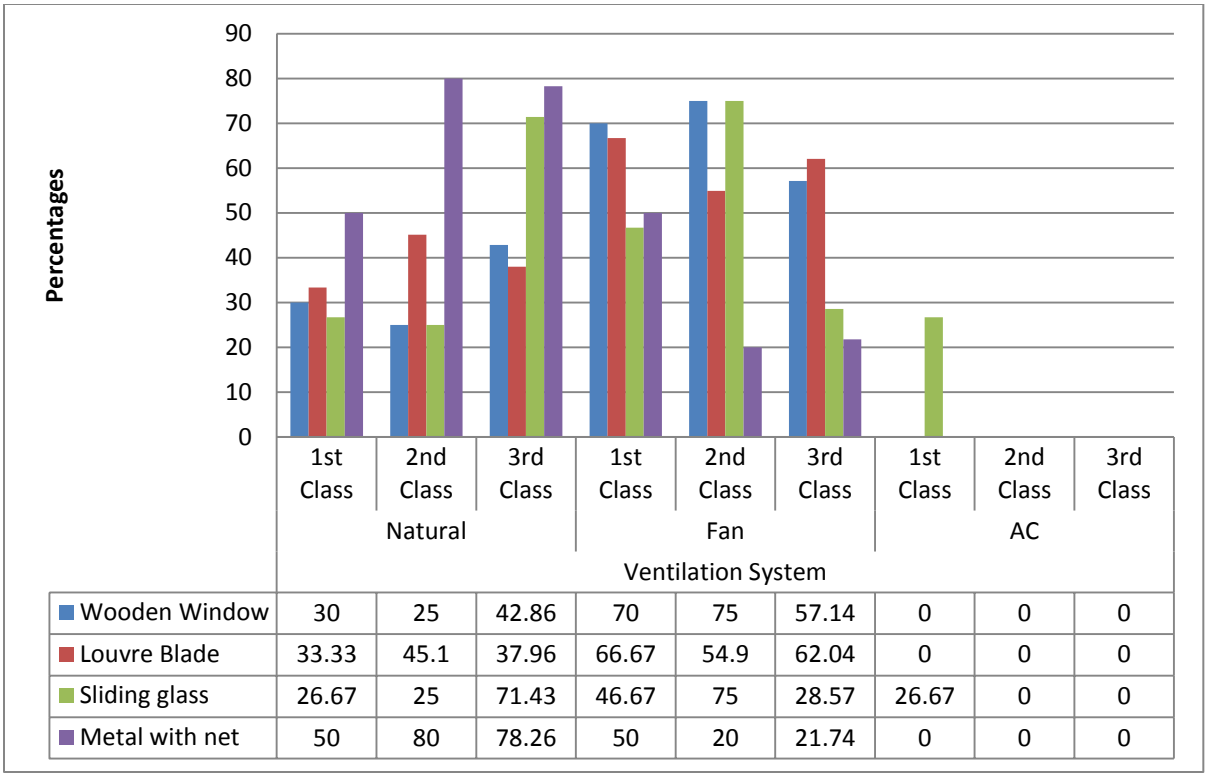
Figure 26: Window types within dwelling units in non-electrified households in ASEM



Source: 2014 Energy Survey

Electrified households who use wooden windows in the municipality mostly depend on fan ventilation systems. Almost 70% of first class households who use wooden windows depend on fans while 30% depend on natural ventilation systems.Almost 75% and 57% of second and third class electrified households respectively, who use wooden windows, also depend on fans. For those who use louvre blades, 67%, 55% and 62% of first, second and third class electrified households depend onfans, respectively. While 33%, 45% and 38% of first, second and third class households respectively depend on natural ventilation systems. For households that use sliding glazed windows, 27%, 25% and 71% of first, second and third class householdsrespectively depend on natural ventilation systems while a corresponding 47%, 75% and 29% respectively use fans. However, about 27% of first class households who have sliding glazed windows use air conditioners (AC) as their main ventilation systems. Households with metals and net as their main window types on their dwelling units, the natural ventilation systems are what they use (Figure 27).

Figure 27: Window type in the dwelling unit vis-à-vis ventilation system (%) being used in ASEM



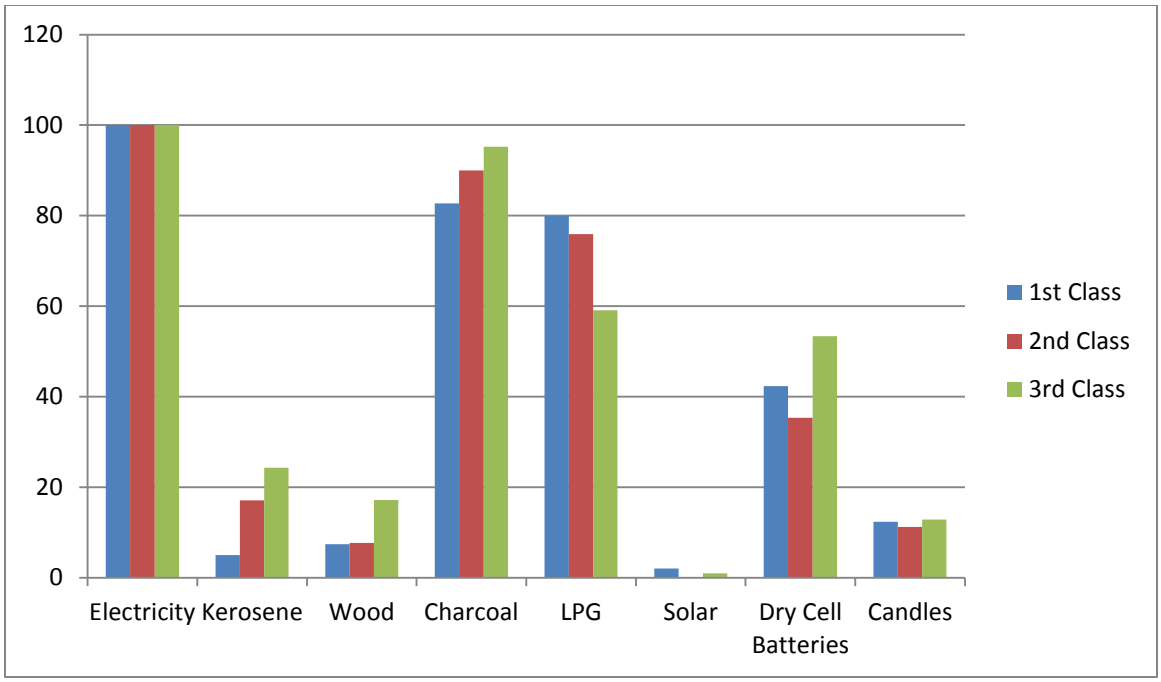
	Natural			Fan			AC		
	1st Class	2nd Class	3rd Class	1st Class	2nd Class	3rd Class	1st Class	2nd Class	3rd Class
Wooden Window	30	25	42.86	70	75	57.14	0	0	0
Louvre Blade	33.33	45.1	37.96	66.67	54.9	62.04	0	0	0
Sliding glass	26.67	25	71.43	46.67	75	28.57	26.67	0	0
Metal with net	50	80	78.26	50	20	21.74	0	0	0

Source: 2014 Energy Survey

4.1.1 Residential energy consumption

All electrified households in the municipality use electricity while 80%, 76% and 59% of first, second and third class electrified households respectively use LPG fuel. Almost 83%, 90% and 95% of first, second and third class electrified households respectively use charcoal fuel,while 7%, 8% and 17% of first, second and third class electrified householdsrespectively use wood fuel. Other fuel types such as dry cell batteries and candles also have significant usage rate in the municipality. It is estimated that 42%, 35% and 53% of first, second and third class electrified households respectively use dry cell batteries, while 12%, 11% and 12% of first, second and third class electrified households respectively use candles in the municipality (Figure 28).

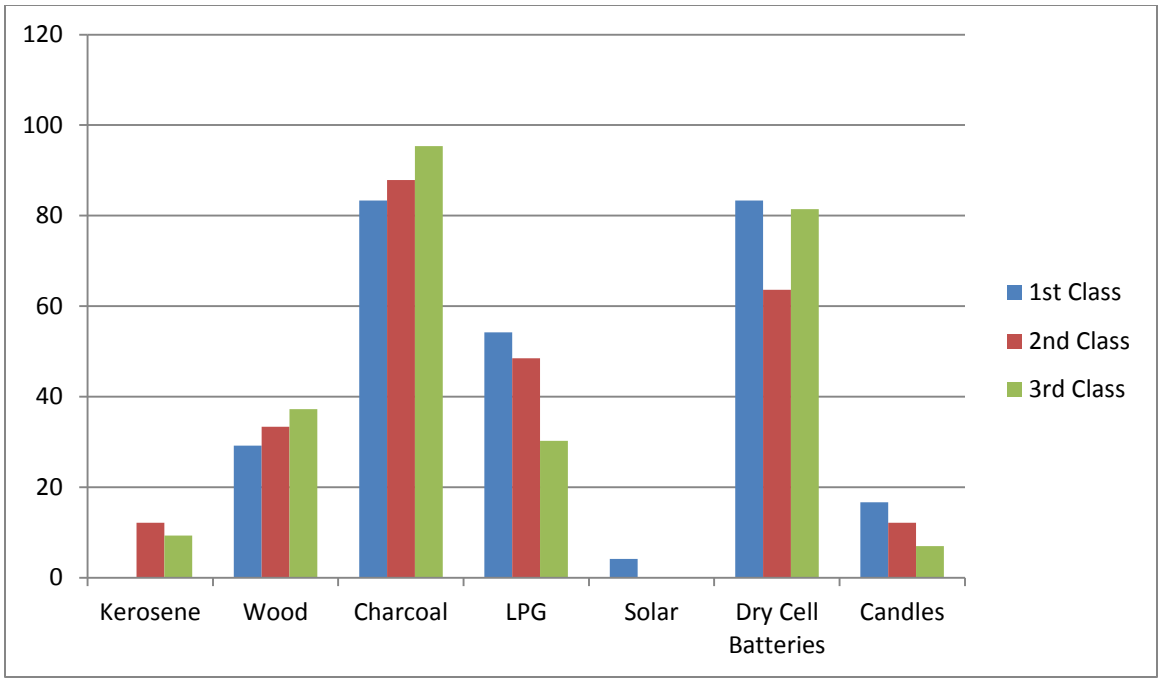
Figure 28: Fuel types and percentage of usage in electrified householdsin ASEM



Source:2014 Energy Survey

For non-electrified households in ASEM, 54%, 48% and 30% of first, second and third class households respectively use LPG fuel while 83%, 88% and 95% of first, second and third class households use charcoal fuel. Approximately, 29%, 33% and 37.21% of first, secondand third class households use wood fuel, respectively. Non-electrified households use extensively other fuel types including dry cell batteries and candles as well. About 83%, 64% and 81% of first, second and third class households respectively use dry cell batteries while 17%, 12% and 7% of first, second and third classhouseholds respectively use candles (Figure 29).

Figure 29: Fuel types and percentage of usage in non-electrified householdsin ASEM

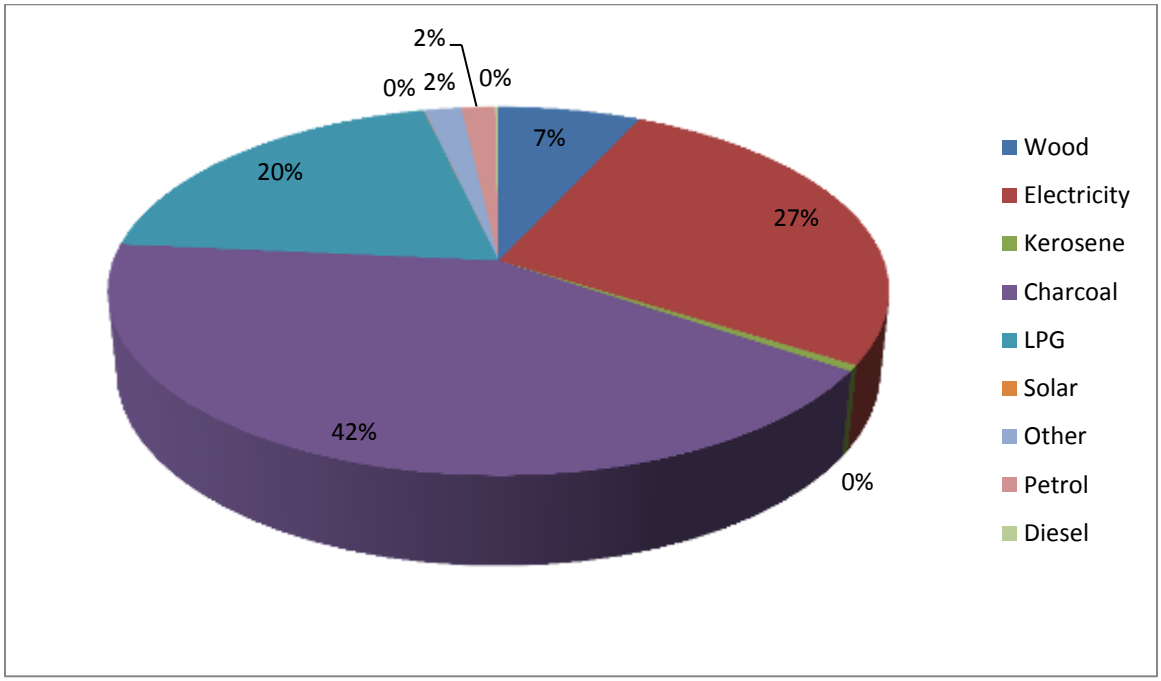


Source: Energy Survey, 2014

The residential sector accountedfor 16% of the total energy consumed in ASEM, in 2013, and rankedas the second biggest consumer of energy after the transport sector. Third class households consume about 42% of the total energy being consumed by the residential sector in the municipality, while second and first class households consume 33% and 25%respectively. The relative shares of energy consumption among the various settlement classes are due to the composition of these classes of settlements in the municipality.

Charcoal fuel constitutes the largest share (42%) of the total energy consumed by the household sector in ASEMA. This is followed by electricity (27%), LPG (20%) and firewood (7%). Petrol and other fuel types (dry cell batteries and candles) make up about 2% each of the total energy consumption by the residential sector while diesel, solar and kerosene constitute less than one percent of the total energy consumed by the residential sector in the municipality (Figure 30).

Figure 30: Percentage share of total energy consumption per energy carriers in ASEM as of 2013



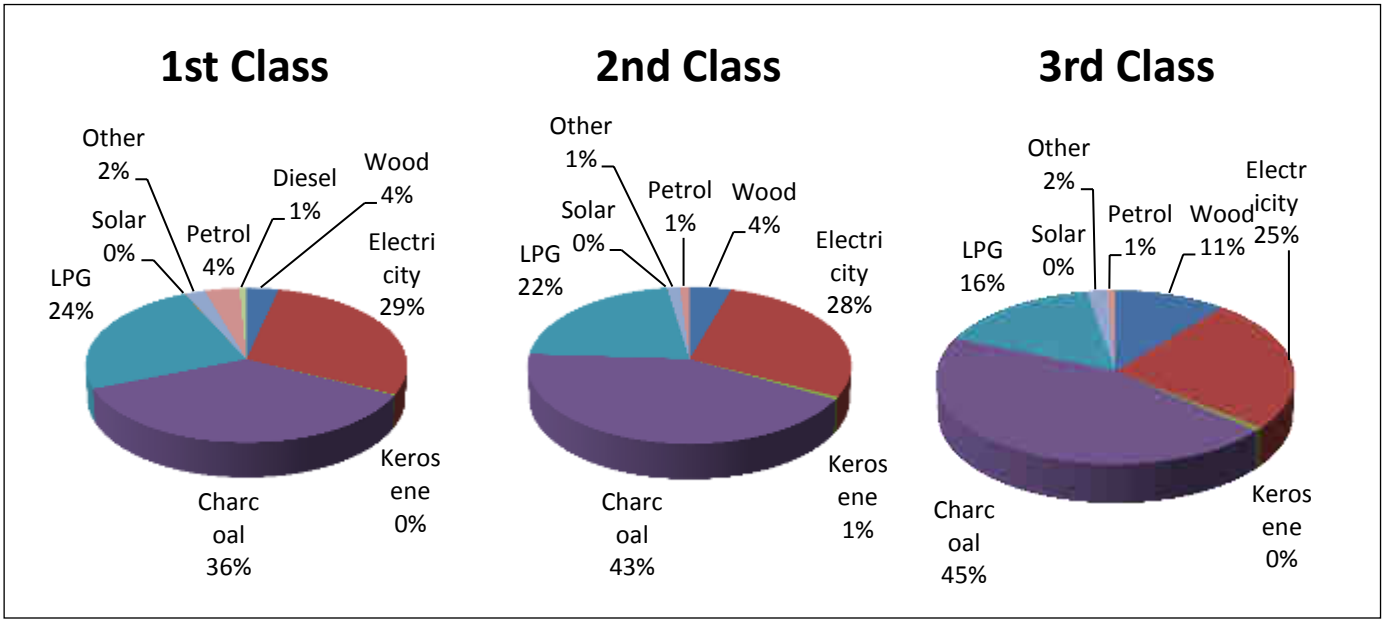
Source; Energy Survey, 2014

Figure 31 comprises all the energy related consumption issues in the three settlement classes. Withinthe three settlement classes, charcoal consumption is the largest among all the sources in the municipality. In first class households, charcoal constitutes about 36% of the total energy consumed by the residential sector while electricity, LPG and petrol constitute 29%, 24% and 4% of the total energy consumed respectively. Dry cell batteries and candles constitute 2% while diesel constitutes about 1%. Similar to the first class households, charcoal constitutes the largest share (43%) in the total energy consumed insecond class households in the municipality. Electricity consumption constitutes about 28% of the total energy consumed, while LPG follows with 22% in the total energy consumed by second class households. Firewood constitutes 4% of total energy consumed, whiledry cell batteries and candles, kerosene and petrol constitute 1% eachin the total energy consumed by second class households.

In the third class settlements, charcoal consumption again constitutes the largest share (45%) of all energy sources consumed. Electricity and LPG constitute 25% and 16% respectively of the total energy consumed, while firewood constitutes about 11%. Dry cell batteries and candles constitute about 2% and petrol about 1% share in the total energy consumed by third class households. Solar and kerosene fuels constitute less than 1% of the total energy consumed by third class households. It is apparent from the survey results that, though residents or households in ASEM consume quite a substantial amount of biomass energy, there is also evidence of

massive consumption of modern forms of energy (electricity and LPG fuels) in the municipality. Modern forms of energy together constitute about 53% share of total energy consumed among first class households, 50% share of total energy consumed by second class households and 41% share in the total energy consumed by third class households.

Figure 31: Percentage of total fuel consumed by settlement classification from energy sources in ASEM

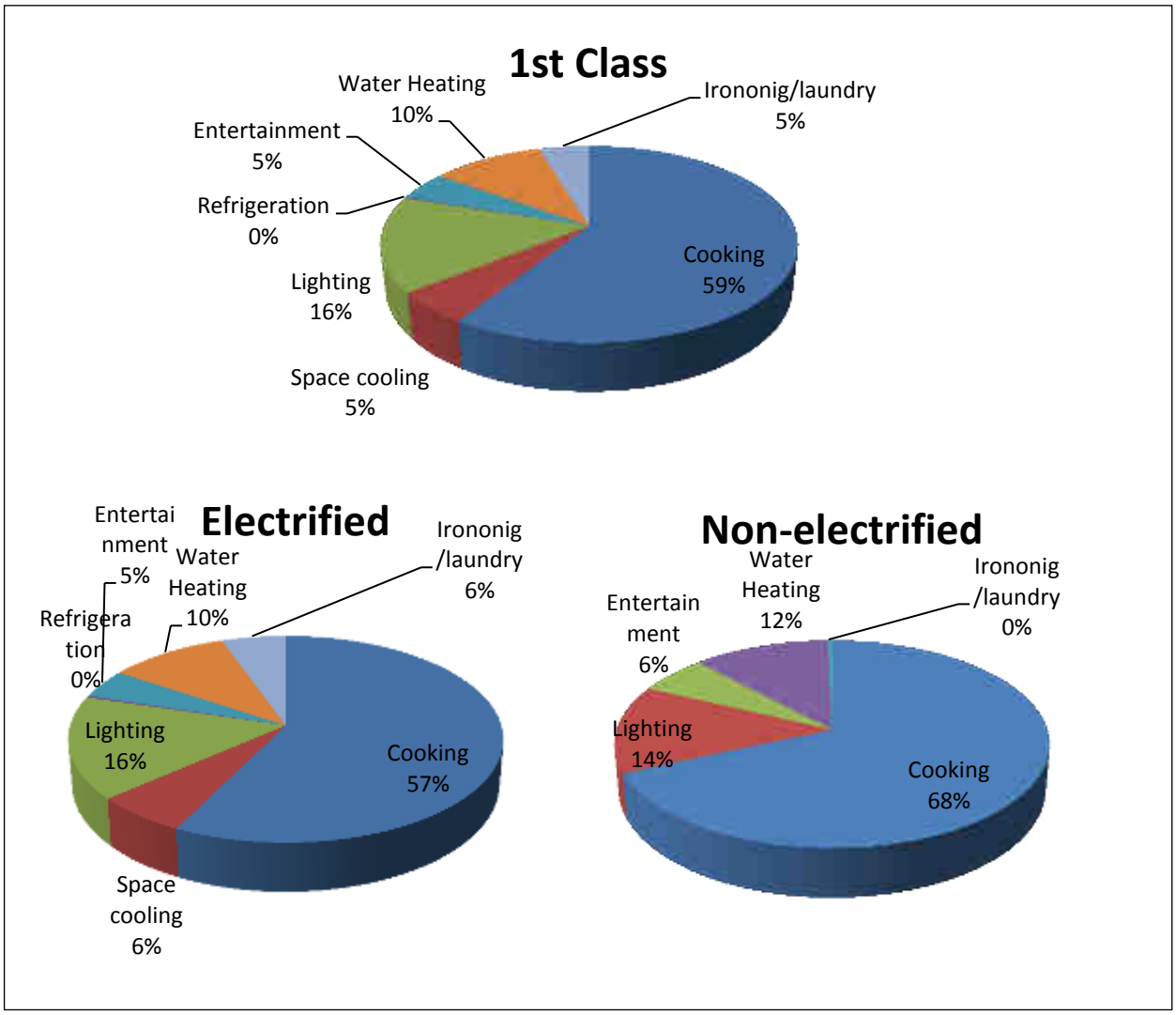


Source: 2014 Energy Survey

4.1.2 Energy Consumption by end-use in the residential sector ofASEM

Among the various end-uses of energy in the first class households, cooking consumes the highest energy (59%), followed by lighting (16%) and water heating (10%)(Figure 32). Entertainment, space cooling and ironing/laundry consume about 5% each of the total energy in this settlement class.The consumption patterns do not differ significantly among electrified and non-electrified first class households as Figure 23 shows. Cooking consumes 57% of the total energy in electrified households, followed by lighting (16%) and water heating (10%). Space cooling and laundry consume 6% each, while entertainment consumes 5% of the total electrified first class household energy. Among non-electrified first class households, cooking consumes the most energy, about 68% while lighting and water heating consume about 14% and 12% respectively. Entertainment consumes about 6% of the total energy of non-electrified first class households.

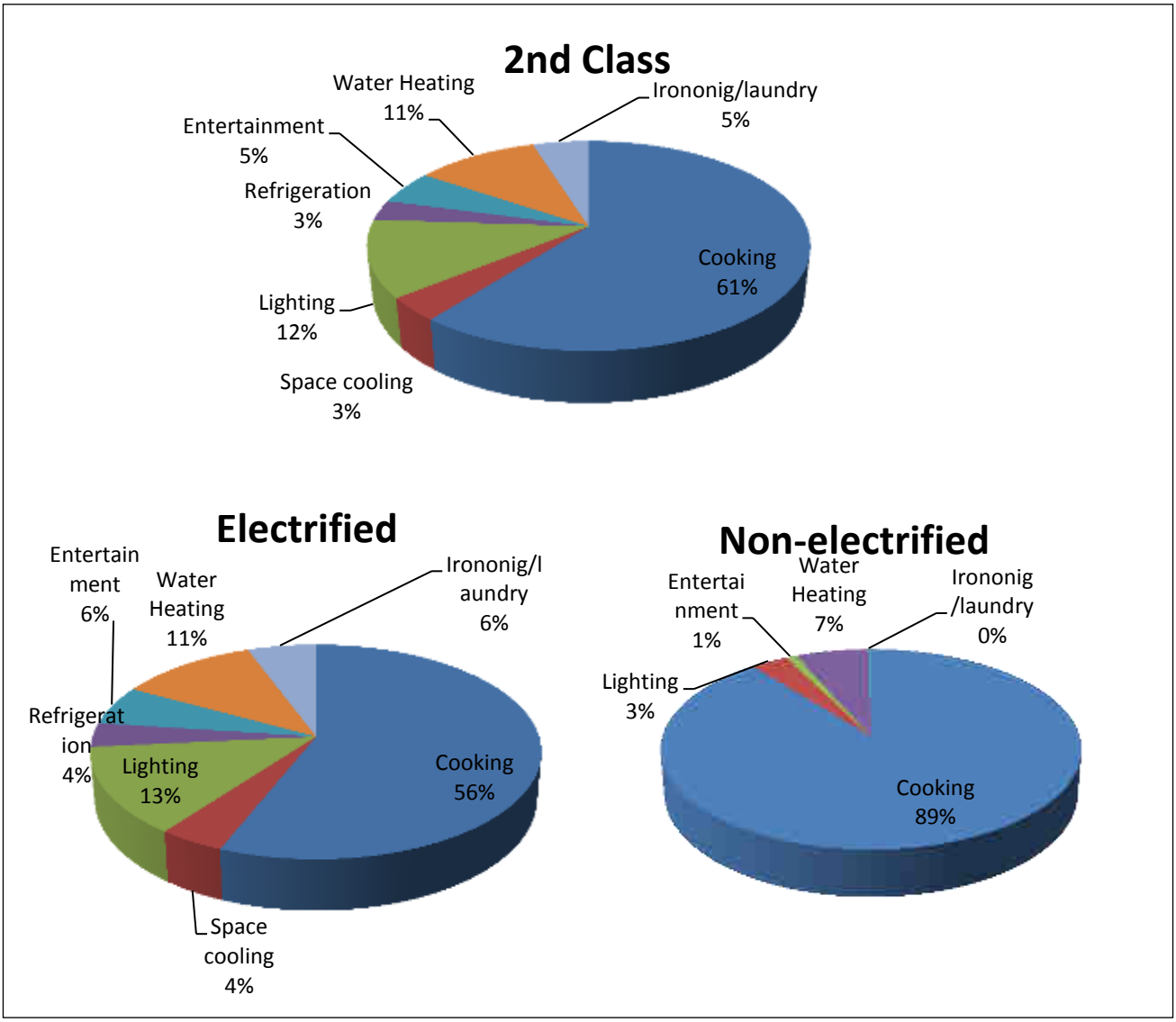
Figure 32: Percentage share of energy consumption by end-use in first class householdsin ASEM



Source: Energy Survey, 2014

The end-uses of energy in the second class settlements are not significantly different from that of first class settlements (Figure 33). Cooking is the most energy intensive end-user in second class households, consuming about 61% of the total energy of these households. Lighting and water heating consume about 12% and 11% respectively,while entertainment and laundry/ironing consume about 5% each of the total second class household's energy. Among electrified households in the second class, cooking consumes about 56% while lighting and water heating consume about 13% and 11% respectively. In non-electrified second classhouseholds, cooking consumes about 89% of the total energy, while water heating, lighting and entertainment consume the remaining in the proportions of 7%, 3% and 1% respectively.

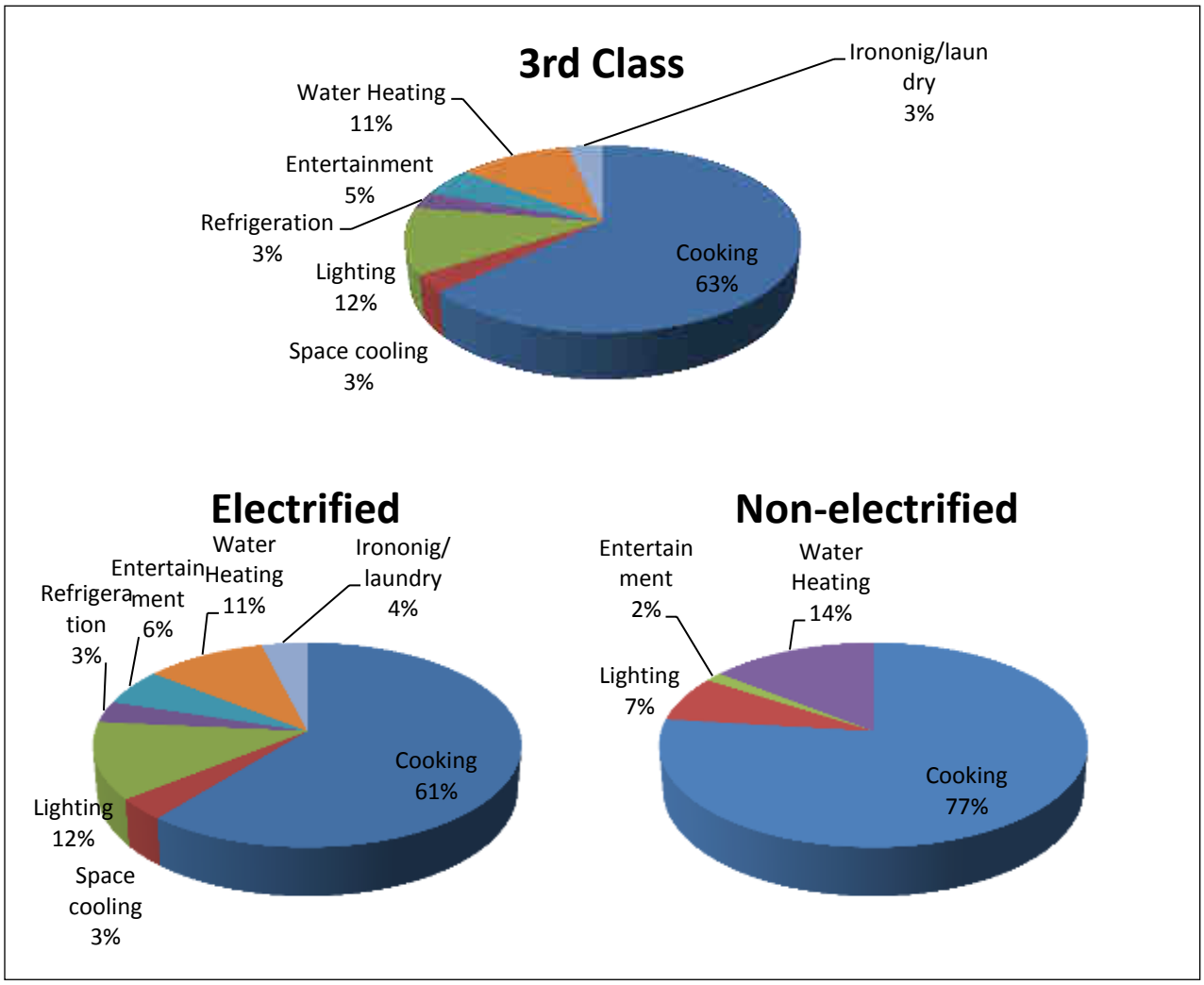
Figure 33: Percentage share of energy consumption by end-use in second class households in ASEM



Source: 2014 Energy Survey

The pattern of energy end-useamong third class households follows the trends ofboth the first and second class households. Cooking consumes about 63% of the total energy of third class households, followed by lighting (12%) and water heating (11%).Entertainment consumes about 5%, while space cooling,ironing and refrigeration each, consumes 3% respectively.Almost 61% of energy used in third class electrified households goes into cooking compared to 77% for non-electrified households. Lighting and water heating consume about 12% and 11% respectively of total energy in electrified third class households. However, in the non-electrified third class households, lighting and water heating consume 7% and 14% respectively of total energy (Figure 34).

Figure 34: Percentage share of energy consumption by end-use in third class households in ASEM



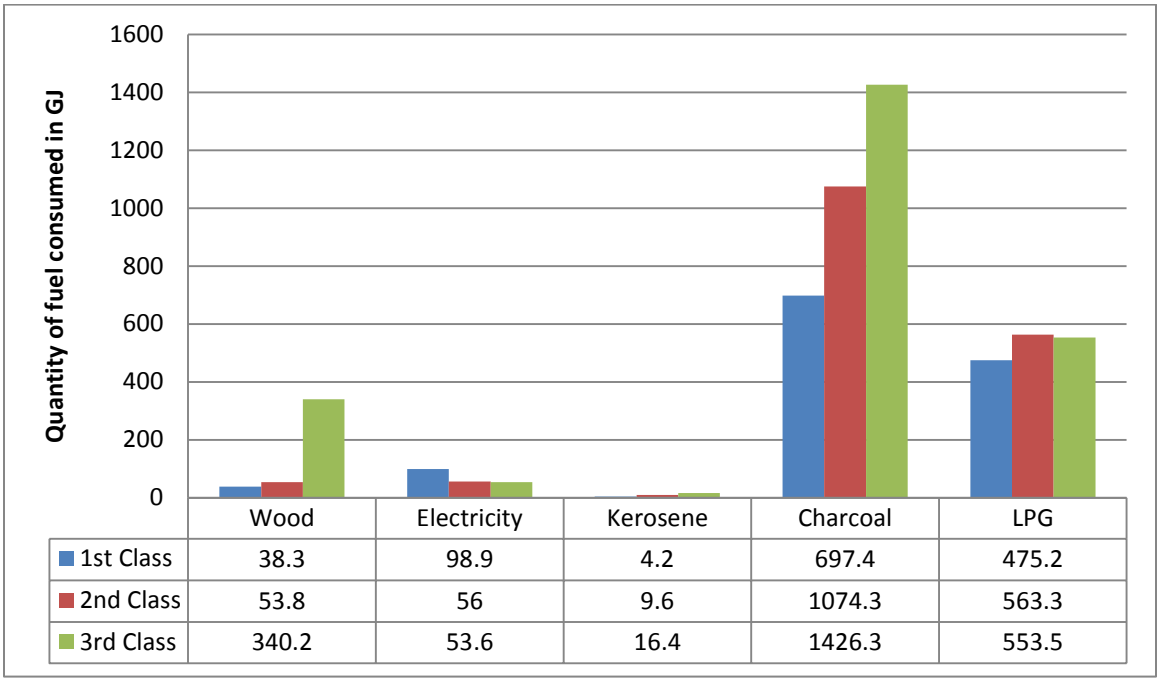
Source: 2014 Energy Survey

4.1.3 Sources of energy for different end-uses in the residential sector of ASEM

The sources of energy for cooking among electrified households in ASEM are shown in Figure 35. 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, electricity and wood fuels for

their cooking activities. Third class electrified households also use more charcoal, followed by LPG, wood, electricity and kerosene.What these figures point to is a high-level of multiple energy use within households within the municipality.

Figure 35: Sources of energy for cooking among electrified households in ASEM

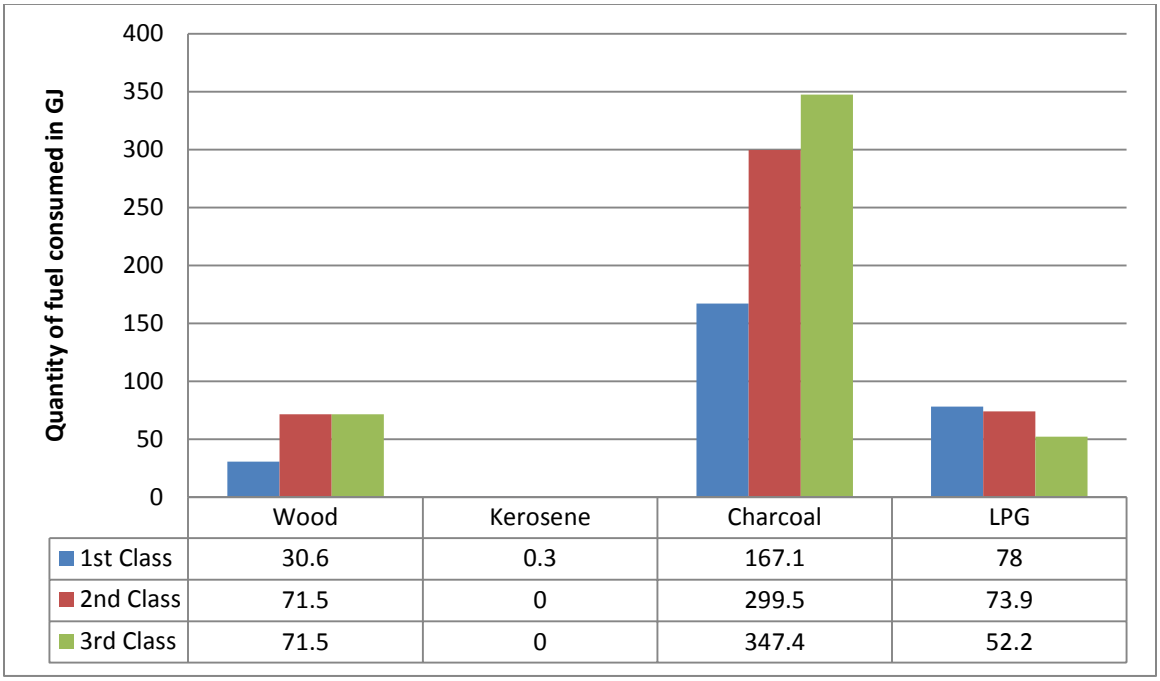


	Wood	Electricity	Kerosene	Charcoal	LPG
1st Class	38.3	98.9	4.2	697.4	475.2
2nd Class	53.8	56	9.6	1074.3	563.3
3rd Class	340.2	53.6	16.4	1426.3	553.5

Source: 2014 Energy Survey

First and second class non-electrified households depend mostly on charcoal, LPG and wood fuels for their cooking needs while third class non-electrified households depend mostly on charcoal, wood and LPG for their cooking activities in the municipality (Figure 36). Kerosene fuel plays more of a supportive role to the use of firewood and charcoal rather than as a main cooking fuel on its own. There are, however, a few households who have kerosene stoves that are used directly for cooking with kerosene as the main cooking fuel.

Figure 36: Sources of energy for cooking among non-electrified households in ASEM

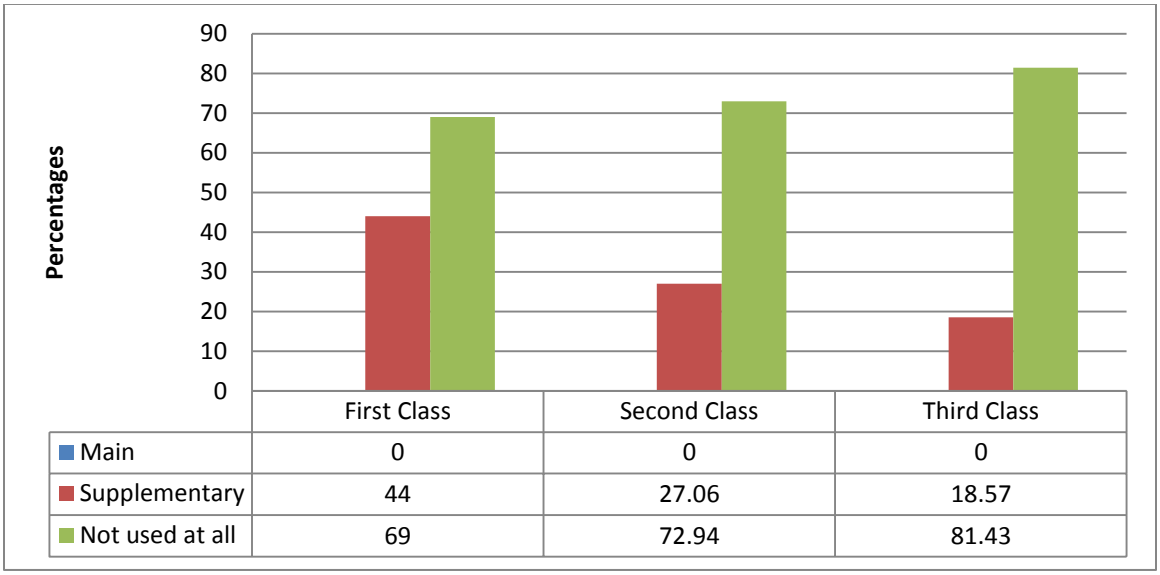


	Wood	Kerosene	Charcoal	LPG
1st Class	30.6	0.3	167.1	78
2nd Class	71.5	0	299.5	73.9
3rd Class	71.5	0	347.4	52.2

Source: 2014 Energy Survey

Within electrified households, electricity is mainly used as a supplementary energy source for cooking in all three settlement classes in ASEM. The commonestelectrical gadgetsin use are blenders, rice cookers, toasters and electric stoves. About 44%, 27% and 19% of first, second and third class households respectively use electricity as supplementary energy source for cooking (Figure 37). Those who use mainly electricity are motivated by the urban influence. Others also regarded electricity as being easy to access and use without much health hazards. Households that do not use electricity as a supplementary energy source for cooking cited the issue of electricity being less affordable compared to other fuel sources.From the survey results over 90% of all households using electricity as a supplementary cooking energy sourcerevealed that they will continue to use electricity for cooking in the future. About 70%, 73% and 67% of first, second and third class householdsrespectively, who use electricity for cooking in the municipalitybelieve there is a shortfall in electricity supply in the municipality due to the rapid urbanisation.

Figure 37: Role of electricity in cooking (% of households who use electricity)



	First Class	Second Class	Third Class
Main	0	0	0
Supplementary	44	27.06	18.57
Not used at all	69	72.94	81.43

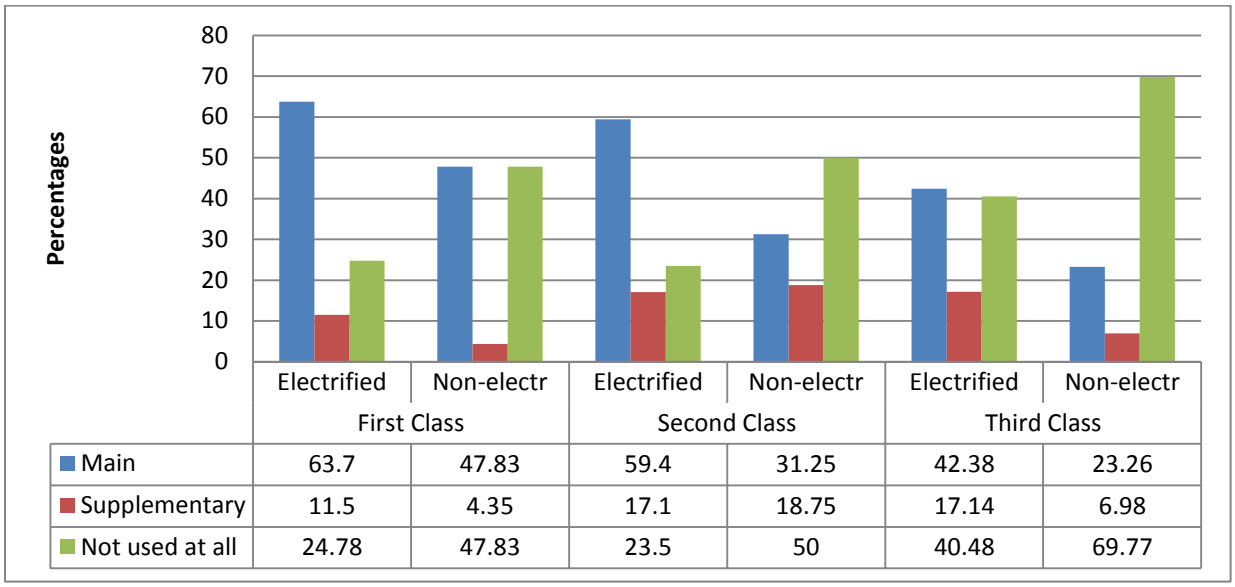
Source: 2014 Energy Survey

In first class electrified households about 64% of them use LPG as their main cooking energy source while 12% use it as a supplementary source. Among second class electrified households, 59% use LPG as their main cooking fuel while 17% use it as a supplementary energy source (Figure 38). Almost 42% and 17% use LPG as their main and supplementary sourceamong third class electrified households, respectively. Gas stoves/burners and cylinders that store LPG are the technologies that are used for this fuel type. Many who use LPG either as their main or supplementary cooking energy argued that it is cheap, somehow easy to access (reliable), easy to use, and has no health hazard. The non-users of LPG, however, cited its unaffordability as the main reason for their non-use of LPG. About 65%, 63% and 62% of first class, second and third class householdsrespectively who use LPG for cooking in the municipality believe that, though LPG is more accessible now, there has been a shortage in supply of LPG in the municipality in recent years compared to the past, due to urbanization.

In relation to the non-electrified households, about 48%, 31% and 23% of first, second and third class households, use LPG as their main cooking fuel while a corresponding 4%, 19% and 7% respectively use it as a supplementary cooking energy source (Figure 38). Those who use LPG for cooking reported that they use LPG because it is reliable, readily available and convenient to use while some were also under the 'urban influence'. Non-users of LPG, however, pointed out that LPG was unaffordable. About 69%, 94% and 92% of first, second and third class

householdsrespectively reported their willingness to continue using LPG in the future while 85%, 58% and 67% respectively opined that there is inadequacy in the supply of LPG to the municipality due to urbanization.

Figure 38: Role of LPG in cooking (%of households who use LPG)



	First Class		Second Class		Third Class	
	Electrified	Non-electr	Electrified	Non-electr	Electrified	Non-electr
Main	63.7	47.83	59.4	31.25	42.38	23.26
Supplementary	11.5	4.35	17.1	18.75	17.14	6.98
Not used at all	24.78	47.83	23.5	50	40.48	69.77

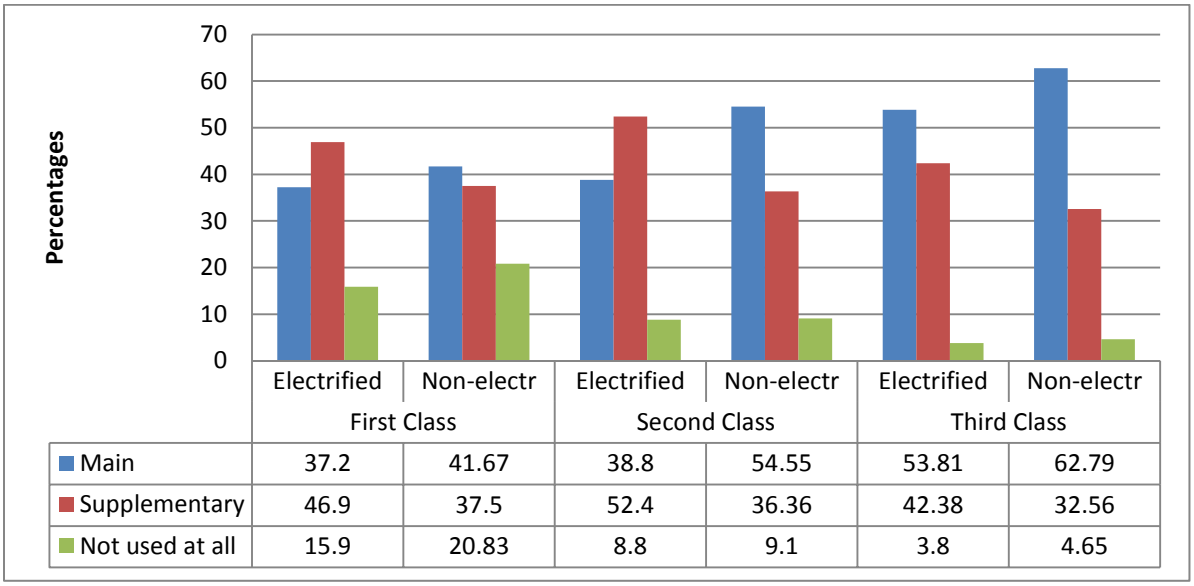
Source: 2014 Energy Survey

About 47%,52% and 42% of first,second and third class electrified households respectively use charcoal as a supplementary fuel for cooking, with only 37%, 39% and 54% of first, second and third class electrified households using charcoal as their main cooking fuels (Figure 39).Coalpot and locally manufactured efficient cook stoves (Gyapa) are the technologies used for cooking with the charcoal fuel. Households who use charcoal as their main energy source for cooking argue that it is cheap and somehow reliable whilemany who use charcoal as supplementary cooking energy source argued that they use it to support LPG fuel. Some non-charcoal users attributed their non-usage to the inconveniencies and the health hazards associated with charcoal use while others, especially third class households, cited its unaffordability compared to firewood. About 80% of households who use charcoal revealed that they will continue to use it in the future. Almost 46%, 44% and 24% of first, second and third class households respectively who use charcoal in the municipality believe there is a shortage in supply of charcoal in the municipality in recent times compared to the past due to urbanization.

Charcoal is widely used in non-electrified households in the municipality. About 42% of first class non-electrified households use charcoal as their main cooking fuels while 38% use it as a supplementary energy source for cooking. In second class non-electrified households, 55% of

households use charcoal as their main cooking energy source while 36% use it as a supplementary source. In third class households, 63% use charcoal as a main cooking energy source while 33% also use it as a supplementary cooking fuel (Figure 39). Coal pot and efficient 'gyapa' cooking stoves are the common technologies used for cooking with charcoal fuel within non-electrified households. Those who do not use it based on health reasons and the stress in using charcoal for cooking. Those who use it observed that it is easy to access and cheap as well. Approximately, 79%, 63% and 80% of first, second and third class households respectively noted that they will continue to use charcoal in the future. While a corresponding 89%, 60% and 76% respectively are of the opinion that charcoal supply is diminishing in the municipality due to urbanization.

Figure 39: Role of charcoal in cooking (Percentages of households who use charcoal)



	First Class		Second Class		Third Class	
Main	37.2	41.67	38.8	54.55	53.81	62.79
Supplementary	46.9	37.5	52.4	36.36	42.38	32.56
Not used at all	15.9	20.83	8.8	9.1	3.8	4.65

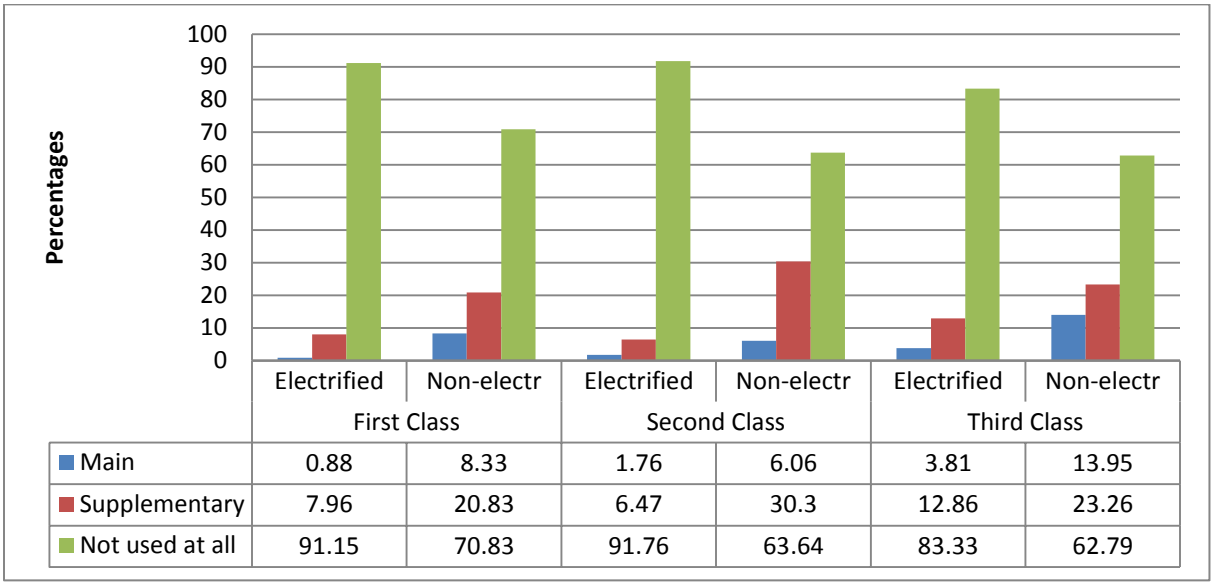
Source: 2014 Energy Survey

In electrified households in the municipality, firewood usage is not very common. Less than 1% of first class households, 1.8% and 3.8% of second and third class electrified households respectively use firewood as a main cooking fuel while 8%, 6% and 13% representing the same classes respectively use it as a supplementary source (Figure 40). Heath, metal stand and sometimes, three cement blocks erected on the ground are the technologies used in cooking with the firewood fuel. Many households who use firewood, either as their main or supplementary

cooking energy source argue that it is cheap while some households who do not use firewood fuel attributed their non-use to health hazards associated with firewood, and others cited the fact that firewood is difficult to get.An estimated 70%, 28% and 45.7% of first, second and third class households respectively, who use firewoodrevealed that they will continue to use it into the future. Also, about 60%, 54% and 60% of first, second and third class households respectively believe there is a shortage in the supply of firewood to the municipality in recent times compared to the past due to urbanization.

The use of firewood for cooking in non-electrified households in the municipality is still important. About 8%, 6% and 14% of first, second and third class non-electrified households respectively use firewood as a main cooking fuel in the municipality while a corresponding 21%, 30% and 23% respectively use it as a supplementary cooking fuel (Figure 40). For the non-electrified households who use firewood for cooking, they use it because it is affordable and easy to get. About 50% noted that they willcontinue to use firewood for cooking in the future while 71%, 58% and 75% of first, second and third class non-electrified households respectively observed the shortage in firewood fuel supply to the municipality due to urbanization (deforestation?).

Figure 40: Role of firewood in cooking (%of households who use firewood)

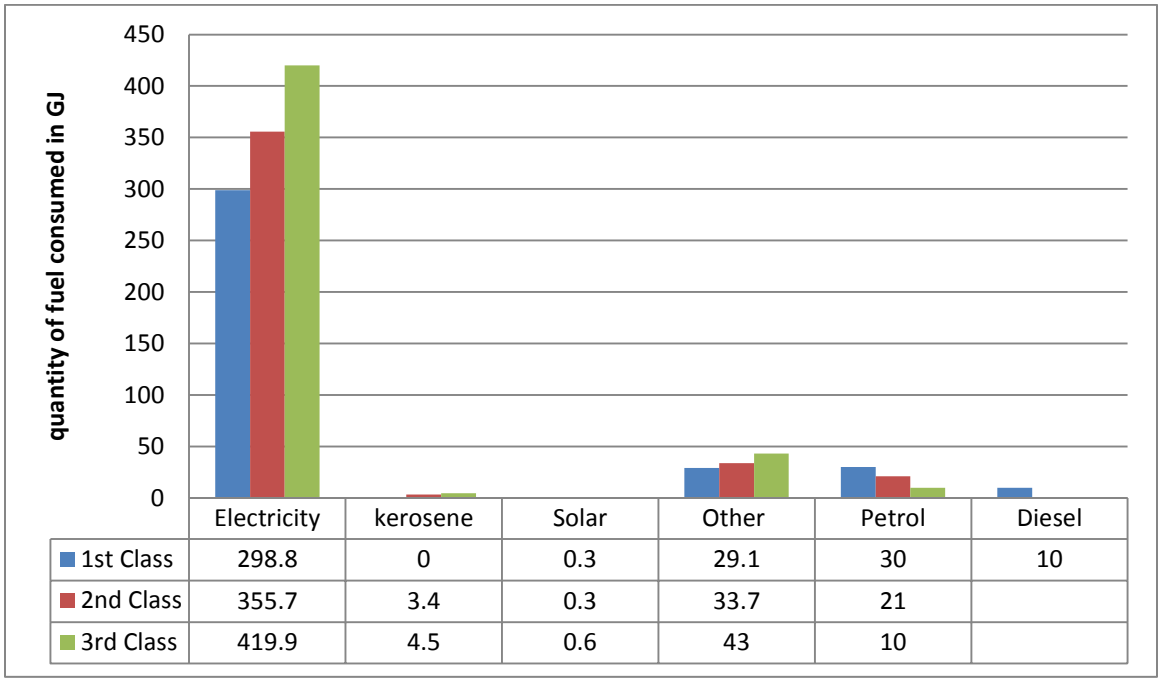


	First Class		Second Class		Third Class	
	Electrified	Non-electr	Electrified	Non-electr	Electrified	Non-electr
Main	0.88	8.33	1.76	6.06	3.81	13.95
Supplementary	7.96	20.83	6.47	30.3	12.86	23.26
Not used at all	91.15	70.83	91.76	63.64	83.33	62.79

Source: 2014 Energy survey

Figure 41 encapsulates the relative sources of energy for lighting in electrified households in ASEM. 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 including dry cell batteries and candles, petrol and diesel powered generators for lighting purposes. 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 technology and kerosene are also used in small quantities.

Figure 41: Sources of energy for lighting in electrified households in ASEM



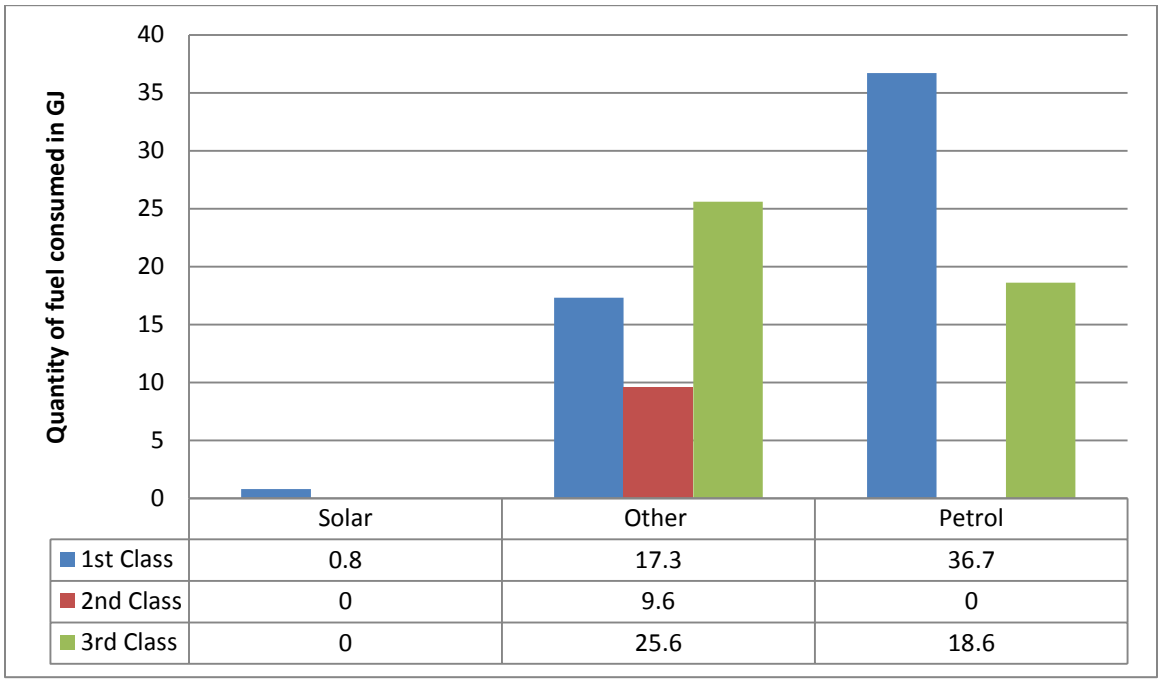
	Electricity	kerosene	Solar	Other	Petrol	Diesel
1st Class	298.8	0	0.3	29.1	30	10
2nd Class	355.7	3.4	0.3	33.7	21	
3rd Class	419.9	4.5	0.6	43	10	

Source: 2014 Energy Survey

Non-electrified households on the other hand depend on dry cell batteries, candles and also petrol fuelfor lighting in the municipality (Figure 42). First class non-electrified households dependmore on petrol powered generators and other energy sources (dry cell batteries and candles). Second class non-electrified households depend more on dry cell batteries and candles, while third class non-electrified householdsalso use dry cell batteries and candles as well as petrol fuels to power generators for lighting purposes. 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 42: Sources of energy for lighting in non-electrified households in ASEM



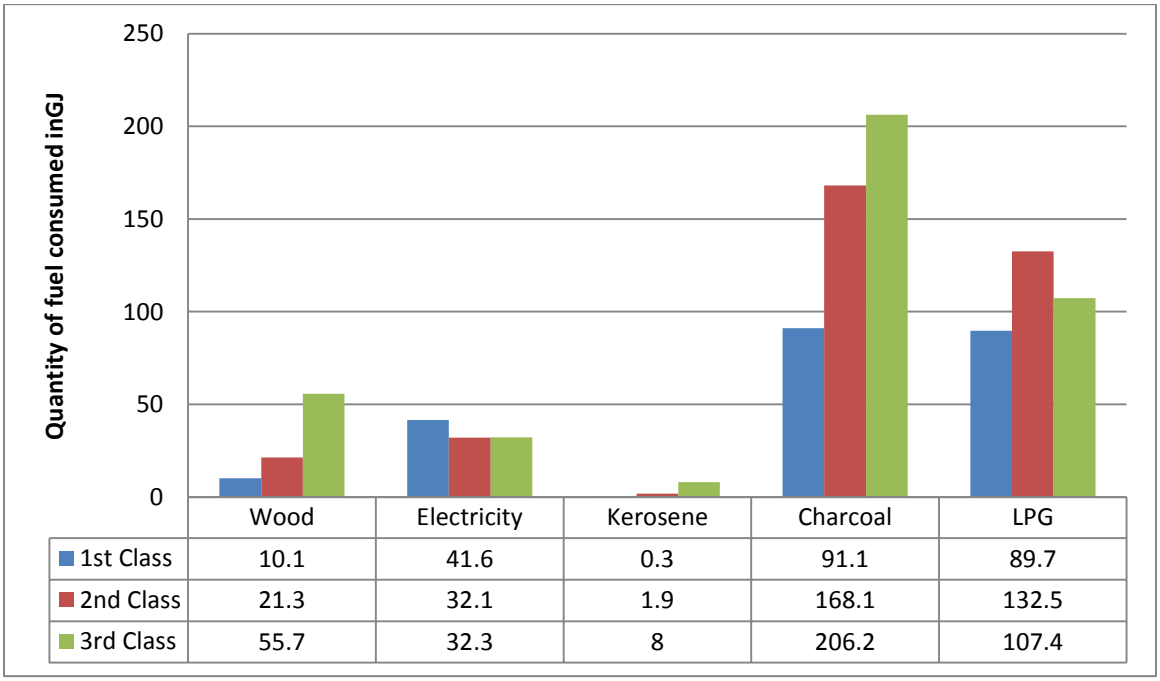
	Solar	Other	Petrol
1st Class	0.8	17.3	36.7
2nd Class	0	9.6	0
3rd Class	0	25.6	18.6

Source: 2014 Energy Survey

Electrified households in the ASEM depend on electricity, charcoal, LPG and wood fuels for their water heating needs. Third class electrified householdsuse relatively more of charcoaland wood fuels to satisfy these needs than first and second class electrified households (Figure 43). Second class electrified households use more LPG than first and third class households for water heating. On the other hand, first class electrified households use more electricity than second and

third class electrified households for water heating, with the commonest technologies used being electric heaters and kettles.

Figure 43: Sources of energy for water heating in electrified households in ASEM



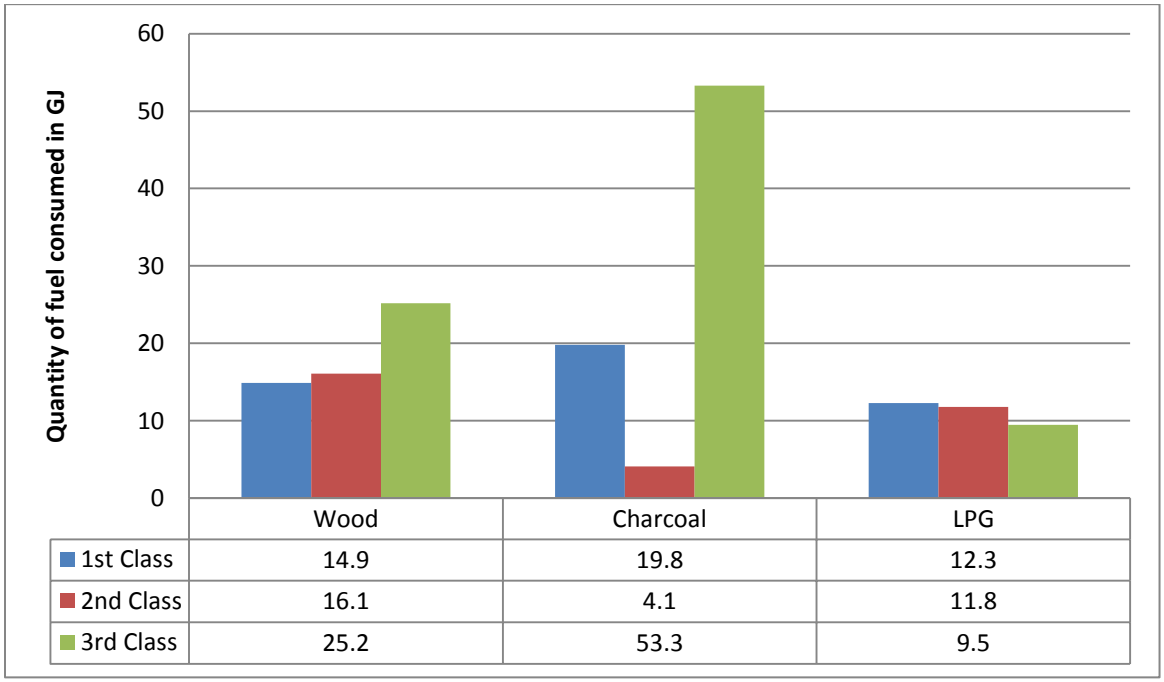
	Wood	Electricity	Kerosene	Charcoal	LPG
1st Class	10.1	41.6	0.3	91.1	89.7
2nd Class	21.3	32.1	1.9	168.1	132.5
3rd Class	55.7	32.3	8	206.2	107.4

Source:2014 Energy Survey

Non-electrified households in the municipality use charcoal, wood and LPG fuels for water heating. Charcoal is used more extensively by third class non-electrified households than first and second class non-electrified households for water heating. Wood fuels are also used more by third class non-electrified households than first and second class non-electrified households for

water heating relatively. For the use of LPG however for water heating, there are more first class non-electrified household users than second and third class household users (Figure 44).

Figure 44: Sources of energy for water heating in non-electrified households in ASEM



	Wood	Charcoal	LPG
1st Class	14.9	19.8	12.3
2nd Class	16.1	4.1	11.8
3rd Class	25.2	53.3	9.5

Source: 2014 Energy Survey

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

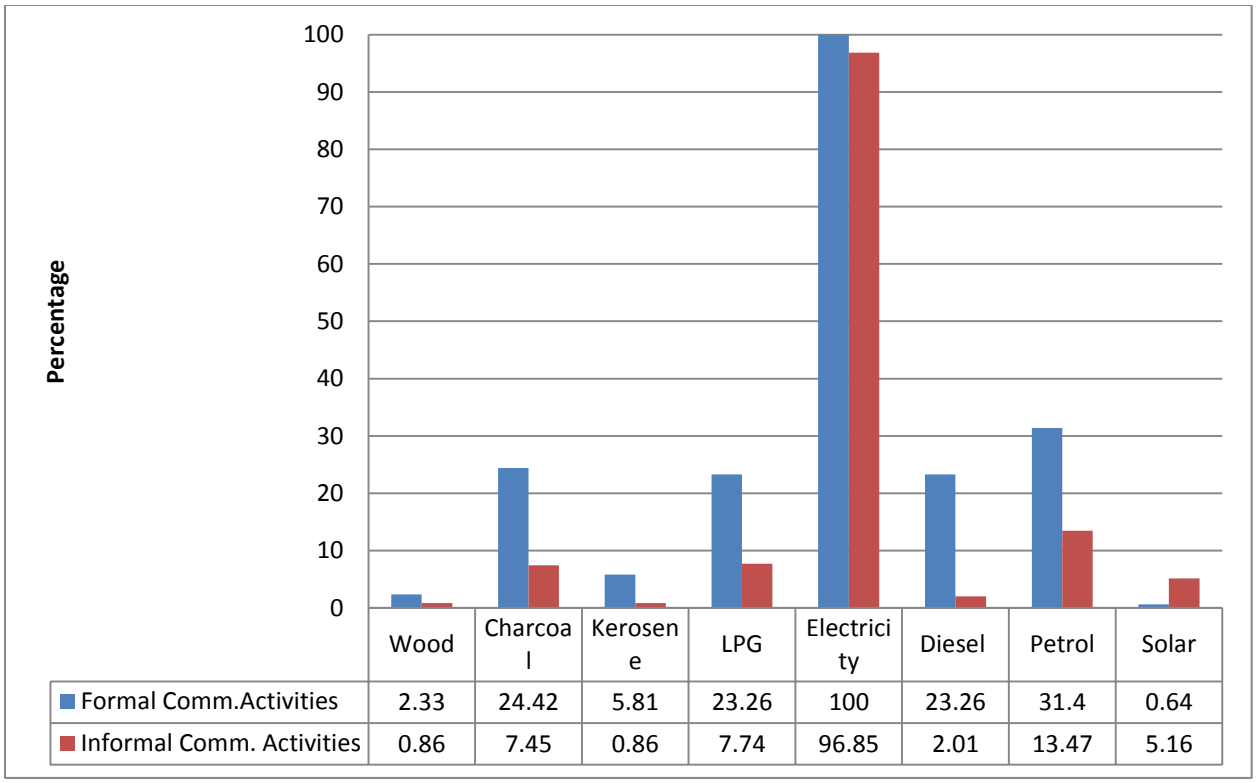
machines as the technologies while charcoal fuel is used in non-electrified households for ironing using the metallic (box) iron.

4.2 Commercial Sector

The commercial sector accounts for 13% of the total energy consumed in the ASEM in 2013. The sector ranks third in the order of the biggest energy consuming sectors in the municipality. 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 1:4 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 thisSoE 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.

All formal commercial activities in the municipality consume electricity vis-à-vis approximately97% of informal commercial activities (Figure 45). Apart from electricity, the commercial sector activities in the municipality also use charcoal, LPG, diesel, petrol and to a little extent, wood, kerosene and solar. Higher numbers of the formal commercial activities use these fuel types than the informal commercial activities, except for solar energy. 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 46).

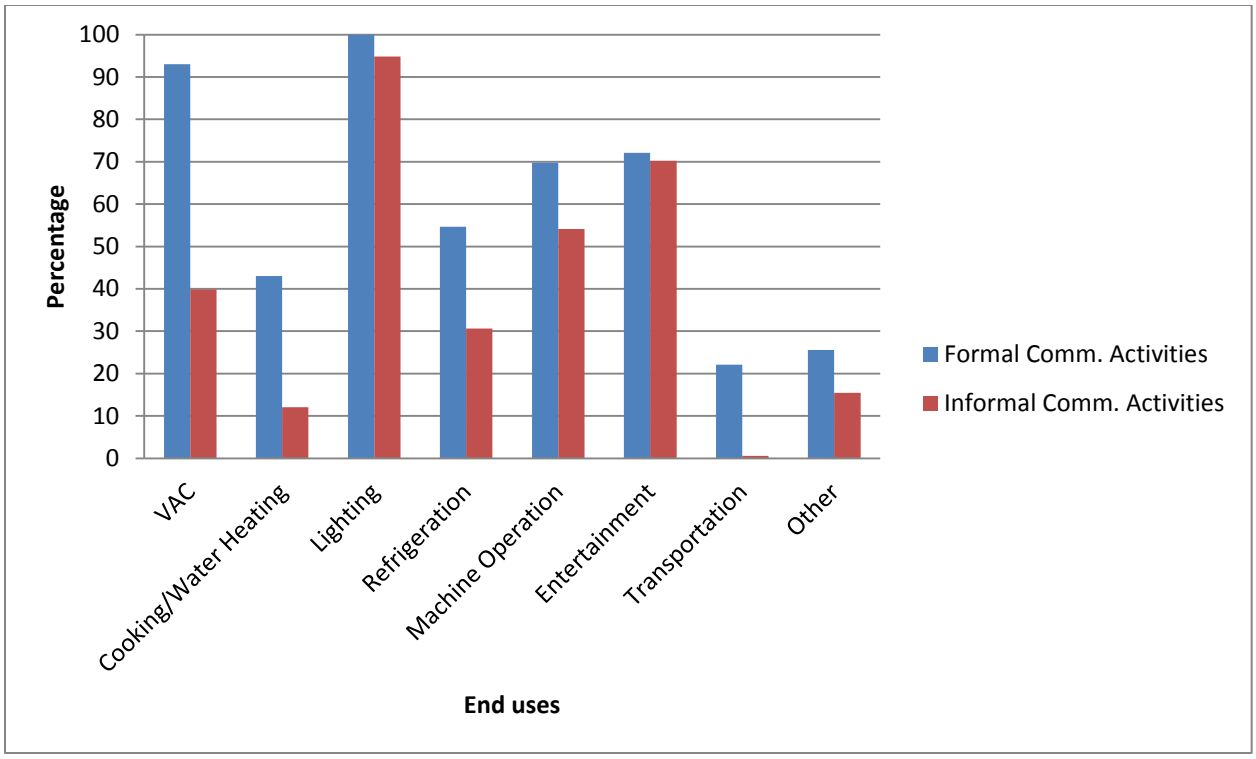
Figure 45: Commercial activities and the percentage share in the use of different fuel types in ASEM



	Wood	Charcoal	Kerosene	LPG	Electricity	Diesel	Petrol	Solar
Formal Comm.Activities	2.33	24.42	5.81	23.26	100	23.26	31.4	0.64
Informal Comm. Activities	0.86	7.45	0.86	7.74	96.85	2.01	13.47	5.16

Source: 2014 Energy Survey

Figure 46: Commercial activities and the percentage share of end-uses in ASEM



Source: 2014 Energy Survey

Informal commercial activity levels in the municipality have increased tremendously since 2010 (Table 12). The total floor space covered by informal activities in 2010 was about 13,826.23 square meters (m^2) (from the sampled commercial activities in the 2014 commercial survey). This increased to 15,106.09 square meters (m^2) in 2011 with a growth rate of 9.26%. In 2013, the informal activity level covered an area of 22,163.32 square meters (m^2) in the municipality. Formal commercial activities in the municipality also expanded since 2010. With a floor area of about 59,337.41 square meters (m^2) in 2010based on the sampled formal activities, the floor space of formal activities increased to around 73,867.53 square meters (m^2) in 2013(Table 12).

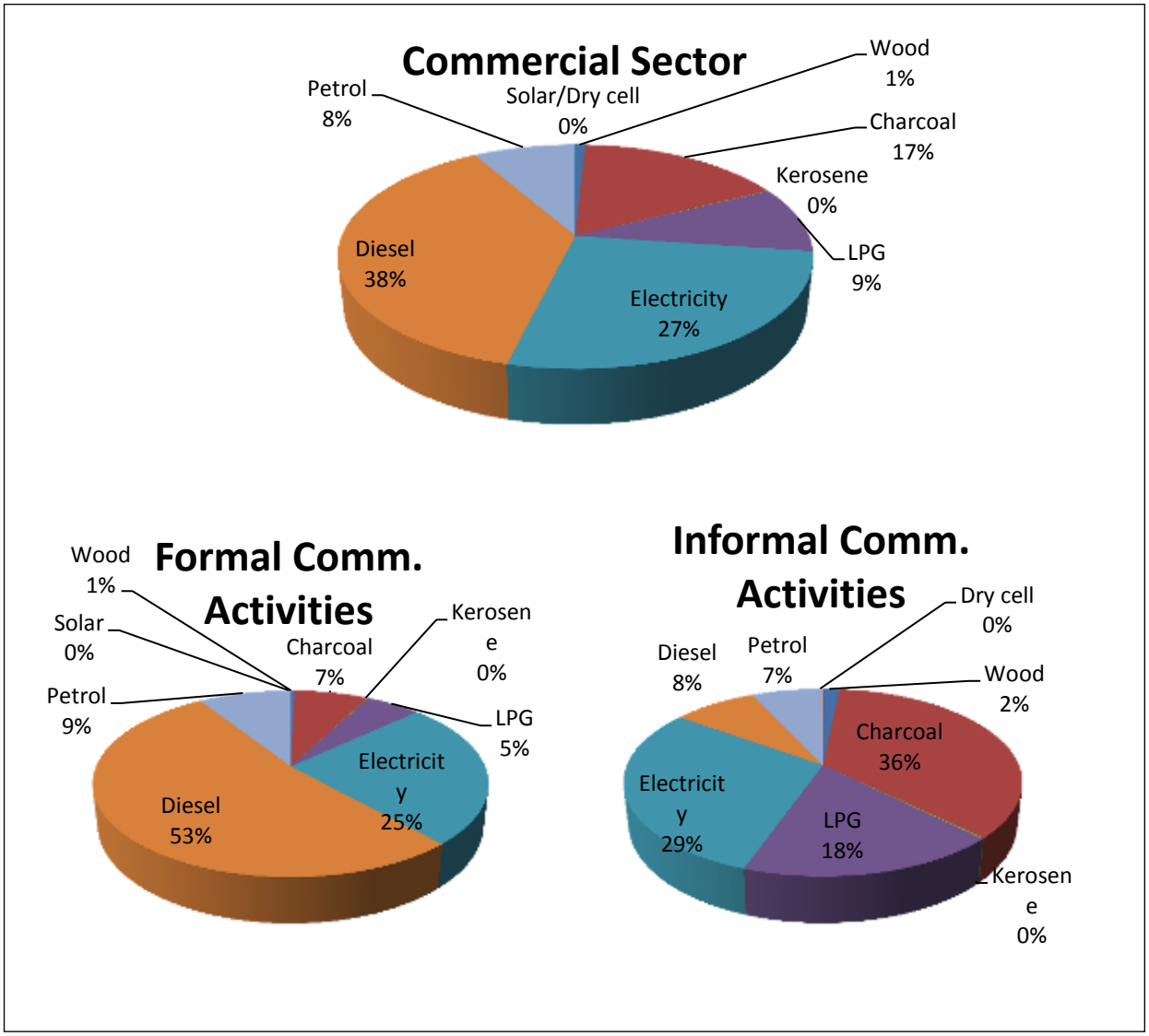
Table 12: Levels of commercial activity in ASEM

Year	Formal		Informal	
	Floor space (m^2)	Growth rate (%)	Floor space (m^2)	Growth rate (%)
2010	59,337.41	-	13,826.23	-
2011	59,545.48	0.35	15,106.09	9.26
2012	62,393.43	4.78	18,884.04	25.01
2013	73,867.53	18.39	22,163.32	17.37

Diesel (38%) and electricity(27%) constitute the largest shares of the total energy consumed in the commercial sector in the ASEM in 2013 (Figure 47). The remaining 35% is shared between charcoal, wood, LPG and petrol fuels, with charcoal constituting about 17%. Kerosene and solar energy are consumed in small quantities in the municipality.

As Figure 47 depicts, formal commercial activities depend largely on diesel fuel as it constitutes about 53% of the total energy consumed by formal commercial activities in the municipality. Diesel fuel is used in generators for power and also by vehicles among formal commercial activities. Electricity constitutes about 25% while petrol, charcoal and LPG constitute 9%, 7% and 5% respectively of the total energy consumed by the formal commercial activities. Among informal commercial activities, however, charcoal is largely consumed, having a share of about 36% of the total energy consumed by informal commercial activities in the municipality in 2013. Electricity and LPG constitute 29% and 18% respectively, while diesel and petrol fuels constitute 8% and 7% respectively.

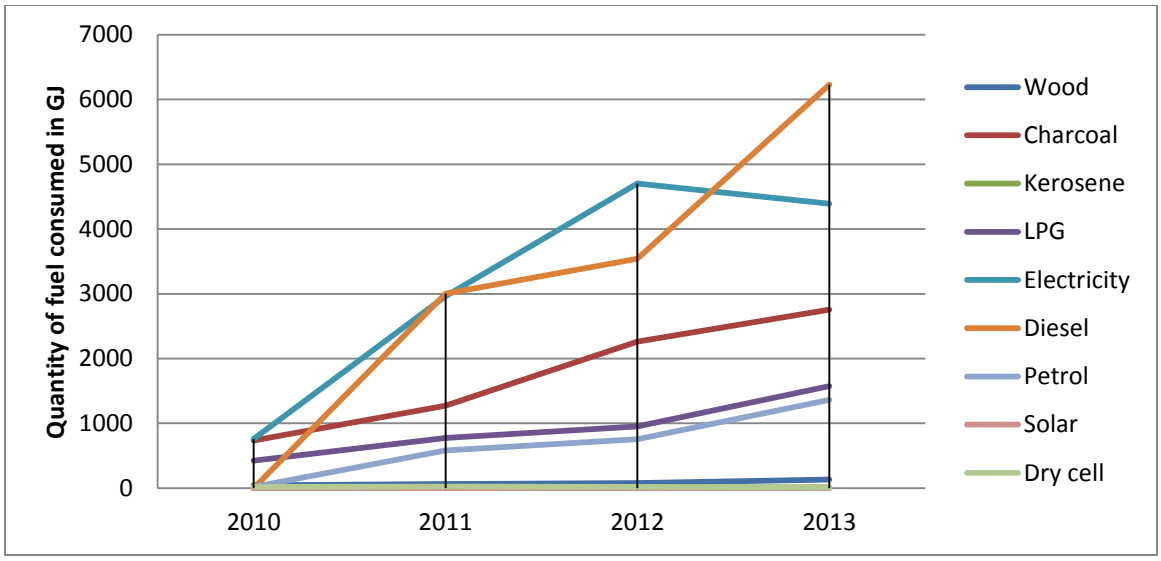
Figure 47: Share of energy consumed in ASEM among various carries in 2013



Source:2014 Energy Survey

Figure 48shows the trend in fuel usage in the commercial sector from 2010 to 2013 in the ASEM. 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 dipping of electricity consumption is attributable to the acute electricity shortages the country has been experiencing since 2012. As a result, most commercial activities have procured industrial power plants/generators, which are fueled by petrol and diesel, hence the increases in their consumption.

Figure 48: Trend in Energy usage in the commercial sector in ASEM



Source: 2014 Energy survey

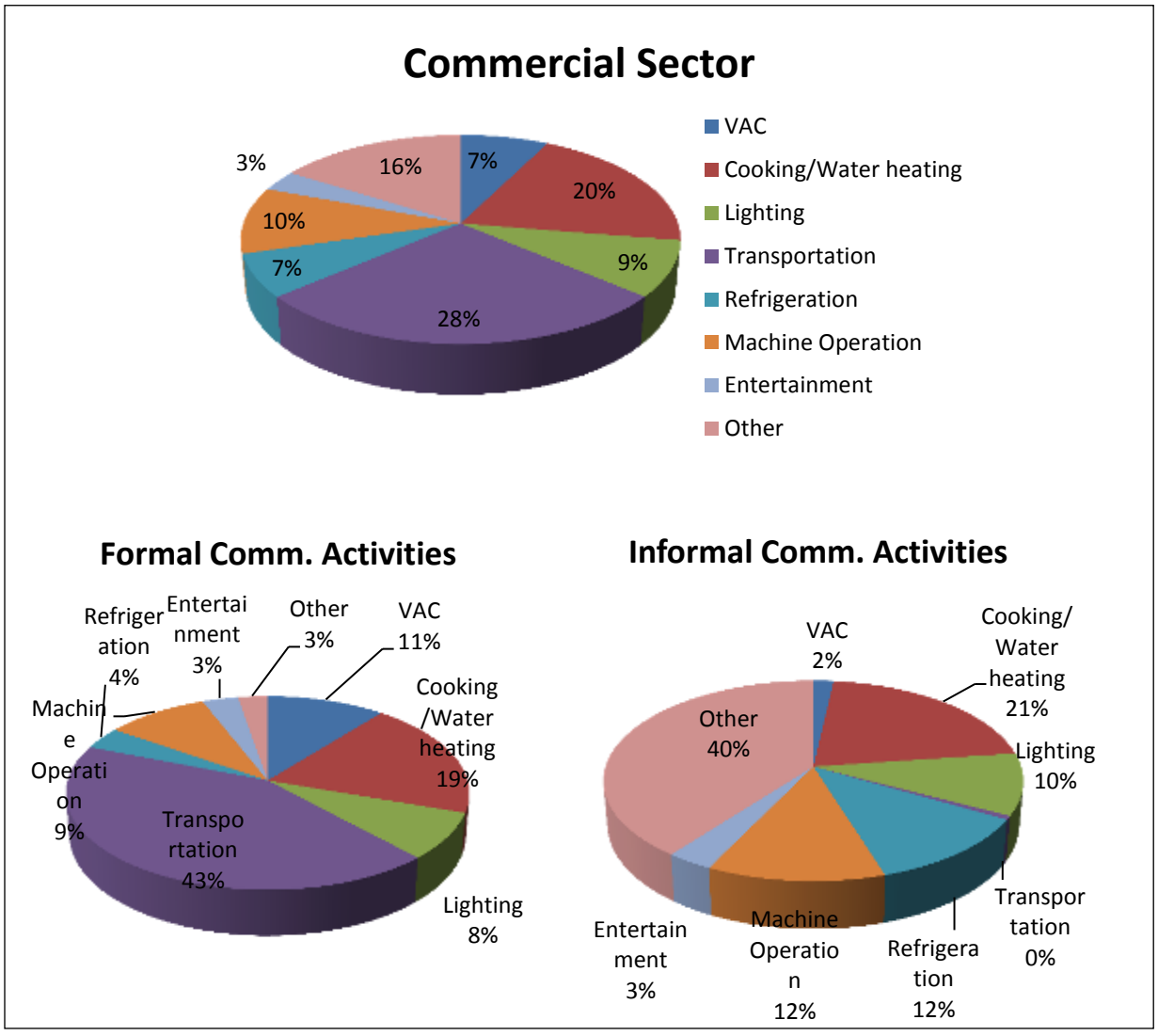
Transportation, cooking, water heating and other commercial activities such as welding, baking, smith activities, soldering and spraying,are the most energy intensive end-uses in the commercial sector (Figure 49). Transportation consumes about 28% of the total energy, while cooking/water heating and other activities consume about 20% and 16% respectively of the total energy by the sector. Machine operation and lighting consume about 10% and 9% respectively,while 7% each is consumed by refrigeration services and ventilation and air conditioning of the total energy used by the commercial sector. Entertainment accounts for only about 3%..

Within the formal commercial activities, transportation accounts for the largest (43%) consumption of energy. About 19% of energy is consumed by cooking/water heatingactivities, especially in schools (school feeding programme), hospitals and hotels/guest houses. Machine operations such as the use of computers, printers, photocopy machines and others consume about 9% of the total energy in the formal commercial sector, while lighting uses about 8%. Refrigeration and entertainment account for 4% and 3% respectively of the total energy used in the formal commercial sector.

Other commercial activities such as welding, baking, smith activities, soldering and spraying are the most energy intensive activity in the informal commercial sector (Figure 49). These activities consume about 40% of the total energy within the informal commercial sector. Cooking/water heating comes second, consuming about 21% of the total energy of the informal commercial sector. Cooking and water heating are undertaken by the teeming restaurants, bars and food joints in the municipality. Machine operation and refrigeration each consumes about 12% of the total energy consumption by the informal commercial sector. The machine operations include

machines used in mechanic shops, sewing machines in tailoring shops and other machines used in other informal commercial activities. Additionally, lighting and entertainment consume 10% and 3% respectively of the total informal commercial sector's energy consumption in the municipality.

Figure 49: Percentage share of total energy consumed among various end-uses in the commercial sector in 2013 in ASEM



Source: 2014 Energy Survey

4.3 Industrial Sector

The industrial sector accounts for 3% of the total energy consumed in the ASEM 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- mining and quarrying; manufacturing; and construction - to enhance an understanding of the pattern of energy consumption among these sub-sectors.

Table 13 shows the total level of industrial activity in ASEM with the production outputs converted into tonnes. In 2010, the total production of the industrial sector was around 9,651.74 tonnes, mainly from the construction sub-sector. This production level increased to 14,697.25tonnes, 829,260.95 tonnes and 1,003,627.02 tonnes in 2011, 2012 and 2013 respectively, with the highest contributor being the mining and quarrying sub-sector, followed by construction.

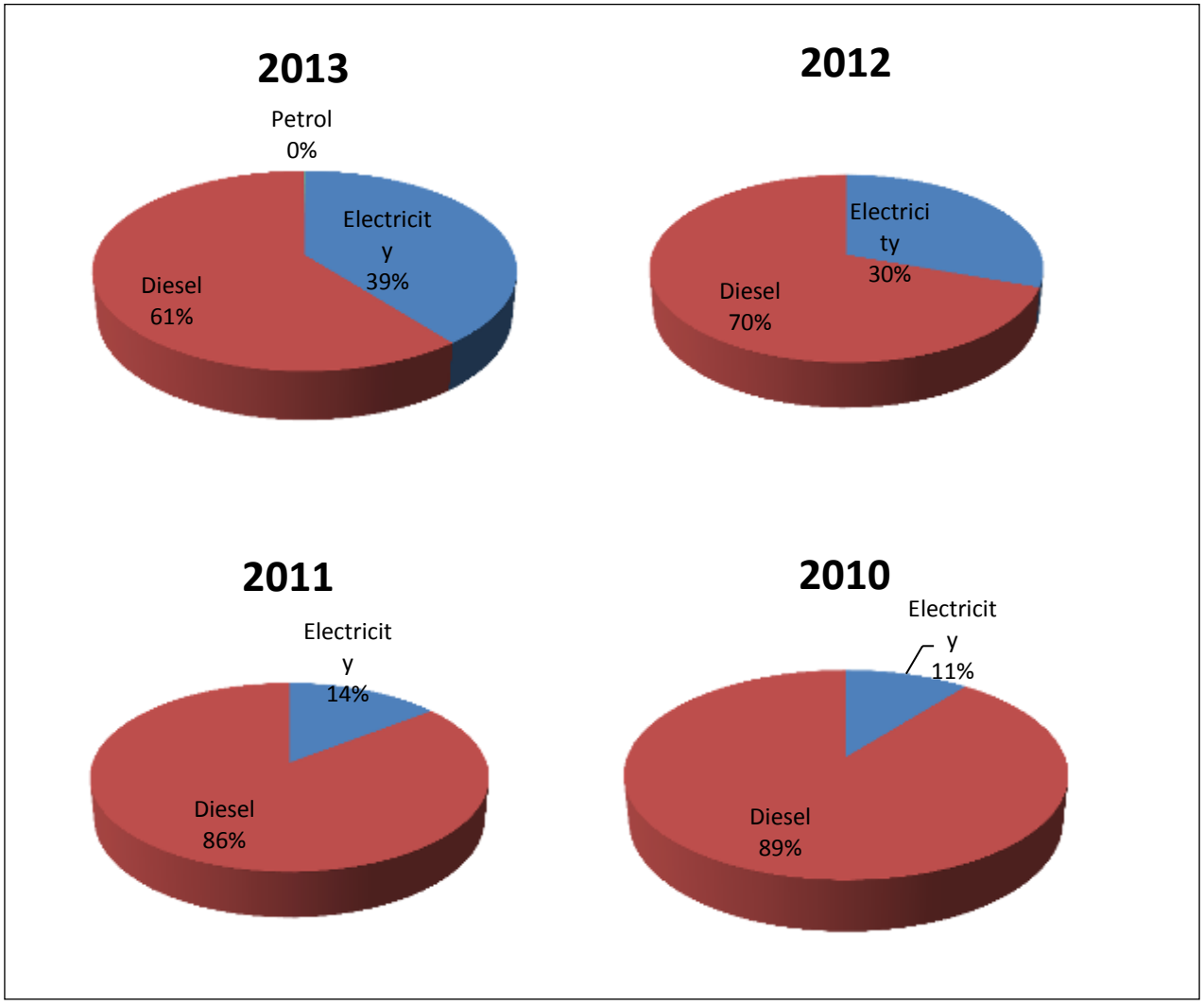
Table 13: Total level of industrial activity in ASEM

Sub-sectors	Activity level in tonnesper production			
	2010	2011	2012	2013
Mining & Quarrying	_	_	800,500	850,000
Manufacturing	_	_	2,566.44	115,677
Construction	9,651.74	14,697.25	26,194.51	37,950.02
Total	**9,651.74**	**14,697.25**	**829,260.95**	**1,003,627.02**

Source: 2014 Energy Survey

The industrial sector consumes two main kinds of fuel: electricity and diesel as depicted in Figure 50. The trend in energy consumption in the industrial sector within ASEM since 2010 reveals that, though diesel fuel has been consumed in much bigger quantities than electricity since 2010, the proportion of electricity consumption has experienced an increased rate over the period. Industrial activities are heavily dependent on petroleum fuels to power their industrial power plants for electric power. In 2010 and 2011 over 80% of the total energy consumed in the industrial sector came from diesel fuel, with electricity contributing a little over 10% of the total energy consumed by the sector within the municipality in those years. In 2012, 70% of the total energy consumed by the industrial sector came from diesel while 30%. Similarly in 2013, diesel constitutes about 61% of the total energy consumed by the industrial sector in ASEM while electricity only constitutes about 39%. Despite the current shortfall in electricity supply to the municipality, new and emerging industrial players in the municipality always favoured electricity connection to the national grid. This accounts for the observed increasing trend in electricity consumption by the industrial sector since 2010.

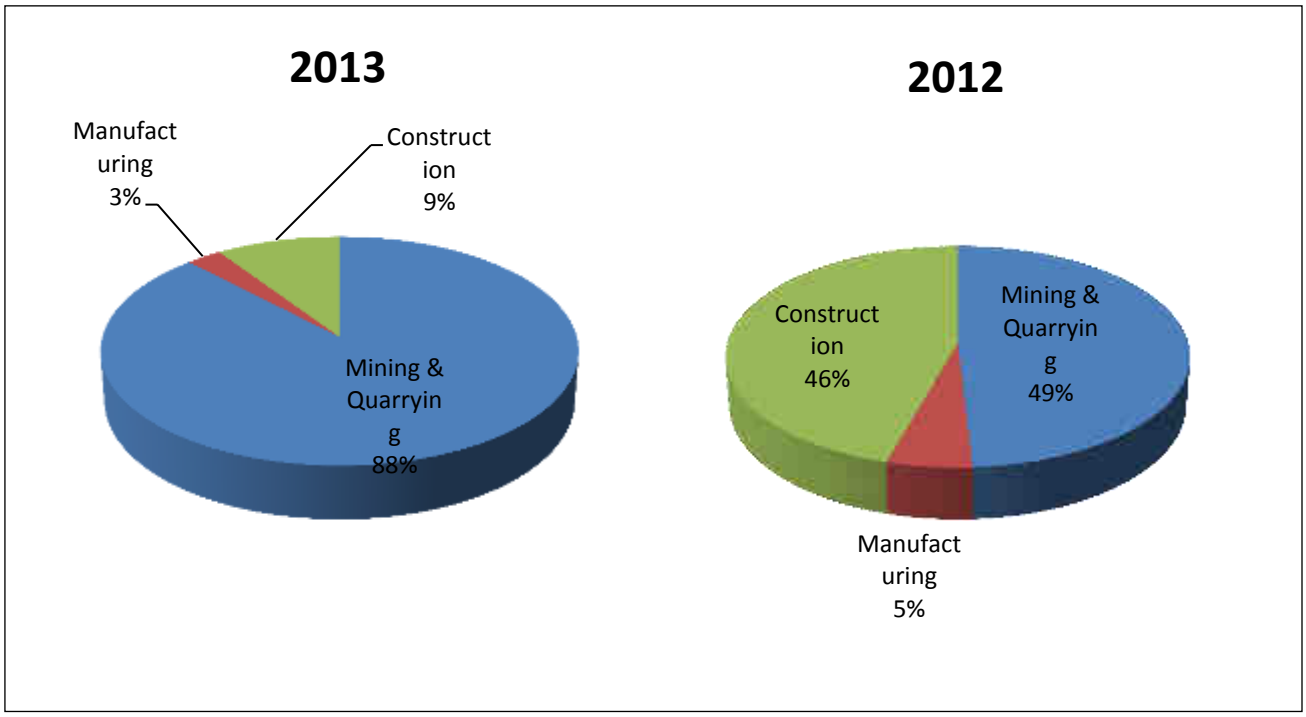
Figure 50: Percentage share of energy sources consumed by industrial sector in ASEM from 2010 to 2013



Source: 2014 Energy Survey

Mining and quarrying is the most energy intensive sub-sector of the industrial sector in the ASEM. The sub-sector consumed about 49% of the total energyin the industrial sector in 2012, followed by the construction sub-sector (46%), with manufacturing consuming the least (%...?). The pattern is similar in 2013, with mining and quarrying constituting about 88% of the total energy consumption in the industrial sector while the construction and manufacturing sub-sectors consume 9% and 3% respectively (Figure 51).

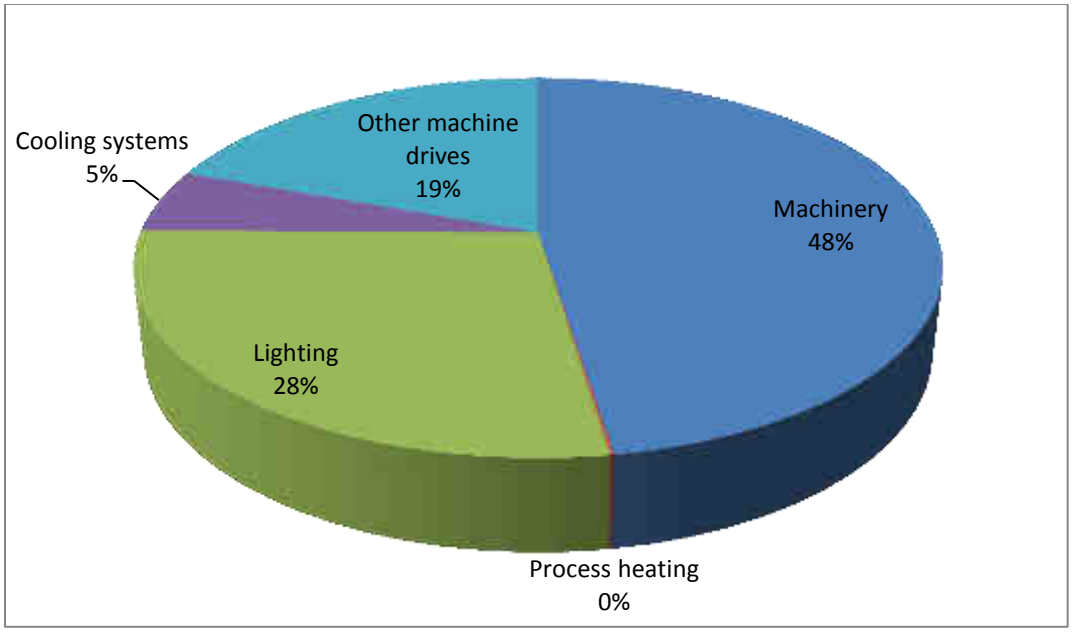
Figure 51: Share of total energy consumption among various industrial sub-sectors in ASEM in 2012 and 2013



Source:2014 Energy Survey

About 48% of the total energy consumed in the industrial sector is used on machinery. Industrial activities often involve heavy machines that depend solely on energy to power them. These include vehicular machines in the mining and quarrying sub-sector, sachet water manufacturing machines, and cement blocks cutting machines in the construction sub-sector. Lighting accounts for about 28% of the total energy consumption in the industrial sector while other machine and cooling systems consume about 19% and 5% respectively of the total industrial energy consumption (Figure 52).

Figure 52: Share of energy consumption among industrial demands in 2013 at ASEM



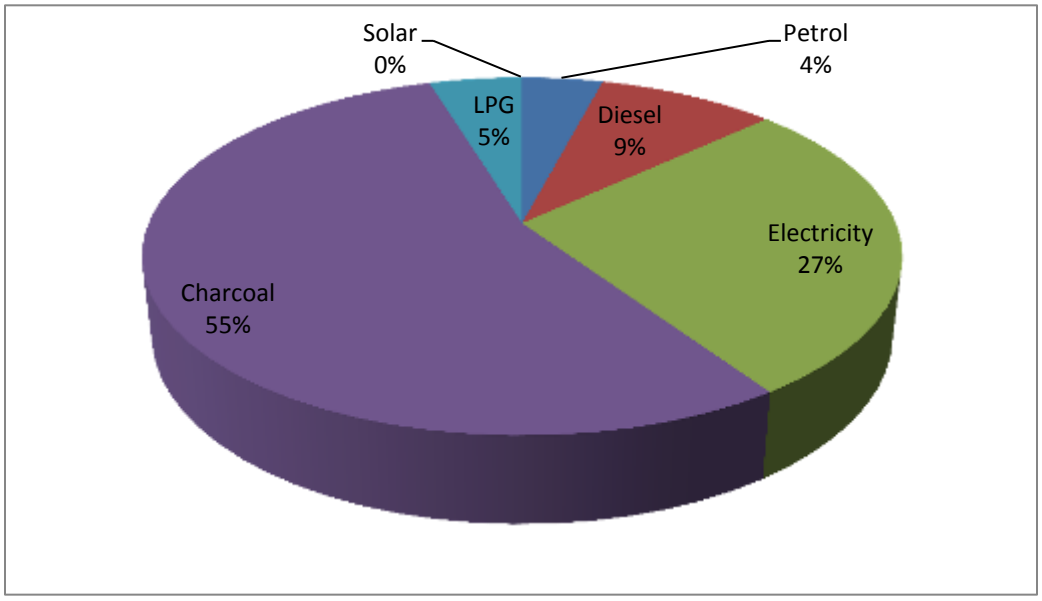
Source: 2014 Energy Survey

4.4 Agricultural Sector

The agricultural sector is the least energy consuming sector in the municipality and the sector accounts for less than 1% of the total energy consumed in the ASEM. The main mechanised agricultural activities in the municipality include poultry farming,cash croppingand pineapple farms. In terms of tonnage of production per year, the agricultural sector produced about 267.843 tonnes in 2010, 536.62 tonnes in 2011 before falling to 312.44 tonnes in 2012. However, production picked up again in 2013 when about 494.45 tonnes of agricultural outputs were produced.

Charcoal fuel constitutes about 55% of the total energy consumed by the agricultural sector, followed by electricity (27%). The remaining 18% is from diesel, LPG and petrol fuels as shown in Figure 53.

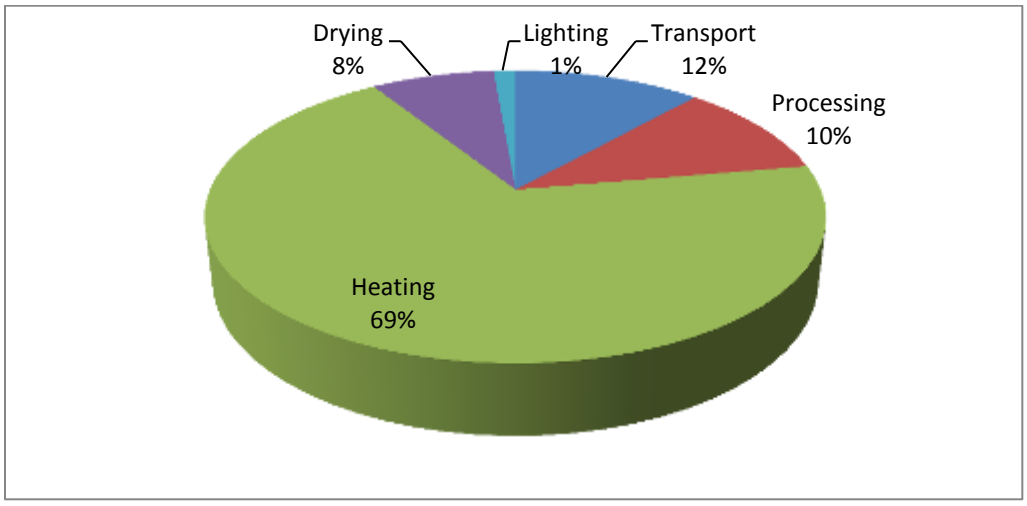
Figure 53: Percentage share of Energy sources consumed by agricultural sector in ASEM



Source:2014 Energy Survey

Heating is the agricultural process or activity that takes the biggest share (69%) of energy in the sector. Transportation is the second most consuming agricultural activity, using about 12% of the total energy consumed by the agricultural sector. Processing of agricultural products, drying and lighting consume about 10%, 8% and 1% of the total energy consumed by the sector, respectively(Figure 54).

Figure 54: Share of energy consumed among various end-uses in the agricultural sector



Source: 2014 Energy Survey

4.5 Transport Sector

The transport sector is the most energy intensive sector in the municipality, consuming about 3,372,729.5 GJ of energy. Vehicle population in the municipality grew by 9.76% from 2012 to 2013 (Table 14). The total number of vehicles in the municipality in 2013 consisted of 15 public vehicles, 22,203 private vehicles and 7,292 commercial vehicles (Table 15). Most of the heavy passenger, light passenger, mini buses, taxis and motorbikes are efficient vehicles althougha 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 trucks are used for commercial purposes. There are 15 Metro Mass Transit (MMT) buses (more than 12 passenger vehicles) operating in the municipality that are publicly owned. Five of the MMT buses were broken down in 2013 which reduced the number of the MMT buses to15, from the 2012 number of 20.

Table 14: Population of vehicles in ASEM from 2012 to 2013

Type	Number of vehicles		Growth	Efficient vehicles
	2012	**2013**		**No. & (%)**
Heavy passenger vehicle >12	20	15	-25.00%	15 (100)
Light passenger vehicle <12	19,708	21,898	11.11%	17,518.4 (80)
Mini buses	5,850	6,150	5.13%	3,690 (60)
Taxi	1,000	1,120	12.00%	784 (70)
Motorbikes	60	62	3.33%	55.8 (90)
Tricycle	53	30	-43.40%	27 (90)
Light trucks	60	70	16.67%	42 (60)
Meduim trucks	30	45	50.00%	27 (60)
Heavy trucks	105	120	14.29%	72 (60)
TOTAL	**26,886**	**29,510**	**9.76%**	

Source: 2014 Energy Survey

Table 15: Distribution of vehiclepopulation by sector/ownership in ASEM as at 2013

Type	Public	Private	Commercial Passenger
Heavy passenger vehicle >12	15		
Light passenger vehicle <12		21,898	
Mini buses			6,150
Taxi			1,120
Motorbikes		40	22
Tricycle		30	
Light trucks		70	
Medium trucks		45	
Heavy trucks		120	
TOTAL	**15**	**22,203**	**7,292**

Source:2014 Energy Survey

The average usage of vehicles is shown in Table 16. The MMT buses transport about 43,200 people per week from various locations in the municipalityin 2013 while light passenger vehicles, which are often private cars, transport about 394,164 people per week in the municipality in 2013. Mini buses (trotro) transport about 7,380,000 people per week in the municipality while taxis transport about 336,000 people per week. The use of mini buses has grown over the years (about 15%), while the use of taxis also increased by 5% since 2010.

Table 16: Average usage of vehicles per week in ASEM in 2013

Type	Units	Use		Growth
		2010	**2013**	
Heavy passenger vehicle >12	people/week	48,884	43,200	-12%
Light passenger vehicle <12	people/week	328,331	394,164	20%

Mini buses	people/week	6,393,000	7,380,000	15%
Taxi	people/week	319,200	336,000	5%
Motorbikes	people/week	5,833	5,952	2%
Tricycle	tonnes/week	446	450	1%
Light trucks	tonnes/week	1,868	2,100	12%
Meduim trucks	tonnes/week	1,760	2,025	15%
Heavy trucks	tonnes/week	5,052	5,400	7%

Source: 2014 Energy Survey

In relation petrol, its average cost per litre increased from GHC2 in 2012 to GHC2.56 in 2013. Diesel on the other hand was about GHC2 per litre in 2012 and increased to an average of GHC2.44 per litre in 2013. The cost per 1 kilogram of LPG was about GHC2.57 in 2012, but increased to an annual average of GHC 2.72 per kg in 2013 (Table 17). A total of about 14,763,000litres of petrol was sold in the ASEM in 2012, increasing to about 17,100,000litresbeing sold in 2013 (Table 16). About 19,427,500litres of diesel was sold in 2012 in the municipality, but decreasedby 10% to about 17,442,000 litres in 2013. About 41,425,020 kg of LPG were sold in 2012,but decreased in 2013 to about 40,218,480 kg (Table 18).

Table 17: Trends in average cost (GHC) of fuel in the ASEM from 2012 to 2013

	Unit	2012	2013
Diesel	GHC/litre	2	2.44
Petrol	GHC/litre	2	2.56
LPG	GHC/litre	2.57	2.72

Source: 2014 Energy Survey

Table 18: Trends in total quantity of fuel sold in ASEM in 2012 and 2013

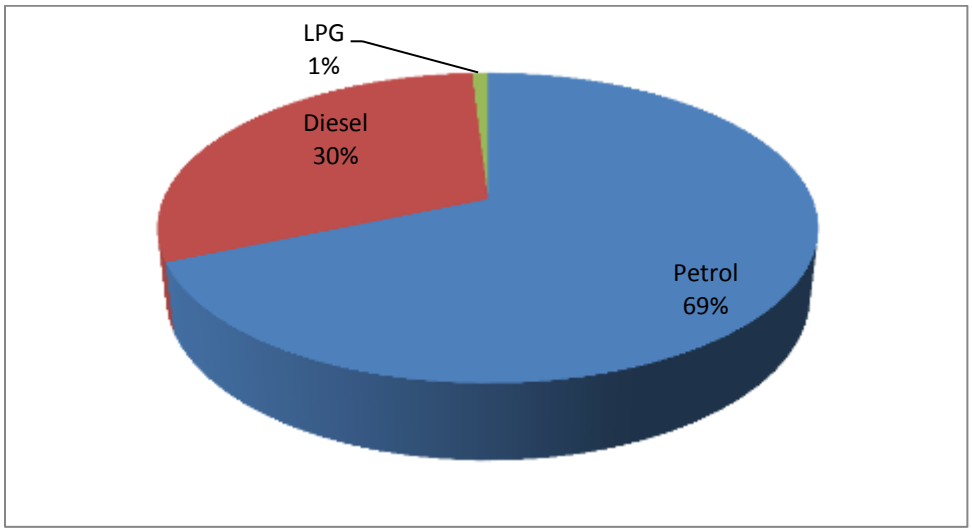
	Unit	2012	2013	Growth
Diesel	Litres	19,427,500	17,442,000	-10%
Petrol	Litres	14,763,000	17,100,000	15.83%

LPG	Kg	41,425,020	40,218,480	-2.91%

Source: 2014 Energy Survey

About 69% of the total energy consumed by the transport sector in the ASEM is from petrol (Figure 55). Diesel fuel constitutes about 30% of the total energy used by the transport sector while 1% of LPG is consumed. 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 or diesel. While the use of LPG by taxis has environmental benefits, it inadvertently created a shortage of LPG for domestic users in the past. Mini-buses (trotro) and the trucks are very dependent on diesel fuels for commercial purposes.

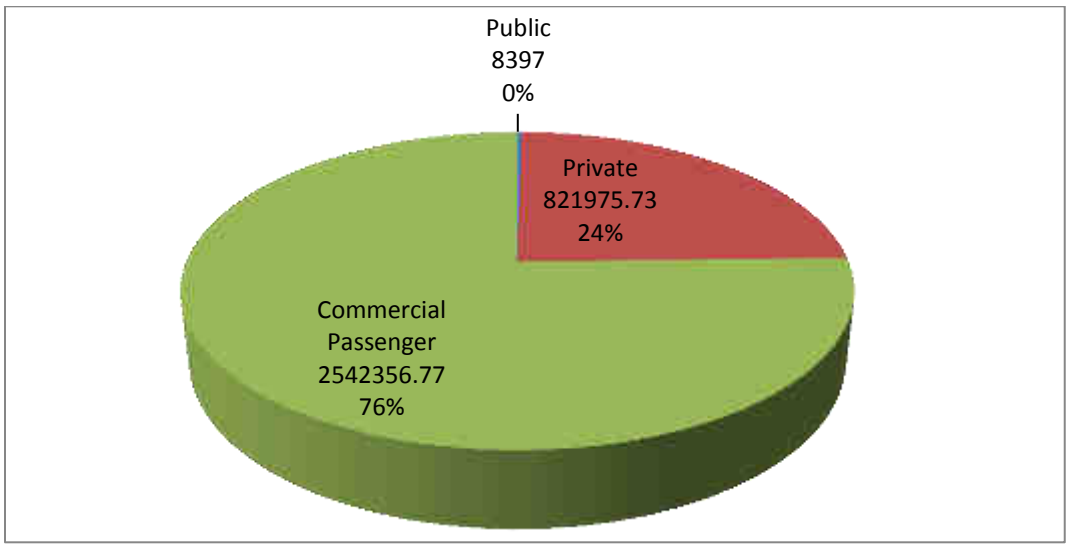
Figure 55: Percentage share of fuel type consumed by the transport sector in ASEM



Source:2014 Energy Survey

Commercial vehicles consume about 76% of the total energy in the municipality. This is followed by private vehicles, which consume about 24% 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 in the ASEM (Figure 56).

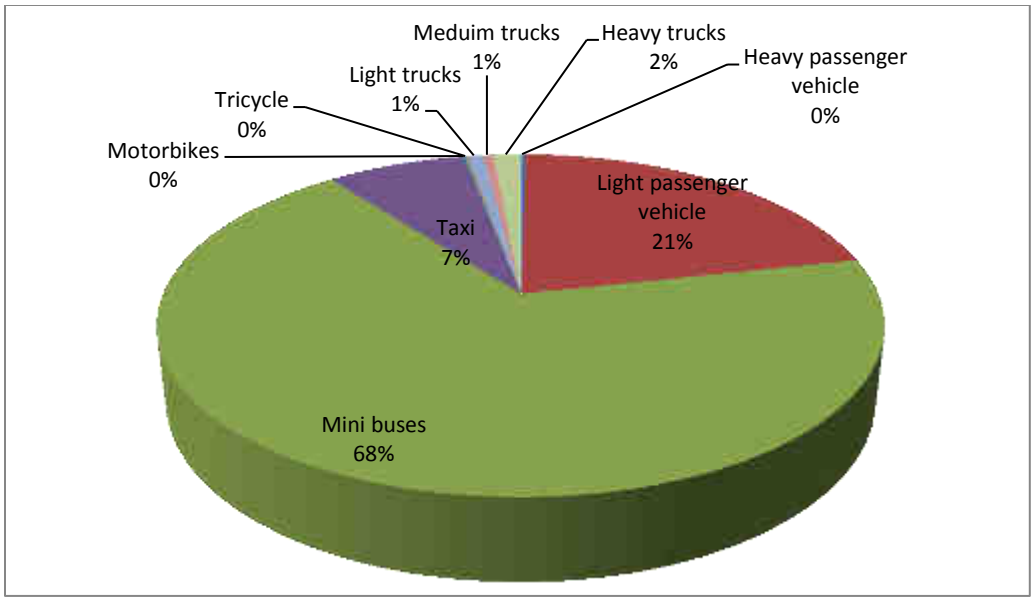
Figure 56: Percentage share of energy consumed by different vehicular operations in ASEM



Source: 2014 Energy Survey

Figure 57 shows the share of energy consumption among the different types of vehicles in ASEM. Energy consumption by mini-buses constitutes the highest (68%) consumption in the transport sector, followed by light passenger vehicles (21%). Taxis consume about 7% of the total energy of the transport sector while all the trucks (light, medium and heavy) together consume about 4% of the total energy in the transport sector. Tricycles and heavy passenger vehicles (MMT buses) consume less than 1% of the total energy consumed in the transport sector in ASEM.

Figure 57: Percentage share of energy consumed by vehicle types in ASEM



Source: 2014 Energy Survey

4.6 Local Government Sector

The Awutu Senya East Municipal Assembly (ASEMA)is the second least energy intensive sector in the municipality,slightly above the agricultural sector. ASEMA consumes less than 1% of the total energy of the municipality. The energy is primarily consumed in the municipal buildings (through lighting, ventilation and air conditioning, refrigeration and office machinery), and in municipal vehicles. The ASEMA currently operates from 5 office buildings with a total floor space of about 7,375m^2, in 2013 (Table 19). The Assembly had 7 diesel-engine vehicles in 2012 with an average usage of 16,380km per year. The number of vehicles used by the Assembly increased to 10 in 2013 and together, they covered a distance of about 23,400km in 2013 (Table 20).

Table 19 Office buildings occupied by ASEMA and the total floor space of the buildings

Year	No. of building	Floor space (m^2)
2012	5	7,375
2013	5	7,375

Source: 2014 Energy Survey

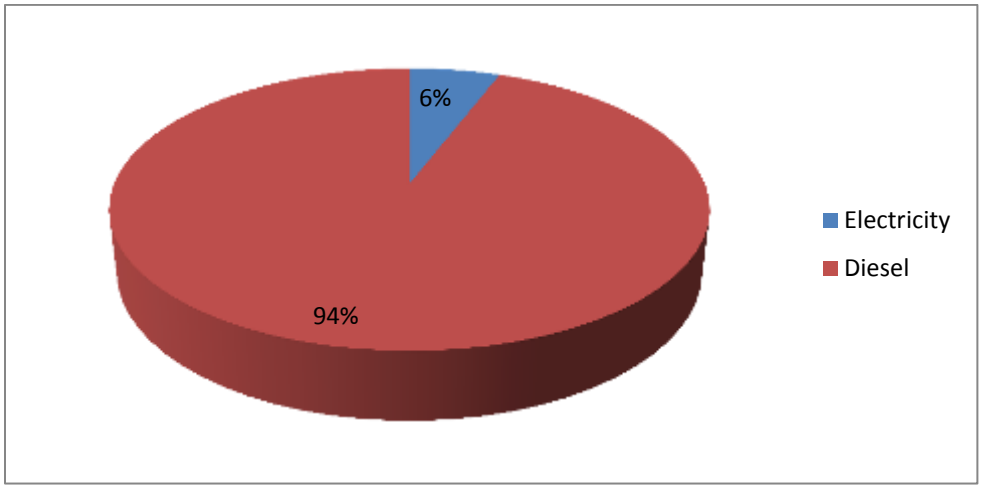
Table 20 Total number of vehicles used by ASEMA and vehicle mileage

	2012	2013
No. of vehicle	7	10
Km/year	16,380	23,400

Source: 2014 Energy Survey

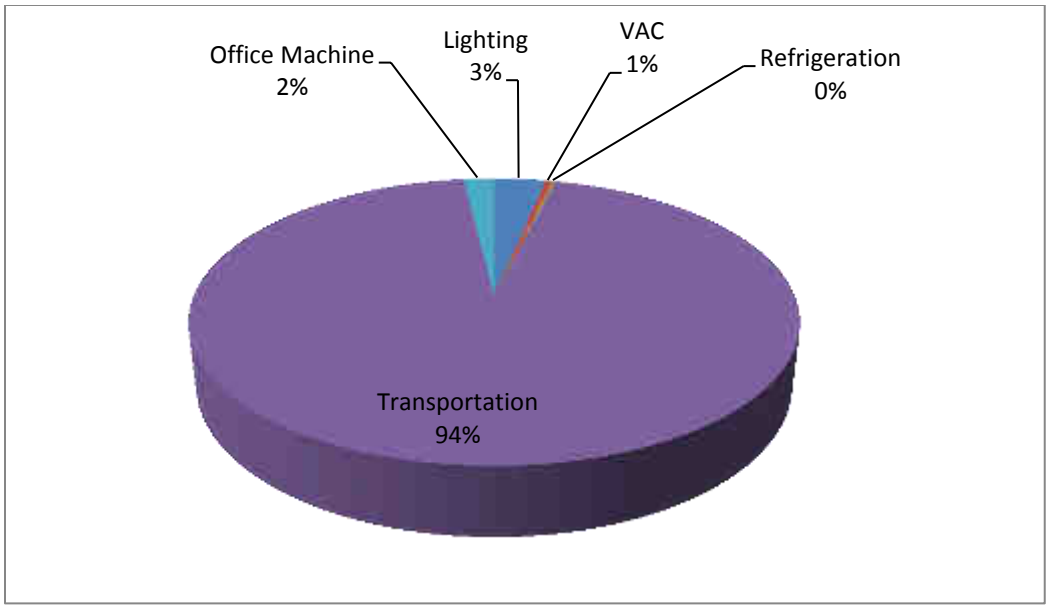
The predominant energy source consumed by ASEMAis diesel fuel (94%). This fuel type is used mainly by the Assembly's vehicle fleet, the Assembly does not operate any back-up generators. Electricity consumption,from the national grid, constitutes only about 6% of the total energy consumed by the ASEMA in 2013. Of the total electricity consumption lighting accounts for 3% of that, office machines (2%), ventilation and air conditioning (1%), refrigeration consumes less than 1% (Figure 59).

Figure 58: Share of total energy consumed by carriers in ASEMA



Source: 2014 Energy Survey

Figure 59: Percentage share of energy consumption in ASEMA by various end-uses



Source: 2014 Energy Survey

SECTION FIVE

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

5.0 Introduction

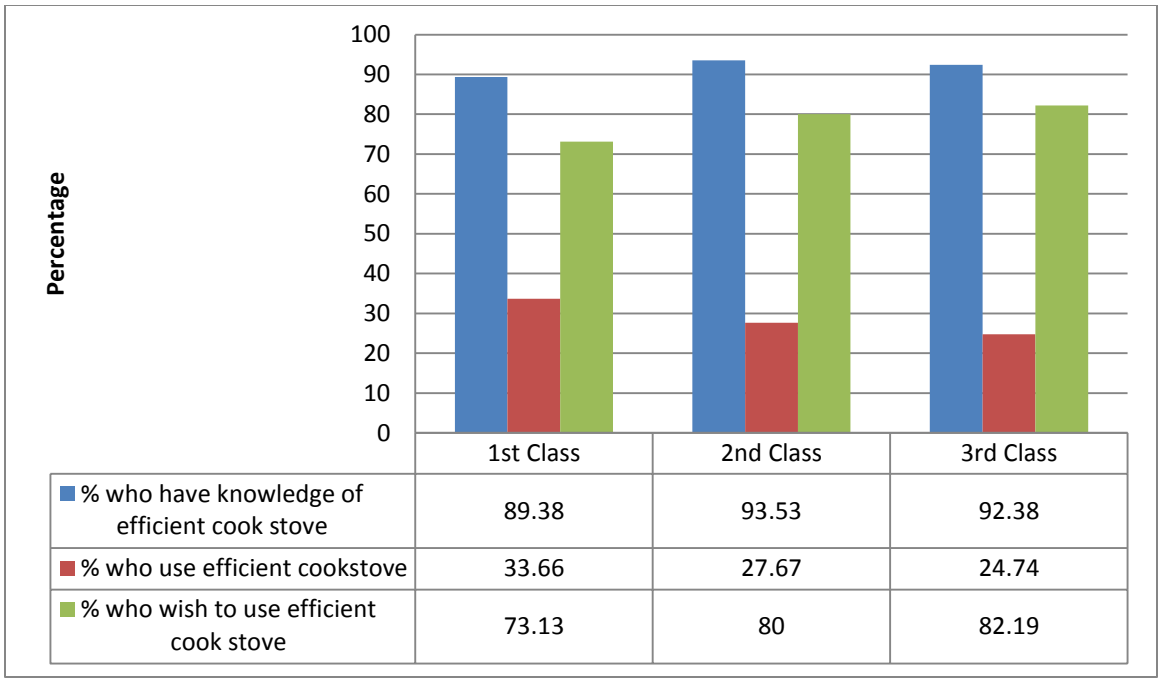
This section assesses the depth of knowledge and awareness on energy efficiency within the ASEM community. The section also assesses the adoption of energy efficiency measures being run by the national energy institutions such as the Energy Commission of Ghana. The assessment helps to gauge the penetration rate of these national programmeswithin the municipality 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 an 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 gases (GHG) emissions(Energy Commission, 2011). The campaign for the use of *Gyapa* is championed by the Energy Commission (EC) of Ghana and other non-governmental organisationsand 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 ASEM. Figure 60 shows the percentage of people who have knowledge on the efficient cookstoves, those who currently use it and those who wish to use it in the future.

Knowledge on the existence of *Gyapa*cookstoves in the ASEM is very highas more than 85% of electrified households across all three classes of settlements indicated their awarenessof thecookstoves. Conversely, a very low percentage of these households currently use the efficient cookstoves despite the high level of awareness (Figure 60). Meanwhile, the percentage of electrified households who wish to use efficient cook stoves is also high, above 70% for all three classes of settlements, implying the possibility of increase in use of the technology in the municipality in future. Among non-electrified households, more than 70% of households noted their awareness of energy efficient cook stoves. However, less than 35% of such households with highly perceived awareness rate have used these efficient cook stoves. Over 85% expressed willingness to use these energy efficient cook stoves (Figure 61).

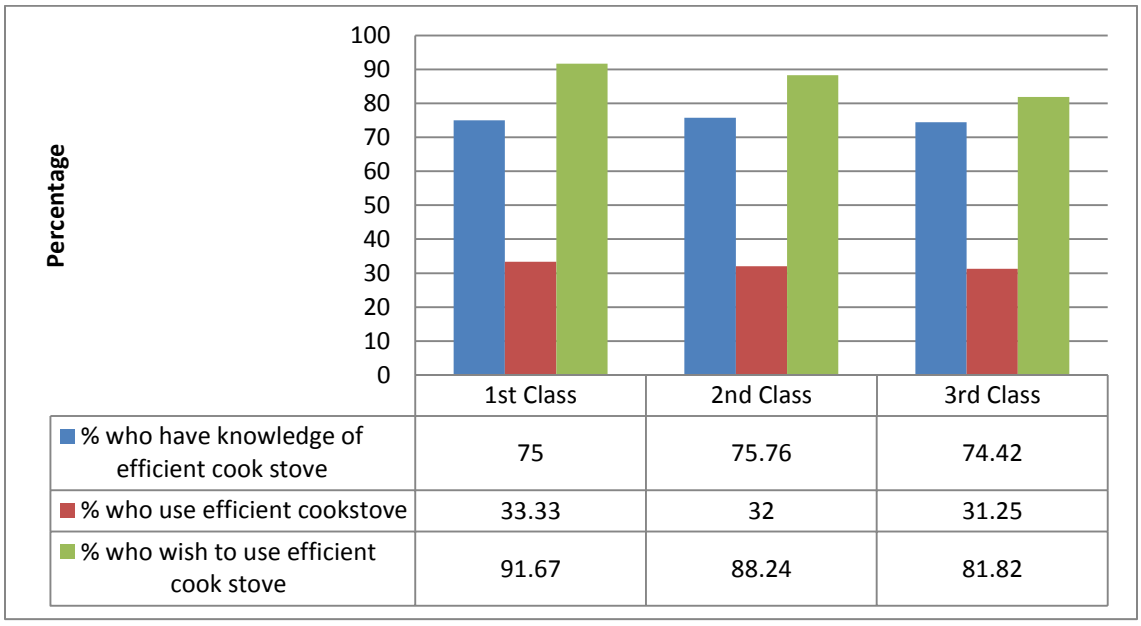
Figure 60: Percentage of electrified households who have knowledge, are using or wish to use efficient cook stoves in ASEM



	1st Class	2nd Class	3rd Class
% who have knowledge of efficient cook stove	89.38	93.53	92.38
% who use efficient cookstove	33.66	27.67	24.74
% who wish to use efficient cook stove	73.13	80	82.19

Source: 2014 Energy Survey

Figure 61: Percentage of non-electrified households who have knowledge, areusing or wish to use efficient cook stoves in ASEM



	1st Class	2nd Class	3rd Class
% who have knowledge of efficient cook stove	75	75.76	74.42
% who use efficient cookstove	33.33	32	31.25
% who wish to use efficient cook stove	91.67	88.24	81.82

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 compact fluorescent lamps

(CFLs) in the country, which helped reduce peak load of electricity by 124 MW (Energy Commission, 2010). This programme was described by the EC as successful and the extent of penetration and coverage of the programme in the ASEM confirms this success story. From the survey, 100% of allfirst class households use energy efficient bulbs for lighting, while 99% all of second and third class households each use efficient lighting bulbs. Those who still depend on the old fluorescent and incandescent bulbs (less than 1%) expressed the views that the old fluorescent 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 fluorescent bulbs.

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

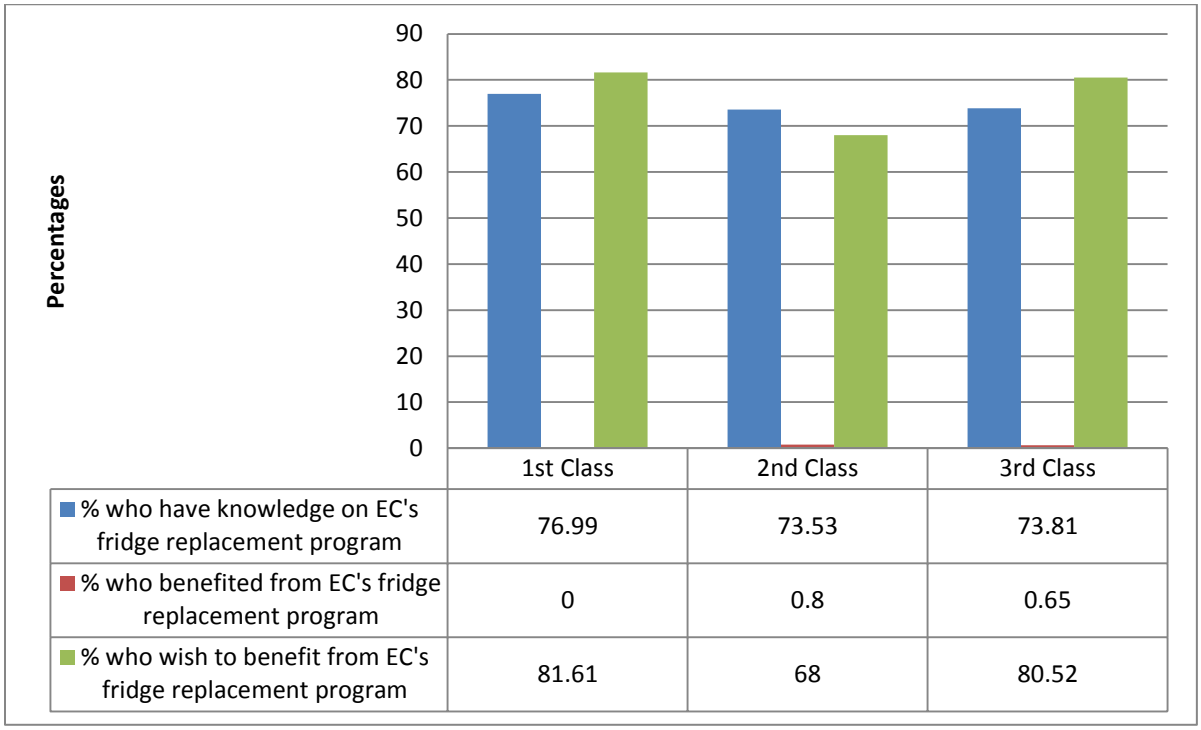
In the last quarter of 2011, the EC of Ghana commenced the 'Refrigerator Energy Efficiency' project, which was expected to run up to 2014. The project intended to introduce very efficient refrigerators into the economy with the potential of reducing electricity consumption in refrigerators by 50% in 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 asAir Conditioners (AC) and Compact Fluorescent Lamps (CFL)) are required to import and sell onlyproducts that meet minimum efficiency and performance standards approved by the Ghana Standards Board. However, the importation of second-hand inefficient refrigerators, from Europe, is still a common practice in Ghana and people still demand them because they are considered cheaper than the new ones.

In the ASEM, about 55%of first class electrified households who use fridges and freezers acquired them new while some 45% of first class electrified householdsalso acquired second-hand brands. In second class electrified households, some 45% acquired their fridges and freezers at their new states while some 58% of them rather went in for second-hand brands. About 64% of those who use fridges and freezers in third class electrified households acquired them at their second-hand state. Only 36% bought and use new fridges and freezers in third class electrified households in the ASEM.

With respect to the EC's fridge replacement programme, the survey results show that it is well known in the ASEM. Over 70% of households across all three settlement classes have knowledge on the programme. Regardless of the high awareness, patronage of the programme is rather abysmal. None of the households in the electrified first class participated in the programme, while 0.8% and 0.65% of the second and third class electrified households benefited from the programme (Figure 62). 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 62: EC's fridge replacement programme: knowledge and accessibility



	1st Class	2nd Class	3rd Class
% who have knowledge on EC's fridge replacement program	76.99	73.53	73.81
% who benefited from EC's fridge replacement program	0	0.8	0.65
% who wish to benefit from EC's fridge replacement program	81.61	68	80.52

Source: 2014 Energy Survey

5.3 Energy Commission (EC) Appliance Efficiency Labels

The Energy Efficiency Standards and Labels programmewas 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 underLI1815 to import, display for sale or sell air conditioners and compactfluorescent lamps in Ghana unless they meet the minimum performancestandards and are properly labeled.

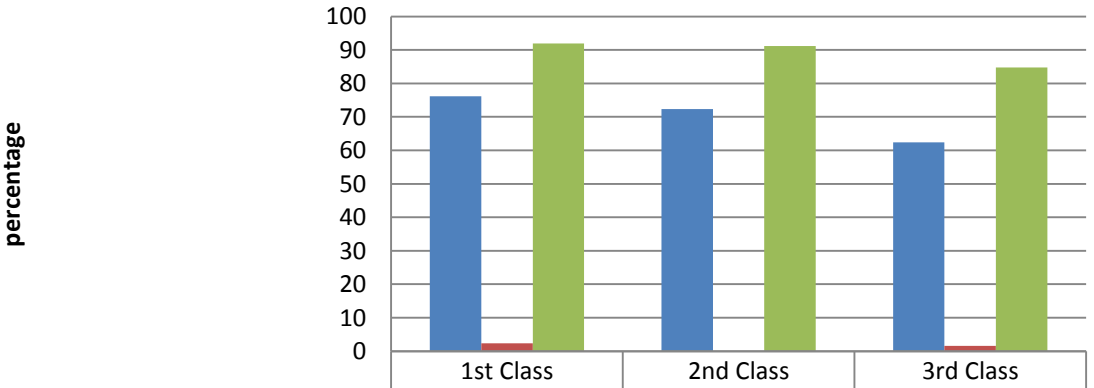
In the survey, households in the ASEM were asked whether the new appliances they bought had the energy efficiency labels on them. For those who use air conditioners, -- in First class

households—about 75% of them bought the ACs with the EC's efficiency labels on them while 25% of them bought new ACs without the efficiency labels. For refrigerators users, about 49% of First class households bought new refrigerators with the EC's efficiency labels displayed on them. About 48% and 50% of Second and Third Class refrigerators users bought new refrigerators with the efficiency labels displayed on them while 48% each of second and third class electrified households who use refrigerators also bought new refrigerators without the EC's efficiency labels displayed on them.

5.4 Renewable Energy Technology (RET) adoption in ASEM

Information gathered from the 2014 Energy Survey reveal that public knowledge on RETs is quite encouraging in ASEM. About 76% and 46% of first class electrified and non-electrified households respectively have knowledge on renewable energy. About 72% and 53% of second class electrified and non-electrified households have knowledge on renewable energy while 62% and 37% of third class electrified and non-electrified households respectively, are also aware of renewable energy (Figures 63 and 64). The most common RETs known to these household members are solar PVs and wind.

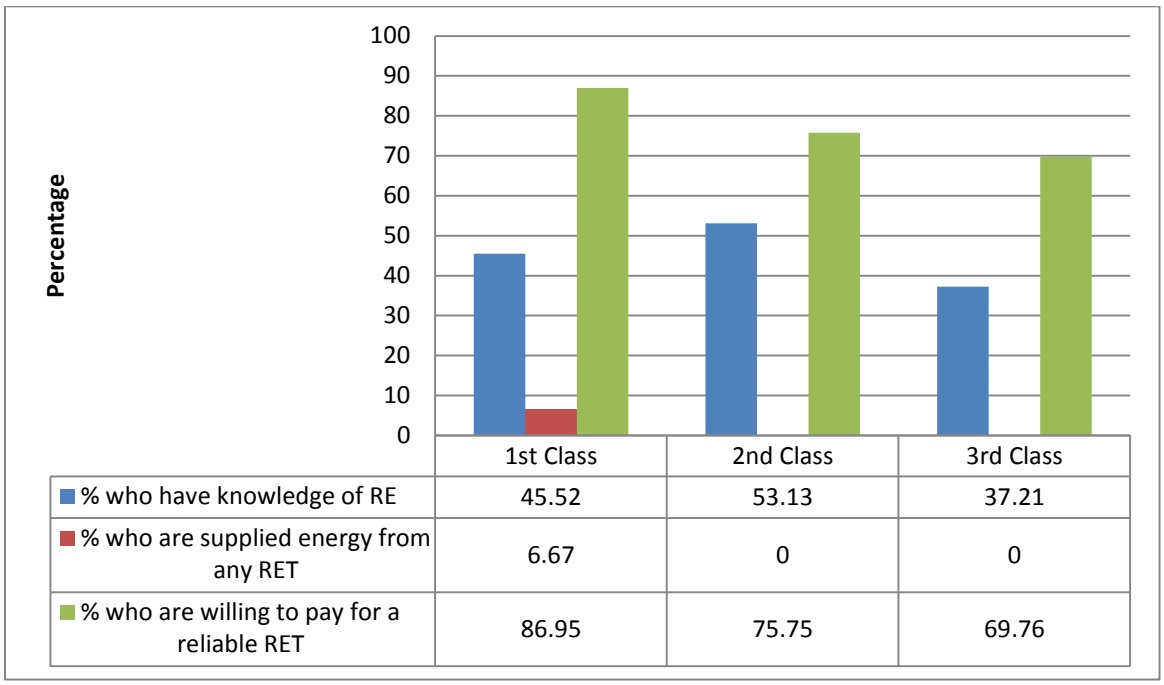
Figure 63: Percentage of electrified households who have knowledge of RE, supplied energy from RETs and are willing to pay for RET



	1st Class	2nd Class	3rd Class
% who have knowledge of RE	76.11	72.35	62.38
% who are supplied energy from any RET	2.35	0	1.56
% who are willing to pay for a reliable RET	91.89	91.12	84.71

Source: 2014 Energy Survey

Figure 64: Percentage of non-electrified households who have knowledge of RE, supplied energy from RETs and willingness to pay for RET



	1st Class	2nd Class	3rd Class
% who have knowledge of RE	45.52	53.13	37.21
% who are supplied energy from any RET	6.67	0	0
% who are willing to pay for a reliable RET	86.95	75.75	69.76

Source: 2014 Energy Survey

Despite the awareness level, more than 90% 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 70% 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 ASEMA 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 the municipal officials.

6.1 Mandates of ASEMAin influencing energy supply, demand and efficiency

ASEMA 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 unelectrified, illegal connection activities and congestions on transformers due to population increases. 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 strides in terms of energy production. There are some street lights in the municipality that are powered through the solar photovoltaic (PV) systems.

ASEMA 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 planson 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 townlayouts (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.

ASEMA 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

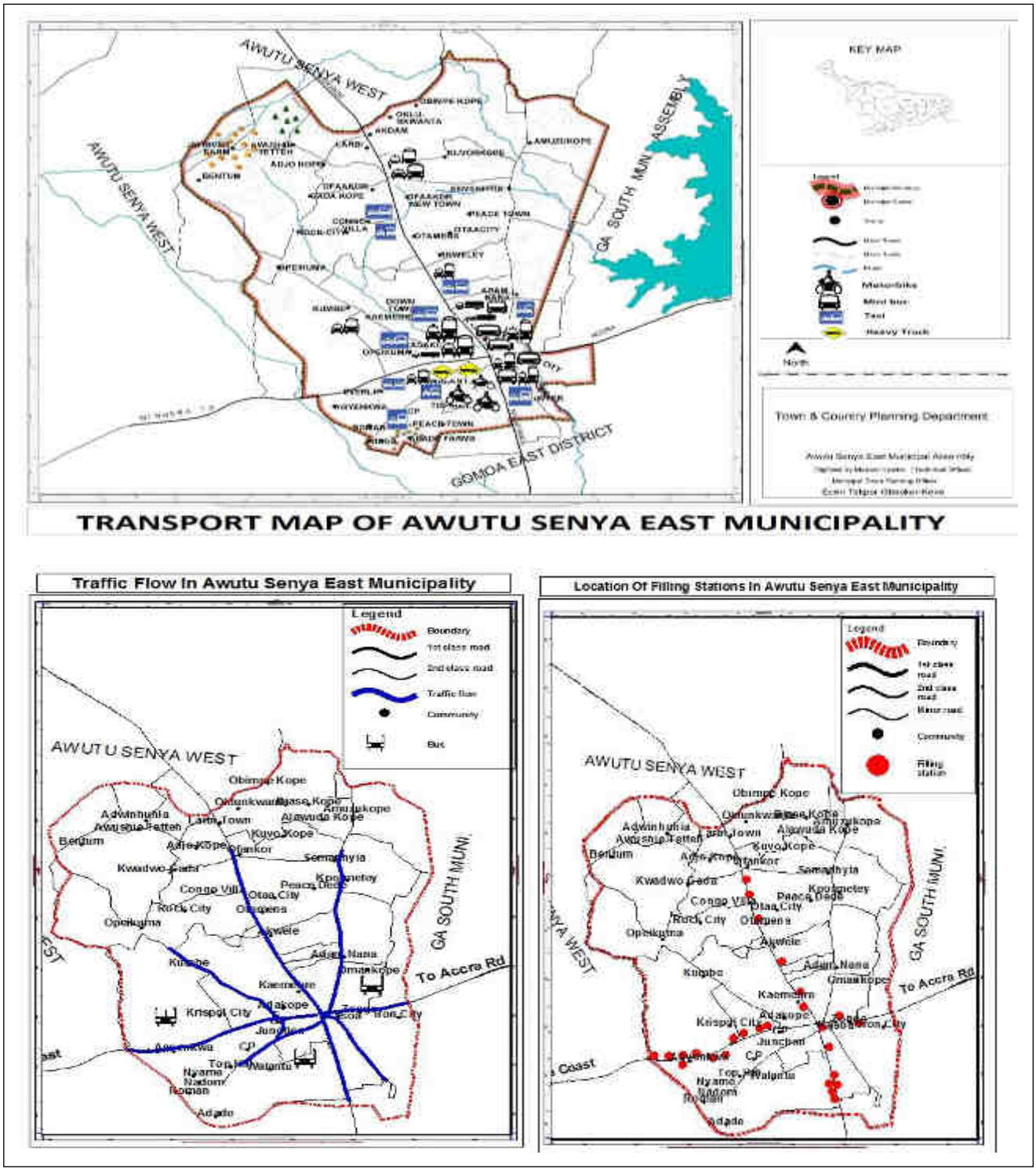
in certain areas of the municipality. Occasionally, ASEMA embarks on slum management programmesin order to limit inconveniencies in such areas. In terms of transport management, there are 56 urban passenger transport operator unions in the municipality that are regulated by the Assembly. The Assembly, 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 ASEMA over new developments in ASEM

Electricity extension to new communities and also to new residential buildings and other structures in already connected communities is an ongoing activity. The Assembly has no direct control over such connections, but indirectly provides information regarding such communities. The ASEMA has full control over spatial layouts of the municipality and building structures. In 2013, about 277 permits were issued for permanent structures in the municipality. This includes 245 residential structures, 30 commercial structures (such as office structures, stores and warehouses) and 2 churches. No permits were given for temporal structures such as container and kiosk placements. 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 Assembly has no control over construction and maintenance of roads in the municipality (which are mandates of the Urban Roads Department). Though not playing a major implementation role, ASEMA is keenly facilitating an on-going World Bank and Brazilian-funded US$160 millionKasoa Interchange project with a 20km alternative town roads, bridges and flyovers which are supposed to distribute traffic in the municipality.The Assembly also 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 eight (8) liquid fuel service stations and two (2) LPG 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 withthe general layouts of the area. Recently, ASEMA undertook a GPS survey in order to map out the positioning of various activities including transport, educational and health facilities' accessibilities, traffic flow in the municipality. The survey results guided the production of a traffic flow and transport maps for ASEM (Figure 65). As evident from the maps, traffic flows heavily in and out of the major communities and the central market area (Kasoa Market) of the municipality. This transport concentration around major communities and routes has influenced the establishment of fuel service stations along those routes in the municipality as shown in Figure 65.

Figure 65: Maps of Traffic flow, Location of filling stations and transport in ASEM



Source: ASEMA, 2014

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 ASEM. 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 ASEM.

Major findings: Most electrified households in ASEM live in separate and compound houses and they predominantly use louvre blade window types while non-electrified households, who live mostly in separate houses, have wooden windows as the predominant window type. About 70% of electrified households who use wooden and louvre blade window types often depend on fan for ventilation while the remaining 30% depend on the natural ventilation system in the municipality. Similarly, 60% of electrified households who use louvre blade window types depend on electric fans for ventilation while the remaining 40% who use louvre blade windows depend on the natural ventilation systems. For electrified households with sliding glass windows, majority depend on the electric fans and close to 30% of first class households rely on air conditioners while few depend on the natural 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 significantproportion of households in all three settlement classes use modern forms of energy. Electricity and LPG constitute about 47% of the total energy consumption of the residential sector of ASEM. However, the residential sector of ASEM still depends heavily on biomass energy specifically, for cooking activities. Charcoal and firewood constitute the largest share (49%) in the residential sector's energy consumption. 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 municipalityin 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 ASEMA, a lot can be done in terms of sustainable use of biomass energy such as promoting the use of energy efficient cookstoves.

Major findings: The commercial, industrial and agricultural sectors inASEM 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 consumption of petroleum fuels in these sectors has increased tremendously over the years due to the current shortfall in electricity supply to the municipality. Diesel constitutes about 38% of the total energy consumed by the commercial sector and 61% 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 electricity supply.

Implications: The production of clean energy using RETs by commercial and industrial activities in the municipality is non-existent 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 (*trotro*), taxis and the public transport system in the municipality. The mini-buses (trotros) transport about 7380000 people per week in the municipality while taxis and the public transport (MMT buses) transport about 336000 and 43200 people per week respectively, in the municipality.

Implications: Effective regulation of the transport systems in the municipality including facilitating the Bus Rapid Transit project, 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: Knowledge on the on-going national energy efficient programmesin ASEMA is very high. More than 85% and 70% 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 70% of electrified and 80% 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 underminepatronage of the programmes.

Major findings: Lighting is the second most energy consuming activity in the Awutu Senya East Municipal Assembly after transportation (which consumes virtually all the diesel fuel procured by the Assembly).

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 ASEMA. Individual behavioral actions also have consequences on the total energy consumed by the Assembly. 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.

Also suggest adding 'findings' and 'implications' on the following:

- Spatial planning – very linked to efficient transport system. Need to direct spatial form of ASEM to support efficienttransport system, densifying along corridors, mixed zoning to attract business so that moves from being a 'dormitory' for Accra to having its own employment base.
- Energy efficiency in buildings (mentioned above already, but worth emphasizing I think)

- RETs- also mentioned above, and worth separating out in specific point – willingness to pay for such RETs exists provided helps with reliability
- Possibly additional point linked to expenditure on energy - depending on findings as mentioned earlier
- Informal and formal commercial growth (retail mostly I think?) is growing very fast. Energy provision to support this economic activity should be considered?
- Maybe a finding on use of charcoal for cooking vs electricity – is this a function of the cost of electricity or on a preference for charcoal? In other words is there a welfare improvement for the poor implication that emerges from this?
- RETs – maybe mention that the waste generated may provide an opportunity for landfill methane harvesting, which could be explore in future.
- Data – paucity of data that exists on urban energy use that exists in the country. Very useful for strategic purposes for urban areas.

(Cross-check: the above implications should cover all the major areas of sustainable energy strategy development that have arisen from the SoE data collection – including (1) Access, (2) Efficiency (transport and other energy) and (3) Renewables – which is how SE4All categorises sustainable energy. I think it does.)

References

Bawakyillenuo, S. (2007). Effective government policy and institutional frameworks: Pivots for the dissemination and sustainability of solar PV in rural areas in the developing world: The case of Ghana. In *Proceedings of the International Solar Energy Society (ISES) Solar World Congress 2007 on Solar Energy and Human Settlement.* Vol. 5, pages 2878 2882. Beijing, China, September 18-21, 2007. Tsinghua University Press.ï»¿

Bawakyillenuo, S. and Agbelie, I.S.K. (2013).Overview of Energy and other important features of Ghana.SAMSET working paper.

Codjoe, S.N.A. and Owusu, G. (2011). Climate change/variability and food systems: Evidence from Afram Plains, Ghana. Regional Environmental Change, Vol. 11(4):753-765.

Energy Commission, Ghana, 2006; Strategic National Energy Plan 2006-2020. Annex I of IV Energy Demand Sectors of the Economy

Energy Commission , Ghana 2010. 2010 Energy (Supply and Demand) Outlook for Ghana. April 2010

Energy Commission , Ghana (2013). 2013 Energy (Supply and Demand) Outlook for Ghana. April 2013

Energy Commission of Ghana (2014). National Energy Statistics 2000-2013

Energy commission, Ghana (2014).2014 Energy (Supply and Demand) Outlook for Ghana. April, 2014.

Environmental Protection Agency (EPA) 2011. National Greenhouse Gas Inventory Report for 1990-2006. Volume 1: Synthesis Report

Environmental Protection Agency (EPA) 2015.2014 National Carbon accounting. Ghana's National Greenhouse Gas Inventory Report.

Environmental Protection Agency (EPA) and Ministry of Environment, Science, Technology and Innovation (MESTI) (2011). Ghana's Second National Communication to the UNFCCC. The Republic of Ghana

Ghana Statistical Service (GSS) (2002). 2000 Population and Housing Census: Summary Report of Final Results.

Ghana Statistical Service (GSS) (2013). 2010 Population and Housing Census: National Analytical Report.

Ghana Statistical Service (2013).2010 Population and Housing Census.Regional Analytical Report.Central Region.

Ghana Statistical Service(2014), 2010 Population and Housing Census. District Analytical Report. Awutu Senya East Municipal.

Institute of Statistical, Social and Economic Research (ISSER) 2012; Ghana Social Development Outlook 2012. Accra: ISSER

Ministry of Energy, 2010; National Energy Policy. Accra: Republic of Ghana.

Ministry of Environment, Science, Technology and Innovation (MESTI) (2012).Ghana National Climate Change Policy.The Republic of Ghana.

Osei-Boateng, C. and Ampratwum, E. (2011).The Informal Sector in Ghana.Fredrich Ebert Stiftung, Ghana

Zoomlion Ghana Limited (2013). Landfills Department.2013 Annual report. Ghana

APPENDIX 1

COMMUNITY CLASSIFICATION-AWUTU SENYA EAST MUNICIPALITY

NO.	ZONAL COUNCIL	CLASS (COMMUNITIES)		
		FIRST	**SECOND**	**THIRD**
1.	**KASOA ZONAL COUNCIL**	Iron City New Town	Banat Prince Derrick MaameOsofo	KasoaZongo Dokustekope
2.	**KPORMETEY ZONAL**	Adam Nana Joe Mends	Semenshia Lamptey Mills	Amuzukope Infrgate Area

	COUNCIL		Bigman Town Kingdom Town Freetown	Mount Zion Area Christian Hill Ghana Flag Songai Zone 6 Asempa Ghana Flag
3.	**OFAAKOR ZONAL COUNCIL**	Otamens	Andam/Larbi Town Ofaakor Newtown	Rock City GadaKope Alic AwushieTetteh/Kaneshie Bentum Queen City Okwampi KoverKope
4.	**OPEIKUMA ZONAL COUNCIL**	American Town	Krispol City Asamoah Town Adom City Doctor Jesus Estate Down	Adakope Ayigbe Town Diamond City Opeikuma Anigyekrom
5.	**AKWELEY ZONAL COUNCIL**	Kaemebre	Down Town Ash Town Akweley Township	
6.	**WALANTU ZONAL COUNCIL**	CP Windy Hills Biakoye Blue Rose Estate Chief Imam Mosque Top Hill CP Roman Down CP Winga Town Little Rock Area	Walantu CP Abease CP Last Stop CP Poultry Farm CP Evelip Farm CP Holly Valley Agenkwa CP Tipa Junction Walantu Junction	