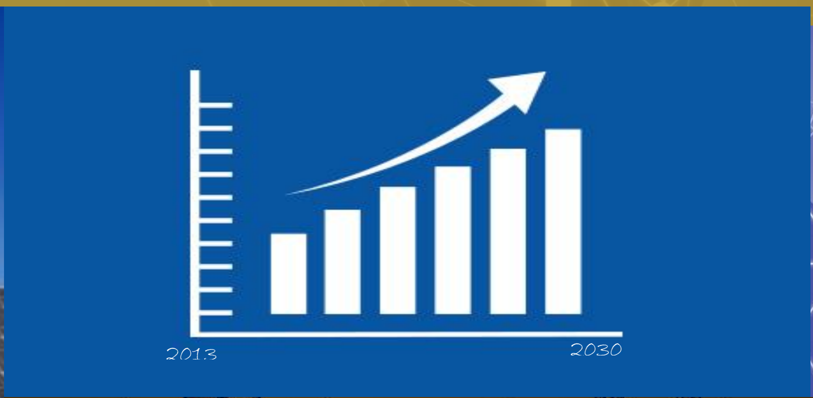
# ENERGY FUTURES: THE 2030 OUTLOOK FOR AWUTU SENYA EAST MUNICIPALITY

Dr. Simon Bawakyillenuo | Innocent S.K Agbelie

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SAMSET
Supporting Sub-Saharan Africa's Municipalities with Sustainable Energy Transitions

# Energy Futures: The 2030 OUTLOOK
# FOR Awutu Senya East Municipality

**Dr. Simon Bawakyillenuo & Innocent S.K Agbelie**

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This energy futures report is produced from the Awutu Senya East Municipality LEAP Modelling Technical Report by SAMSET-ERC, which was prepared based on the Awutu Senya East Municipality 2014 State of Energy (SoE) data gathered by ISSER. Hard copies of this report, the SoE and Sustainable Energy Strategy reports are available at ISSER and Awutu Senya East Municipal Assembly while soft copies are available online at: www.samsetproject.net

## SAMSET Project

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 fundamental objective is to improve the "knowledge transfer framework" so as to enhance research and capacity building efforts geared towards this challenging area.

## SAMSET Ghana

This document is produced by the Ghana SAMSET team, led by Dr. Simon Bawakyillenuo and Mr. Innocent Komla Agbelie of the Institute of Statistical, Social and Economic Research (ISSER), University of Ghana. Dr. Bawakyillenuo is the country project coordinator (Lead) of the SAMSET project and generally researches on energy and the environment, energy policy, renewable energy, environmental policy, climate change and green economy. Mr. Agbelie is an economist and project assistant on the SAMSET project. His research interest lies in sustainable development, energy and green economy.

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# CONTENTS

## 1.0 Introduction

Different energy future scenarios simulated on the bases of alternative prevailing and planned energy policies and strategies are pre-requisite for a sustainable energy planning and development in the energy sector. An in-depth understanding of such present and future scenarios of different energy perspectives at the municipalities, inform and shape their energy strategies along the sustainable energy transition's pathway. As such, applying appropriate modelling techniques to surveyed energy data for forecasting and simulation draws out the business as usual (BAU) and intervention scenarios that are relevant for local policy makers.

Awutu Senya East Municipality (ASEM) is one of six[1] beneficiary Sub-Sahara African municipalities on the SAMSET project and located in the Central Region of Ghana. ASEM was selected based on its rapid urbanisation rate, with recorded 3% population growth rate as at 2010 (GSS, 2014a) and the numerous energy related challenges it is confronted with. As part of the Ghana SAMSET work output, an energy survey was undertaken in ASEM across all energy demand and supply sectors in 2013 to understand the state of energy in the municipality. The State of Energy (SoE) report[2] for ASEM has since been produced from the gathered data. However, the survey data also serves as input data for modelling different future energy consumption behaviours of various sectors in the municipality for a definite period of time.

This ASEM's energy futures report, thus highlights the different energy consumption scenarios in the future for ASEM, including BAU and others backed by energy efficiency policy intervention programmes. Local authorities appreciate better the evidence-based future scenarios that emanate from scientific simulation methodologies to help them take informed policy decisions towards sustainable energy transitions. Discussed in the subsequent sections are the type of data used by the modelling tool for the simulation across the various energy sectors, description of the modelling tool and procedure, discussion of sectoral energy futures in relation to the BAU scenarios and finally, policy recommendations from the implications of the various scenarios are raised.

## 2.0 Data Needs, Types and Energy Sectors

With a population growth of 3% per annum, ASEM's population was estimated to be about 118,474 in 2013 from the 2010 figure of 108,422. The total number of households in ASEM in 2013 was estimated at 43,795 households (Bawakyillenuo & Agbelie, 2014) with 83% of them being electrified. Thus, ASEM's GDP (also known as gross value added) using the population for 2013 has been estimated to be GHC321.1 million (current).

The dataset for the model was collected in 2013 by the SAMSET-Ghana through a survey and stakeholder workshops within ASEM. The data collection process included the following:

- Surveys of 593 households, 435 commercial businesses and 33 industrial businesses in the municipal area.

[1] SAMSET partner municipalities in Awutu Senya East and Ga East in Ghana; Kasese and Jinja in Uganda; and Cape Town and Polokwane in South Africa.
[2] Report available online at www.samsetproject.net

- Focus groups discussions with stakeholders
- Interviews with municipal staff
- Municipal records

The baseline year for the model is 2013 as the survey data were collected in that year. In certain instances this dataset was augmented with data from literature and online sources. The scope of energy systems models, even of a bounded municipal area, covers a very broad range of activities, hence, it was also necessary to make assumptions regarding certain issues.

The general form of a LEAP model involves the division of the energy demand side into typical economic sectors:

- Transport
- Municipal Services
- Households/Residential
- Industry
- Commercial
- Agriculture

On the other hand, the supply sectors are typically put under the node 'Transformation', albeit not exclusively, as shown below:

- Transmission and Distribution
- Electricity Production
- Oil Refining
- Charcoal Production

## 3.0 Methodology: Modelling Tool

The model is developed based on the Stockholm Environment Agency's (SEI) Long range Energy Alternatives Planning System (LEAP) platform. LEAP is essentially an accounting type simulation model, although other uses and features have emerged as the product has developed. The rationale for the selection of LEAP as a tool for the SAMSET project has been documented in project outputs (Tait, McCall, & Stone, 2014) while a lot has been written about the tool by SEI[3] . For the SAMSET project, LEAP is used to create a bottom-up data driven picture of Awutu Senya's energy system on both the supply and demand side, projecting a reference case into the future. Scenarios are then developed to project how the municipality's driven interventions may alter the pathway of this reference case, reduce energy consumption and mitigate $CO_2$ emissions.

The general mathematical formula used in calculating the energy consumption of the services in a sector is via a simple accounting formula as outlined below. For the sake of simplicity, we will assume that a technology may be either a different means of doing the same thing, for example, travelling by

[3] See http://www.energycommunity.org (Accessed; 21/10/2016)

bus or by car but also using a different energy carrier/fuel such as a petrol fuelled car or an electric car.

For a given year in the time horizon of the model we have the following:

Energy Consumption of a Sector = (equal) The Sum of all the Energy Consumptions of Services Required by the Sector. This is expressed as follows.

$E_S = \sum (\theta_i X \eta_i X O_S)$

Where:

$E_S$ = The Energy Consumed by a Service in a given year
$\theta_i$ = Share of Service supplied by Technology i
$\eta_i$ = The energy intensity (equivalent to efficiency) of Technology I in units of energy required per units output for example MJ/[passenger km] or GJ/[ton steel]
$O_S$ = The output of a service required in a given year in physical units for example, passenger km of passenger transport, tons of steel or GJ of heating

The period considered for the modelling is 2013 to 2030. For a bottom-up model to be reliable, the assumed activity levels and energy intensities used in services need to be calibrated so that the total energy consumed in the model in the base year, agrees with the total energy known to have been supplied to the system in that year (Mccall and Tait, 2016). This total energy data typically comes from recorded total electricity sales and petroleum fuel sales obtained from the major utilities. Acquiring this data and validating it is therefore an important first step in the modelling process.

In the model developed for ASEM, all fuels sold within the municipality, with the exception of transport fuels, are assumed to be consumed within the boundary and thus, count toward its emissions levels. The representation of transport in a spatially bounded scope such as a municipality is inherently problematic. Given the commuting behaviour to central Accra and traffic passing through, it is reasonable to assume that a significant portion of petrol and diesel that is sold within ASEM transits the boundary while fuel from elsewhere enters the municipality daily (Mccall and Tait, 2016). In this framework an attempt is made to represent intra-boundary and transboundary trips either being generated in or attracted to ASEM and corridor trips, of which ASEM is neither the origin nor destination but which refuel there. LEAP's tree structure allows the user to include or discard these sub-nodes in reporting results depending on the scope of interest. The LEAP model was created to represent all major sectors of ASEM as a bottom up simulation model, and this was calibrated with known fuel sales (mainly liquid fuels and electricity) within the municipal boundary. The main drivers for this model are population and economic growth (one local, and one regional).

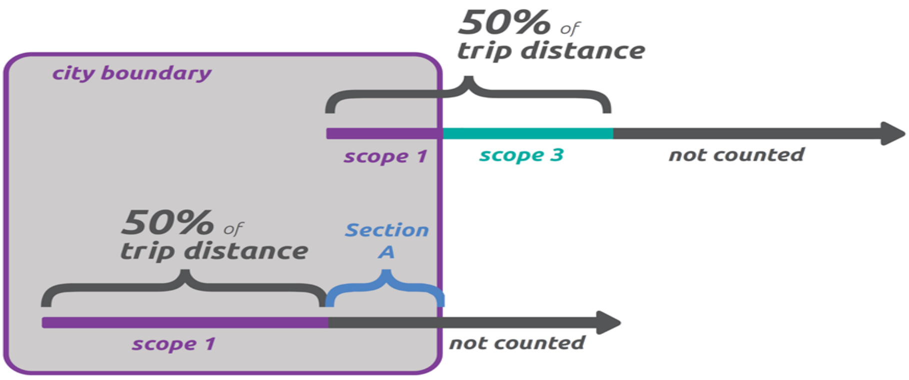
In a collaborative effort to develop practical methodologies for local scale GHG emission inventories, The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC Protocol) has developed a standardised approach to deal with these issues (World Resources Institute, 2014). This protocol recommends that data and models be organised in different scopes, which tackle the spatial problem in different ways as follows:

Scope 1: Only trips that originate and end within the boundary are included. Upstream emissions embedded in energy carriers like petrol diesel and electricity are excluded.

Scope 2; Upstream emissions from electricity supply are added.

Scope 3: Transboundary trips originating and ending within the bounded area are included in scope 3. A few methods may be considered but ideally the method of induced activity is preferred whereby 50% of the total trip length that occurs outside the boundary is accounted for as shown in Figure 1. Trips that pass through the bounded area are excluded completely in this methodology. It is, however, recognised that in general sophisticated traffic models for a city are required to track transboundary trips to this level of detail.

**Figure 1: Induced activity method for accounting for transboundary trips in GHG inventories**




Source: Mccall and Tait (2016)

## 4.0 Sectoral Energy Futures

Discussed in this section are the various future scenarios for ASEM in connection with the various sectors, making reference to the business as usual scenario to be discussed first of all. The current state of energy across ASEM's energy sectors have been discussed extensively in the ASEM SoE and ASEM modelling technical reports[4]. With reference to the baseline year's (2013) data, energy consumption trends are estimated for almost two decades (through to 2030) under various relevant and necessary assumptions and policy initiatives or programmes.

### *4.1 Business as usual (BAU)*

With accounting multi-sectorial models such as this one, population and economy are generally assumed to be the main elements that drive the overall activity, translating into the energy consumption of the municipality. Recent economic growth rates for Ghana are shown in Table 1.

[4] Available at www.samsetproject.net

**Table 1: Recent economic growth rates for Ghana**

| **Growth Rates - %** | **2009** | **2010** | **2011** | **2012** | **2013** |
|---|---|---|---|---|---|
| GDP at current market prices | 21.3 | 25.8 | 29.9 | 25.3 | 24.7 |
| GDP at constant 2006 prices (%) | 4 | 8 | 15 | 8.8 | 7.1 |
| **Non-Oil GDP at constant 2006 prices** | **4** | **7.7** | **9.6** | **8.1** | **6.5** |

Source: Ghana Statistical services (2014b)

Based on the recent socio-economic performance of the country, the following assumptions were made for the purposes of the modelling regarding economic growth, population growth and fuel prices:

- Up to 2020, the economy will grow at national rates of 7.2% on average – this is the average of non-oil GDP over the last 5 years.
- From 2020 to 2030, the economy will 'slow' somewhat to a 6.5% year on year growth rate on average.
- The population growth rate assumed till 2030 is 3% per annum
- Assuming an exchange rate of GHC 2.31to a 1 USD in 2013, the following fuel prices are assumed in the ASEM model:
  - **Table 2: Per unit fuel prices in 2013 in ASEM**

| **Fuel** | **Per unit** | **2013** |
|---|---|---|
| Petrol | litre | 1.11 |
| Diesel | litre | 1.06 |
| LPG | kg | 1.18 |
| Charcoal | kg | 0.23 |

Source: Mccall and Tait (2016)

- Electricity cost adopted from the public Utilities Regulatory Commission (PURC) were mapped to households and non-residential customers in ASEM as
  - **Table 3: Electricity prices for ASEM in 2013 and 2014**

| | **Grouping** | **GH Pesewas** | **USD Existing** | **USD new approved** |
|---|---|---|---|---|
| **ASEM users:** | **kWh** | **2013** | **2013** | **2014** |
| HH3 | 0-150 | 13.54 | 0.06 | 0.11 |
| HH2 | 151-300 | 20.19 | 0.09 | 0.16 |
| HH1 | Avg. 301-600 and 601+ | 24.08 | 0.10 | 0.19 |
| Industry | Avg. 301 – 600 and 600+ | 36.76 | 0.16 | 0.29 |
| Formal Comm. | 601+ | 42.43 | 0.18 | 0.33 |
| Informal Comm. | 0-300 | 25.27 | 0.11 | 0.20 |

Source: Mccall and Tait (2016)

- It is assumed the electricity price will remain constant in real terms from 2015 onwards (i.e. no change after adjusting for inflation).

Other relevant assumptions for the business as usual model with respect to the various sectors are stated below.

***Commercial Sector***

- It is assumed that the formal commercial sector growth follows that of the national growth trajectories for Ghana, with an elasticity of 0.9.
- The informal commercial sector, however, which makes up a significant part of the economy is assumed to follow population growth rates since the informal sector by nature is driven largely by the inability of the formal economy to create new jobs (Osei-Boateng and Ampratwum, 2011).

***Transport Sector***

- The demand for private transport passenger-km is driven by population and income (GDP/capita) growth while the demand for public transport passenger-km is driven by the growth in the population without access to a car. Private transportation - light vehicles and motorbikes are assumed to have the characteristics of the base year – no change in occupancy rates, and similar fuel efficiencies.
- Future public transportation is assumed to have similar characteristics to the base year, with the addition of Bus Rapid Transport (BRT).
- BRT comes into effect by 2020 – with buses departing from Kasoa to Accra.
- BRT takes up about 10% by 2020 (the start year) and 40% of bus *trotro* (mini commercial vehicles) passenger demand by 2025.
- BRT are assumed to be 10% more fuel efficient per passenger-km than the buses.
- Freight tonne-km for trucks is driven by local industry growth.
- Corridor freight demand is driven by GDP (this is a reflection of national growth).
- Corridor passenger demand is driven by GDP per capita.

***Local government***

- The energy use of municipal buildings or offices is assumed to grow at 10% of the household growth rate. It is assumed that, in principle, municipal energy use that is not transport will track general household growth.
- Transport related energy consumption (diesel consumption) is assumed to follow household population growth as well, but with an elasticity of 0.8 – on the basis that population growth will drive the amount of refuse removal that is needed

*Household Sector*

- The composition of household categories is projected to change. Specifically, it is assumed that there will be a shift to 2nd and 3rd class household categories as shown below in Table 4.
  - **Table 4: Changes in household composition by category in ASEM**

| | ***Share in 2014*** | **Project share in 2030** |
|---|---|---|
| HH1 Electrified | 19% | 15% |
| HH1 Unelectrified | 4% | 1% |
| HH2 Electrified | 29% | 32% |
| HH2 Unelectrified | 6% | 5% |
| HH3 Electrified | 35% | 42% |
| HH3 Unelectrified | 7% | 5% |
| | 100% | 100% |

Source: Mccall and Tait (2016)

*Industrial sector*

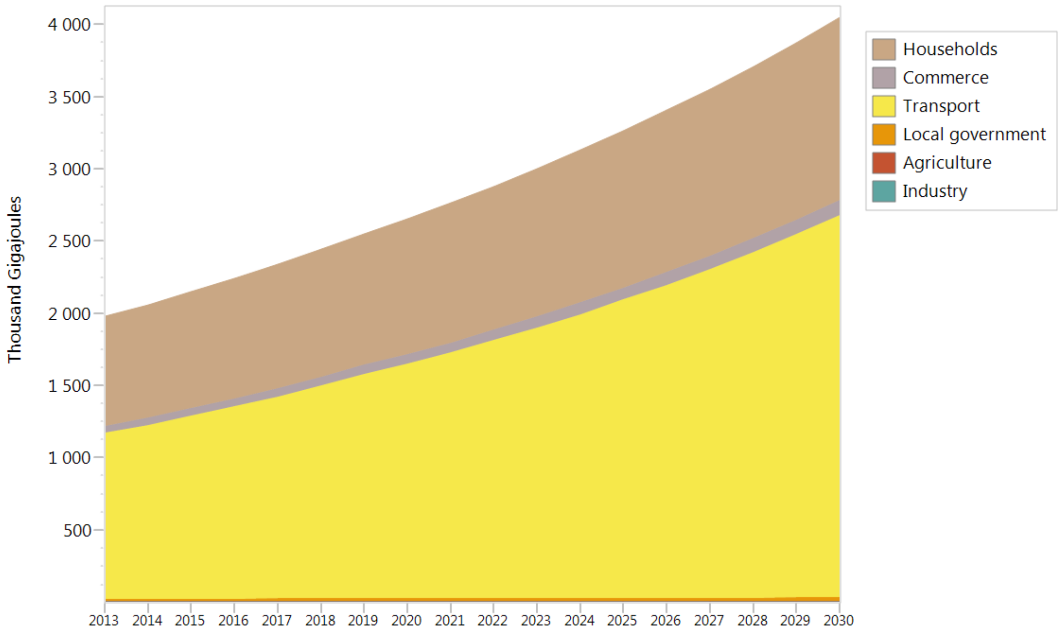
- Construction – follows local economy growth with elasticity of 0.8.
- Manufacturing – follows local economy growth with elasticity of 0.8.
- Mining and quarrying – assumed to be low at 2% pa until 2025 and 0% to 2030 assuming a limit on extraction has been reached by 2025.
- It is assumed there are no changes to the characteristics of the industry sector of ASEM over the modelling time horizon, and that the energy intensities remain as they are throughout the model horizon.

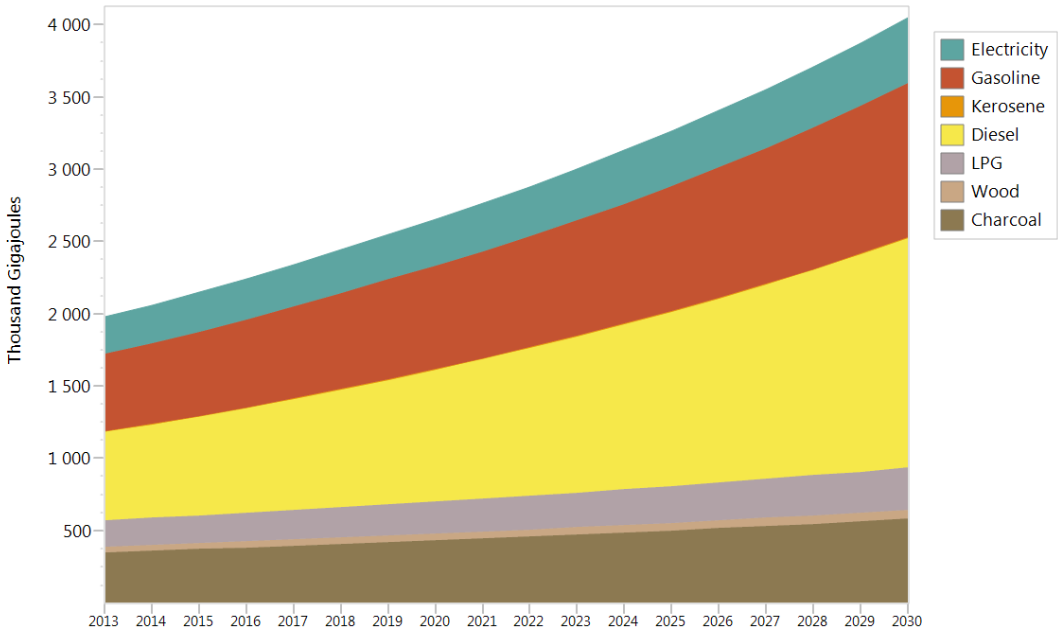
*Agricultural Sector*

- It is assumed in the BAU case that the agriculture sector output remains about 500 tonnes per year until 2020, and then steadily declines until 2030 to about 30 tonnes per year.

ASEM's estimated energy consumption by sector and fuel for the business as usual scenario under scope one methodology are depicted in Figure 2. The transport and the household sectors remain the largest energy sectors in ASEM. From about 1.15million GJ and 750,000 GJ of energy consumed in 2013, the transport and household sectors will consume a little over 2.5million GJ and 1.3million GJ respectively by 2030 with the assumption of not fully considering transboundary trips. In direct correlation, gasoline and diesel fuels are observed to be in high demand, constituting nearly one-third of the total consumable fuel by 2030 followed by charcoal, electricity and LPG fuels.

**Figure 2: ASEM energy consumption by sector (above) and by fuel (below) for the BAU scenario for scope 1 methodology**

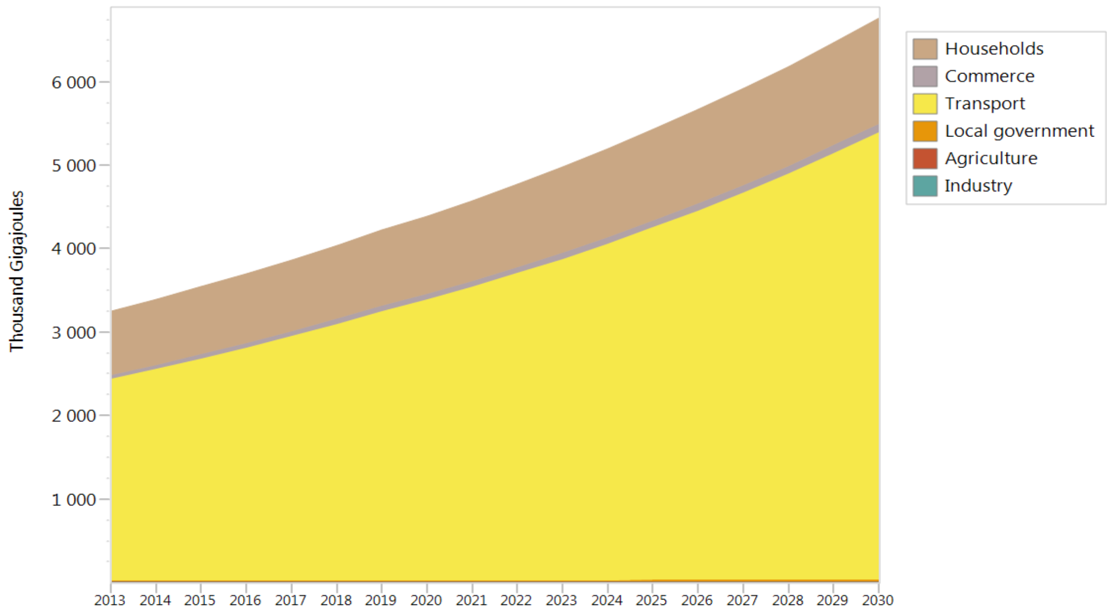


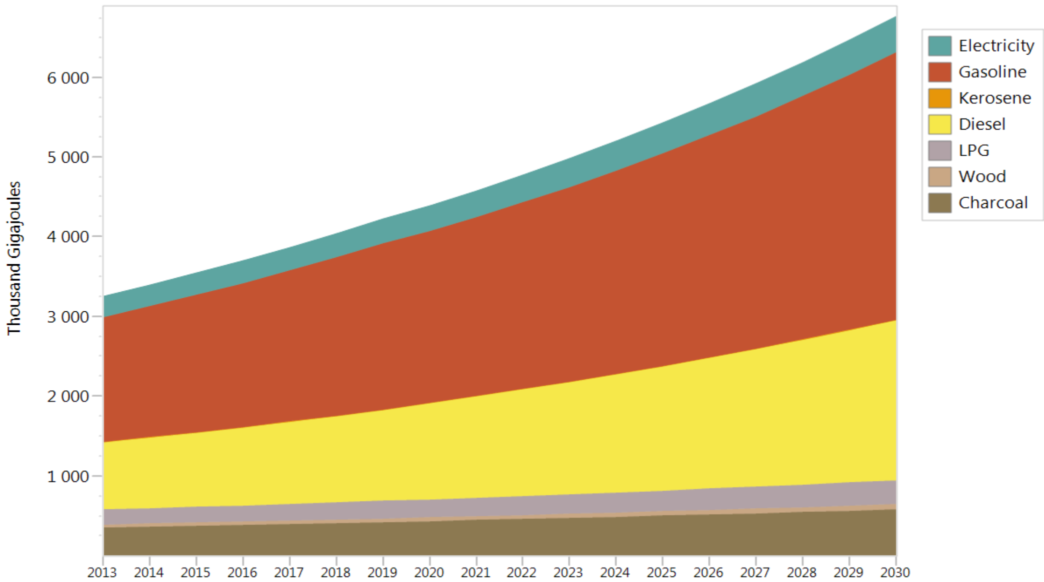




Source: Mccall and Tait (2016)

With full consideration of transboundary trips (scope 3), total energy consumption by 2030 is estimated around 6.7million GJ with transport sector alone consuming for about 5.2million GJ while household sector consumes about 1.2million GJ. Gasoline alone accounts for about half of the total demand by 2030 followed by diesel, charcoal electricity and LPG (Figure 3).

**Figure 3: ASEM energy consumption by sector (above) and by fuel (below) for the BAU scenario for scope 3 methodology**

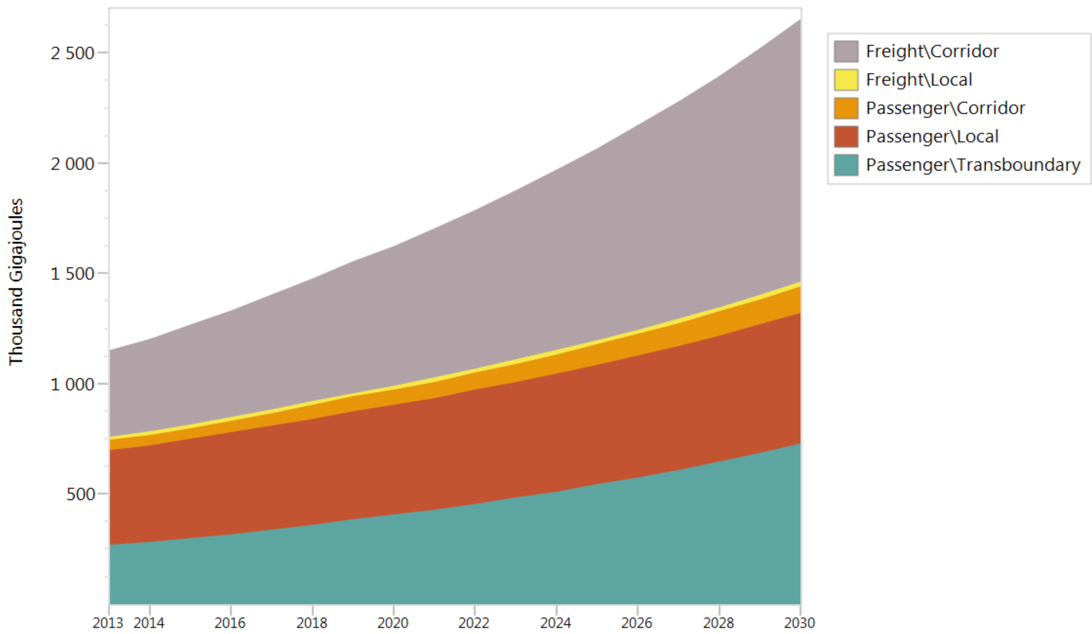


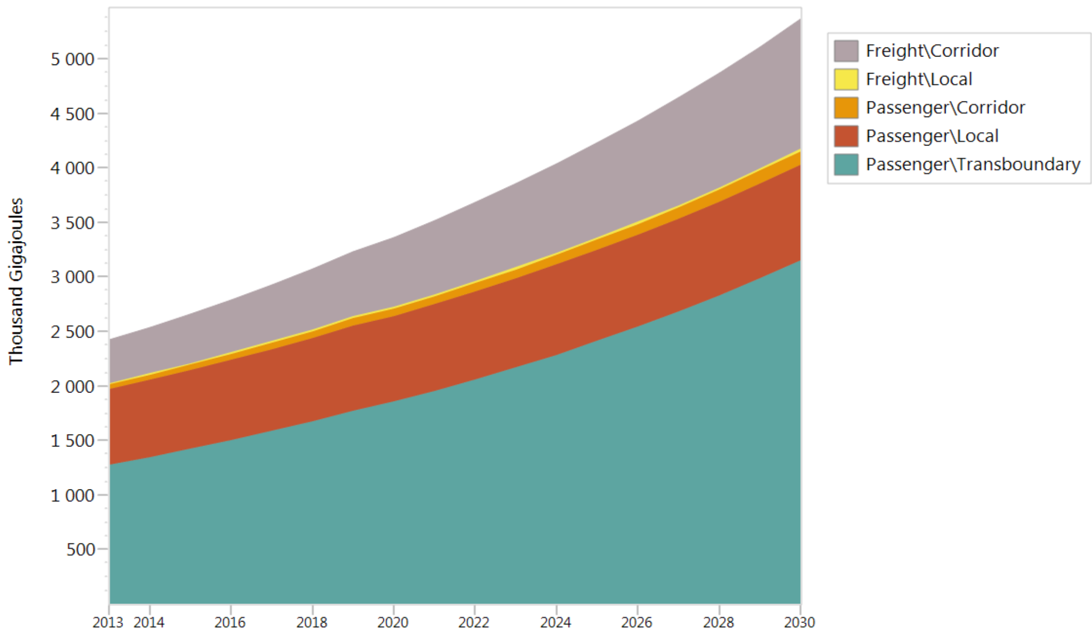




Source: Mccall and Tait (2016)

Figure 4 shows the estimated fuel consumption by the transport sector in ASEM from 2013 to 2030 under scopes 1 and 3 methodologies. Freights, carried by trucks of all sizes account for a little below half of the total transport energy demand in ASEM followed by passenger movement within ASEM and beyond under scope 1 methodology. Under scope 3 methodology, more than half of the 5.5m GJ of energy to be demanded by the transport sector in 2030 will hugely be as a result of transboundary passenger carriage (Figure 4).

**Figure 4: Transport energy demand by subsector for scope 1 (above) and scope 3 (below) methodology**




Source: Mccall and Tait (2016)

According to the BAU model results, the household sector (second largest after the transport) is estimated to consume about 1.25million GJ of energy by 2030 with charcoal fuel constituting almost half (550,000 GJ) of the total demand, followed by electricity and LPG fuels (Figure 5). The model results further reveal that third, second and first classes electrified households are the most energy consuming household categories in ASEM (Figure 6).

**Figure 5: Household energy consumption by fuel for ASEM**

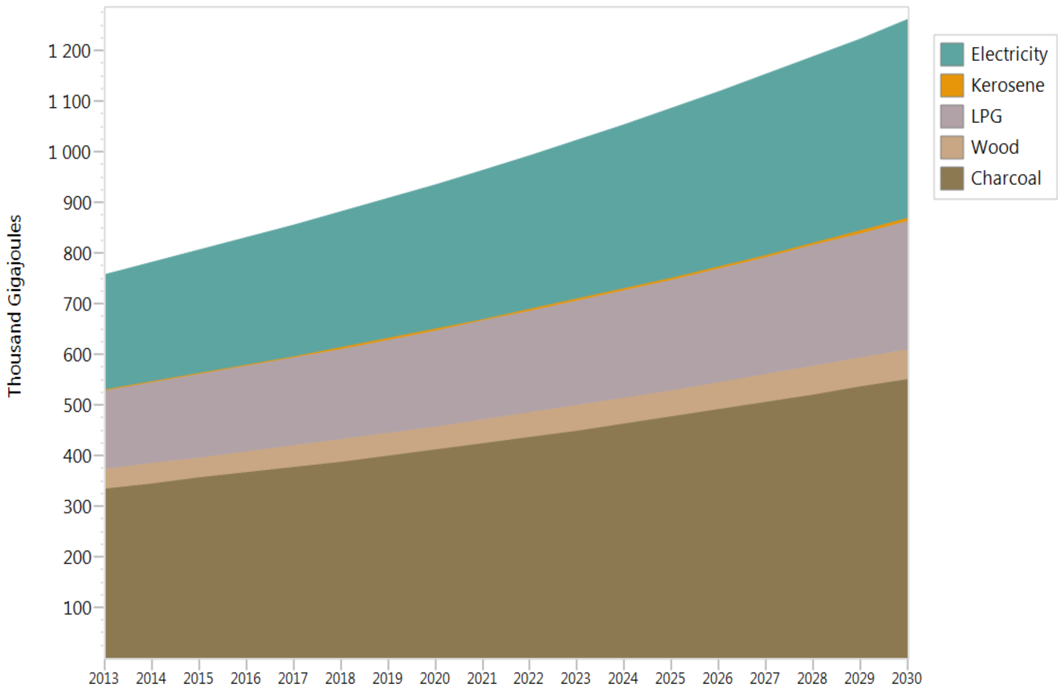
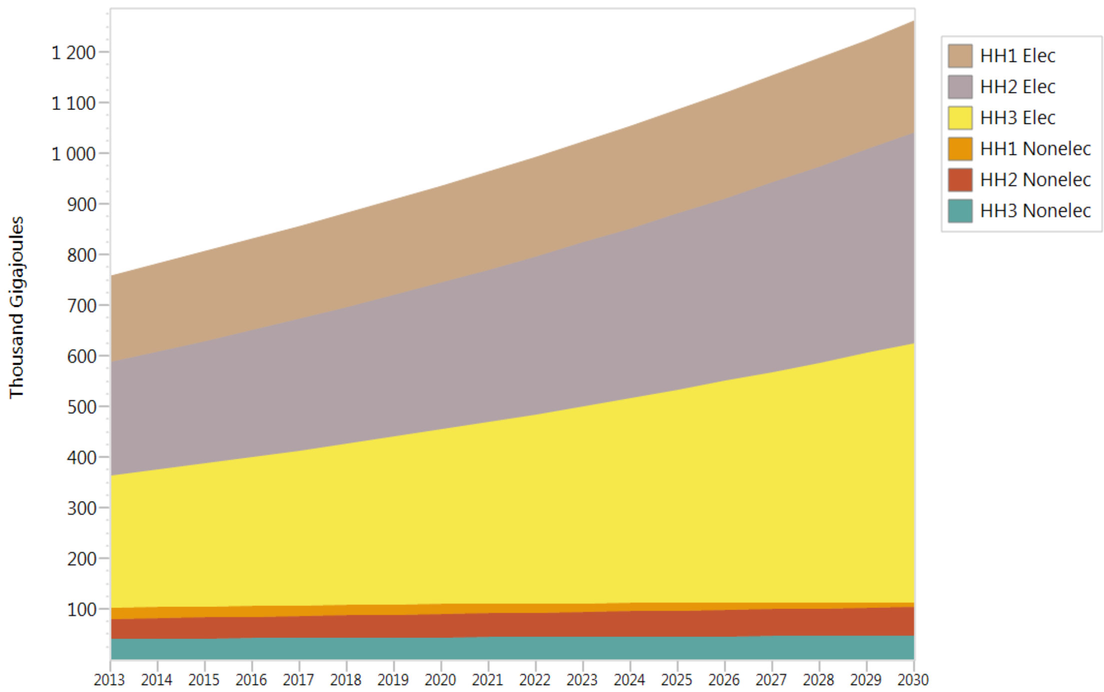



**Figure 6: Household energy consumption by fuel for ASEM**

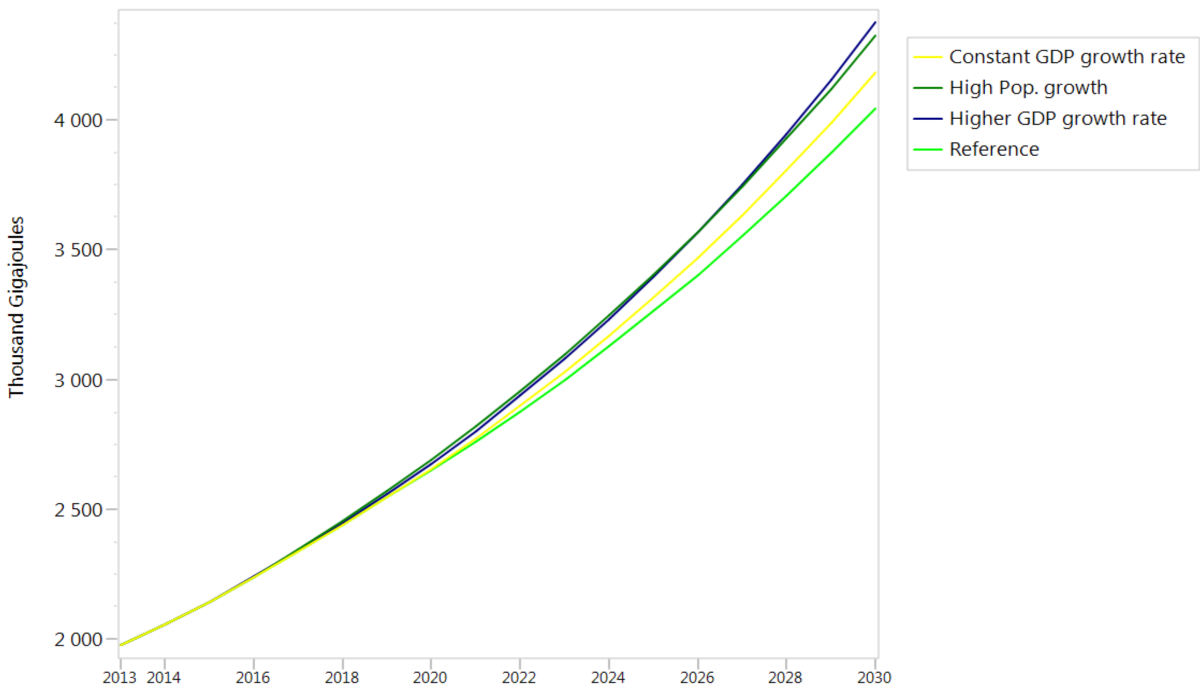



Source: Mccall and Tait (2016)

Further discussed under the BAU scenario are two sensitive assumptions; possible increase in the main key determinants, population and GDP growth, than assumed earlier. The impact of increase in population rate from 2017 value of 3% to 3.5% in 2020, then again 4% through to 2030 on ASEMs energy consumption is explored together with the assumptions that the economic growth rate continues to grow at the same level of 7.2% and the scenario where the GDP growth rate increases to 8% p.a by 2020.

A constant economic growth rate of 7.2% has nearly half the impact that increasing the population growth rate from 3% to 4% by 2020 has on energy consumption, while increasing the GDP growth rate from 7.2% in 2013 to 8% by 2020 has a similar overall impact on energy consumption compared to the increased population growth scenario (Figure 7).

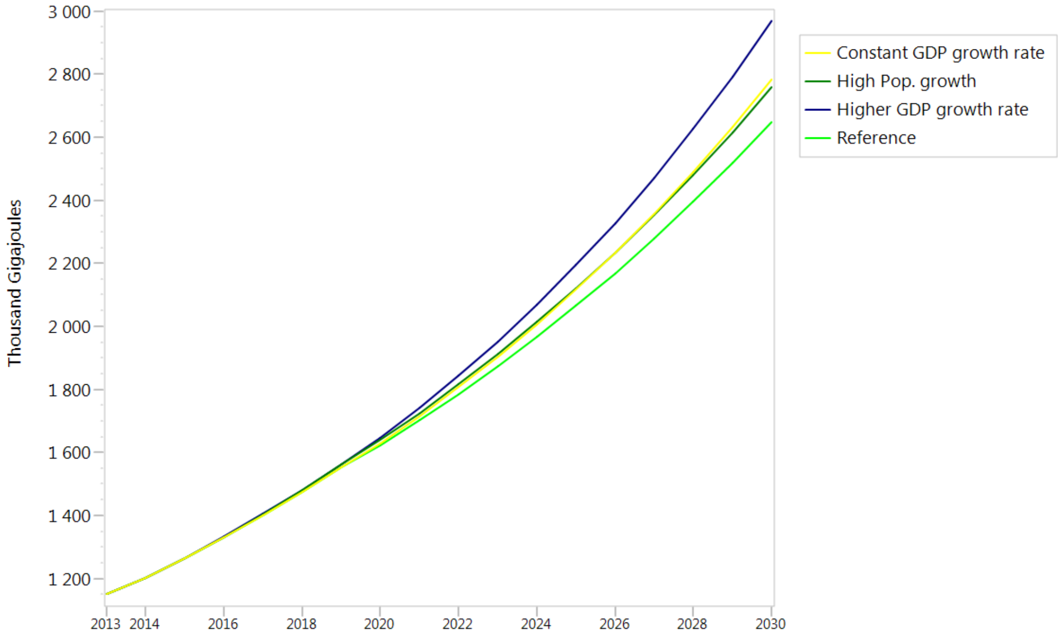
**Figure 7: ASEM energy consumption comparing the two sensitivity scenarios to the reference scenario (scope 1 methodology)**




Source: Mccall and Tait (2016)

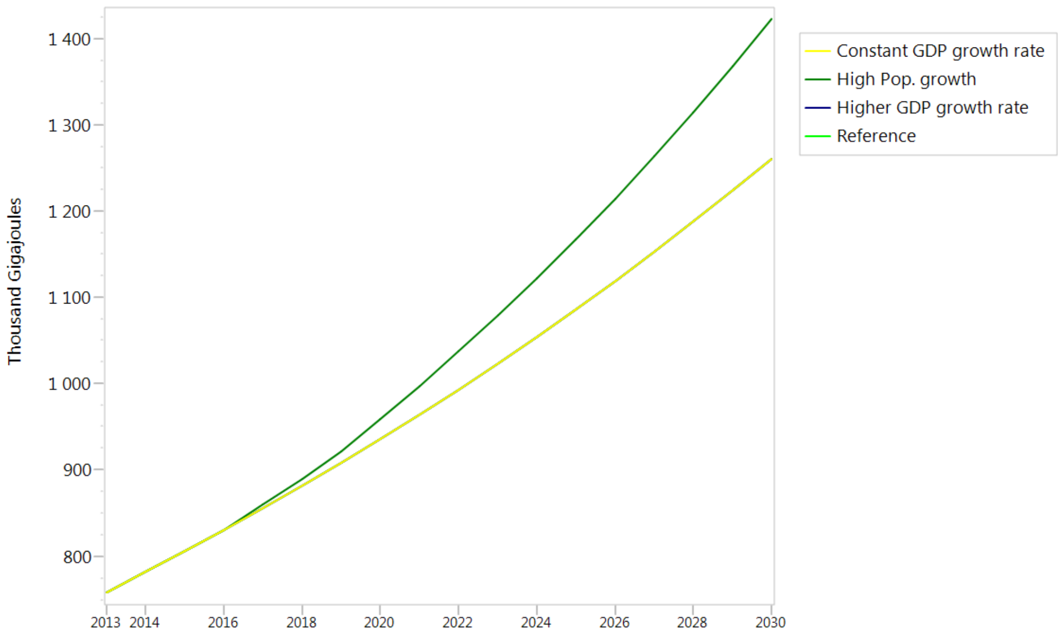
Narrowing down on the transport and household sectors, which are the largest energy sectors, it is observed that the transport sector is more sensitive to the assumed economic growth rate than to the assumed population growth rate (Figure 8). Keeping the GDP growth rate constant at 7.2% year on year instead of reducing it to 6.5% year on year from 2020 resulting in a 7.5% bigger economy in 2030, drives roughly the same change in fuel consumption as stepping the population growth rate up from 3% in 2013 to 4% in 2030, a 12.8% total increase in population relative to the reference case over the period. The lack of change in the household sector energy consumption with GDP growth is due to the current model structure whereby the households are not inherently linked to GDP (Figure 9).

**Figure 8: Transport sector fuel consumption for sensitivity scenarios (scope 1 methodology)**




Source: Mccall and Tait (2016)

**Figure 9: ASEM household energy consumption for the sensitivity scenarios**




Source: Mccall and Tait (2016)

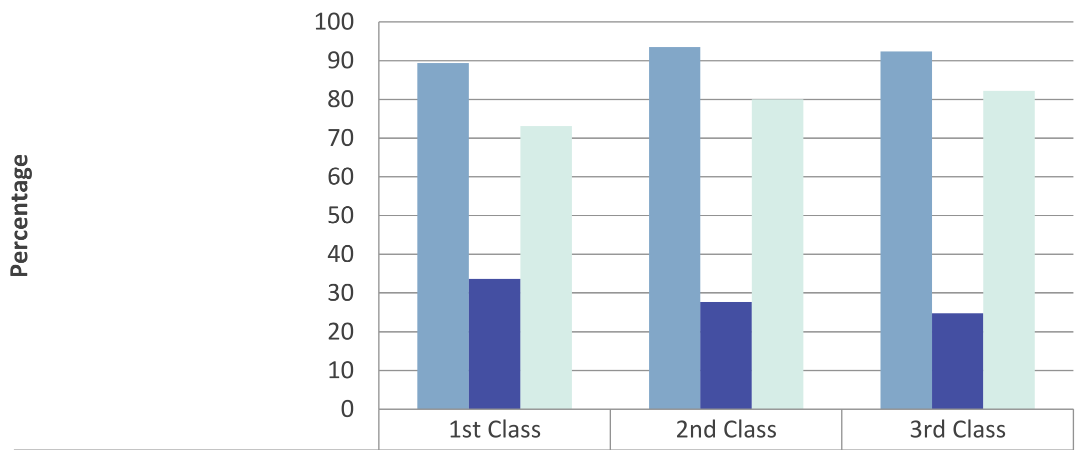
## 4.2 *Efficiency Intervention scenarios*

This sub-section looks at the future energy consumption model of ASEM taking into consideration three different energy efficiency programmes promoted by the national government and pioneered through the national energy institutions like the Energy Commission of Ghana. The energy efficiency interventions include promotion of the use of energy efficient cook stoves, energy efficient refrigerators and access to modern fuels i.e. electricity and LPG. ASEM's energy consumption dynamics are modelled based on relevant assumptions with regards to these energy efficient programmes.

### 4.2.1 *Efficient cookstoves scenario*

The energy efficient (EE) cookstove locally called '*Gyapa'* uses about 50% less charcoal than the old traditional charcoal stove. The proportion of electrified and non-electrified households who have knowledge of EE cookstoves, the proportion using energy efficient cookstove and the proportion who wish to use EE cookstoves as revealed in the 2013 ASEM Energy survey are shown in Figures 10 and 11.

**Figure 10: Awareness and use of the Gyapa cook stove in electrified households 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 SoE Surveys in ASEM and GEM (2014)

**Figure 11: Awareness and use of the Gyapa cook stove in non-electrified households 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 |

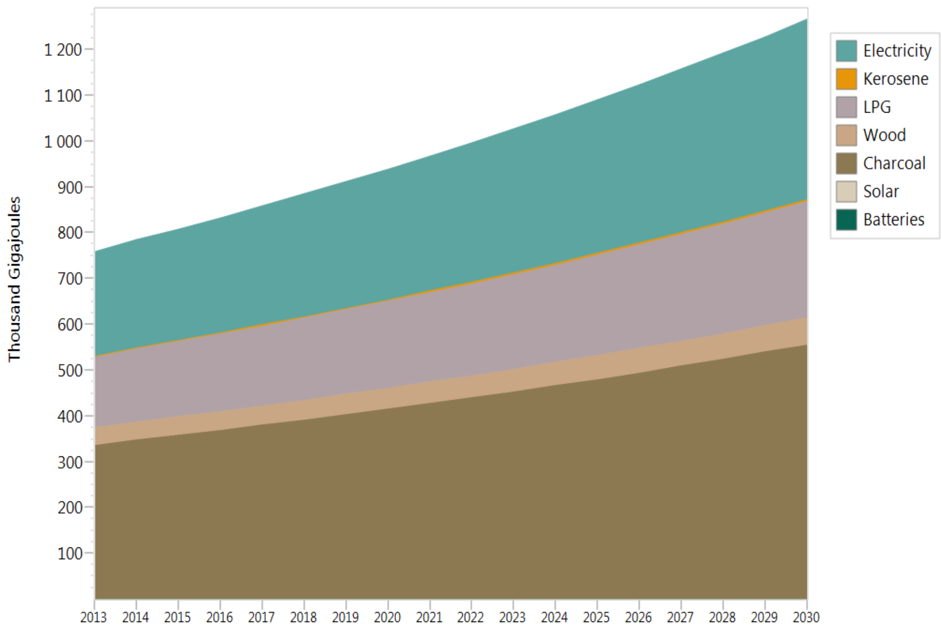
Source: ISSER SoE Surveys in ASEM and GEM (2014)

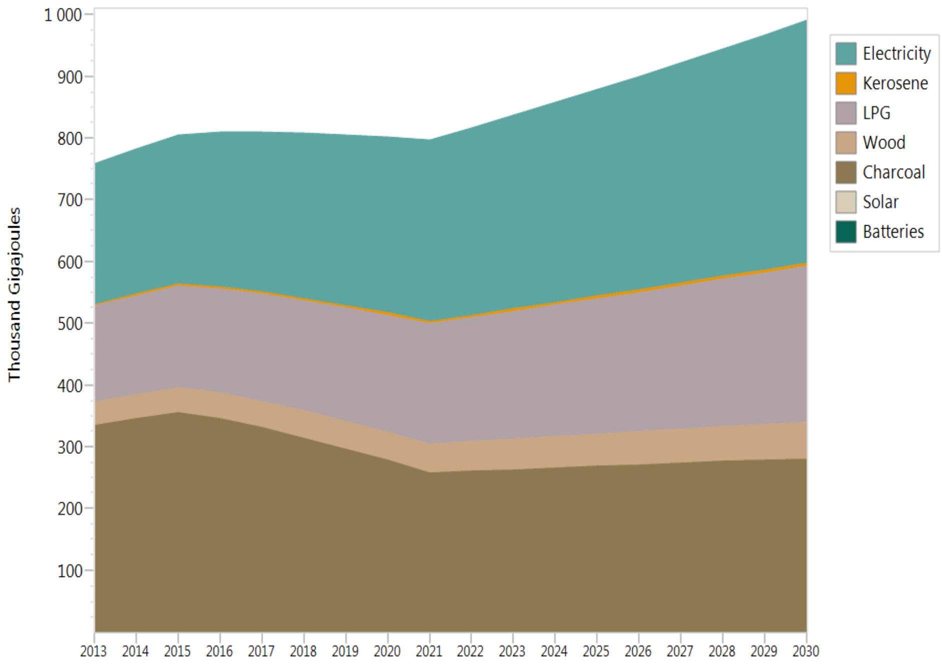
Additional key assumptions with respect to this EE programme include (upholding the earlier assumptions on population and GDP growth rates):

- All households who expressed a desire to have a *Gyapa*, from the SAMSET survey obtain them between 2016 and 2021.
- All remaining households who do not obtain one by 2021, do so by 2030.
- Gyapa uses 50% less charcoal relative to the old/traditional charcoal stove.
- Gyapa costs 10 USD and have a 3 year lifespan.

Accordingly, the estimated energy consumption by the household sector is shown in Figure 12 in relation to the reference BAU scenario. It is observed in the figure (lower chart) that charcoal consumption flattens up from 2021 to 2030 where almost all households are using energy efficient stoves. Instead of the 550,000 GJ of charcoal estimated to be consumed by 2030 under the BAU, the EE cookstove usage will reduce charcoal consumption to almost half the BAU consumption (about 300,000 GJ). This ultimately translates into significant reduction in total energy consumption in ASEM as depicted in Figure 13.

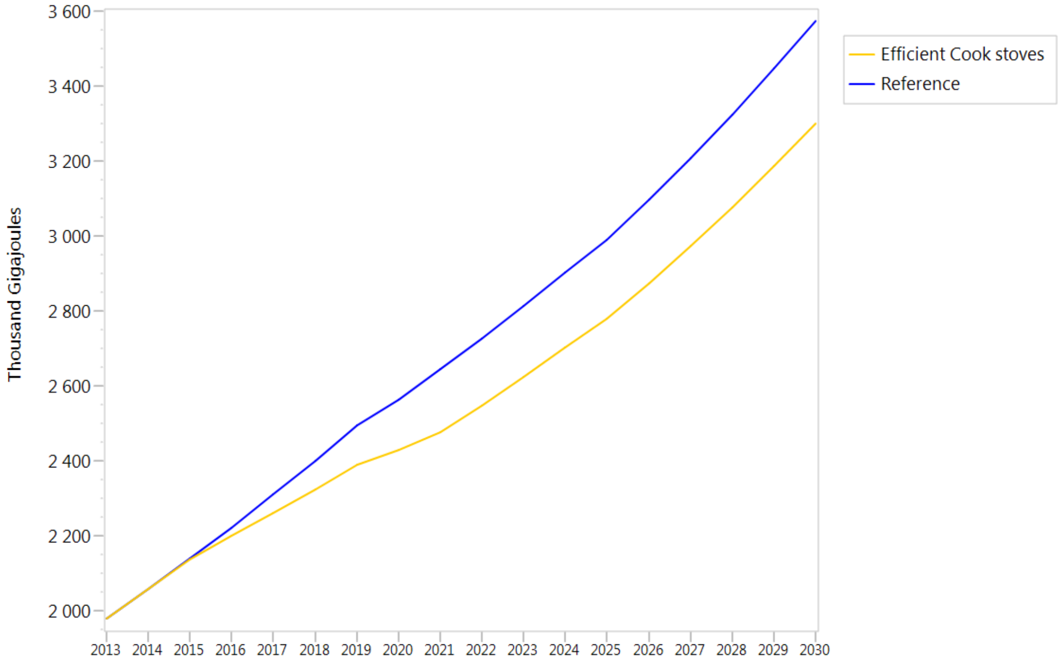
**Figure 12: The household sector energy consumption by fuel in the reference scenario (above) and efficient cook stove scenario (lower)**




Source: Mccall and Tait (2016)

**Figure 13: ASEM total energy consumption for reference and household efficient cook stoves scenario**




Source: Mccall and Tait (2016)

The total cumulative fuel savings and costs savings arising from using EE cookstove, given assumed prices, are as presented below. This can be set against the cost of a rebate or replacement program but it should be borne in mind that this comparison would not include the externality costs arising from indoor air pollution and contribution to climate change, which is another area in which this type of model can be improved. From Table 5, ASEM will likely save 14,056 tonnes, 47,914 tonnes and 92,201 tonnes of charcoal by 2020, 2025 and 2030 respectively, representing GHS 6m, GHS 21m and GHS 41m in those years.

**Table 5: Cumulative Fuel and Cost savings for Efficient cook stoves**

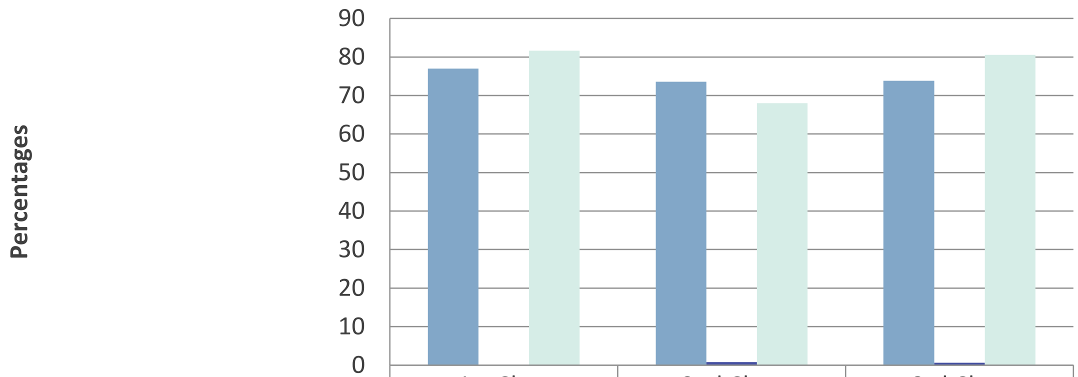
| | 2016 | 2020 | 2025 | 2030 |
|---|---|---|---|---|
| Tonnes charcoal saved | 935 | 14 056 | 47 914 | 92 201 |
| Million Cedi (2013) | 0.3 | 6 | 21 | 41 |

Source: Mccall and Tait (2016)

#### 4.2.2 *Energy Efficient refrigerators scenario*

The Energy Commission of Ghana leads the promotion of the use of energy efficient refrigerators introduced in Ghana since 2011. The new fridges were expected to consume 250kWh a year as compared to the old inefficient ones which consumed about 1200kWh a year on average. The 2014 energy survey results reveal little usage of the efficient refrigerators in ASEM (Figure 14).

**Figure 14: Efficient fridge awareness and usage in ASEM**




| | 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 |

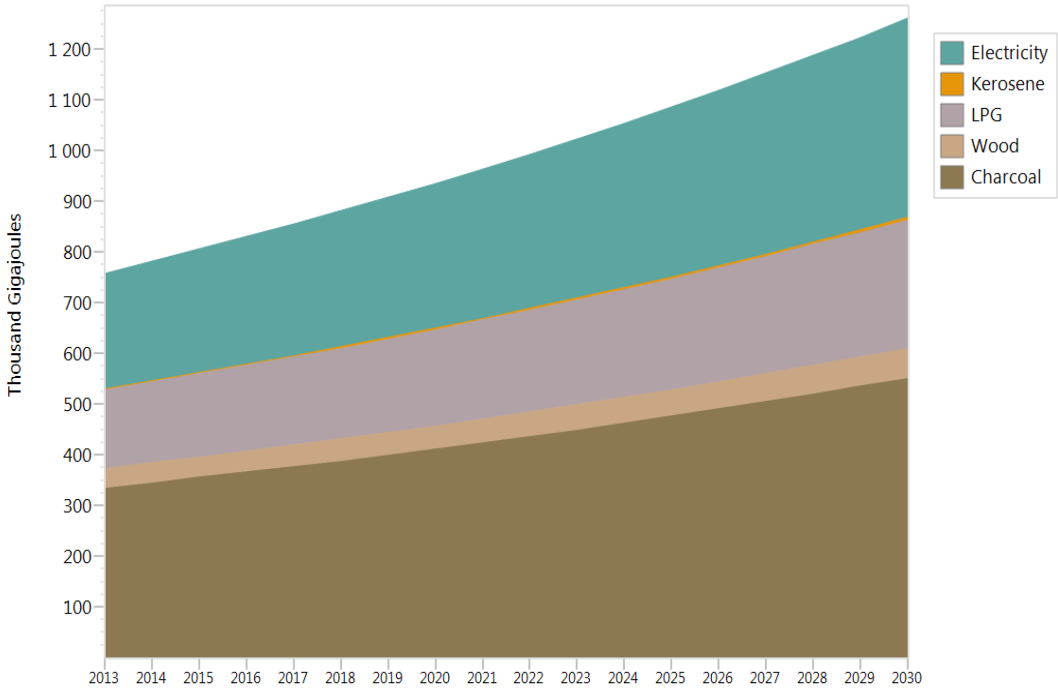
Source: ISSER SoE Surveys in ASEM and GEM (2014)

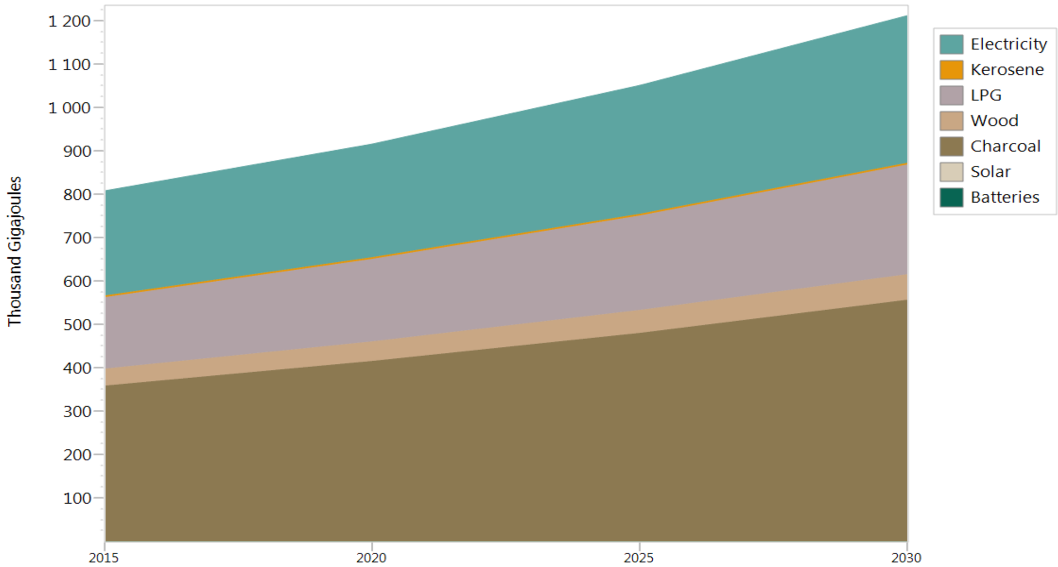
The key additional assumptions considered under this scenario include:

- Between 2016 and 2021, all households who expressed interest in the SAMSET survey to take part in the efficient fridges program, obtain a new efficient fridge by 2021.
- All the remaining households that do not partake before 2021, obtain a new fridge by 2030.
- New fridges are 50% more efficient than old inefficient fridges
- New fridges cost 444 USD and have a 15 year lifespan
- Old inefficient fridges cost 173 USD and have a 7.5 year lifespan

ASEM's household energy consumption with the assumed EE refrigerator scenario is shown in Figure 15 below in comparison with the BAU scenario.

**Figure 15: Household sector fuel consumption for BAU (above) and for the Efficient Fridges scenario (below)**

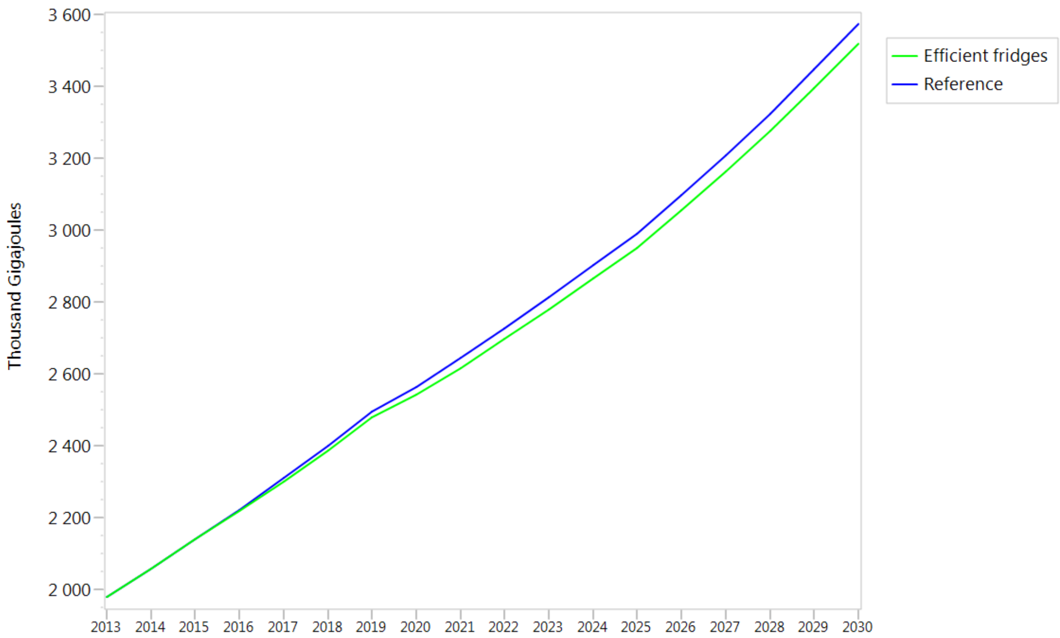



Source: Mccall and Tait (2016)

From the figure above, only a marginal reduction is observed in the household energy demand in ASEM for the EE refrigerator assumption, solely accountable by the electricity fuel. This is observed further in the total ASEM's energy consumption with the EE refrigerator assumption relative to the BAU scenario (Figure 16).

**Figure 16: Total ASEM energy consumption for the reference and efficient fridges scenarios**




Source: Mccall and Tait (2016)

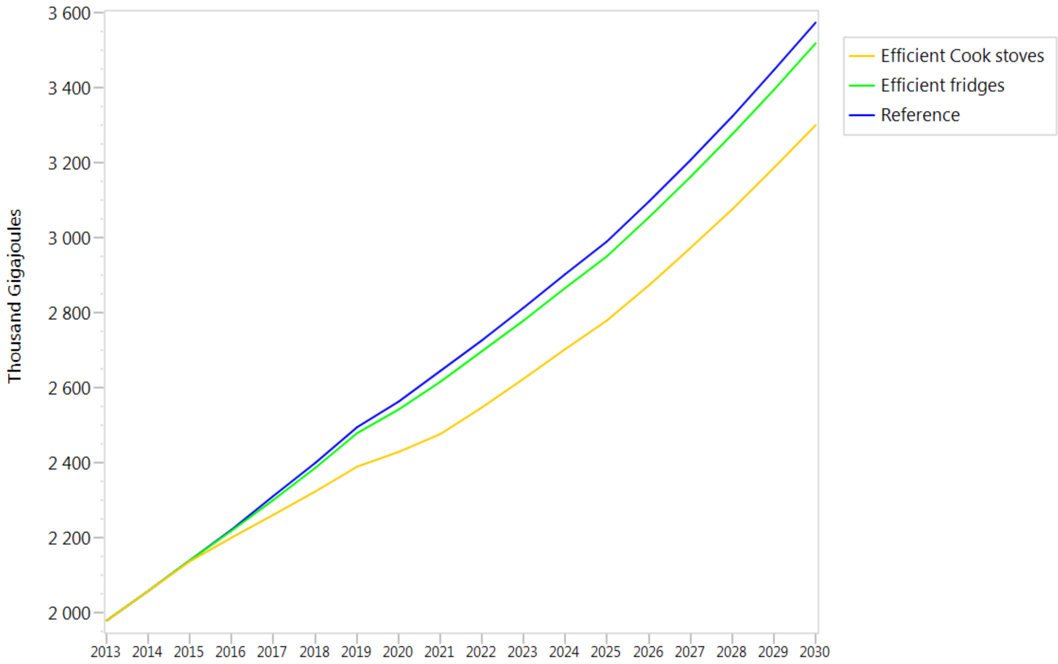
In terms of cumulative savings, the EE refrigerator assumption will save about 11.3 million kWh, 20.6 million kWh and 29.2 million kWh of electricity by 2020, 2025 and 2030 respectively, the equivalent of GHS 5m, GHS 19m and GHS 39m respectively (Table 6). Comparing the EE cookstove and refrigerator programmes, the former programme has a slight edge over the latter in terms of their energy savings potentials. Refrigeration accounts for less than 10% of total households' energy consumption as at 2013 in ASEM as observed in the 2014 energy survey results. On the contrary, cooking accounts for over 70% of households' energy demand in ASEM. Hence, EE cookstoves interventions will have greater effects on total energy consumption than EE refrigerator interventions as observed in Figure 17.

**Table 6: Total cumulative savings from efficient fridges scenario**

| | **2016** | **2020** | **2025** | **2030** |
|---|---|---|---|---|
| Million kWh | 1.12 | 11.30 | 20.63 | 29.20 |
| Million Cedi | 0.33 | 5 | 19 | 39 |

Source: Mccall and Tait (2016)

**Figure 17: Total energy consumption of ASEM comparing household scenarios**




Source: Mccall and Tait (2016)

### *4.2.3 Household access to modern energy scenario*

Explored under this scenario is the impact of households increased access to modern energy (LPG and electricity) on fuel consumption in the household sector. The SoE report for ASEM shows that significant proportion of households use LPG for cooking relative to electricity which many perceived to be expensive. The model thus assumes that most households would prefer to cook using gas (LPG) than electricity going into the future, as presented in Table 7.

While households start the uptake of more frequent use of clean fuels, the use of charcoal is assumed to decrease. Thus, the average intensity for the clean fuels increases while the average intensity for charcoal (the majority of non-clean fuel use) decreases (Table 8). The numbers for electricity and LPG intensities come from the study by Cowan (2008), while the charcoal intensities change is an assumption that the average intensity usage will drop by 75% as most cooking is done on LPG (and electricity for some households) while some still use charcoal for cooking.

**Table 7: Shares for households using fuels for cooking in the access to modern fuels for cooking scenario**

| | HH class | End use | Shares* in % for 2030 (2013) | | |
|---|---|---|---|---|---|
| | | | Electricity | LPG | Charcoal |
| Electrified | HH1 | Cooking | 25 (0) | 95 (75.2) | 30 (82.3) |
| | | Other appliance use | 70 (43.4) | | |
| | HH2 | Cooking | 20 (0) | 90 (75.9) | 40 (89.4) |
| | | Other appliance use | 55 (27) | | |
| | HH3 | Cooking | 5 (0) | 87 (60) | 50 (87.9) |
| | | Other appliance use | 40 (19) | | |
| Non-electrified | HH1 | Cooking | | 85 (54.2) | 50 (83.3) |
| | | Other appliance use | | | |
| | HH2 | Cooking | | 70 (45.5) | 58 (87.9) |
| | | Other appliance use | | | |
| | HH3 | Cooking | | 65 (30.2) | 60 (95.3) |
| | | Other appliance use | | | |

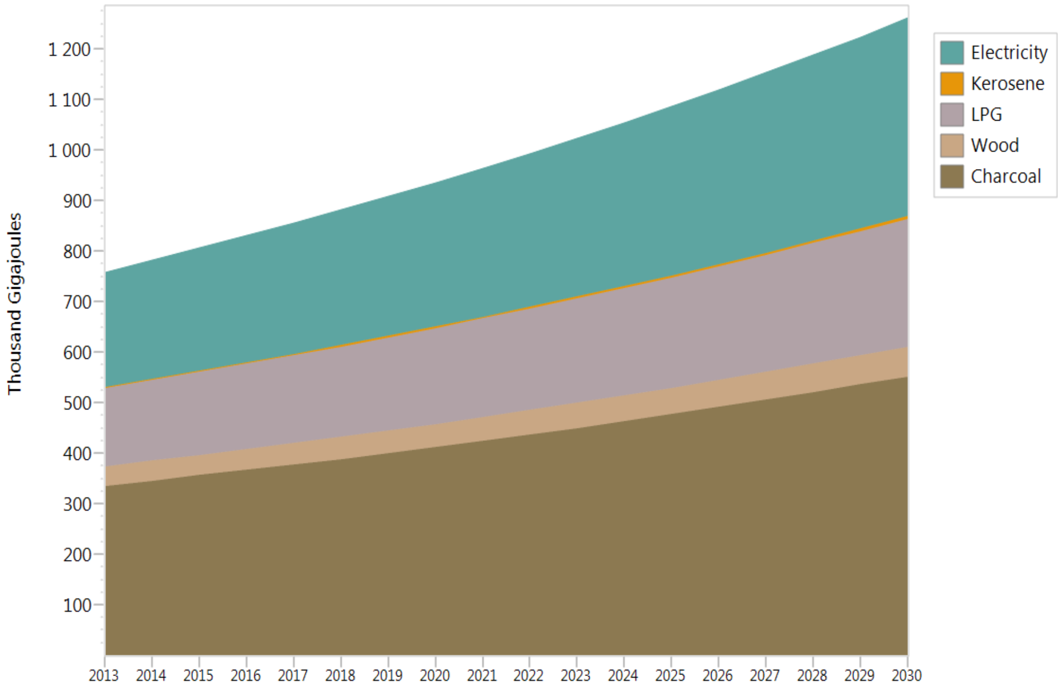
* Note that the shares do not need to sum to 100% as most households use multiple fuels
Source: Mccall and Tait (2016)

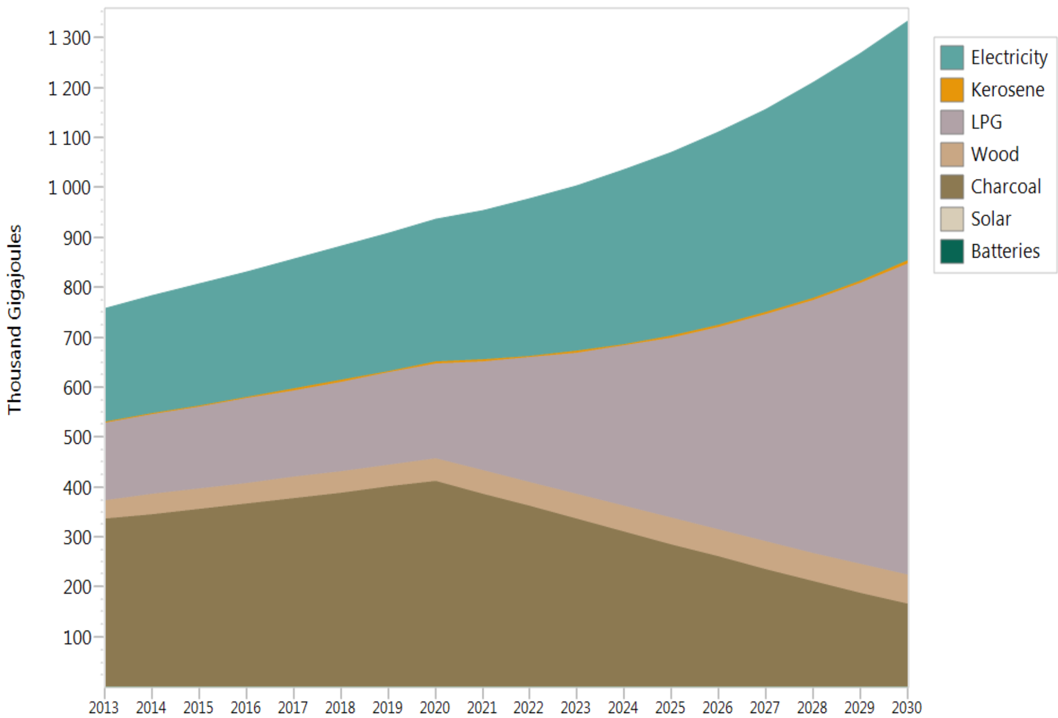
**Table 8: The average energy intensity for each fuel type for cooking in the access to modern energy scenario**

| | HH class | End use | Intensity value GJ/HH for 2030 (2013) | | |
|---|---|---|---|---|---|
| | | | Electricity | LPG | Charcoal |
| Electrified | HH1 | Cooking | 2 (1.5) | 8 (5) | 1 (8.5) |
| | | Other appliance use | 3.5 (2.5) | | |
| | HH2 | Cooking | 2 (1.5) | 7 (4.1) | 1.2 (8.2) |
| | | Other appliance use | 3 (2.1) | | |
| | HH3 | Cooking | 2 (1.5) | 6 (2.8) | 1.3 (8) |
| | | Other appliance use | 3 (2.3) | | |
| Non-electrified | HH1 | Cooking | | 5.5 (3.8) | 1.4 (9.4) |
| | | Other appliance use | | | |
| | HH2 | Cooking | | 4 (2.6) | 1.6 (11.7) |
| | | Other appliance use | | | |
| | HH3 | Cooking | | 3.5 (1.4) | 1.5 (9.8) |
| | | Other appliance use | | | |

Source: Mccall and Tait (2016)

**Figure 18: The household energy consumption by fuel for the reference scenario (above) and the access to modern energy scenario (below)**



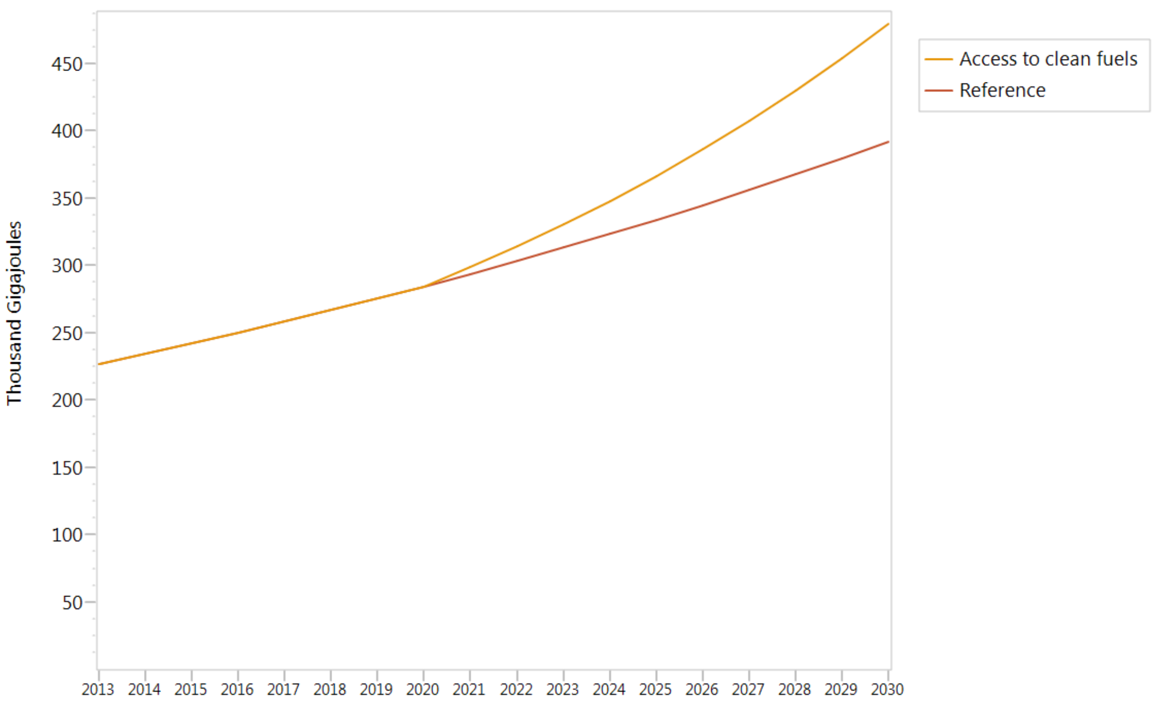




Source: Mccall and Tait (2016)

The modelling results for increased access to modern energy scenario is shown in Figure 18 above in comparison with the BAU scenario. Total household energy consumption clearly increased under the access to modern energy scenario relative to the BAU scenario mainly on account of LPG and electricity consumption. From 2020, LPG consumption will likely increase from about 200,000 GJ to about 620,000 GJ by 2030 under the increased access to modern energy scenario compared to about 250,000 GJ of LPG consumption by 2030 under the BAU scenario. Similarly, electricity consumption increases by about 22% by 2030 relative to the reference scenario (BAU).

On the contrary, charcoal consumption decreases by about 70% under the increased access to modern energy scenario relative to the BAU reference scenario. The net result is an increase in fuel consumption of almost 100,000 GJ in the year 2030 clearly depicted in Figure 19.

**Figure 19: Comparing household energy consumption for the access to modern energy scenario for ASEM relative to the reference scenario**




Source: Mccall and Tait (2016)

ASEM household sector's energy consumption impact is presented in Table 9, showing a large increase in consumption of LPG (about 37 thousand tonnes) and electricity (about 113 thousand tonnes) while charcoal consumption decreased significantly through to 2030 (Table 9).

**Table 9: The cumulative energy impact for the access to modern energy scenario for ASEM**

| | | 2021 | 2025 | 2030 |
|---|---|---|---|---|
| Electricity | MWh | 1 412 | 25 132 | 113 166 |
| LPG | Tonnes | 487 | 8 457 | 37 148 |
| Charcoal | Tonnes | -1 306 | -19 841 | -73 390 |

Source: Mccall and Tait (2016)

## 5.0 Conclusion and Recommendations

The population growth of ASEM estimated at 3% since 2010 according to the Ghana Statistical Service coupled with overall positive performance of the entire country will translate into accelerated energy demand in ASEM in the future. According to the LEAP modelling results based on the 2013 SoE data, if all things remain still with energy consumption activities and behaviours (BAU), the entire ASEM will demand a total of about 4m GJ of energy (without full consideration for transboundary trips) and 6.8m GJ of energy (full consideration for transboundary trips) by 2030. The transport and household sectors remain the energy intensive sectors with petrol (gasoline), diesel, charcoal and electricity the dominant fuel types to be consumed largely by 2030 under the business as usual scenario.

This energy consumption trend could be altered through sustainable energy efficiency programmes. If all households that wished to use energy efficient cookstoves acquire them by 2021 with the remaining households acquiring them by 2030, between 48 and 92 thousand tonnes of charcoal, representing GHS 21 million and GHS 41 million would be saved by 2025 and 2030 respectively, reducing ASEM's total energy consumption from about 3.6 m GJ to 3.3m GJ in 2030. Similarly, if all households that wished to use EE refrigerators acquire them by 2021, with all remaining households acquiring some by 2030, about 21m kWh and 29m kWh, representing about GHS 19 million and GHS 39million would be saved by 2025 and 2030 respectively, translating into a marginal reduction in ASEM's total energy consumption by 2030. If efforts are directed towards expanding access to modern energy like the LPG and electricity fuels, this will have significant impact on ASEM's total energy consumption by increasing households' energy consumption to about 480,000 GJ from the BAU scenario of about 390,000 GJ, but at the same time reduce charcoal consumption significantly by about 73,390 tonnes by 2030, which has environmental gains.

The various scenarios presented above call for policy directions and sustainable actions from the local authority of ASEM to guarantee sustainable energy futures by 2030. In this regard, the following recommendations have been advanced as actions that can be considered to spur on sustainable energy strategy development in ASEM.

- Promote the patronage and use of energy efficiency cookstoves in ASEM. The energy efficient cookstove is confirmed above to have significant reduction in households' energy consumption of charcoal and overall reduction in ASEM's energy consumption. Education through practical demonstration of the use of this technology in the presence of households can ensure total conviction, trust and mass patronage of energy efficient cookstoves in ASEM.

- Promotion of the use of energy efficient refrigerators in ASEM. To ensure large scale usage of efficient refrigerators in ASEM so as to bring about the desired reduction effects in total energy consumption by 2030, it will require collaborative efforts with the Energy Commission of Ghana (EC), academics and donor agencies to roll-out effective education and awareness creation on the energy efficient refrigerators. This should include functional demonstration and effective media advertisements that will convince potential users of the technology.
- Increase access to modern fuel types; electricity and LPG. Though a little out of the direct jurisdiction of Awutu Senya East Municipal Assembly (ASEMA), the local authority can still influence accessibility to these fuel types through working closely with relevant players such as the Electricity Company of Ghana, EC and other private players. Education and promotion of renewable energy (especially solar and biogas) among households and commercial sectors can bring about increased accessibility to electricity, while granting permits to deserving oil firms for the establishment of LPG service stations in the municipality can promote usage among households.

## References


Bawakyillenuo, S. & Agbelie, I. (2014). Awutu Senya East State of Energy Report. ISSER, University of Ghana, Legon, Accra.

Cowan, B. (2008). *Alleviation of Poverty through the Provision of Local Energy Services (APPLES*). Project no. EIE-04-168. Cape Town, South Africa.

Ghana Statistical Service (2014a). 2010 Population and Housing Census District Analytical Report – Awutu Senya East Municipality. Accra, Ghana.

Ghana Statistical Service (2014b). Gross Domestic Product 2014. GSS National Accounts Statistics, April 2014. Available online at: http://www.statsghana.gov.gh/docfiles/GDP/GDP_2014.pdf (Accessed 21/09/2015)

Mccall, B. & Tait, L. (2016). Awutu Senya East LEAP Modelling Technical Report. Research Report Series. Energy Research Centre (ERC), University of Cape Town. Available online at: www.samsetproject.net

Osei-Boateng, C. & Ampratwum, E. (2011). The Informal sector in Ghana. Ghana: Friedrich Ebert Stiftung. Available online at: http://library.fes.de/pdf-files/bueros/ghana/10496.pdf (Accessed 12/04/2015)

Tait, L., McCall, B. & Stone, A. (2014). Energy futures modelling for African cities – selecting a modelling tool for the SAMSET project. Energy Research Centre, University of Cape Town

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