ENERGY COMMISSION

STRATEGIC NATIONAL ENERGY PLAN

(SNEP 2030)
Final Draft

VOLUME ONE

Energy Demand Projections for the Economy of Ghana

July 2019

Executive Summary

The Energy Commission was established by the Energy Commission Act, 1997 (Act 541), with the mandate to, inter alia, prepare, review and update periodically indicative energy plans. The indicative energy plans provide a framework, which guides decision-makers to ensure that all reasonable demands for energy in the economy are met sustainably.

In pursuance of this mandate, the Commission developed the Strategic National Energy Plan (SNEP) from 2006 to 2020, which was published in 2006.

However, the country's energy-economy landscape has undergone major changes, such as the discovery of commercial quantities of crude oil in the country in 2007 and the rebasing of the country's economy in 2006 and 2013. These led to the need to review and update the SNEP (2006 – 2020).

The specific objectives[1] of the SNEP update are to:

- identify possible energy demand profiles for the country up to 2030;
- assess long-term energy supply from both domestic and import sources to determine their potential for meeting the country's future energy requirements;
- formulate energy supply options or strategies (oil, natural gas, coal, hydropower, nuclear, wind, biomass and solar, etc.) and assess their strengths and weaknesses to determine long term sustainable supply;
- compare alternative scenarios and energy supply strategies by evaluating their financial, environmental and social impacts and benefits;
- identify all the possible current and future energy supply constraints or challenges (e.g. domestic energy resource limitations, financial requirements, social, environmental challenges, policy initiatives, etc.);
- identify key policy issues and promising options for transitioning to long-term sustainable development of the country's energy sector and the economy; and
- develop an Action Plan for the implementation of policy recommendations.

Planning Guidelines

The guidelines for the review and update of the Strategic National Energy Plan (2006 – 2020) were based on the goals of National Energy Policy – 2010, the Ghana Shared Growth and Development Agenda (GSGDA, 2010 – 2013 and 2014 to 2017), the Coordinated Programme for Economic and Social Development Policies (2017-2024) and government programmes such as integrated bauxite and aluminum programme; one-district, one-factory; and planting for food and jobs. The specific guidelines included energy sector policy goals such as:

(i) achieving universal access to the national electricity grid by 2020;

[1] These objectives are for the whole SNEP update which includes both demand and supply sides

(ii) achieving 10% renewable[2] energy in the total national energy supply mix by 2030; and
(iii) achieving LPG use penetration of 50% of households by 2030.

The specific socio-economic policy goals included are:

(i) accelerating economic growth rate by a minimum of 8.0% per annum;
(ii) supporting agricultural modernisation, natural resource development, (particularly oil and gas); and
(iii) pursuing an employment-led economic growth strategy by linking agriculture to industry, particularly manufacturing.

Planning Methodology

The projections start from 2020 and end in 2030. The base year for the planning study, however, is 2010. The choice of 2010 was dictated by the fact that it was a normal year without any severe energy supply constraints. Furthermore, the Ghana Statistical Service conducted the 2010 Population and Housing Census, which provided a large amount of useful demographic data. The Energy Commission also undertook a National Energy Use Survey in 2010 to collate useful information on energy use patterns and intensities in the household, service, and industry sectors. All these information sources served as vital inputs for the energy planning study.

The simulation tool (software package) used for the energy planning study is the Long-Range Energy Alternatives Planning (LEAP). The LEAP software was used to simulate the plausible demand scenarios for the following purposes:

(i) determining the country's future energy demand profiles,
(ii) analysing the energy supply strategies over the planning period, and
(iii) evaluating the impact of recommended energy policies.

Stakeholder Participation

The stakeholder involvement in the SNEP process is part of the strategy to ensure effective stakeholder ownership, which would facilitate the implementation of the recommendations of the energy planning study. A number of stakeholders were thus identified as collaborating partners in this respect.

[2] Hydropower plants above 100 MW are, by Renewable Energy Law 2011 (ACT 832) of Ghana, not considered as renewable

Description of Scenarios

Two scenarios were developed to capture plausible socio-economic outlooks of the country. These are the Business-as-usual (BaU) scenario and the Accelerated Economic Growth (AEG) scenario.

(i) Business-as-usual Scenario (BaU)

The BaU scenario describes a socio-economic outlook based on trends from the historical past until 2030. These include the following:

- population[3] would increase from 24.7 million in 2010 to 38 million in 2030 at an average annual growth rate of 2.17%,
- urbanisation rate was projected to increase from 50.9% in 2010 to 65.0% in 2030 at an average annual rate of 1.2%, and
- GDP was projected to increase from US$ 32.2 billion (in current prices) in 2010 at an average annual rate of 7.1% to US$ 126.9 billion (current prices) in 2030[4].

(ii) Accelerated Economic Growth (AEG)

The AEG scenario considers the objectives of the Ghana Shared Growth and Development Agenda, Medium-Term National Development Policy Framework (2018-2021) and the Coordinated Programme for Economic and Social Development Policies (2017-2024), which included actions already taken and those yet to be undertaken by the government such as the 'One District-One Factory' industrial initiative and the 'planting for food and jobs' policy. Under the accelerated economic growth;

- the population was projected to increase from 24.7 million in 2010 at an average annual rate of 2.09% to 37.4 million in 2030,
- urbanisation rate was projected to increase from 50.9% in 2010 to 66.0% in 2030 at an average annual rate of 1.3%, and
- GDP was projected to increase from US$ 32.2 billion (current prices) in 2010 at an average annual rate of 8.3% to US$ 158.6 billion (current prices) in 2030.

[3] Ghana Statistical Service, Ghana Population Projection, October 2014

[4] In the Ghana Long Term National Development Plan (2018-2057) concept paper 2016, real GDP in 2030 would to be US$ 29.73 Also, the average annual growth rate of 7.1 from 2010 to 2030 for the BaU scenario is inline with the average annual growth rate 7.4 (with oil) and 5.6 (without oil) from 2017 to 2019 from Ministry of Finance (letter referenced MOF/RSD/ADMIN/03/17, dated 20th April, 2017).

Drivers and Assumptions made for Energy Demand

The main drivers of energy demand are as follows:

- demographic factors such as population, changes in the shares of urban and rural population, and the changes in urban and rural household sizes would drive sectoral activities such as cooking and space cooling;
- economic factors such as personal disposable income levels, changes in structure of the economy (i.e. shares of industry, services and agriculture in total GDP); influence on the acquisition of energy-consuming appliances; average travel distance per person, type of vehicle and propulsion modes, fuel substitution, and energy intensity of the economy;
- Government policies such as the National Electrification Scheme, accelerated industrialisation policies (e.g. one-district-one-factory; integrated iron and steel industries; and integrated bauxite industries), accelerated agriculture (e.g. planting for food and jobs), and the promotion of productive uses of electricity would drive the demand of electricity. Meanwhile, the promotion of energy efficiency programmes would reduce waste in energy utilisation and could contribute to a reduction in the overall growth in primary energy demand.
- Promotion of energy efficiency programmes such as labelling of energy appliances such as air conditioners and freezers, adoption of CFL & LED bulbs, would reduce waste in energy utilisation and could contribute to a reduction in the overall growth in final energy demand.

Final Energy Demand Projection

The Energy Demand sectors of the economy comprise:

- Residential or Household
- Commercial and Services
- Transport
- Agriculture and Fisheries
- Industry

Final Energy Demand could be defined as Primary Energy supplied minus transformation and transmission (transportation) losses. It is, therefore, the net or actual energy needed by the Demand Sectors.

The final energy demand projections from 2020 to 2030 are discussed in the following order.

(a) Total Energy Demand

For the BaU scenario, the total energy demand would increase by about 60% from 9,753 ktoe in 2020 to 15,552 ktoe in 2030 whiles that of the AEG scenario would increase by over 100% from 10,314 ktoe in 2020 to 22,091 ktoe in 2030.

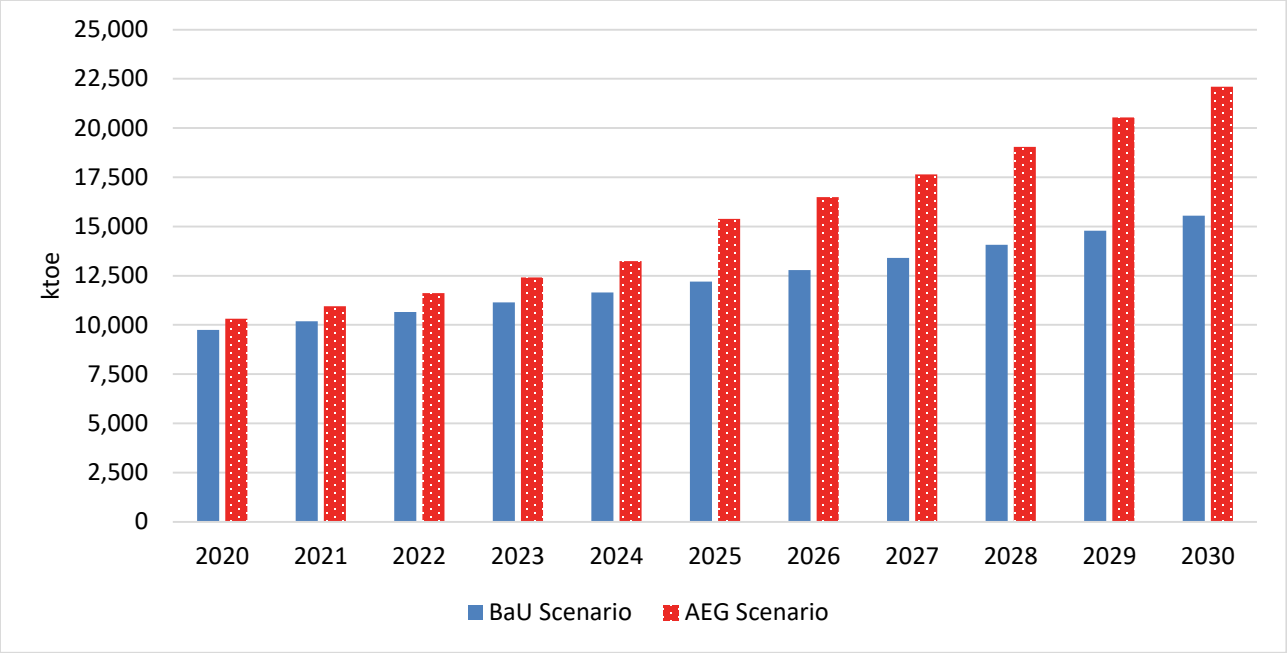

Figure E1: Final Energy Demand Projection from 2020 to 2030 by Scenario

(b) Sectoral Shares

In terms of shares, the dominant energy-consuming sector would be transport, accounting for about 51% of the total final energy demand for the BaU scenario and about 44% for the AEG scenario.

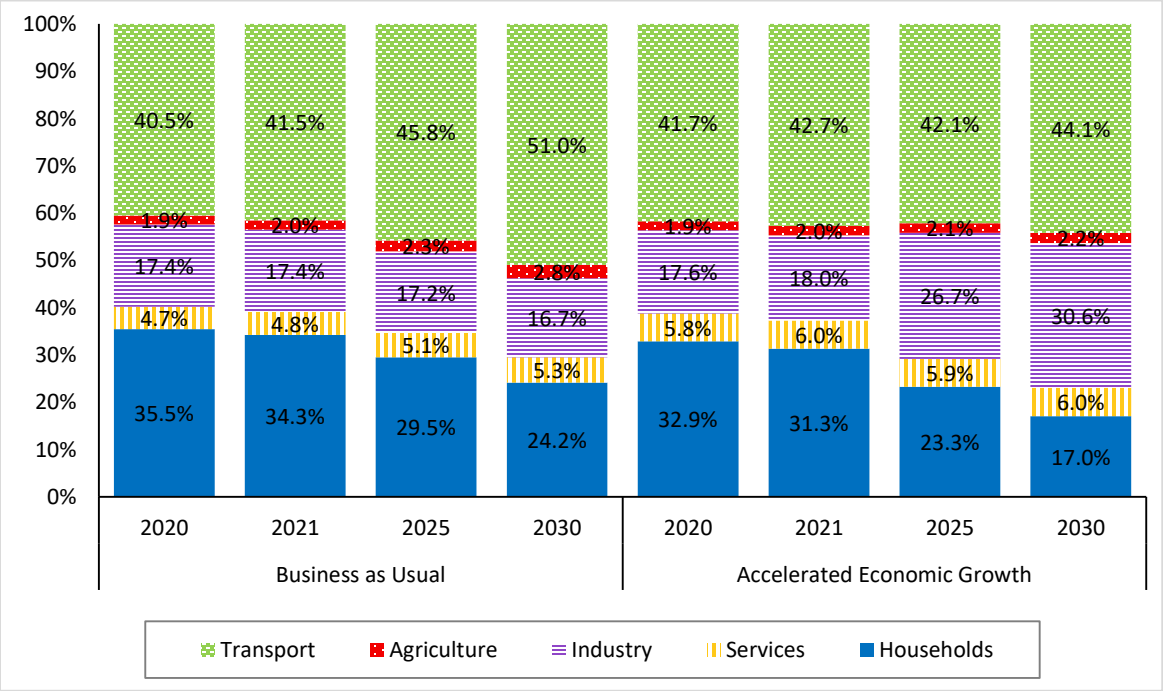

Figure E2: Sectoral Shares of Final Energy Projection for 2018 and 2030

(c) Energy Intensity

The energy intensity[5] of the economy (total final energy demand in kgoe per unit of GDP) would decrease from 153 kgoe per 1,000 USD in 2020 to 123 kgoe per 1,000 USD in 2030 for the BaU scenario. It would decrease, for AEG scenario, from 144 kgoe per 1,000 USD in 2020 to 139 kgoe per 1,000 USD in 2030.

(d) Household Sector Final Energy Demand

Total energy demand by the Household sector would increase from about 3,459 ktoe in 2020 to 3,761 ktoe in 2030 at an average annual growth rate of 0.8% for the BaU scenario and from 3,395 ktoe in 2020 at an average annual growth rate of 1.0% to 5,765 ktoe in 2030 for the AEG scenario. Demand for electricity, LPG and charcoal would increase whilst firewood and kerosene demand would decrease.

(e) Service Sector Final Energy Demand

Total energy demand for the Service sector would increase from about 463 ktoe in 2020 at an average annual growth rate of about 6.0% to 826 ktoe in 2030 for the BaU scenario and from 602 ktoe in 2020 at an average annual growth rate of 8.2% to 1,327 ktoe in 2030 for the AEG scenario. Electricity, LPG and charcoal demands increased, as expected, but firewood demand would decrease.

(f) Industrial Sector Final Energy Demand

Total energy demand by the Industrial sector would increase from 1,511 ktoe in 2020 at an average annual growth rate of 4.8% to about 2,418 ktoe in 2030 under the BaU scenario and from 1,650 ktoe in 2020 at an annual average growth rate of 14.7%, to 6,451 ktoe in 2030 for the AEG scenario. Manufacturing and mining sub-sectors would account for about 95% of the sector's demand. Demand for all fuels used in the sector is expected to increase but natural gas would have the highest increment owing to demand from the processing of expected iron and bauxite into steel and alumina respectively.

(g) Agricultural and Fisheries Sector Final Energy Demand

The total energy demand by the Agricultural sector would increase at an average annual growth rate of 9.0% from 185 ktoe in 2020 to 437 ktoe in 2030 for the BaU scenario and at an annual growth rate of 9.3% from 200 ktoe in 2020 to about 489 ktoe in 2030 for the AEG scenario.

[5] Energy intensity is a measure of the energy efficiency of an economy. It is calculated as units of energy used to produce a unit of GDP.

(h) Transport Sector Final Energy Demand

The total energy demand by the Transport sector would increase from 3,950 ktoe in 2020 at an annual average rate of 7.2% to 7,926 ktoe in 2030 for the BaU scenario and from 4,301 ktoe in 2020 at an average rate of 8.5% to 9,751 ktoe in 2030 for the AEG scenario.

(i) Electricity Demand

Final electricity demand would increase at an average annual growth rate of 5.1% from 18,542 GWh (1,594 ktoe) in 2020 to 30,570 GWh (2,629 ktoe) in 2030 for the BaU scenario and from 21,971 GWh (1,889 ktoe) in 2020 at an average annual growth rate of 8.1% to 47,926 GWh (4,121 ktoe) in 2030 for the AEG scenario.

(j) Petroleum Products Demand

The total demand for petroleum products (excluding natural gas) would increase from 4,831 ktonne in 2020 at an average annual rate of 6.9% to 9,458 ktonne in 2030 for the BaU scenario. Under the AEG scenario, demand would increase from 5,272 ktonne in 2020 at an average annual rate of 8.6% to 12,077 ktonne in 2030.

(k) Natural Gas Demand

Natural gas demand would increase from about 2500 mmscf in 2020 for both scenarios to 5100 mmscf and 104,654 mmscf respectively in 2030. Its demand would mainly be driven by the expected iron and bauxite processing industries.

(l) Woodfuel Demand

Woodfuel demand would reduce at an annual average growth rate of 0.2% from 3,104 ktoe in 2020 to 3,041 ktoe in 2030 for the BaU scenario and at an annual average growth rate of 0.3% from 2,918 ktoe in 2020 to 2,824 ktoe in 2030 for the AEG scenario.

Conclusions and Recommendations

Conclusions

i. The Transport sector would become the dominant energy demand sector throughout the planning period. The transport sector would account for 51% of the total final energy demand for BaU and about 44% for AEG scenarios in 2030.

ii. Because of the increasing penetration of electrical appliances in the Household and Services sectors; and energy-intensive nature of industrial processes, electricity demand would increase at an annual rate of 5.1% for BaU and 8.1% for the AEG scenarios. The electricity demand per household would increase by 58% for the BaU scenario and 55% for the AEG scenario between 2020 and 2030.

iii. LPG demand, for the BaU scenario, indicates about 30% of all households would require LPG as their main fuel for cooking in 2020 compared to 41% of households in urban areas. In 2030, LPG penetration is expected to be about 39% and 42% for BaU and AEG scenarios respectively, but still less than the government's expected target of 50%. Meanwhile, penetration in urban areas in 2030 is expected to be 48% and 51% while rural would be 19% and 23% for BaU and AEG respectively.

iv. In order to achieve government's 50% LPG penetration target by 2030, the demand for LPG in households would have to increase, by about two-folds, from 224 ktoe (207 ktonne) in 2020, at an annual growth rate of 8.0%, to 483 ktoe (448 ktonne) by the end of 2030.

Recommendations

i) As a result of the dominant share of the transport sector in the total final energy demand, there is the need to implement measures such as improved public transport infrastructure. Besides, there should be a modal shift from more fuel-intensive to less fuel-intensive modes such as moving freight from road to rail transport in order to reduce transport energy demand and the related polluting gaseous emissions. Passenger transportation using electric vehicles (full plug-in or hybrid), and using solar as a source of electricity should be promoted to provide an alternative to petroleum for passenger transportation.

ii) The growth in the demand for electricity would require a carefully planned and upgraded generation capacity supported by improvements in efficiency of the power infrastructure, electricity end-uses and industrial processes. The current high electricity prices need to be reduced to propel economic activity.

iii) Since high demand for wood-fuel would persist particularly in rural households with a potential threat of deforestation, greater penetration of improved cook-stoves and LPG in households coupled with an accelerated programme of woodfuel cultivation would be needed. Therefore, promotion and adoption of improved cookstoves with fuel savings potential of at least 15% should be intensified.

Preface

THE ENERGY COMMISSION, established by the Energy Commission Act (Act 541, 1997) is mandated to prepare, review and update periodically indicative national energy plans to ensure that all reasonable demands for energy are met in a sustainable manner. Indicative plans are based on the scenario that all demand for energy is met, assuming there are no constraints to supply. It is undertaken to promote more stable and efficient growth through quantitative forecasts of sectors of the economy, and accompanied by a list of policy measures intended to help fulfil the plan. The Commission will, therefore, make the necessary policy recommendations for the removal of any existing and foreseeable constraints to the energy supply to facilitate the rapid and sustainable growth of the economy.

In conformity with this mandate, the Commission in 2000 commenced the country's first integrated long term indicative sustainable energy plan called the Strategic National Energy Plan (SNEP) with 2000 and 2020 as the base and end year respectively.

Conventionally, the top-down approach has mostly been used for energy planning, and there had been tendencies to make long term forecasts based on the supply-side projections. However, activities on the supply-side do not necessarily arise as a result of demand. For instance, increasing demand does not necessarily call for investment in generation and transmission without first considering cost and the option of fuel substitution and energy efficiency. Moreover, conventional planning has placed more emphasis on commercial grid electricity, relegating to the background the potential of renewables and distributed or embedded generation. A paradigm shift in energy policy and planning was thus necessary. Broadening the sources and types of energy supply and integrating them into high-quality utility service for the total growth of the economy is mainly what SNEP is about.

SNEP is also a comprehensive way of looking at the available energy sources and resources of the country and how to tap them economically and timely to ensure secure and adequate energy supply for sustainable economic growth now and into the future.

The first SNEP was completed and published in 2006. However, in that very year 2006, Ghana rebased its economy (national account) from 1993 to 2006. Another rebasing was undertaken in 2013. Further, in 2007, the country discovered commercial oil field, the Jubilee field and started production in 2010. These affected the supply projections and therefore necessitated the need to update the SNEP (2006-2020) and consequently shifting the reference (reporting) and end years from 2006 and 2020 to 2020 and 2030 respectively. SNEP is long term since most capital investments in the energy sector are relatively high with a lifetime of 20 years or more on the average.

SNEP (2020-2030) is thus the second SNEP produced by the Energy Commission in accordance with its mandate. The goal of SNEP (2020-2030) is to contribute to the development of a sound energy market that would provide sufficient, viable and efficient energy services for Ghana's economic

development. It places emphasis on policy, economic trends and drivers which underpin the long-term vision for the energy sector.

Specific government policies that have impact on energy demand such as the One District One Factory and the Planting for Food and Jobs policies have been considered in determining the energy demand scenarios.

The potential effects of fuel substitution such as the use of electricity in place of petroleum fuels in transport on some demand sectors have been taken into consideration.

Energy efficiency measures have also been emphasised in the SNEP and major sectors for energy conservation have been examined in this respect.

The energy sector is broadly divided between demand for energy and supply of energy to the economy. The SNEP (2020-2030) is, therefore divided into two volumes:

- Volume One covers the Demand Sectors of the Economy, namely Residential (household); Commercial & Services; Agriculture; Industry and Transport.

- Volume Two covers the supply-side of the energy sector, namely, Electricity (or Power); Petroleum (or Oil and Gas) and Renewables.

The SNEP analysis had been carried out using the LEAP (Long-range Energy Alternative Planning) computer-based model. LEAP was adopted for its comparative user-friendliness in addition to having sub-programmes to handle both supply-driven and demand-driven projections at the same time and for ease of comparison.

Time series analysis was applied for sectors with known planned future production outputs and committed power plants to be commissioned or retired in the future. Regression analysis was used for projecting demand for sectors with limited data.

The principal results of the demand analysis with LEAP was the net final energy demand projections, that is after bulk transportation or transmission and distribution (retailing) losses have been deducted from the gross energy production.

The choice of 2010 as the base year was influenced by the fact that in that year, a national Population and Housing Census was undertaken and that provided a wealth of reliable data on the country's demographics which were very essential inputs for the modelling. While 2020 was chosen as the reporting or reference year.

In developing and elaborating the SNEP (2020-2030), the Energy Commission since 2012 had conducted empirical studies, workshops and series of stakeholders' consultative meetings with major institutions representing the various sectors of the economy.

It is hoped that the diverse stakeholders and users of this document will find it informative and useful. Feedback on how the Commission could improve the SNEP, making it more living and relevant at any point in time to the various stakeholders is most welcome.

Dr A.K. Ofosu Ahenkorah
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Abbreviations and Acronyms

AEG	Accelerated Economic Growth
AGI	Association of Ghana Industries
AGR	Average Growth Rate
AMSEC	Agriculture Mechanization Service Centres
ATK	Aviation Turbine Kerosene
BaU	Business as Usual
BMI	Business Monitor International
BRT	Bus Rapid Transit
CFL	Compact Fluorescent Lamp
CSIR	Council for Scientific and Industrial Research
DPK	Dual Purpose Kerosene
DVLA	Drivers and Vehicle Licensing Authority
GCNet	Ghana Community Network
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GHS	Ghana Cedi
GLSS	Ghana Living Standard Survey
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
GWh	Gigawatt-hour
HEG	High Economic Growth
IIR	Institute of Industrial Research

kgoe	Kilogram of Oil Equivalent
km	kilometres
ktoe	Kilo Tonnes of Oil Equivalent
ktonnes	Kilotonnes
kWh	kilowatt-hour
LEAP	Long-Range Energy Alternatives Planning
LED	Light Emitting Diode
LPG	Liquefied Petroleum Gas
MDG	Millennium Development Goals
MEG	Moderate Economic Growth
MLME	Medium and Large-scale Manufacturing Enterprises
MSME	Micro and Small-scale Manufacturing Enterprises
MW	Megawatt
MWh	Megawatt-hour
NDPC	National Development Planning Commission
NEP	National Energy Policy
NES	National Electrification Scheme
NIDMAP	National Irrigation Development Master Plan
PUE	Productive Uses of Energy
RFO	Residual Fuel Oil
SLT	Special Load Tariff
SMEs	Small and Medium Scale Enterprises
SNEP	Strategic National Energy Plan

TV	Television
US$	United States Dollar
USD	United States Dollar
VALCo	Volta Aluminium Company

Acknowledgements

This study is based on a background analysis undertaken using the Long-range Energy Alternative Planning System (LEAP) model developed by the Stockholm Environment Institute (SEI) in Boston, USA and made available to the country at no financial cost. The Energy Commission appreciates the assistance.

The study further acknowledges the individual and the collective efforts of the Board of the Energy Commission for its leadership and support.

Individuals and institutions also supported the study by providing diverse data and information. The Commission, therefore, wishes to acknowledge the contributions of all these institutions, notable among them are the National Petroleum Authority, Ghana Chamber of Mines, Association of Ghana Industries, Electricity Company of Ghana, Volta River Authority, Ghana Grid Company Ltd and Driver and Vehicle Licensing Authority.

Finally, the Commission acknowledges the tremendous inputs from the Ghana Statistical Service, National Development Planning Commission, Institute of Statistical Social and Economic Research of the University of Ghana, Institute of Development Studies of University of Cape Coast and the Brew Hammond Energy Centre of the Kwame Nkrumah University of Science and Technology for especially reviewing the initial draft of the report and making very useful comments.

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Chapter One: Introduction

1.1 Background

The primary socio-economic goal of all the development frameworks proposed for the country is to promote a competitive, fast-growing and productive economy. The fulfilment of this goal is premised on the provision of sustainable and relatively affordably priced energy to all sectors of the economy.

The Energy Commission was established by an Act of the Ghanaian Parliament, the Energy Commission Act, 1997 (Act 541), with the mandate to, inter alia, prepare, review and periodically update indicative energy plans to ensure that all reasonable demands for energy are met. These indicative energy plans would serve to provide frameworks to guide decision-making processes to ensure that all reasonable demands for energy for the economy are met sustainably.

This provision in the Energy Commission Act 1997 fits into the economic objectives of the country's 1992 Constitution, which mandates that "the national economy is managed in such a manner as to maximise the rate of economic development and to secure the maximum welfare, freedom, and happiness of every person in Ghana"[6]. The management of the national economy cannot be executed without proper energy planning to guide policy and decision-makers in the country. This tenet of the Constitution ensures that every elected Government pursues policies, which ultimately lead to the "establishment of a just and free society", where every Ghanaian has the opportunity to live a long, productive and meaningful life[7].

In the pursuance of its planning mandate, the Commission undertook its first national indicative energy planning study beginning 2000 and was released in 2006, which is referred to as the Strategic National Energy Plan (SNEP 2006 to 2020) designated as SNEP I. The study provided the framework to guide public and private decision-making processes to ensure the provision of sustainable energy for Ghana's long-term economic development.

The SNEP I adopted 2000 as the base year for its energy demand projections and analysis, with 2006 as the reference year. However, the country's energy-economy landscape has undergone major changes, such as the discovery of commercial quantities of crude oil and natural gas in the country in 2007 and the rebasing of the country's economy in 2006 and 2013. These necessitated the need to review and update SNEP I. The updated SNEP would cover 2020 to 2030 and be designated as SNEP II.

[6] 1992 Constitution of the Republic of Ghana, Article 36.1
7. 1992 Constitution of the Republic of Ghana

The specific objectives of the SNEP II study are to:

- identify possible energy demand profiles for the country from 2020 to 2030,
- assess long-term energy supply from domestic energy resources to determine their potential for meeting the country's future primary energy requirements and if not, the levels of primary energy imports,
- assess energy supply options or strategies (oil, natural gas, coal, hydropower, nuclear, wind, biomass and solar) and their strengths and weaknesses (costs, environmental impacts and technical constraints) to determine sustainable energy security,
- identify key policy issues and promising policy options for transition to long-term sustainable development of the country's energy sector and the economy,
- develop an Action Plan for the implementation of recommendations, and
- develop a Communication Strategy for the dissemination of the results of the energy planning study.

1.2 Planning Guidelines

The guidelines for the review and update of SNEP I were based on the goals of National Energy Policy – 2010, the Ghana Shared Growth and Development Agenda (GSGDA, 2010 – 2013 and 2014 to 2017), Medium-Term National Development Policy Framework (2018-2021) and The Coordinated Programme for Economic and Social Development Policies (2017-2024). The specific guidelines included energy sector policy goals to:

(i) achieve universal access to electricity supply by 2020, and
(ii) achieve LPG use penetration rate of 50% of households by 2030.

The specific socio-economic policy goals included are to:

(i) accelerate economic growth rate to at least 8.0% per annum,
(ii) support agricultural modernisation, industrialisation, natural resource development, particularly oil and gas, and
(iii) pursue an employment-led economic growth strategy by linking agriculture to industry, particularly manufacturing.

The fulfilment of the aforementioned socio-economic aspirations coupled with the average annual population growth rate of 2.1–2.5% requires a stable, relatively affordable and cost-competitive sustainable energy supply. These factors, in the light of the medium-term energy sector policy goals, would define the drivers and establish the scope of this energy planning study.

1.3 Demographic Outlook

The population of the country in the future and its structure are expected to have an impact on the future demand for energy despite the implementation of energy efficiency programmes to reduce energy use intensity.

1.3.1 Population Projections

According to the Population and Housing Census carried out in 2010, the total population for the year 2010 was estimated to be about 24.7 million. According to the Medium-term National Development Policy Framework; Ghana Shared Growth and Development Agenda, GSGDA (2010 – 2013), the country's population growth rate would averagely decline to not more than 2.2% per annum between 2010 and 2020 in order to achieve the government's projected per capita target of US$ 3,000 by 2020[8].

The population for the BaU scenario is projected to increase from 24.7 million in 2010 to 30.9 million in 2020 at an average annual rate of 2.1%. On the other hand, the Medium-Term National Development Policy Framework; Ghana Shared Growth and Development Agenda, (2010 – 2013) and (2014 – 2017) projected an average annual growth rate of 2.2%. The population is estimated to further increase to 38.0 million by 2030, with an overall average annual rate of 2.17%. In the case of the AEG scenario, the population would increase from 24.7 million in 2010 to 37.4 million in 2030 at an average annual rate of 2.09%, which would be in line with the Government population policy aimed at decreasing the population growth rate to 1.5% by 2020[9].

Figure 3.6 shows the trend in the country's total population from 2000 - 2010 with respect to the actual population and the two demographic projections from 2010 to 2030.

[8.] National Development Planning Commission: "Medium-Term National Development Policy Framework: Ghana Shared Growth and Development Agenda, 2010 - 2013". Volume 1.

[9] National Population Council: "National Population Policy – (Revised Edition)", 1994

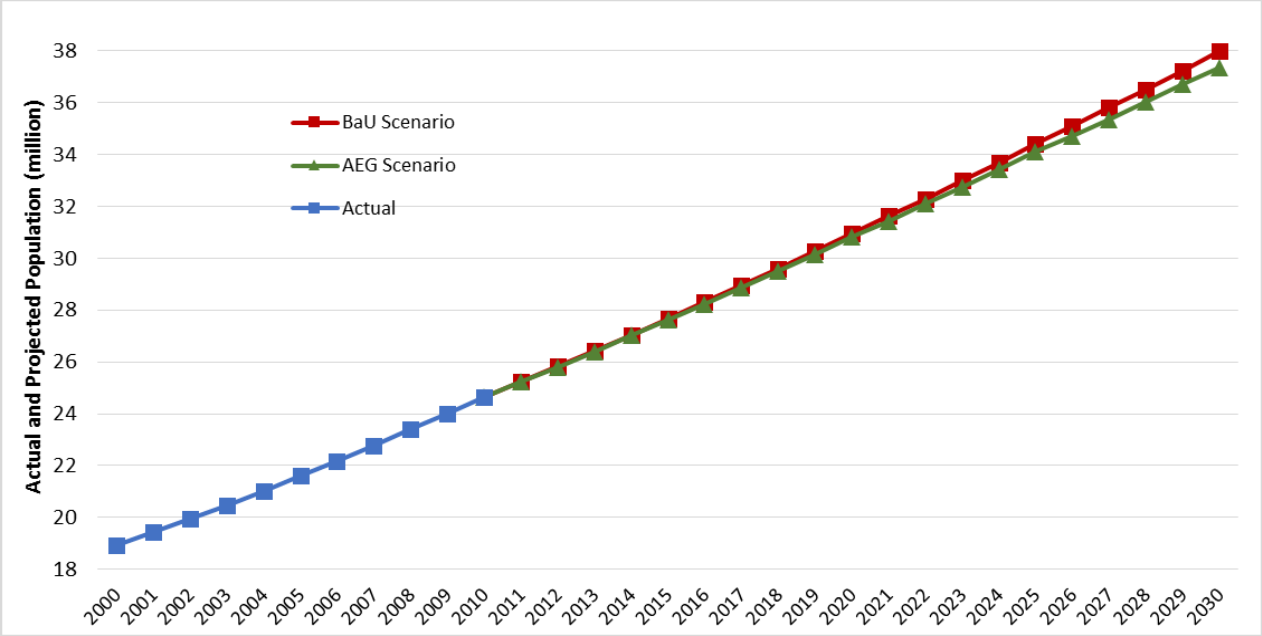


Figure 1.1: Ghana's Population Outlook up to 2030

1.3.2 Outlook of Structure of the Population

The structure of the country's total population has been shifting from a dominant rural share in the past towards an increasing urban share. The total urban population in 2010 accounted for 50.8%[10] of the total population compared to 43.8%[11] in 2000. The average annual inter-censual urban population growth rate was 4.2% compared to an average annual growth rate of 2.7% for the entire population. The share of the total urban population is projected to be 65.0% of the total population for the BaU scenario in 2030 based on the historical trend. The change in the structure of the population between 2010 and 2030 according to the BaU scenario is shown in Figure 3.7.

[10.] Ghana Statistical Service: "Ghana – 2010 Population and Housing Census", National Analytical Report, May 2013
[11.] Ghana Statistical Service: "Ghana – Population and Housing Census 2000".

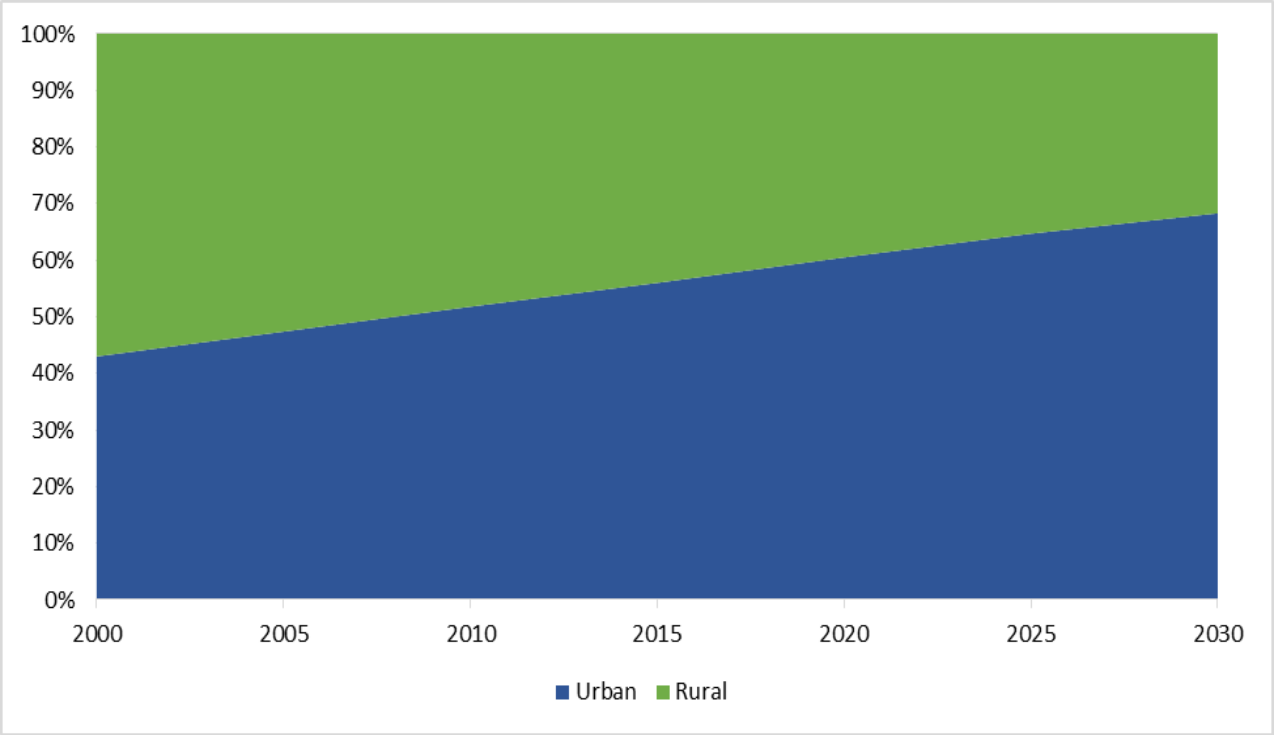


Figure 1.2: Share of Population Structure between 2010 and 2030 under the BaU Scenario

In the case of the AEG scenario, the share of the urban population was projected to be about 66% in 2030.

1.3.3 Growth in the Total Number of Households

The total number of households in the country increased from 3.7 million in 2000 at an average annual growth rate of 4.2% to 5.6 million in 2010. The high growth rate in household formation was due to the high urbanisation rate and the decrease in the average household size from 5.1 in 2000 to 4.4 in 2010. A further increase in the share of urban population in the future is projected to reduce the average household size.

The projected household size based on the historical trend is projected to reduce to 3.94 for the BaU scenario in 2030. Hence, the number of households was projected to increase from 5.6 million in 2010 to 9.65 million in 2030. In the case of the AEG scenario, the higher urbanisation rate would further reduce the average household size to 3.84 by 2030. Consequently, the total number of households was projected to be 9.73 million in 2030 for the AEG scenario.

1.4 Macro-economic Outlook

A number of empirical studies have established a strong correlation between some economic variables and energy demand. As an example, the total GDP in the future and the changes in the structure of the GDP would have varied impacts on the future demand for energy.

1.4.1 Economic Output and Growth Projections

The GDP projections used for this study is based on 2006 series. This has been the base year for GDP analyses in the country from 2010 until 2018 when the economy was rebased using 2013 as base year.[12]

Regarding the economic performance in the past, the total GDP (in current prices) increased at an average annual rate of 13.2% from US$ 20.33 billion (current prices) in 2006 to US$ 48.65 billion[13] (current prices) in 2013. As a result of the challenges experienced by the economy, the total GDP dropped from US$ 48.65 billion in 2013 to US$ 42.68 billion in 2016.

The BaU scenario was based on using the average GDP growth rate of 7.1% from 2010 to 2016 to evaluate the total GDP from 2016 to 2030. The total GDP for the BaU scenario would increase from US$ 32.19 billion (in current prices) in 2010 at an average annual rate of 7.1% to US$ 126.9 billion (current prices) in 2030.

The AEG scenario tried to capture a perspective of the Government's policy to reduce the population growth rate to lower than 2.2% per annum whilst sustaining economic growth rate above 8.0% to achieve a per capita GDP of at least US$ 3,000 in 2020[14]. The GDP is then projected to increase at an average annual rate of 8.3% to US$ 158.6 billion (current prices) in 2030. Therefore, the average annual GDP growth rate from 2010 to 2030 is 8.3%.

1.4.2 Structural Transformation of the Economy

The economy experienced a marginal structural transformation from 2006 to 2016. The Services sector in 2016 accounted for the largest share of 54.4% of the total GDP formation compared to 48.8% in 2006. The share of industry in the total GDP accounted for 25.3% in 2016 compared to 20.8% in 2006 whilst that of agriculture was 20.3% in 2016 compared to 30.4% in 2006. The significant structural changes in the economy include the production of crude oil and natural gas from the Jubilee Fields,

[12] The current 2013 base year was not used because the analyses in the document were completed before the rebasing was done. As such all GDP figures are in the 2006 base year series.
[13.] Ghana Statistical Service: "Revised 2016 Annual Gross Domestic Product", April 2016 Edition
[14] National Development Planning Commission in the Medium-Term National Development Policy Framework: Ghana Shared Growth and Development Agenda, 2010 – 2013

which accounted for the increased industry share despite the drastic decline in the share of manufacturing output from 10.2% in 2006 to 4.8% in 2016.

According to the BaU scenario, the country's economy would not experience any significant structural change. The service sector would continue to be the dominant sector in the economy. The industry sector share of GDP is projected to increase from 25.3% in 2016 to 30.1% in 2030. In the case of the agricultural sector, its share in the total GDP would further decrease from 20.3% in 2016 to about 18.9% in 2030. The projected changes in the structure of the GDP would significantly influence the demand for energy in the future for the BaU scenario. In the case of the AEG scenario, the Services sector's share of the GDP is projected to increase to 52.2% in 2030 whilst that of the industrial sector is projected to increase to 30.6%. The share of the agricultural sector is projected to decrease to 17.2% in 2030. However, the increased mechanisation in the agricultural sector is projected to increase the sector's productivity.

As part of the AEG agenda, the government's long-term strategy is to address the country's infrastructural deficit and thereby sustain a high economic growth rate. The government would develop the country's oil and gas industry to promote downstream salt-based and petrochemical industries. The government also seeks to develop an integrated aluminium industry and promote agro-based industries to link the agricultural and manufacturing sectors of the economy.

1.4.3 Income per Capita Outlook

The country's income per capita increased from US$ 929 in 2006 at an average annual growth rate of 10.4% to US$ 1,841 in 2013 but decreased to US$ 1,508 in 2016. The government's objective is to maintain a high steady economic growth rate to ensure an infrastructural and socio-economic transformation in the long term. This plan is to move the economy from a lower middle income into a higher middle-income status with a per capita income of US$ 3,000[15] by 2020.

The per capita income for the BaU scenario is projected to increase to US$ 3,341 in 2030. The AEG scenario is based on a per capita income target of US$ 3000 in 2020. The per capita income is further projected to increase to US$ 4,243 in 2030. These projected per capita income levels would influence personal income levels, changes in lifestyle, ownership of electrical appliances and energy demand.

1.4.4 Appliance Ownership Outlook

Empirical studies show that disposable income correlates positively with ownership and usage of energy-use devices such as vehicles and electrical appliances (e.g. refrigerators, air conditioners, washing machines, blenders, televisions, etc.). In 1991/92, the percentage of households owning

[15.] National Development Planning Commission: "Medium-Term National Development Policy Framework: Ghana Shared Growth and Development Agenda, 2010 - 2013". Volume 1, December 2010

refrigerators was 8.2% of the total number of households[16]. However, when the mean annual household expenditure increased to GHS 424.4 and GHS 1,918.0 in 1998/99 and 2005/06 respectively, the percentage of households owning refrigerators also rose to 16.6%[17] and 21.0%[18] of the total number of households respectively. Share of households owning refrigerators increased to 33.1% when the mean annual household expenditure rose to GHS 9,313 in 2012/13 as stated in Ghana Living Standards Survey – Round 6.

Table 3.7 shows the ownership of refrigerators and freezers in 1999[24], 2006[25]and 2013[19]. A trend-line was used to evaluate the share of refrigerators and freezers for the other years of the BaU scenario.

Table 1.1: Actual and Projected Household Ownership of Refrigerators and Freezers for BaU Scenario

	1999	2000	2006	2010	2015	2020	2025	2030
	Actual and Projected Penetration of Refrigerators							
Metro Urban	4.06	41.6	49.3	56.2	57.9	60.7	63.9	68.7
Other Urban	26.5	27.1	32.8	38.2	45.3	54	63.8	72.7
Coastal Rural	8.6	8.5	9.8	12.6	13.7	15.4	17.5	20.5
Forest Rural	8	7.6	8.7	12.5	15.7	19.6	24.4	30.5
Savannah Rural	1.1	1.3	3	4.8	5.8	7.3	8.8	11.4
	Actual and Projected Penetration of Freezers							
Metro Urban	11.7	12	13.7	14.6	15.8	17.2	18.8	20.6
Other Urban	5.9	6.1	7.1	7.8	8.2	8.8	9.5	10.2
Coastal Rural	2.1	2.2	2.9	3.4	3.9	4.5	5.1	5.6
Forest Rural	1.5	1.6	2.3	2.8	3.1	3.6	4.1	4.9
Savannah Rural	0.9	0.9	1	1.1	1.4	1.7	2.1	2.5

Source: Historical values from Ghana Statistical Service, Ghana Living Standard Survey (GLSS) 1-6. Projected values form Energy Commission

Table 3.7 shows that an increase in the household ownership of refrigerators and freezers would continue in all localities in the country up to 2030 due to increase in household disposable income.

1.5 Government Policies and Programmes

The principal goal of the government's medium-term development policy, as expounded by the Ghana Shared Growth Development Agenda, Medium-Term National Development Policy Framework (2018-2021) and The Coordinated Programme for Economic and Social Development Policies (2017-

16. Ghana Statistical Service: "Ghana - Ghana Living Standards Survey, Report on the Third Round", March 1995
17. Ghana Statistical Service: "Ghana - Ghana Living Standards Survey, Report on the Fourth Round", October 2000
18. Ghana Statistical Service: "Ghana - Ghana Living Standards Survey Fifth round" September 2008
19 Ghana Statistical Service: Ghana Living Standards Survey (2012/2013) – Round 6, August 2014

2024). These are to accelerate job creation and income generation, thus reducing poverty and enhancing shared growth. The medium-term development policy hinges on the following themes:

(i) ensuring and sustaining macroeconomic stability;
(ii) enhancing the competitiveness of the country's private sector;
(iii) accelerating the modernisation of the country's agriculture sector; and
(iv) developing the infrastructure and energy sector, including the oil and gas sub-sectors.

The detailed development objectives of these themes set out the framework for the country's socio-economic outlook and energy policy.

The major objectives of the Government's policy for the energy sector are spelt out in the National Energy Policy 2010 document. The highlights of these objectives are:

(i) increasing access to affordable cleaner energy services;
(ii) promoting efficient energy use in all the sectors of the economy;
(iii) stimulating productive use of energy and economic development; and
(iv) ensuring energy supply security through diversity[20].

In the process of updating the SNEP I, the energy demand projections and supply analysis took into account energy-related initiatives, policies and programmes, that already existed and those yet to be implemented.

Recently government has updated the policy to include accelerated industrial growth under the one district one factory policy. The industry is further being strengthened under the integrated Aluminium project. Agriculture is also receiving a boost under the planting for food and jobs policy. These policy initiatives will require high amounts of energy, particularly electricity, to be realised.

1.5.1 Increase Access to Modern Forms of Energy

In the light of expanding infrastructure and increasing access to cleaner forms of energy, the government in the late 1980s initiated the National Electrification Scheme, the LPG promotion programme and reforms in the electricity and downstream petroleum sectors.

[20.] Ministry of Energy and Petroleum: "National Energy Policy (Revised)", June 2009

National Electrification Scheme

The National Electrification Scheme (i.e. NES) was initiated in 1989 as the Government's principal platform to achieve an overall policy goal of electrifying the whole country by extending the national electricity grid to all parts of the country over a 30-year period (i.e. from 1990 to 2020).

At the commencement of the NES, only 480 towns in the country were connected to the national grid. The number of households connected to the national grid increased from 28.5% of the 3.32 million households in 1991 to 43.8% of the 3.71 million households in 2000. In 2010, 64.2% of 5.60 million households in the country were connected to the national grid. The rate in 2018 was 84.3%. The government's target, however, is to ensure universal access by 2020.

National LPG Promotion Programme

The government launched a National LPG Promotion Programme in 1989 to achieve the policy objective of promoting the use of LPG as a clean cooking fuel alternative to charcoal and firewood. The policy strategy was to utilise the LPG from the refinery and in so doing arrest the rapid rate of charcoal and firewood use, which was contributing to deforestation. Although the programme was interrupted in 1995, the number of households using LPG as the main source of cooking fuel increased from 2.2% of the 3.3 million households in 1991 to 6.1% of the 3.71 million households in 2000 and then to 18.2% of the 5.6 million households in 2010 [21] [22] [23]. In 2009, the government re-launched the promotion of LPG as cooking fuel.

Following a series of fatal gas explosions in some parts of the country, the Ministry of Energy and the National Petroleum Authority rolled out the Cylinder recirculation model in 2017. The cylinder recirculation model under the National Liquefied Petroleum Gas (LPG) Promotion Policy will help in minimising and possibly eliminating gas explosions in the country. Ghana Cylinder Manufacturing Company is expected to produce 37,000 cylinders needed for the pilot project, in Obuasi in the Ashanti Region and Kwaebibirim in the Eastern Region in 2019. In accordance with this, NPA came up with a new license which will be added to the existing one which is the cylinder bottling plant license. This initiative aims to achieve a target of 50% of households in the country using LPG as the main cooking fuel by 2030.

However, the share of households under BaU scenario using LPG as the main cooking fuel would not achieve the Government's target of 50% of households by 2030.

21. Ghana Statistical Service: "Ghana - Ghana Living Standards Survey 3 -1991, Third round".
22. Ghana Statistical Service: "Ghana – Population Data Analysis Report" Volume 1, August 2005
23. Ghana Statistical Service: "Ghana – 2010 Population and Housing Census", National Analytical Report, May 2013

1.5.2 Promoting Efficient Use of Energy in all Sectors

The government additionally has adopted a policy to promote the efficient use of energy in all sectors of the economy. The policy strategies include the adoption of energy-efficient technologies such as LED bulbs, refrigerating appliances, improved cook-stoves and energy-efficient transport systems[24]. The government has also enacted legislation to prohibit the importation of inefficient energy appliances such as incandescent lamps and used electrical appliances such as refrigerating appliances and room air conditioners.

1.5.2.1 Efficient Electric Motors and Drives

Electric motors are used in refrigerators, vacuum cleaners, air conditioners, fans, computer hard drives, automatic car windows, and multitudes of other appliances and devices to convert electrical energy into useful mechanical energy. Studies show that electric motors consume as much as 40-70 percent of manufacturing sub-sector electricity required.

The Energy Foundation, in 1999, undertook a feasibility study into the establishment of motor repair and sales centres to serve as outlets for energy-efficient motors and drives in the country. The study indicated that repeated motor refurbishments lead to efficiency losses. It, therefore, proposed the establishment of private motor centres in the country. The Centre will sell energy-efficient motors and provide motor advisory and repair services as well. Refurbishing electric drives and motors of capacity less than 1HP results in a higher efficiency loss compared to that of higher motor capacities. Coupled with the higher refurbishment cost (for capacities less than 1HP, refurbishment cost is about 60% cost of new purchase), it was recommended that electric motor less than 1HP should not be refurbished.

1.5.2.2 Efficient Lighting Devices

In 1999, the Energy Foundation undertook a survey, which indicated that incandescent lamps accounted for about 79% and 51% respectively of the interior and exterior lighting loads in the country. The survey results showed that Compact Fluorescent Lamps (CFL), which use about 20 - 30% of the energy used by incandescent lamps and may last 6 to 10 times longer, accounted for just 1% and 0% of interior and exterior lighting loads[25] respectively in 1999. The survey and the corresponding findings were necessary, especially as household lighting load accounts for a large proportion of the

[24] Bus Rapid Transit system

25. Sachu Constantine, et. al. "Ghana Residential Energy Use and Appliance Ownership Survey: Final Report on the Potential Impact of Appliance Performance Standards in Ghana", March 1999

peak power demand in the country. In the year 2000, lighting loads alone accounted for between 60% and 65% of the total household electricity use[26].

The government implemented a National CFL Exchange Programme in 2007 in an effort to mitigate electricity supply deficit due to generation shortfall from the Akosombo and Kpong Hydropower Generating Stations. The objective of the programme was to reduce the peak demand by replacing 6.0 million incandescent lamps in households and some selected government institutions with CFLs at no cost to the beneficiaries. As part of the programme, the government enacted a Legislative Instrument (L.I 1932[27]) in 2008 to prohibit the importation, manufacture and sale of incandescent lamps and implemented an Energy Efficiency Standards and Labelling scheme for CFLs with a long term goal of promoting the use of efficient bulbs.

The penetration of CFLs in households increased from 20% in 2007 to 79% in 2009[35] as a result of the programme. Household penetration of CFLs increased from 85% in 2010 to almost 100% in 2016 as a result of the importation ban as mentioned above. The penetration of Light Emitting Diodes (LEDs) lamps, which consume about 40 – 60% less energy compared to CFLs in households, is relatively lower. In an effort to promote the use of LED lamps, the government waived import duty and VAT on the importation of LED lamps into the country in 2011. Minimum Performance Standards were developed to ensure the safe and efficient use of LED lamps in the country. The use of LED lamps is projected to increase consequently, decreasing the household lighting load. It is expected that the penetration of LED lamps for the BaU scenario would increase to 13% and 2% in 2030 in the urban and rural localities respectively unless government takes other special initiatives to promote mass adoption of LED bulbs in the country.

1.5.2.3 Refrigerator Turn-in and Rebate Scheme

In 2006, the Institute of Industrial Research (IIR) of the Council for Scientific and Industrial Research (CSIR) undertook a study on the use of refrigerating appliances in the country on behalf of the Energy Commission. The study results indicated that refrigerating appliances being used in the country consumed on the average 1,200 kWh per unit per annum, which is about three times the world average of less than 500 kWh per unit per annum. Furthermore, other studies have also demonstrated that there is a higher than normal refrigerating energy consumption in the country as a result of the fact that a large number of the refrigerating appliances imported and sold in the country were not manufactured for tropical climates.

26. Energy Commission of Ghana. "Report: Evaluation of the Government of Ghana CFLs Programme", September 2009.

[27] Energy Efficiency (prohibition if manufacture, sale or importation of incandescent filament, used refrigerators, used refrigerator-freezer, used freezer and used air-conditioner) Regulations, 2008

Current energy-efficient refrigerators generally use, for example, 40% less energy than the conventional models in 2001[28]. It has been estimated that there were 1.67 million inefficient conventional refrigerating appliances in the country in 2010, which increased to about 2 million[29] in 2012. The total energy used by these refrigerating appliances could have been 40% less if all these appliances were replaced with efficient ones. Thus, in September 2012, the government launched the Refrigerator turn-in and Rebate Scheme to promote the use of efficient refrigerating appliances and transform the refrigerating appliance market in the country. The scheme was expected to replace about 50,000 inefficient refrigerating appliances with more efficient and environmentally friendly ones over a three-year project period.

The implementation of the scheme was expected to lead to an estimated annual electricity savings of 8 GWh[38]. However, at the end of the project, only 10,000 inefficient refrigerators have been turned in[38]. In order to ensure the effectiveness of promoting the use of efficient refrigerating appliances, the government enacted a Legislative Instrument, LI 1932 in 2008 to ban the importation of used refrigerating appliances and a Legislative Instrument, LI 1958 (Energy Efficiency Standards and Labelling – Household Refrigerating Appliances (Amendment Regulations)) in 2009 to prevent the importation and use of new appliances which do not meet minimum standards.

1.5.2.4 Dissemination of Improved Cook-stoves

In 1999, about 30.6% (1.29 million) households were using charcoal as their main fuel for cooking[30], which increased to 1.69 million (30.6% of households) in 2006[31]. In 2010, about 1.92 million or 31.0% of the households used charcoal as their main cooking fuel[32] compared to 2.10 million or 31.5% of the households in 2013[33]. Despite the increasing charcoal use, there still exist strong imbalances in the urban and rural communities. Whilst 43.6% of urban households used charcoal as the main cooking fuel in 2012/13, only 16.5% of the rural households used charcoal. The use of charcoal would, however, increase in the medium term but would start decreasing in the long term due to the shift towards LPG use.

In the case of firewood use, about 2.6 million or 62.5% of households used firewood as their main fuel for cooking in 1999. This number increased to 2.96 million or 53.5% of households in 2006. The number of households using firewood as the main fuel for cooking, however, decreased to 2.73 million or 41.3% in 2013. Despite the decrease in the use of firewood, there still exist large disparities between urban and rural households. Whilst only 14.3% of urban households used firewood as the main cooking fuel in 2012/13, 74.8% of rural households used firewood. Although the total number of

[28] Energy Commission: "Refrigerator Rebate Scheme Project", 2016 First Quarter Report
[29] Number of Household using Refrigerating Appliances were estimated from GLSS 4, 5 and 6 Report
[30] Ghana Statistical Service: "Ghana - Ghana Living Standards Survey, Report on the Fourth Round", October 2000
[31] Ghana Statistical Service: "Ghana - Ghana Living Standards Survey Fifth round" September 2008
[32] Ghana Statistical Service: "Ghana – 2010 Population and Housing Census", National Analytical Report, May 2013
[33] Ghana Statistical Service: Ghana Living Standards Survey (2012/2013) – Round 6, August 2014

households using firewood is generally decreasing, the decrease would be gradual unless measures are taken to reduce its dependency.

It is estimated that about 700,000 improved charcoal stoves have been sold in the country between 2002 and 2011. Furthermore, government plans to disseminate about 2.0 million improved charcoal and firewood stoves[34].

1.5.2.5 Bus Rapid Transit System

In the medium-term policy framework, the Ghana Shared Growth and Development Agenda, the government expressed its intention to implement a low energy intensity Bus Rapid Transit (BRT) system. The BRT system is a part of the Ghana Urban Transport Projects and a strategy to fulfil the policy that 80% of all trips in urban localities in the country should be done through public mass transit systems. The Bus Rapid Transit System is a least-cost option to provide an efficient and affordable bus transit system and would be piloted in the country's two largest cities – Accra and Kumasi. It has been assumed that the BRT system is projected to account for 15% of urban passenger traffic in 2030 for the BaU scenario and 10% of urban passenger traffic for the AEG scenario.

1.5.3 Productive Uses of Energy

The share of electricity used in the productive sectors of the economy decreased from 62% in 2000 to about 33% in 2010[35]. The drastic decrease was due to the suspension of the aluminium smelter's operation in 2010. In 2010, the aluminium smelter accounted for 0.08% of the total electricity used compared to 36% in 2000.

Non-farm household enterprises also play an important role in the economy of the country. They are businesses that are not related to agriculture and take place at the household level. In 1998/99, about 1.9 million households or 49.0% of the total number of households in the country operated non-farm enterprises of one sort or another[36]. In 2005/06, the number of households that operated non-farm enterprises increased to 3.2 million or 46.4% of the total number of households in the country, of which 48.0% were in rural communities. According to GLSS 5, about 76% of the rural household enterprises are manufacturing and every four in five trading business in the rural areas are operated by women. In 2012/13, approximately 3.7 million households, representing 44.3% of households in the country operated non-farm enterprises[37]. About 50.3% of these non-farm enterprises are in urban areas, while a little over one-third (36.8%) are in rural localities.

[34] Energy Commission of Ghana. "Sustainable Energy for All Action Plan - Ghana", June 2012
[35] Energy Commission of Ghana "National Energy Statistics 2000 - 2013", April 2014
[36] Ghana Statistical Service: "Ghana - Ghana Living Standards Survey, Report on the Fourth Round", October 2000
[37] Ghana Statistical Service: Ghana Living Standards Survey (2012/2013) – Round 6, August 2014

The non-farm enterprises are engaged in mainly trading and manufacturing activities, which require various forms of energy. Non-farm businesses such as trading depend on the use of electricity for lighting and operating musical and other instruments. Non-farm enterprises engaged in manufacturing activities use energy in the form of electricity for lighting and LPG, charcoal or firewood for heating. These non-farm enterprises would form the basis of SMEs and play a significant role in the country's socio-economic development.

1.6 Organization of the SNEP

The SNEP study is reported in three volumes as follows:

(i) Volume One presents the energy demand projections and analysis;
(ii) Volume Two presents an assessment of the country's energy resources and the energy supply strategies developed to meet future demand; and
(iii) Volume Three presents the recommended national energy policies.

The contents of Volume One of the SNEP are structured as follows; the assessment of the SNEP (2006 - 2020) final energy demand projections and the actual energy consumption from 2006 to 2018 is presented in Chapter Two. The results of the energy demand projections for the different sectors of the economy (households, commercial and service, industry, agriculture and transport) are presented in Chapter Three whiles, Chapter Four presents it by fuel types. The conclusions and recommendations are subsequently presented in Chapter Five.

1.7 The Role of Stakeholders

As the effective participation of stakeholders is essential to this energy planning process, a series of stakeholder consultations were undertaken to provide the platform for stakeholders to collaborate, share information as well as contribute to the process by providing comments and reviews. The Energy Commission, therefore, invited several stakeholders including representatives from industries, government and non-governmental organisations as well as academia to comment on assumptions, preliminary analysis and results, and identify the key issues affecting the sectors. The key issues and recommendations provided by the stakeholders are presented in Annex 10.

1.8 Energy Planning Methodology

The base year for this planning study is 2010. The choice of 2010 was dictated by the fact that it was a normal year without any severe energy supply constraints. Furthermore, the Ghana Statistical Service conducted the 2010 Population and Housing Census, which provided a large amount of useful demographic data.

The Energy Commission also undertook a National Energy Use Survey in 2010 to collate useful information on energy use patterns and intensities in the household, service, and industry sectors. The Ghana Statistical Service also conducted the Ghana Living Standard Survey (GLSS) Round 6 and 7 in 2013 and 2017, respectively. All these information sources served as vital inputs for the energy planning study.

Historical annual data on energy supply (i.e. crude oil, natural gas, electricity and oil products) were obtained from the Energy Commission's National Energy Statistical Bulletin. Detailed electricity consumption data for Special Load Tariff (SLT) and non-residential SLT customers for 2010 were obtained from the Electricity Company of Ghana and Northern Electricity Distribution Company.

Information on the annual production output, energy use patterns of companies in the mining sector and growth rates of mineral production were obtained from the Ghana Chamber of Mines and the Minerals Commission. Information on future cement and steel production were based on inputs from the Association of Ghana Industries (AGI) and projections by the Business Monitor International (BMI)[38].

The base year data for road passenger and freight vehicle population in the country was obtained from the Drivers and Vehicle Licensing Authority (DVLA).

The simulating tool used for the energy planning study is the Long-Range Energy Alternatives Planning (LEAP) which was also used in SNEP I. The LEAP, developed by Stockholm Environmental Institute-Boston, is a medium to long-term scenario-based planning model. The model was used to simulate the plausible demand scenarios to:

(i) determine the country's future energy demand profiles,
(ii) analyse the energy supply strategies over the planning period, and
(iii) evaluate the impact of energy policies.

Calculations were carried out on an annual time-step basis, i.e. using a time interval of one year. Nonetheless, the duration could be extended for an unlimited number of years. Studies typically include historical period known as the *Current Accounts or base year,* which was 2010 for this study. The model was run to test its ability to replicate known statistical data for the base year and also to evaluate demand and supply data for multiple future scenarios. A forecast period from 2020 to 2030 was used for this study.

The LEAP model comprised three key modules, which are:

(i) demand,
(ii) transformation, and
(iii) resources.

[38] www.bmiresearch.com

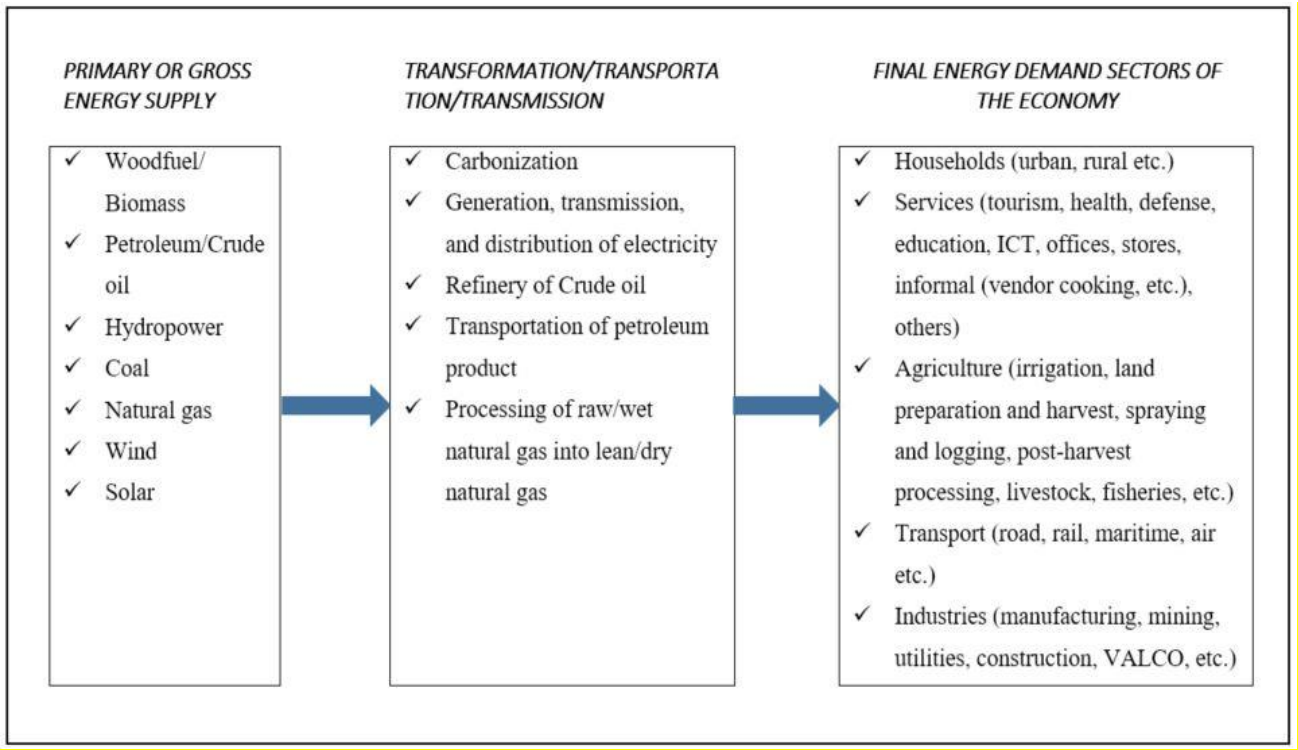


Figure 1.3: Energy Supply – Consumption Continuum

Final Energy Demand can be defined as Primary energy supplied minus transformation and transmission (transportation) losses. It is, therefore, the net or actual energy needed by the Demand Sectors.

Each module in the LEAP model requires inputs to produce results, which also served as further input to other modules. Outputs of the various modules served as final results and/or inputs for other modules.

The demand module was used to evaluate the energy demand for the various sectors of the economy (e.g. household, industry, etc.). A tree-structure to represent end-uses (e.g. cooking, lighting, etc.) under each sector and the technology options for each end-use was developed. Detailed information on the activity variables (e.g. rate of household formation, changes in the structure of the population, industrial output, penetration of electrical appliances etc.) and changes in energy intensities of the technology options under each end-use (e.g. kWh per tonne of steel produced, litres of gasoline per passenger-kilometres) that drive energy demand are fed into the LEAP model. The model evaluates the energy demand profiles for a Business-as-Usual (BaU) scenario and an alternative scenario for different policy options. The bottom-up approach is used for this study.

The primary inputs into the transformation module are techno-economic data for all energy supply technologies, which must come online to supply energy over the planning period. This module employs a simulation technique to analyse the energy supply strategies (e.g. electricity generation and

capacity expansion options, oil refinery production and capacity expansion options, charcoal production options, etc.), which are developed to meet the projected energy demand.

Finally, the resource module evaluates and tracks the primary energy resources required to fuel the activities captured in the demand module. It also evaluates primary energy production, sufficiency, imports and exports. The LEAP model is also used to evaluate the environmental loadings (e.g. GHG or pollutant emissions of all the technology options captured in the demand module as well as fuels in the transformation module), and cost-benefit analyses (based on the social cost of resources).

The planning tool used for electricity supply strategies is the Integrated Planning Model (IPM). IPM provides true integration of wholesale power, system reliability, environmental constraints, fuel choice, transmission, capacity expansion, and all key operational elements of generators on the power grid in a linear optimization framework. The IPM was used for the capacity planning and analysis of the implications of alternative strategies/policies by determining the least-cost method of meeting energy and peak demand requirements over the specified period.

1.9 Descriptions of Scenarios

The study developed possible scenarios based on the evolution of sectoral activity variables (e.g. number of households etc.), penetration of energy-use technologies (e.g. air conditioning equipment) and implementation of Government policies (e.g. promotion of energy efficiency, special stimulus packages such as one district one factory policy, planting for food and jobs, etc) over a ten-year period from 2020 to 2030, which are used as the framework for the country's energy future. The study developed the following two scenarios:

(i) Business-as-Usual (BaU) scenario, and
(ii) Accelerated Economic Growth (AEG) scenario.

The BaU scenario is based on the average and current performance of the economy whilst the AEG scenario takes into consideration the objectives of the Ghana Shared Growth and Development Agenda, actions already taken and those planned or proposed to be taken by the government such as "one district-one factory" to achieve a relatively higher economic growth. As such, the AEG scenario is based on the Government's long-term population policy objective of annual population growth rate of 2.2% by 2020 and a per capita income of about US$ 3,000 in 2020. A brief overview of the two scenarios is presented in Table 1.1

Table 1.2: Overview of the Scenarios for Strategic National Energy Plan Update

Scenario Name	Description of scenario	2030
Business-as-Usual	Population growth rate follows historical trend	38.0 million *AGR of 2.2%
	GDP growth rate follows historical trend	US$ 126.9 billion *AGR of 7.1%
Accelerated Economic Growth	Population growth rate of 2.1% to 2030	37.4 million *AGR of 2.1%
	Average GDP growth rate of 8.3% to 2030	US$ 158.6 billion *AGR of 8.3%

* Average growth rate (AGR) from 2010 to 2030

1.9.1 Business-as-Usual (BaU) Scenario

The BaU scenario describes a socio-economic outlook based on trends from the historical past and spans up to the year 2030. The population is projected to increase from 24.7 million in 2010 to 38 million in 2030 at an average annual growth rate of 2.17%[39].

The total GDP is projected to increase from US$ 32.2 billion (in current prices) in 2010 at an average annual rate of 7.1% to US$ 126.9 billion (current prices) in 2030[40]. The estimated per capita GDP is projected to be US$ 3,341 in 2030.

1.9.2 Accelerated Economic Growth (AEG) Scenario

The AEG scenario considers the objectives of the Ghana Shared Growth and Development Agenda and The Coordinated Programme for Economic and Social Development Policies (2017-2024), actions already taken and those planned or proposed to be taken by the government such as the "one-district one-factory" initiative. The Ghana Statistics Service (GSS) further projects the population to increase from 24.7 million in 2010 at an average annual rate of 2.09% to 37.4 million in 2030.

Therefore, the total GDP is estimated to increase from US$ 32.2 billion (current prices) in 2010 at an average annual rate of 8.3% to US$ 158.6 billion (current prices) in 2030 with a corresponding GDP per capita of US$ 4,243.

[39] Ghana Statistical Service, 2010 Population & Housing Census Report-Population Projections/Prospects, October 2014. National Development Planning Commission in the Medium-Term National Development Policy Framework: Ghana Shared Growth and Development Agenda, 2010 – 2013 however projects a growth rate of 2.2%

[40] The average annual growth rate of 7.1% from 2010 to 2030 for the BaU scenario is inline with the average annual growth rate 7.4% (with oil) and 5.6% (without oil) from 2017 to 2019 from Ministry of Finance (letter referenced MOF/RSD/ADMIN/O3/17 dated 20th April, 2017)

Chapter Two: Review of SNEP I

2.1 Overview of the SNEP I study

In undertaking the SNEP I, the year 2000 was chosen as the base year, the year 2006 as the reference year and 2020 as the end year. Three energy demand scenarios were developed and the LEAP model was used to simulate these scenarios to evaluate their energy demand implications from 2000 to 2020.

2.1.1 SNEP I Study Scenarios

The SNEP I study developed three demand scenarios, which captured the plausible economic, demographic and Government policy outlooks between the years 2000 and 2020. A brief description of these three scenarios is as follows:

(i) Business-as-Usual Economic Scenario

This was based on the following assumptions:

- The total number of households would increase from 3.70 million in 2000 at an average annual growth rate of 2.45% to 6.00 million households in 2020 and the share of urban households would increase from 47.4% in 2000 to 57.3% in 2020.
- The total GDP would increase from US$ 7.3 billion in 2000 at an average annual growth rate of 4.18% (which is the average growth rate of total GDP from the historical past, i.e. from 1990 to 2000) to US$ 17.0 billion in 2020.

(ii) High Economic Growth (HEG) Scenario

This scenario was based on the following assumptions:

- Total number of households and the share of urban households remain the same as that for the Business-as-Usual scenario.
- The total GDP would increase from US$ 7.3 billion in 2000 to US$ 39.4 billion by 2020 based on Government's socio-economic policy goal to achieve a real GDP per capita of US$ 1,000 by 2016 by promoting economic growth of above 8.8% per annum.

(iii) Moderately Economic Growth (MEG) Scenario

This scenario was based on the following assumptions:

- Total number of households and the share of urban households remain the same as that for the Business-as-Usual scenario.

- The total GDP would increase from US$ 7.3 billion in 2000 at an average annual rate of 6.3% to US$ 25 billion in 2020, which is the average between the High Economic Growth scenario and the BaU scenarios.

2.1.2 Government Policy Issues

The main Government policies that guided the energy demand projections during the SNEP 1 study were the restoration of operations of the Volta Aluminium Smelter (VALCO) and the National Electrification Scheme, which seeks to provide universal electricity access in the country by 2020. The following policy scenarios were considered for the operation of the aluminium smelter:

(i) The aluminium smelter would come online in 2006 with two pot-lines, which would then be increased to three pot-lines in 2007 and then to four pot-lines by 2008. The operation four pot-line in 2008 would be maintained until 2012 when the number of pot-lines would be increased to five until the year 2020 for the BaU scenario. For the other scenarios, it was assumed that the sixth pot-line would come online after 2012 and operate through 2020.

(ii) The second assumption was that the aluminium smelter would come online in 2006 and operate with only three pot-lines through to 2020.

2.1.3 Outturn of Key Energy Demand Drivers and Assumptions

This section presents some key drivers and assumptions that guided the results of the energy demand projections compared to the performance of these drivers and assumptions from 2000 to 2018.

Table 2.1: Outturn of Some Drivers for Energy Demand

Drivers for Energy Demand	2000	2006	2010	2018
Households (million)				
Projected number of households	*3.70*	*4.28*	*5.60*	*7.22*
Actual number of households	3.70	4.70	5.60	7.05
% Average GDP Growth Rate (Constant 1993 prices)				
Projected MEG	*6.3*			
Projected HEG	*8.8*			
Actual average GDP growth rate from 2000-2009	5.44			
% Average Sectoral Growth rates (Constant 1993 prices)				
Projected Service Growth rate- MEG	*7.58*			
Projected Service Growth Rate -HEG	*12.27*			
Actual Service growth rate from 2000-2009	6.45			
Projected Manufacturing growth rate -MEG	*6.75*			
Projected Manufacturing growth rate -HEG	*10.91*			
Actual Manufacturing growth rate from 2000-2009	3.05			
Number of vehicles	511,755	841,314	1,230,468	2,381,518
Diesel Vehicle population growth rate 2006-2018				9.00
Gaoline Vehicle population growth rate 2006-2018				8.90
Operation of aluminium smelter (number of potlines)				
Projected Operation of aluminium smelter-option 1	4 Potlines in 2000	*2 potlines in 2006*	*3 potlines in 2007 4 potlines in 2008-2012*	
Projected Operation of aluminium smelter-option 2		*3 potlines to come online in 2006 and maintained*		
Actual Operation of aluminium smelter		2 potlines in 2006	No operation from 2007 to 2010; 1 potline from 2011 to 2017	2 potlines in 2018
Energy Efficiency Programmes				
CFL Exchange programme	Was not considered for demand projections			
			CFL Exchange programme was initiated in 2007 leading to increased peneration of CFL bulbs	
Efficient Refrigerator Rebate Scheme	Was not considered for demand projections			
				Refrigerator rebate scheme initiated in 2012

Note: The average GDP growth rates from 2010 is based on 2006 rebase of the economy.

The number of households increased by about 90.5% from 3.70 million in 2000 to 7.05 million in 2018 as against the projected number of households of about 95.1% from 3.70 million in 2000 to 7.22 million in 2018, a decline of about 4.6% from the projected.

Average GDP growth rate (constant 1993 prices) was 5.4% in 2000-2009, a decrease from the projected growth rate of 6.3% and 8.8% respectively for MEG and HEG scenarios. Average GDP growth rates for the service sector was 6.5% in 2000-2009, which indicates a decrease from the projected rates of 7.6% and 12.3% respectively for the MEG and HEG scenarios. The manufacturing sector registered a GDP growth rate of 3.1% in 2000-2009, which is a sharp decline in comparison to projected rates of 6.8% and 10.9% respectively for the MEG and HEG scenarios.

The number of vehicles increased over 100% (365.4%) from 511,755 in 2000 to 2,381,518 in 2018. Diesel vehicles population grew at 9% in 2006-2018 while the gasoline growth rate was 8.9% within the same period.

The operation of the aluminium smelter was categorised into two options. For option 1, the smelter, operating on 4 potlines in 2000, was projected to reduce to 2 potlines in 2006 and increasing to 3 potlines in 2007 and back to 4 potlines in 2008-2012. Option 2 projected the smelter to operate on 3 potlines in 2006 and maintain this. In comparison, the actual operation of the smelter decreased from 4 potlines in 2000 to 2 potlines in 2006 as projected in Option 1. However, there was no operation in 2007-2010. It resumed operation in 2011 on 1 potline till 2018 when it increased to 2 potlines.

2.2 Energy Demand Projections from 2006 - 2018

This section presents the total final energy demand projections for the various sectors as well as for fuels from 2006 to 2018 for the MEG and HEG scenarios only. The BaU scenario was not reported because the average GDP growth rate at the time of publishing the SNEP report was higher than the 4.2%, which was used for the BaU projections.

2.2.1 Energy Demand per capita

The projected per capita final energy demand increased from 331 kgoe in 2006 to 355 kgoe in 2018 for the MEG scenario. In the case of the HEG scenario, it increased from 342 kgoe in 2006 to 430 kgoe in 2018. The actual energy consumption per capita, on the other hand, increased from 233 kgoe in 2006 to 253 kgoe in 2018. The lower actual per capita energy consumption compared to the projected per capita energy demand was mainly due to inadequate energy supply as a result of constraints such as shortfalls in electricity generation, fuel shift from woodfuel to LPG and from kerosene to electricity beyond what was anticipated in the demand projections.

2.2.2 Total Final Energy Demand

The results of the model for the Moderate Economic Growth scenario (MEGS) show that the final energy demand would increase from 7,333 ktoe in 2006 at an average annual rate of 3.0% to 10,504 ktoe in 2018. In the case of the High Economic Growth scenario, the results estimated that the final energy demand would increase at an average annual rate of 4.4% from 7,593 ktoe in 2006 to 12,730 ktoe in 2018. In the case of the actual final energy consumption, final total energy demand increased at an average annual rate of 3.1% from 5,165 ktoe in 2006 to 7,477 ktoe in 2018.

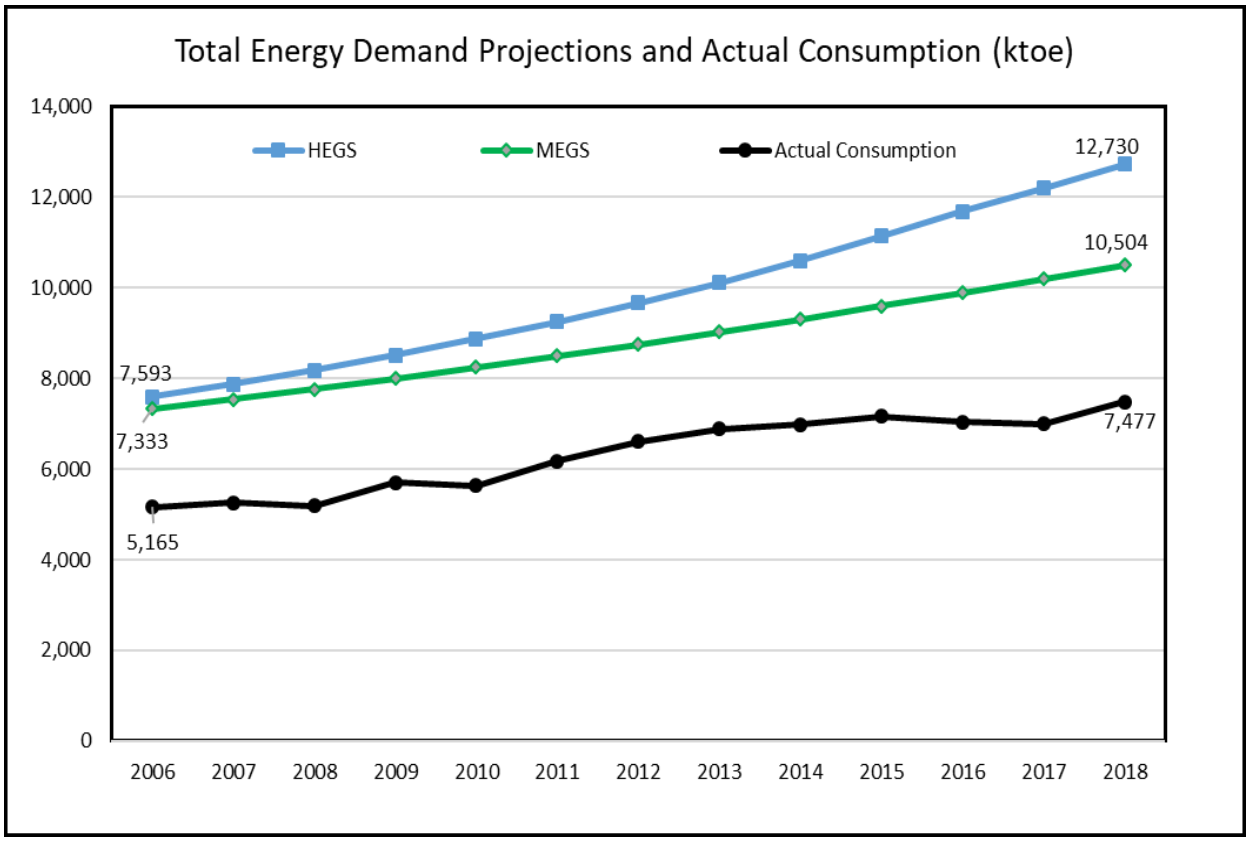


Figure 2.1: Projected Final Energy Demand compared to Actual Use from 2006 to 2018

Figure 2.1 shows that the actual final energy use from 2006 to 2018 was lower compared to the projected final energy demand for the MEG and HEG scenarios. This was attributed mainly to the following:

- VALCo's electricity consumption from 2006 to 2018 fell far short of the projected electricity demand for three potlines. VALCo operated on only one potline from 2011 to 2018

- The recorded relatively lower growth rate of woodfuel consumption compared to what was anticipated for the MEG and HEG scenarios was because of the significant increase in LPG usage (see Figure 2.9), which displaced part of the woodfuel used for cooking in households. For example, the total number of households using LPG as their main fuel for cooking increased at an average annual rate of 15.8% from 526,110 households (or 9.5% total number of households) in 2006[41] to 1,472,134 households (or 22.3% of the total number of households) in 2013[42].

41 Ghana Statistical Service: "Ghana - Ghana Living Standards Survey Fifth round" September 2008
42 Ghana Statistical Service: "Ghana Living Standards Survey (2012/2013) – Round 6", August 2014

- Drastic decrease in kerosene consumption beyond what was anticipated for MEG and HEG scenarios was due to a significant shift to the use of electricity (in line with NES) and battery-powered LED lamps for lighting in rural households, as grid electricity and alternative lighting devices became available.

- Electricity supply constraints that were experienced from 2012 to 2015 and relatively high electricity prices from 2015 to 2018.

2.3 Projections for the Energy Demand by Fuel (2006 - 2018)

The final energy demand in the country was met from electricity, wood-fuel (i.e. firewood and charcoal), and petroleum products (i.e. LPG, gasoline, diesel, kerosene, ATK, RFO and premix gasoline).

2.3.1 Electricity Demand from 2006 to 2018

The final electricity demand was projected to increase from 19,060 GWh in 2006 at an average annual rate of 3.0% to 27,249 GWh in 2018 for the MEG scenario. In the case of the HEG scenario, the total final electricity demand was also projected to increase from 19,960 GWh in 2006 at an average annual growth rate of 4.5% to 33,887 GWh in 2018. However, the actual total electricity used increased from 7,362 GWh at an average annual rate of 5.0 % to 13,185 GWh. Figure 2.2 shows the electricity demand projections for the MEG and HEG scenarios and the actual electricity consumption from 2006 to 2018.

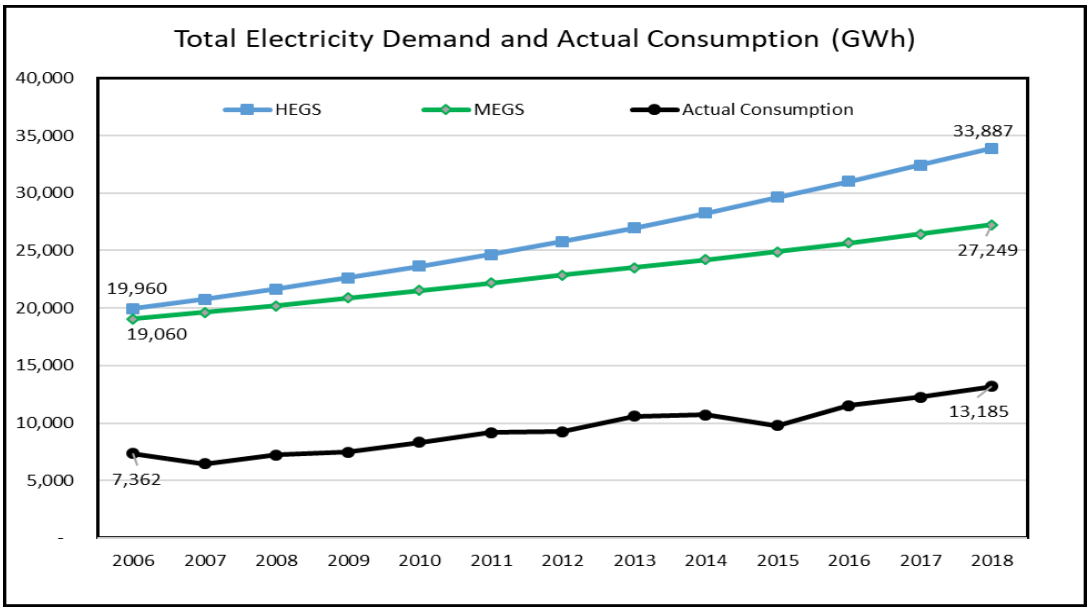


Figure 2.2: Electricity Demand Projection compared to Actual Utilization from 2006 – 2018

Figure 2.2 shows that there was a shortfall in actual electricity consumption compared to the demand projections for both the MEG and the HEG scenarios. The shortfall was as a result of the following:

VALCo was projected to operate three potlines but actually operated two potlines in 2006, virtually operated none from 2007 to 2010 and operated only one potline from 2011 to 2018.

- Reduction in the country's lighting load from 2007 due to the replacement of about 6 million incandescent lighting bulbs with energy-efficient Compact Fluorescent Lamp (CFL) lamps in 2007 (which consequently reduced peak load by about 124 MW).

- Reduction in refrigeration load from 2012 as a result of increased penetration of efficient refrigerating appliances which were promoted under an Efficient Refrigerator Rebate Scheme.
- Inadequate electricity supplied due to infrastructure constraints and fuel supply challenges.
- Reduction in projected electricity sales due to relatively high electricity tariffs.

2.3.2 Petroleum Products Demand from 2006 to 2018

The total demand for petroleum products was projected to increase from 1,941 ktoe in 2006 at an annual average rate of 4.1% to 3,127 ktoe in 2018 for the MEG scenario. In the case of the HEG scenario, the total demand for petroleum products was also projected to increase from 2,089 ktoe in 2006 at an average annual rate of 6.7% to 4,524 ktoe in 2018. The actual consumption of total petroleum products, however, increased from 1,875 ktoe in 2006 at an average annual rate of 5.5% to 3,549 ktoe in 2018. Figure 2.3 shows the projections of the total demand for petroleum products and the actual consumption from 2006 to 2018.

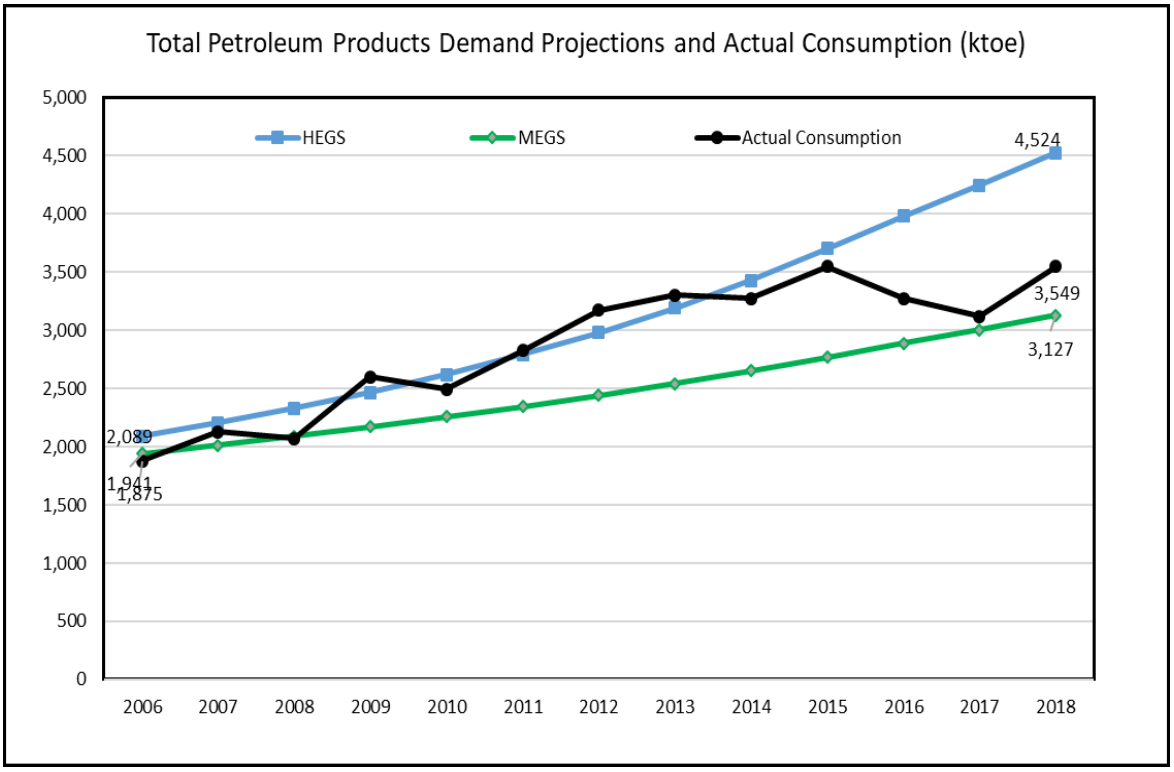


Figure 2.3: Petroleum Products Demand Projection and Actual Consumption from 2006 to 2018

The actual petroleum products consumption outstripped projection for HEG scenario from 2011 to 2013 (see Figure 2.3) but was largely within the projected scenarios. The increase in total petroleum products consumption beyond what was anticipated was due to higher consumption of gasoline, diesel and LPG in electricity gen-sets (owing to load shedding) and vehicles.

2.3.3 Diesel Fuel Demand from 2006 to 2018

The total final demand for diesel was projected to increase from 804 ktoe in 2006 at an annual average rate of 4.7% to 1,396 ktoe in 2018 for the MEG scenario. In the case of the HEG scenario, the total final diesel demand was projected to increase from 902 ktoe in 2006 at an average annual rate of 7.8% to 2,210 ktoe in 2018. However, the actual diesel consumption increased from 953 ktoe in 2006 at an average annual rate of 5.8% to 1,873 ktoe in 2018 surpassing the HEG projections except in 2016, 2017 and 2018 (see Figure 2.4).

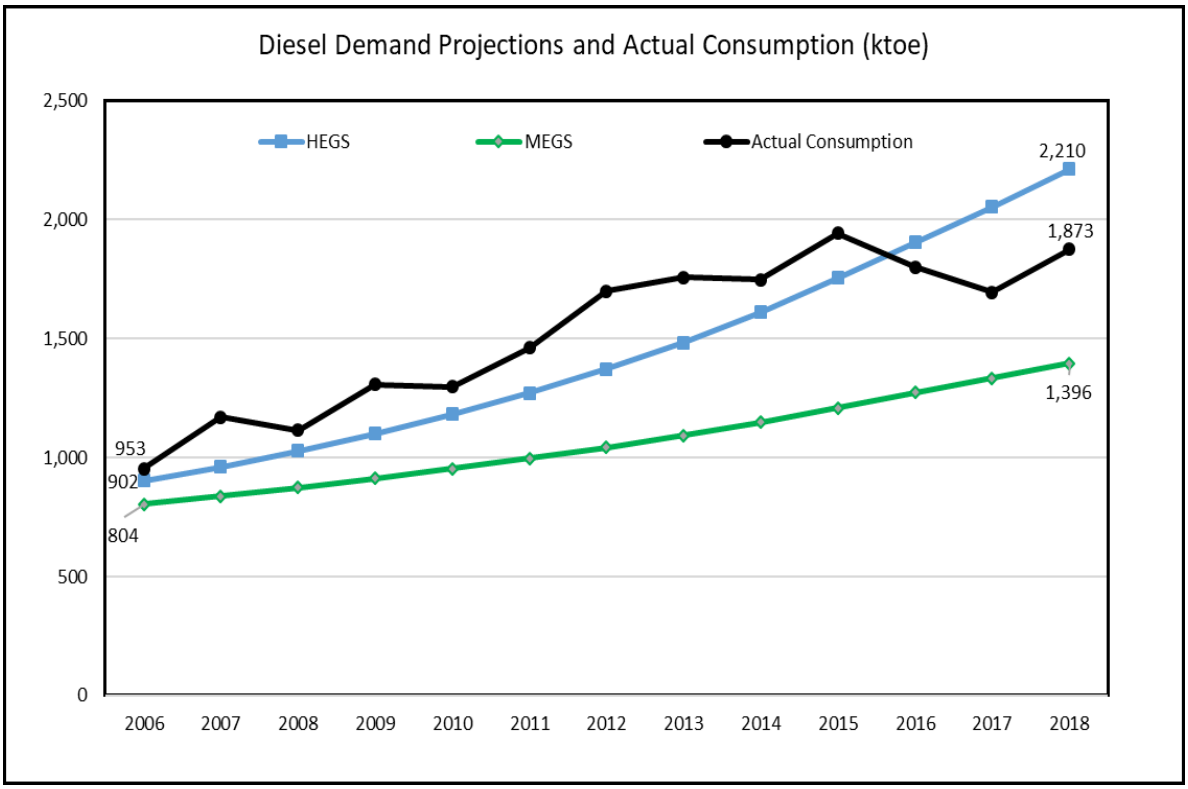


Figure 2.4: Diesel Consumption from 2006 to 2018

Figure 2.4 shows a higher consumption of diesel in 2007, due to the national load shedding exercise from August 2006 to September 2007 and from 2011 to 2016 culminating in an increase in the use of standby electric generator sets. Furthermore, there had been an increase in traffic volume as a result of increase in the total number of registered vehicles using diesel (cars above 2000cc, buses and coaches, trucks, agricultural, construction and mining equipment) in the country (increased from 252,089 in 2006 at an average annual rate of 9% to 708,237 as at the end of 2018). Shortages in electricity supply influenced the increased diesel fuel consumption from 2012 to 2015.

2.3.4 Gasoline Demand from 2006 to 2018

The demand for Gasoline was projected to increase from 671 ktoe in 2006 at an average annual rate of 2.7% to 922 ktoe in 2018 for the MEG scenario. In the case of the HEG scenario, the demand was expected to increase from 671 ktoe in 2006 at an average annual rate of 2.7 % to 920 ktoe in 2018. However, the actual gasoline consumption increased from 537.5 ktoe in 2006 to 572 ktoe in 2008. It then increased rapidly at an average annual rate of 11.4% to about 1,221 ktoe in 2015, before dipping to 1,126 ktoe in 2017 and increasing again to 1,319 ktoe in 2018 (see Figure 2.5).

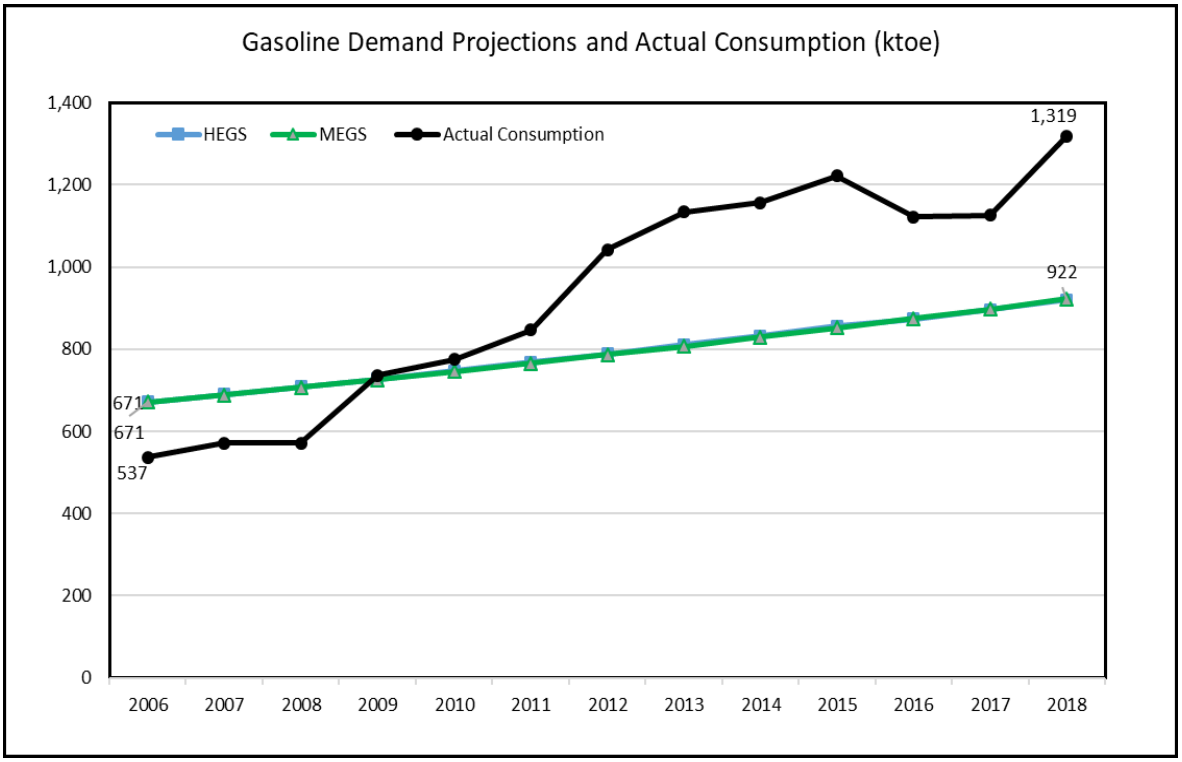


Figure 2.5: Gasoline Demand Projections compared to Actual Gasoline Consumption from 2006 to 2018

Figure 2.5 shows that actual gasoline consumption from 2006 – 2008 was lower compared to the projected gasoline demand. The low gasoline consumption was due to an increase in the number of gasoline fuel vehicles that shifted to the use of LPG as motor fuel as a result of the relatively lower price of LPG during the period. Some of the vehicles using LPG as motor fuel reverted to gasoline in 2009 when LPG lost its relatively lower price advantage. The higher gasoline consumption from 2009 to 2018 than the projected demand could be attributed to the increase in passenger traffic volume and electricity supply shortages experienced between 2012 to 2015. The number of registered motorcycles and cars below 2000cc using gasoline as fuel increased from 588,752 in 2006 at an average annual rate of 8.9% to about 1.6 million at the end of 2018.

2.3.5 Premix Demand from 2006 to 2018

Premix fuel is a blend of premium gasoline to marine mix (a residue from lubricating oil) in a ratio of 29:1. It is formulated in the refinery purposely for the use in outboard motors in Ghana. The demand for premix was projected to increase from 88 ktoe in 2006 at an average annual rate of 5.2% to 162 ktoe in 2018 for the MEG scenario. In the case of the HEG scenario, the demand for premix was projected to increase from 97 ktoe in 2006 at an average annual rate of 7.0% to 219 ktoe in 2018. However, the actual premix consumption increased from 35 ktoe at an average annual rate of 4.3% to 58 ktoe (see Figure 2.6).

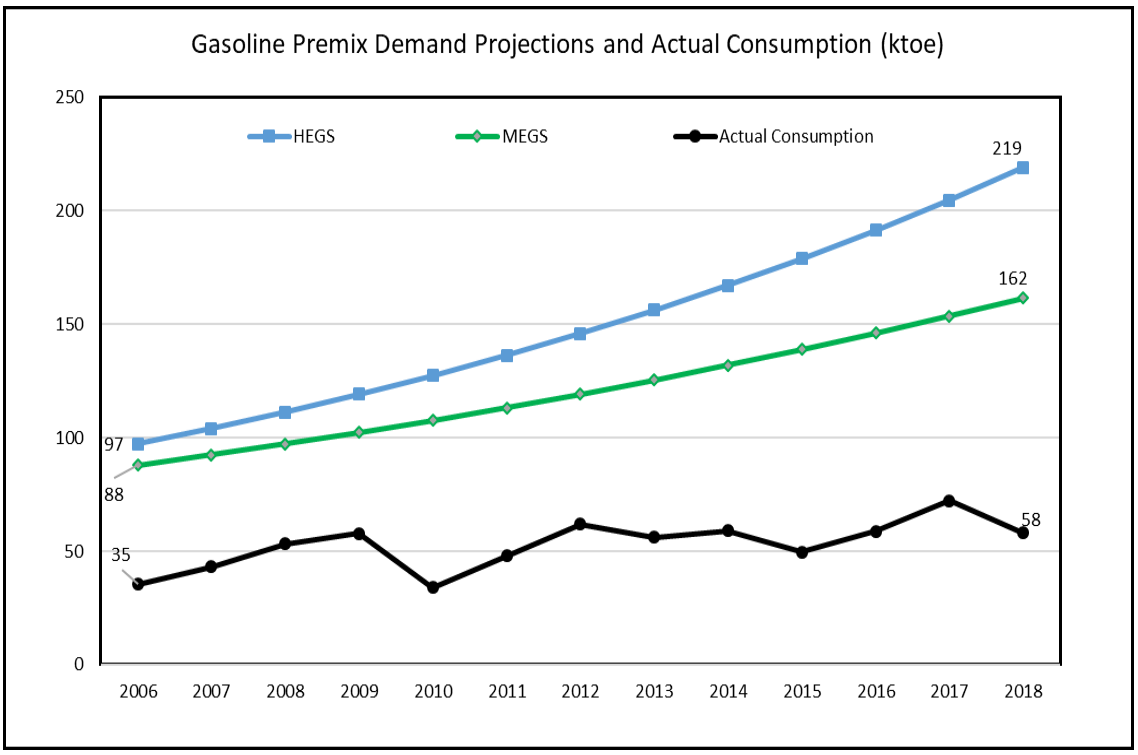


Figure 2.6: Demand Projections compared to Actual Consumption of Premix from 2006 to 2018

2.3.6 Aviation Turbine Kerosene Demand from 2006 to 2018

The country's demand for Aviation Turbine Kerosene (ATK) for domestic air travel was projected to increase from 150 ktoe in 2006 at an annual average rate of 6.3% to 313 ktoe in 2018 for the MEG scenario. The ATK demand for the HEG scenario was projected to increase at an annual rate of 8.8% from 173 ktoe in 2006 to 475 ktoe in 2018. However, the actual ATK consumption was 118 ktoe in 2006, further dropping to 115 ktoe in 2015 but increased to 206 ktoe in 2018 (see Figure 2.7).

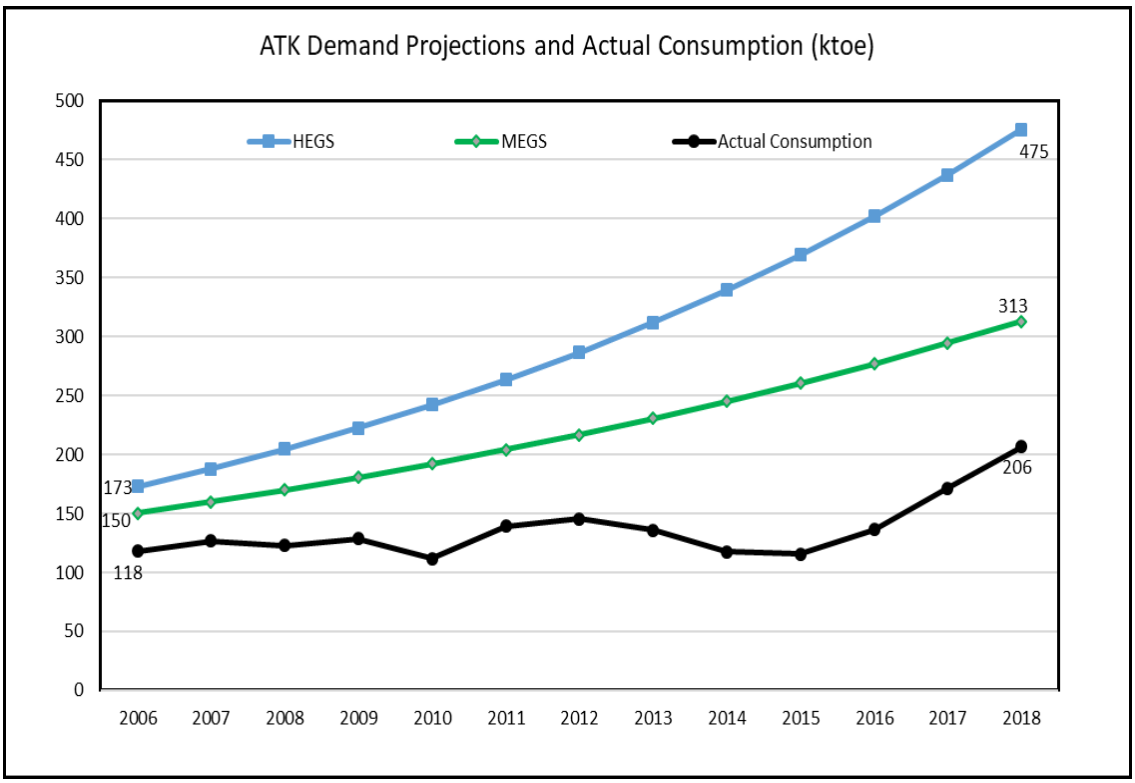


Figure 2.7: Demand Projection compared to Actual Consumption of ATK from 2006 to 2018

The lower profile of ATK consumption was attributable to the decision by major airlines to refuel their aircrafts in neighbouring countries where the price of ATK was comparatively lower[43].

2.3.7 Kerosene Demand from 2006 to 2018

Kerosene is mainly used for lighting in households and communities without access to electricity. The demand for kerosene was projected to decrease from 87 ktoe in 2006 at an annual average rate of 1.9% to 69 ktoe in 2018 for the MEG scenario. In the case of the HEG scenario, the demand was expected to decrease at an annual rate of 2.3% from 78 ktoe in 2006 to 59 ktoe in 2018. Actual kerosene consumption decreased from 79 ktoe in 2006 to 5 ktoe in 2018 at an annual rate of 20.5 (see Figure 2.8).

[43] NDPC Annual Progress Report 2014

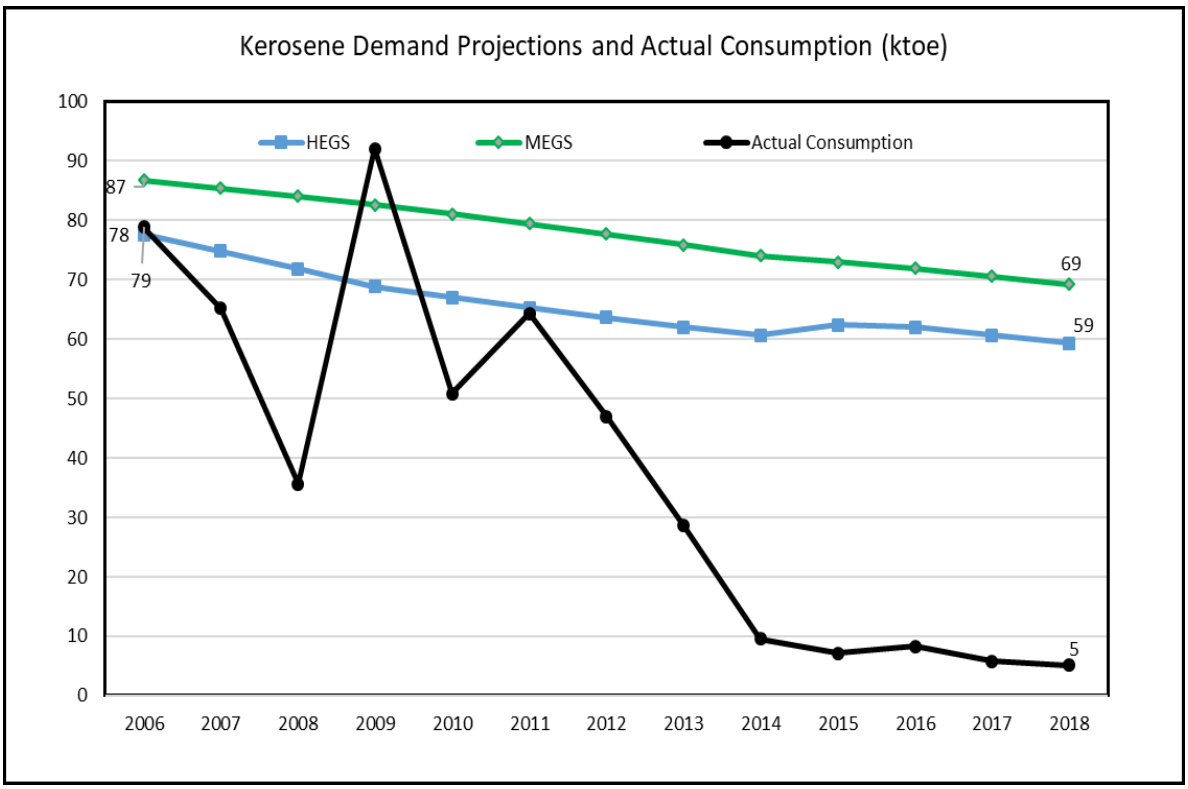


Figure 2.8: Kerosene Demand Projection of the MEG and HEG Scenarios compared to the Actual Consumption from 2006 to 2018

The reduction in actual consumption of kerosene was because of the on-going rural electrification programme as well as the increased penetration of solar LED lamps as lighting devices in rural households. In 2013, the total number of households using kerosene as their main fuel source for lighting was 0.24 million compared to 2.7 million in 2006. On the other hand, the number of households using solar LED lamps as household lighting device increased from 0.03 million in 2006 to 1.6 million in 2013[44,45].

2.3.8 LPG Demand from 2006 to 2018

The demand for LPG was projected to increase from 82 ktoe in 2006 at an annual average rate of 4.7% to 142 ktoe in 2018 for the MEG scenario. In the case of the HEG scenario, the demand for LPG was projected to increase at an annual rate of 5.6% from 85 ktoe in 2006 to 164 ktoe in 2018. The actual LPG consumption increased from 95 ktoe in 2006 at an average annual rate of 13.4% to 429 ktoe in 2018 (see Figure 2.9).

[44] Ghana Statistical Service: "Ghana Living Standards Survey Fifth round" September 2008
[45] Ghana Statistical Service: "Ghana Living Standards Survey (2012/2013) – Round 6", August 2014

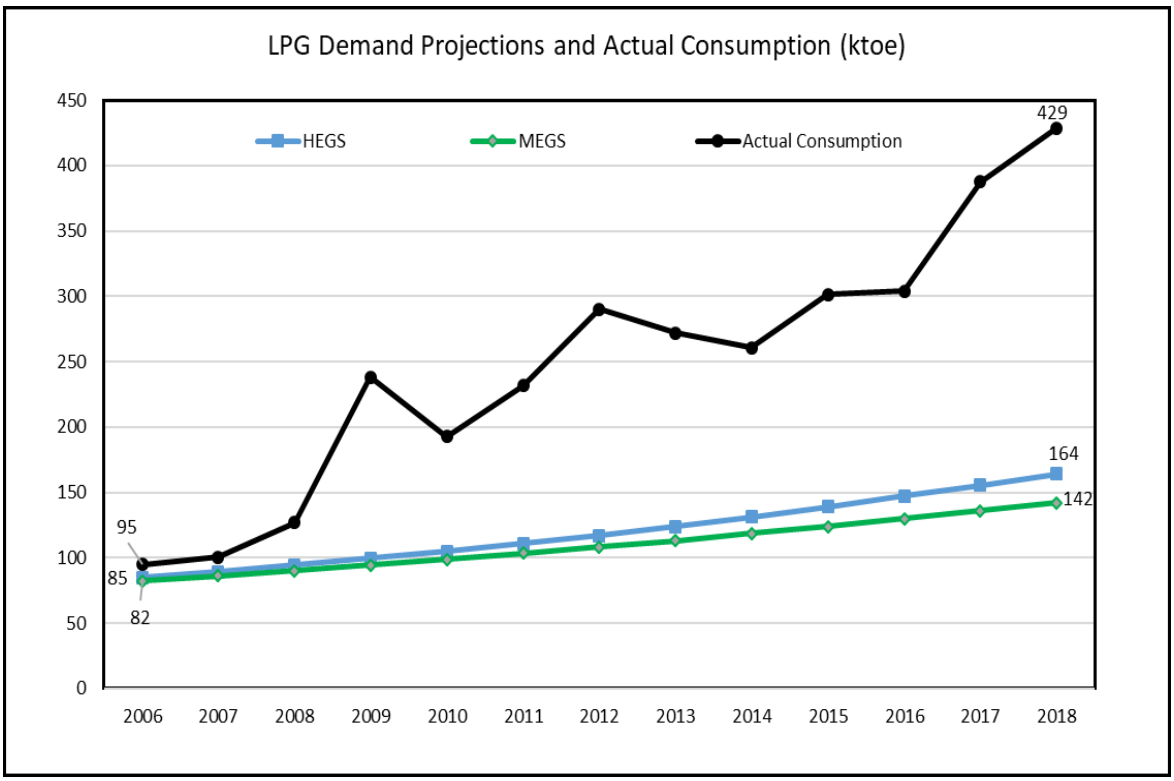


Figure 2.9: Demand Projection compared to Actual Consumption of LPG from 2006 to 2018

The higher than expected LPG consumption profile was attributable to the liberalisation of the downstream petroleum sector in response to the National Petroleum Authority Act, 2005 (Act 691). This led to increased LPG availability in the country.

2.3.9 Residual Fuel Oil (RFO) Demand from 2006 to 2018

The demand for RFO was projected to increase from 59 ktoe in 2006 at an annual average rate of 7.7% to 143 ktoe in 2018 for the MEG scenario. In the case of the HEG scenario, the demand for RFO was projected to increase at an annual rate of 16.3% from 83 ktoe in 2006 to 509 ktoe in 2018. The actual RFO consumption, on the other hand, decreased from 58 ktoe in 2006 at an average annual rate of 14.2% to 13 ktoe in 2016 but increased to 135 ktoe in 2018 (*see Figure 2.10*).

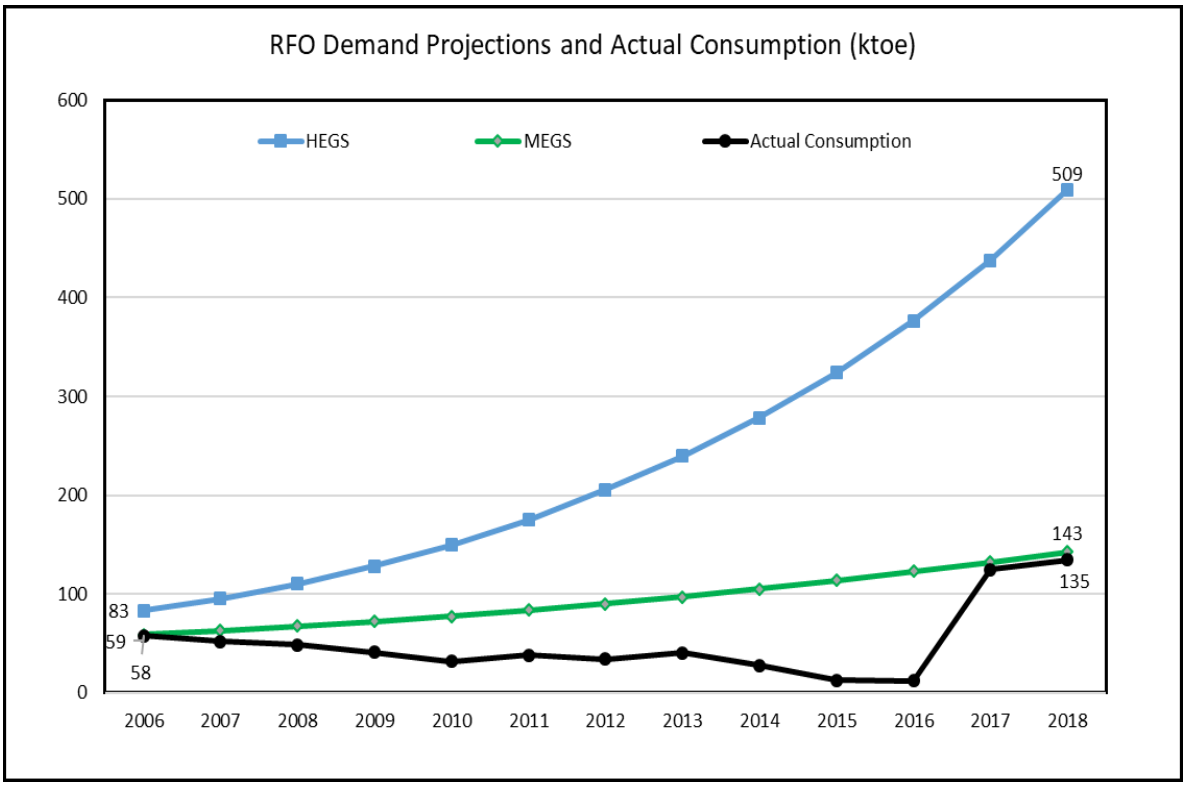


Figure 2.10: Demand Projection compared to Actual Consumption of RFO from 2006 to 2018

This was due to expected industrial growth, especially in the manufacturing sub-sector, which was to grow at an annual rate of 6.8% and 10.9% respectively for the MEG and HEG scenarios but did not happen; the average annual growth rate was just about 3%.

2.3.10 Wood-fuel Demand from 2006 to 2018

The demand for wood-fuel was projected to increase at an average rate of 2.5% from 3,723 ktoe in 2006 to 5,008 ktoe in 2018 for the MEG scenario. In the case of HEG scenario, the wood-fuel demand was projected to increase from 3,757 ktoe at an average annual rate of 2.9% to 5,302 ktoe in 2018. The actual wood-fuel consumption, however, grew at a marginal average rate of 0.4% from 2,671 ktoe in 2006 to 2,795 ktoe in 2018 (*see Figure 2.11*).

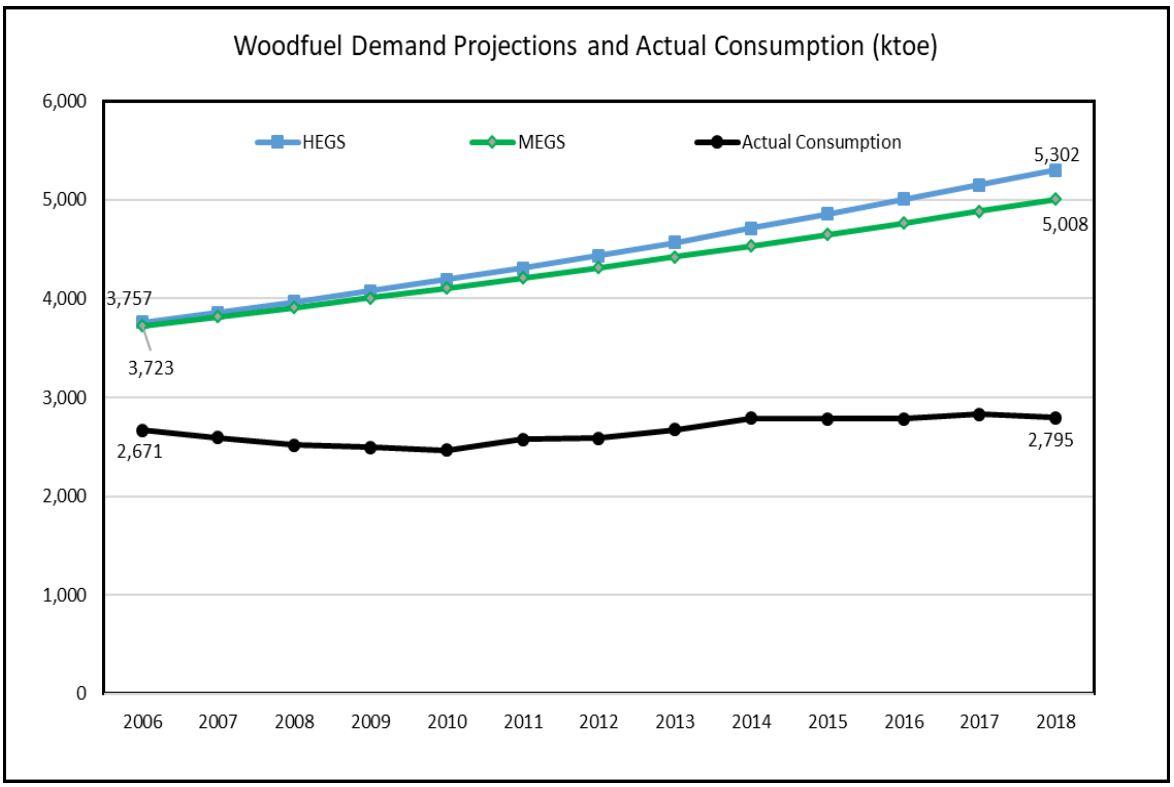


Figure 2.11: Wood-fuel Demand Projections Compared to Actual Consumption from 2006 to 2018

The shortfall was attributable to largely the shift from the use of wood-fuel to LPG as the main fuel for cooking due to government intervention such as supply of free LPG cylinders to rural communities.

2.3.11 Aluminium Smelter's Energy Demand from 2006 to 2018

As one of the operational policy options, SNEP 1 projected that the VALCO smelter would operate three pot-lines with an annual electricity demand of 2,136.1 GWh for the MEG and HEG scenarios. Figure 2.12 presents the projected demand for electricity for the smelter and the smelter's actual electricity use from 2006 to 2018.

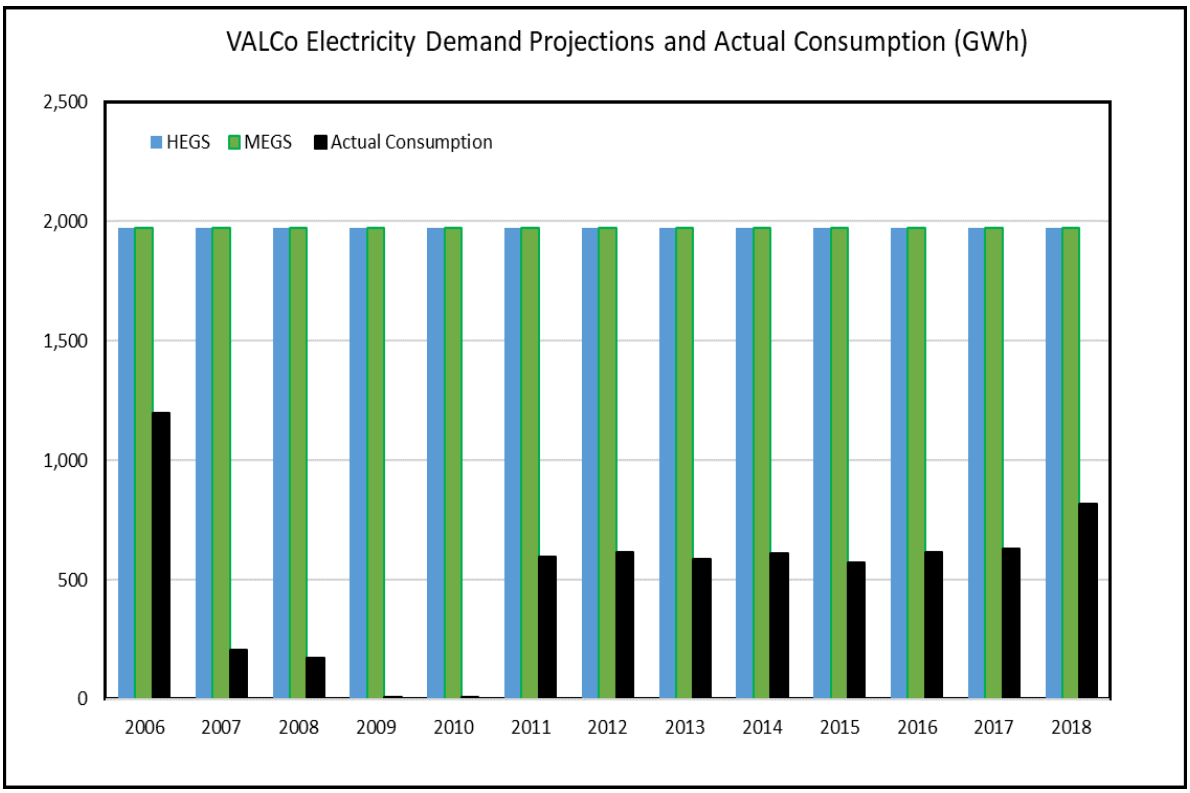


Figure 2.12: Electricity Demand Projected Compared to Actual for Aluminium Smeltering

In 2006, because of low inflows into the Volta Lake, there was a shortfall in hydropower generation as such; there was a cutback in electricity supply to the aluminium smelter. The smelter operated only two potlines with a total electricity utilisation of 1,199 GWh compared to a projected electricity demand of 1,972 GWh. Subsequently, the smelter suspended its operations in 2007 because of electricity tariff issues. The smelter resumed its operations in February 2011 and operated one potline till the end of 2018 when it commenced rehabilitation and operation of a second potline.

2.4 Conclusions

The conclusions derived from the assessment of the final energy demand projections and actual energy consumption from 2006 to 2018 of the SNEP (2006 – 2020) study is as follows:

1. The actual total energy consumption from 2006 to 2018 fell short of the projected demand for MEG and HEG scenarios due to electricity supply constraints and the increased penetration of LPG as cooking fuel and impact of energy efficiency measures, notably the shift from incandescent lamps to CFLs and the refrigerator energy efficiency programme.

2. Actual electricity consumption fell short of the demand projections for the MEG and HEG scenarios because the demand projections assumed the smelter would operate with three

potlines. However, inadequate supply of electricity largely as a result of fuel supply challenges and infrastructure constraints cumulated into electricity load shedding exercises from 2007 to 2008 and from 2012 to 2016.

3. Actual consumption of wood-fuel from 2006 to 2018 was about two-fold lower than the projected demand for the MEG and HEG scenarios due to increasing number of households using LPG as the main fuel for cooking which increased from 526,110 in 2006 to 1,472,135 in 2013.

4. Actual diesel consumption from 2006 to 2017 was higher than the projected demand for the MEG and HEG scenarios because the actual population and the population of vehicles were higher than anticipated for the MEG and HEG scenarios. Also, the load shedding, as mentioned in point 2, contributed to an increase in the use of diesel gen-sets for electricity generation, especially within the productive sectors of the economy.

5. Actual consumption of gasoline from 2006 – 2008 was lower compared to the projected demand because dual-fueled gasoline LPG vehicles shifted to fueling their vehicles with LPG due to the favourable price of the latter. However, when the price advantage was removed, actual gasoline consumption increased. Electricity supply constraints also influenced higher gasoline consumption.

6. Actual consumption of ATK and gasoline premix fell short of the projected demand from 2006 to 2018 due to the higher price of ATK compared to prices in neighbouring countries and supply constraints for premix.

Chapter Three: Energy Demand Projections by Sectors

3.1 Projected Energy Demand by Sectors

3.1.1 Energy Demand (including woodfuel) by Sectors

The total final energy demand for the country is projected to increase from 9,753 ktoe in 2020 at an average annual rate of 4.8% to 15,552 ktoe in 2030 for the BaU scenario. In the case of the AEG scenario, the final energy demand is projected to increase from 10,314 ktoe in 2020 at an average annual rate of 7.9% to 22,091 ktoe in 2030.

The total final energy demand in terms of sectoral shares shows that the energy demand for transportation is the most dominant. It would account for 40.50% of the total final energy demand for the BaU scenario and 41.70% for the AEG scenario in 2020. The next is households, which would account for 35.46% of the total final energy demand for the BaU scenario and 32.92% for the AEG scenario. This is followed by industry, which would account for 15.49% and 15.80% for the BaU and AEG scenarios respectively in 2020. The results of the final energy demand projections from 2020 to 2030 for both scenarios are presented in Table 3.1.

Table 3.1: Final Energy Demand (including woodfuel) by Sectors (ktoe)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Residential	3,141	3,459	3,491	3,602	3,761	3,395	3,432	3,580	3,765
Services	245	463	492	624	826	602	654	904	1,327
Industry	869	1,511	1,587	1,919	2,418	1,630	1,722	3,799	6,451
VALCo	1	186	186	185	185	186	248	309	308
Agriculture	76	185	201	284	437	200	220	316	489
Transport	2,116	3,950	4,232	5,587	7,926	4,301	4,674	6,480	9,751
Total	6,448	9,753	10,190	12,201	15,552	10,314	10,951	15,389	22,091

The results presented in Table 3.1 show that in 2030, the final energy demand for transportation would be the most dominant.

Transportation would account for 50.97% of the final energy demand for the BaU scenario and 44.14% for the AEG scenario, whilst households would account for 24.18% of the final energy demand for the BaU scenario and 17.05% for the AEG scenario in 2030. The industrial sector is projected to account

for 15.55% of the final energy demand for the BaU scenario and 29.20% for the AEG scenario in 2030.

3.1.2 Energy Demand (excluding woodfuel) by Sectors

The total final energy demand (excluding woodfuel, i.e. biomass) would increase from 6,649 ktoe in 2020 at an average annual rate of 6.5% to 12,511 ktoe in 2030 for the BaU scenario. In the case of the AEG scenario, it would increase from 7,396 ktoe in 2020 at an average annual rate of 10.0% to 19,267 ktoe in 2030.

In terms of the sectoral shares (excluding firewood and charcoal), the final energy demand for transportation would be the most dominant in 2020, accounting for 59.4% of the total final energy demand for the BaU scenario and 58.2% for the AEG scenario. The next most dominant sector would be the industrial sector, which is projected to account for 16.3% of the total final energy demand for the BaU scenario and 16.2% for the AEG scenario. The household is projected to account for 13.3% and 14.0% for the BaU and AEG scenarios respectively in 2020.

In 2030, transportation is projected to account for 63.3% of the total final energy demand (excluding firewood and charcoal) for the BaU scenario and 50.6% for the AEG scenario. In this case, the household sector is projected to account for 11.2% of the total final energy demand (excluding firewood and charcoal) for the BaU scenario and 8.7% for the AEG scenarios. In 2030, the industrial sector is projected to account for 14.7% of the total final energy demand for BaU scenario and 30.5% for AEG scenarios.

Table 3.2: Final Energy Demand (excluding woodfuel) by Sectors (ktoe)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Residential	481	884	932	1,141	1,397	1,033	1,088	1,329	1,675
Services	156	361	390	519	721	474	523	758	1,168
Industry	593	1,083	1,144	1,417	1,845	1,201	1,278	3,294	5,876
VALCo	1	186	186	185	185	186	248	309	308
Agriculture	76	185	201	284	437	200	220	316	489
Transport	2,116	3,950	4,232	5,587	7,926	4,301	4,674	6,480	9,751
Total	3,422	6,649	7,086	9,133	12,511	7,396	8,031	12,486	19,267

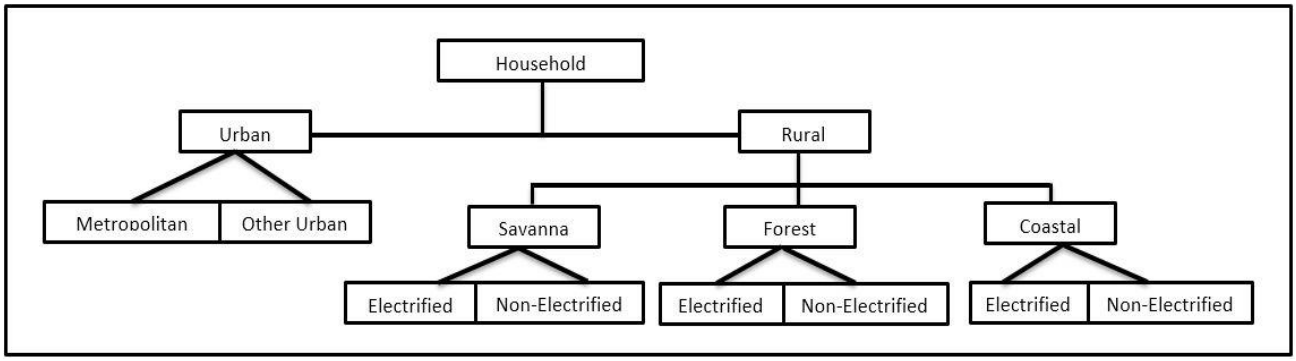
The results presented in Table 3.2 show that energy consumption in the Transport sector would increase at an average annual rate of 7.2% for the BaU scenario and 8.5% for the AEG scenario. The household sector demand would increase at an average annual rate of 4.7% for the BaU scenario and 4.9% for the AEG scenario. The low average annual demand growth rate for the sector is due to the increased use of energy-efficient household appliances and decrease in household sizes.

The Industrial sector's final energy demand would increase at an average annual rate of 5.5% for the BaU scenario and 17.2% for the AEG scenario.

3.1.3 Energy Intensity

The final energy demand per unit of GDP would decrease from 152.59 kgoe per 1,000 USD in 2020 to 122.54 kgoe per 1,000 USD in 2030 for the BaU scenario. In the case of the AEG scenario, the final energy demand per unit of GDP would decrease from 144.35 kgoe per 1,000 USD in 2020 to 139.29 kgoe per 1,000 USD in 2030. This general decrease in the intensity of the final energy demand from 2020 to 2030 would be as a result of the sustained implementation of energy efficiency and fuel substitution programmes.

3.2 Energy Demand by Household Sector



The household sector is classified into urban and rural households. The urban households are further classified into Metro-urban, and Other-urban households while the rural households are classified according to the following ecological zones: Savannah, Forest and Coastal. The rural households in each ecological zone are further classified into households connected to the electricity grid and those not connected to the electricity grid. These classifications are done to obtain homogenous patterns for household energy use, which would contribute to the realistic evaluation of the final energy demand for the various households.

3.2.1 Household Energy Demand by Fuel type

The total final energy demand for the Household sector would increase from 3,459 ktoe and 3,395 ktoe in 2020 at an average annual rate of 0.8% and 1.0% to 3,761 ktoe and 3,765 ktoe in 2030 respectively for the BaU and the AEG scenarios. The low average annual growth rate of the total final energy demand for the household sector can be attributed to the increased penetration of the energy-

efficient household energy use appliances and the decrease in the share of firewood in the household sector's final energy demand. The share of firewood would drop from about 52.1% in 2020 to about 38.8% and 31.9% of the final energy demand for the Household sector, respectively for the BaU and AEG scenarios (see Table 3.3).

Table 3.3: Historical and Projected Final Energy by Household (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	322	653	689	846	1,030	770	806	963	1,190
Kerosene	49.3	2.9	2.3	0.5	0.1	0.1	0.1	0.1	0.1
LPG	109	224	236	292	365	262	281	364	481
Wood	2,064	1,801	1,768	1,609	1,459	1,580	1,548	1,402	1,202
Charcoal	595	773	790	851	905	781	796	849	888
Solar	0.1	4.3	4.0	2.3	2.1	0.8	1.0	1.9	3.8
Total	3,141	3,459	3,491	3,602	3,761	3,395	3,432	3,580	3,765

For the BaU scenario, household electricity demand would increase at an annual rate of 4.7% while LPG demand would increase at 5.0% and charcoal at 1.6%. On the other hand, kerosene demand would drop at an average annual rate of 31%, wood at 2.1% and solar lantern 7.1%.

3.2.2 Household Energy Demand by End-use

The Household sector's end-use energy applications include lighting, cooking, refrigeration, air-conditioning, water heating, clothes washing, dishwashing and miscellaneous uses. The penetration of these appliances in households has increased rapidly over the last decade but is still far from saturation. The penetration of these appliances would further increase due to increase in disposable household income levels. The total final energy demand of the household sector according to household energy end-uses is presented in Table 3.4.

Table 3.4: Final Energy Demand of Household by Activity Type (ktoe)

Energy End-uses	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Cooking	2,773	2,801	2,798	2,756	2,732	2,628	2,629	2,619	2,575
Lighting	179	238	245	274	293	262	263	265	279
Refrigeration	79	160	170	218	283	185	198	257	340
Space cooling	6	19	21	30	42	33	36	53	78
Water heating	0.8	3.1	3.4	4.8	6.9	4.8	5.4	8.1	12.2
Clothes washing	0.7	2.5	2.7	3.8	5.3	3.7	4.0	5.9	8.5
Dish washing	0.1	0.6	0.7	1.0	1.5	1.9	2.2	3.4	5.2
Air circulation	28	71	75	95	118	83	87	104	126
Television	16	41	44	56	71	45	47	57	70
Miscellaneous	59	122	130	164	210	150	161	207	271
Total	3,141	3,459	3,491	3,602	3,761	3,395	3,432	3,580	3,765

The results indicate that cooking is the dominant household energy end-use activity. It would account for 80.99% of the household sector's total final energy demand in 2020 but would decrease to 72.65% in 2030 for the BaU scenario. In the case of the AEG scenario, the share for household cooking activity would decrease from 77.40% in 2020 to 68.38% in 2030. The decrease in the share of energy demand for household cooking activity for the two scenarios is attributable to the decrease in household sizes and the shift from the use of firewood and charcoal to LPG as cooking fuel. At the end-use level, LPG is more efficient than charcoal with firewood being the least.

The next most dominant household end-use activity is lighting. The share of energy demand for household lighting would increase marginally from 6.87% in 2020 to 7.79% in 2030 for the BaU scenario. In the case of the AEG scenario, it is projected to decrease from 7.72% in 2020 to 7.41% in 2030. The decrease in the share of energy demand for household lighting for the AEG scenario is attributed to the expected use of efficient lighting appliances.

The share of household refrigeration in the total energy demand would also increase from 4.62% in 2020 to 7.51% in 2030 for the BaU scenario and from 5.44% in 2020 to 9.03% in 2030 for the AEG scenario. The increase in the share of energy demand for household refrigeration for the two scenarios is attributed to increase in penetration of refrigerating appliances in the country.

In terms of the rate of energy demand for these energy end-use activities for the BaU scenario, the final energy demand for cooking is projected to decrease at an average annual growth rate of 0.3% from 2020 to 2030 whilst that for lighting is projected to increase at 2.1% and refrigeration at 5.9% within the same period. The final energy demand for air-conditioning would increase at 7.9% and that for water heating would increase at 8.5%, clothes and dishwashing at 7.8% and 9.8% respectively. The final energy demand for miscellaneous end-uses would increase at an average annual growth rate of 5.5% from 2020 to 2030.

3.2.3 Energy Demand per household

Final energy demand per household would decrease from 452.52 kgoe in 2020 to 385.12 kgoe in 2030 for BaU scenario. In the case of the AEG scenario, it is expected to decrease from 446.17 kgoe in 2020 to 391.89 kgoe in 2030. This decrease is attributed to the decrease in household sizes, increased penetration of efficient household appliances and the drastic shift from the use of firewood to LPG as cooking fuel.

3.2.4 Energy Demand by Household Sub-sector

Final energy demand for urban and rural localities is presented in Table 3.5. The results indicate that urban households would account for 53.6% of the total household energy use in 2030 compared to 43.5% in 2020 for the BaU scenario. In the case of the AEG scenario, the final energy demand for urban households would account for 60.2% of the total final energy demand in 2030 compared to 47.4% in 2020. This is because more than two thirds (i.e. 67.6%) of households in the country are expected to reside in urban localities for the BaU scenario. In the case of the AEG scenario, it is expected that 68.9% of households in the country would be residing in urban localities by 2030.

Table 3.5: Final Energy Demand of Household by Sector (ktoe)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Urban	1,180	1,506	1,556	1,765	2,015	1,609	1,671	1,935	2,268
Rural	1,961	1,953	1,935	1,837	1,746	1,786	1,762	1,646	1,497
Total	3,141	3,459	3,491	3,602	3,761	3,395	3,432	3,580	3,765

The final energy demand for urban localities would increase from 1,506 ktoe in 2020 at an average annual growth rate of 3% to 2,015 ktoe in 2030 for the BaU scenario. Under the AEG scenario, however, the final energy demand for urban households would be 2,268 ktoe in 2030, increasing from 1,609 ktoe in 2020 at an average annual growth rate of 3.5%. As stated earlier, the low growth rate is due to the decrease in urban household sizes, the shift from the use of charcoal to LPG for cooking and the penetration of energy-efficient appliances.

3.2.4.1 Urban Household sub-sector

The total number of urban households in the country is projected to increase from 4.9 million in 2020 at an average annual rate of about 3.1% to 6.6 million in 2030. The urban households are classified into metro-urban and other-urban households to ensure homogenous energy use patterns for realistic evaluation of urban household's final energy demand.

A. Final Energy Demand by Urban Household Sub-sector

The urban household's total final energy demand for both metro-urban and other urban localities would increase from 1,506 ktoe in 2020 at an average annual growth rate of 3% to 2,015 ktoe in 2030 for the BaU scenario. In the case of the AEG scenario, the total final energy demand for the two urban classes is projected to increase from 1,609 ktoe in 2020 at an average annual growth rate of 3.5% to 2,268 ktoe in 2030.

In 2030 under the BaU scenario, the final energy demand in metro-urban households would account for 43.7% from 41.4% in 2020 of the total final energy demand of urban households. It is expected that the energy demand in other-urban households would drop from 58.6% in 2020 to 56.4% in 2030.

For the AEG scenario, the final energy demand for metro-urban households would account for 41.6% of the urban household's total final energy demand whilst the demand in other-urban households would account for 58.4% in 2020. In 2030 however, the demand in metro-urban households is projected to account for 43.8% of the urban household's total final energy demand while the other-urban household is projected to account for 56.3%. The results of the energy demand by the classes of urban households are further presented in Table 3.6:

Table 3.6: Final Energy Demand of Urban Households by sub-sectors

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Metro Urban	390	624	648	750	879	669	698	822	992
Other Urban	790	882	908	1,016	1,135	940	973	1,113	1,276
Total	1,180	1,506	1,556	1,765	2,015	1,609	1,671	1,935	2,268

The final energy demand in metro-urban localities would increase from 624 ktoe and 669 ktoe in 2020 to 879 ktoe and 992 ktoe in 2030 at an average annual rate of 3.5% and 4.0% for BaU and AEG scenarios respectively. The average annual growth rates for metro-urban localities would be about 35% and 29% more than that of other-urban localities for BaU and AEG scenarios, respectively.

B. Final Energy Demand of Urban Households by End-uses

Analysis of the final energy demand in urban households shows that the dominant end-use activity is cooking. This is projected to account for 66.8% of the urban household's total final energy demand in 2020 and decrease to 62.0% in 2030 for the BaU scenario. The results of the AEG scenario show that the share of the final energy demand for cooking in urban households is projected to decrease from 64.8% in 2020 to 59.2% in 2030.

The next most dominant urban household energy end-use activity is refrigeration, which is projected to account for 10.0% of the urban household's total final energy demand in 2020 and increase to 12.8%

in 2030 for the BaU scenario. In the case of AEG scenario, the share of the final energy demand for refrigeration is projected to increase from 10.6% in 2020 to 13.6% in 2030.

The results of the urban household's final energy demand according to energy end-use activities, are presented in Table 3.7:

Table 3.7: Final Energy Demand of Urban Households by End-use Activities (ktoe)

Energy End-uses	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Cooking	911	1,006	1,032	1,136	1,249	1,042	1,073	1,203	1,342
Lighting	89	135	138	149	157	140	141	144	157
Refrigeration	78	150	159	200	257	170	182	235	310
Space cooling	5	18	20	27	38	31	35	51	76
Water heating	0.8	3.1	3.4	4.8	6.9	4.8	5.4	8.1	12.2
Clothes washing	0.7	2.5	2.7	3.8	5.3	3.7	4.0	5.9	8.5
Dish washing	0.1	0.6	0.7	1.0	1.5	1.9	2.2	3.4	5.2
Air circulation	26.0	52.8	54.9	64.1	75.8	58.3	60.7	71.2	83.9
Television	14.4	30.9	32.4	38.6	46.9	31.2	32.7	39.4	47.2
Miscellaneous	54	107	113	140	177	126	134	174	227
Total	1,179	1,506	1,556	1,765	2,015	1,609	1,671	1,935	2,268

The demand for energy for refrigeration is projected to increase at an average annual rate of 5.5% for the BaU scenario and 6.2% for the AEG scenario. Meanwhile, energy demand for space cooling/air-conditioning would increase at an average annual rate of 7.8% for the BaU scenario and 9.2% for the AEG scenario. The relatively low rates of energy demand for refrigeration in urban households is due to the Refrigerator Energy Efficiency Programme. This programme includes the Rebate Scheme and the Efficiency Standards and Labelling Programme. The activity is expected to help transform the refrigerator market into an efficient refrigerator market.

C. Final Energy Demand of Urban Households by fuels

Electricity is projected to be the dominant fuel for urban households for the AEG scenario in 2030. Its share is projected to increase from 33.3% and 35.30% in 2020 to 38.0% and 40.76% in 2030 for the BaU scenario and AEG scenario respectively. Firewood share is projected to account for 9.3% of the urban household's total energy demand compared to 7.2% in 2030 for the BaU scenario. The AEG scenario indicates that the share of firewood is projected to decrease from 8.68% of the final energy demand in 2020 to 6.3% in 2030.

Charcoal demand is projected to account for 44.1% of the total final energy demand in 2020 compared to 39.1% in 2030 for the BaU scenario and from 41.7% in 2020 to 34.2% in 2030 for the AEG scenario.

In the case of the share of LPG demand, this would increase from 13.2% of the total final energy demand in 2020 to 15.5% of the total final energy demand in 2030 for the BaU scenario and from 14.3% of the urban household's total final energy demand in 2020 to 18.5% in 2030 for the AEG scenario. These results are presented in Table 3.8.

Table 3.8: Final Energy Demand of Urban Household by Fuel (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	266	502	526	630	766	568	598	732	925
Kerosene	6.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
LPG	98	199	209	254	313	230	246	318	420
Wood	371	140	142	146	145	140	141	145	144
Charcoal	438	664	678	735	789	670	684	738	775
Solar	0.0	0.5	0.6	1.0	2.1	0.8	1.0	1.9	3.8
Total	1,180	1,506	1,556	1,765	2,015	1,609	1,671	1,935	2,268

The results of the analysis show that the demand for LPG for cooking is projected to increase at an average annual rate of 4.6% for the BaU scenario and 6.2% for the AEG scenario. On the other hand, the demand for electricity in urban households is projected to increase at an annual average rate of 4.3% for the BaU scenario and 5.0% for the AEG scenario. The higher average annual growth rate of the demand for electricity for the AEG scenario than for the BaU scenario is due to the higher penetration rate of electrical appliances as a result of higher income levels.

Though the share of solar (solar lanterns)[46] would be the lowest among the fuel forms being used in 2030, its growth is the highest among the fuels. It would grow at an average annual growth rate of 16.1% and 16.8% for the BaU and AEG scenarios, respectively.

D. Final Energy Demand per Urban Household

The average final energy demand per urban household is projected to decrease from 309.6 kgoe in 2020 to 305.3 kgoe in 2030 for the BaU scenario. In the case of the AEG scenario, the average final energy demand per urban household would increase from 329.7 kgoe in 2020 to 342.6 kgoe in 2030. The higher energy demand per urban household for the AEG is due to the higher penetration rates of electrical appliances in the AEG scenario compared to the BaU scenario.

[46] Includes solar water heaters, solar PV and solar dry cell

3.2.4.2 Rural Household sub-sector

The total number of rural households is projected to increase from 2.8 million in 2020 at an average annual rate of 1.3% to 3.2 million in 2030 for the BaU scenario and from 2.7 million in 2020 at an average annual rate of 0.9% to 3.0 million in 2030 for the AEG scenario.

A. Final Energy Demand by Sub-Sectors

The total rural household energy demand is projected to decrease from 1,953 ktoe in 2020 at an average annual rate of 1.1% to 1,746 ktoe in 2030 for the BaU scenario. In the case of the AEG scenario, the total rural household energy demand is projected to decrease from 1,786 ktoe in 2020 at an average annual rate of 1.7% to 1,497 ktoe in 2030. The decrease in the energy demand in rural households is due to the decrease in rural household sizes, the low growth rate of the total number of rural households and urbanisation of rural areas.

The Forest sub-sector of rural households is the most dominant in terms of energy demand. Regarding the BaU scenario, the final energy demand in rural households in Forest sub-sector is projected to account for 45.7% of the total energy demand in rural households. Rural households in Savannah and Coastal sub-sectors account for 36.0% and 18.3% respectively in 2020. In the case of AEG scenario, the final energy demand for rural forest households is projected to account for 44.4% whilst the savannah and coastal rural households account for 37.1% and 18.4% respectively of the rural household's total final energy demand in 2020. Forest rural households would remain the dominant rural household sub-sector followed by the savannah and coastal rural households in terms of the final energy demand (see Table 3.9).

Table 3.9: Final Energy Demand of Rural Household by Sub-sector (ktoe)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Coastal	403	358	356	342	327	329	327	315	298
Forest	920	892	878	812	758	794	780	720	645
Savanna	638	703	701	683	660	663	654	611	554
Total	1,961	1,953	1,935	1,837	1,746	1,786	1,762	1,646	1,497

B. Final Energy Demand by End-use Activity

Cooking is the dominant rural household energy end-use activity accounting for about 91.9% of the total final energy demand in 2020. It is projected to account for 84.9% and 82.35% of the total final energy demand respectively for the BaU and AEG scenario in 2030. The next most dominant rural household energy end-use activity is lighting which accounts for about 5.3% of the total final energy demand in 2020; and, projected to account for 7.8% and 8.1% respectively for the BaU and AEG

scenarios in 2030. The projections for total final energy demand in rural households according to energy end-use activities are shown in Table 3.10.

Table 3.10: Final Energy Demand of Rural household by End-use (ktoe)

Energy End-uses	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Cooking	1,862	1,796	1,767	1,620	1,483	1,586	1,555	1,416	1,233
Lighting	90	103	107	125	136	122	122	122	122
Refrigeration	1.4	9.6	11.0	17.5	25.3	14.7	16.1	22.2	30.2
Space cooling	0.2	1.3	1.5	2.3	3.3	1.3	1.3	1.6	2.0
Air circulation	1.9	18.3	20.4	30.5	41.8	24.3	26.0	32.8	42.2
Television	1.2	10.3	11.5	17.2	23.7	13.4	14.4	18.1	23.2
Miscellaneous	4	15	17	24	32	25	26	34	45
Total	1,961	1,953	1,935	1,837	1,746	1,786	1,762	1,646	1,497

Final energy demand for lighting in rural households is projected to increase at an average annual rate of 2.8% for the BaU scenario and decrease at an average annual rate of 0.04% for the AEG scenario. The final energy demand for lighting would increase but its rate of increase is expected to be low. This is due to the drastic decrease in the demand for kerosene vis-à-vis increase in the demand for electricity for lighting (since electricity use for lighting is relatively more efficient than that of kerosene). The energy demand for refrigeration in rural households would increase at an average annual rate of 10.2% and 7.5% for the BaU and AEG scenarios, respectively.

C. Final Energy Demand of Rural Household by Fuel

Firewood would still be the dominant fuel for rural households between 2020 and 2030 for the two scenarios. Its share is projected to decrease from 85.0% of the total final energy demand in 2020 to 75.24% in 2030 for the BaU scenario. In the case of the AEG scenario, the share of firewood is projected to decrease from 80.7% in 2020 to 70.7% in 2030. However, the share of charcoal in the final energy demand for rural households would increase from 5.6% in 2020 to 6.6% in 2030 for the BaU scenario and from 6.2% in 2020 to 7.5% in 2030 for the AEG scenario.

The share of electricity in the total final energy demand in rural households would increase from 7.8% in 2020 to 15.1% in 2030 for the BaU scenario and from 11.3% in 2020 to 17.8% in 2030 for the AEG scenario. The share of LPG in the total final energy demand in rural households is projected to increase from 1.3% in 2020 to 3.0% for the BaU scenario and from 1.8% in 2020 to 4.0% in 2030 for AEG scenario.

Table 3.11: Final Energy Demand of Rural household by Fuel type (ktoe)

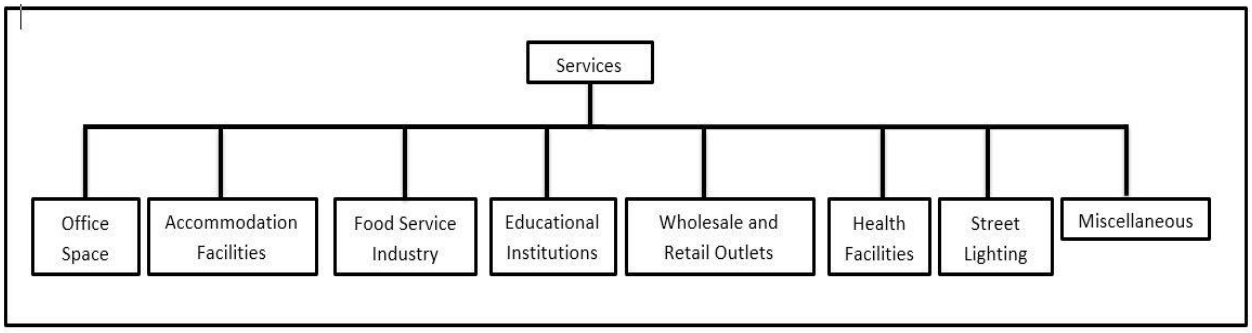
Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	56	152	164	216	264	202	208	232	266
Kerosene	43	3	2	0	0	0	0	0	0
LPG	11	24	27	39	52	32	35	46	60
Wood	1,694	1,661	1,627	1,464	1,314	1,441	1,407	1,257	1,058
Charcoal	157	109	112	117	116	111	111	112	113
Solar	0.0	3.9	3.5	1.3	-	-	-	-	-
Total	1,961	1,953	1,935	1,837	1,746	1,786	1,762	1,646	1,497

In rural households, the demand for LPG for cooking is projected to increase at an average annual rate of 7.9 % for the BaU scenario compared to 6.4% for the AEG scenario. The lower rate of increase in the demand for LPG for the AEG scenario despite a higher rate of LPG penetration is due to the smaller household size due to rural-urban migration. On the other hand, the demand for electricity in rural households is projected to increase at an annual average rate of 5.7% for the BaU scenario and 2.8% for the AEG scenario. The lower average annual growth rate of the demand for electricity for the AEG scenario than the BaU scenario is due to the higher penetration rate of efficient electrical appliances.

D. Final Energy Demand per Rural Household

The final energy demand per rural household would decrease from about 702.6 kgoe in 2020 to 551.7 kgoe and 501.0 kgoe in 2030 respectively for the BaU and AEG scenarios. The low demand in 2030 compared with that of 2020 is attributable to the projected decrease in the rural household sizes, decrease in the use of firewood and a projected increase in the use of energy-efficient appliances.

3.3 Energy Demand by Services Sector



The Services Sector provides goods and services to the general public. It's the link between all other sectors and the public. It comprises of office spaces, accommodation facilities, educational institutions, retailing, health facilities, etc.

The Services Sector is classified into formal and informal sub-sectors. The formal sector comprises office space, accommodation facilities, food service, educational institutions, wholesale and retail outlets, health facilities, street lighting and others. The informal sector is made up of any unregistered service provider. Marketing of consumer goods and the provision of services mainly describe the activities in this sector. The final energy demand of the Services sector was assessed by classifying the formal Services sector into the following sub-sectors: office space; accommodation facilities; health facilities; educational institutions; retailing outlets; restaurants; eateries and miscellaneous. This classification was done to obtain sub-sectors with homogenous energy use patterns, which would ensure a realistic evaluation of the final energy demand of the Services sector.

3.3.1 Energy Demand by Fuel type

The total final energy demand of the Services Sector would increase from about 463 ktoe in 2020 at an average annual rate of 6.0% to 826 ktoe in 2030 for the BaU scenario. In the case of the AEG scenario, the final energy demand would increase from 602 ktoe in 2020 at an average annual rate of 8.2% to 1,327 ktoe in 2030. Table 3.12a shows the Services sector's final energy demand by fuels.

Table 3.12a: Final Energy Demand of Services Sector by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	148	339	366	485	670	447	492	710	1,091
LPG	8	22	24	34	51	28	31	47	78
Wood	45	45	45	43	40	61	62	67	71
Charcoal	44	56	58	62	64	66	69	79	88
Total	245	463	492	624	826	602	654	904	1,327

Final energy demand for the Services Sector shows that electricity would remain the dominant fuel for both the BaU and AEG scenarios. In both scenarios, electricity accounts for about 73-74% of the total final energy demand in 2020 and is projected to increase to 81.2% and 82.2% for BaU and AEG scenarios in 2030. The increase in the share of electricity in 2030 is due to the increased penetration of electrical appliances such as air conditioners, office equipment, lifts and elevators despite the promotion of energy efficiency programmes.

Table 3.12b: Average Annual Growth Rate of Fuel Demand in Services Sector (%)

Fuels	BaU Scenario	AEG Scenario
Electricity	7.0	9.3
LPG	8.8	10.8
Wood	-1.1	1.5
Charcoal	1.3	2.8

The demand for electricity in the Services sector was projected to increase at an average annual rate of 7.0% in the BaU scenario and 9.3% in the AEG scenario. The demand for LPG in the Services sector was projected to increase at an average annual rate of 8.8% for the BaU scenario and 10.8% for the AEG scenario. The demand for woodfuel would decrease at an average annual rate of 1.1% and increase at an average annual rate of 1.3% for firewood and charcoal respectively, in the BaU scenario. However, under the AEG scenario, demand for firewood would increase at an average annual rate of 1.5% while charcoal demand would increase at 2.8%. The low annual rate of increase of woodfuel demand is due to the increased use of LPG as cooking fuel in the Services sector.

3.3.2 Energy Demand of Services Sector by Sub-sectors

The final energy demand for the Services Sector for both the BaU and AEG scenarios from 2020 and 2030 are presented in Table 3.13.

Table 3.13: Energy Demand by Services Sector (ktoe)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Offices	21	32	33	39	49	38	40	51	68
Lodging	19	33	35	45	60	53	59	88	142
Health Facilities	20	34	36	46	63	44	47	64	93
Educational facilities	94	149	156	187	232	207	224	300	428
Retail Facilities	20	83	92	132	197	117	132	207	342
Restaurants and Eateries	36	65	69	86	114	72	77	100	138
Others	13	12	11	11	10	12	12	11	10
Street lighting	23	56	60	79	101	59	63	83	107
Total	245	463	492	624	826	602	654	904	1,327

The contribution of the educational subsector as the dominant sub-sector in terms of energy demand would decrease from about 32% in 2020 to 28% for the BaU scenario but remain the same for the AEG scenario.

The next most dominant energy demand sub-sector of the Services sector is retail establishments, and its share of the total final energy demand is projected to increase from 18-19% in 2020 to 23.9% and 25.7% in 2030 for the BaU and AEG scenarios respectively. The Retail sub-sector is followed by Restaurants & Eateries accounting for about 14% of the total final energy demand in 2020, and its contribution would drop to 13.8% in 2030 for the BaU scenario and 10.4% for the AEG scenario.

3.3.2.1 Final Energy Demand by Office Building

Office buildings/office space in the country were classified into government or public and private office buildings. Energy demand for office buildings/office space is projected to increase from 32 ktoe in 2020 at an average annual rate of 4.3% to 49 ktoe in 2030 in the BaU scenario. In the case of the AEG scenario, energy demand for office buildings/office space is projected to increase from 38 ktoe in 2020 at an average annual rate of 6.1% to 68 ktoe in 2030. The energy demand projections for public and private office buildings/office space is presented in Table 3.14

Table 3.14: Energy Demand by Office Buildings (ktoe)

Sub-Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Government	7	12	12	15	18	14	14	18	24
Private	13	20	21	25	30	24	26	33	44
Total	21	32	33	39	49	38	40	51	68

Public office buildings accounting for about 37% of the total energy demand for Office Buildings in 2020 would rise to 38.0% in 2030 for the BaU scenario but would drop to about 35% in 2030 for the AEG scenario. The main fuel demand for office buildings/office space is electricity. Back-up generation accounts for diesel requirement by the sub-sector. However, it is assumed that the demand for diesel would fade out with improvement in the public or grid electricity supply system.

3.3.2.2 Final Energy Demand by Accommodation Facilities

Accommodation facilities of the Services sector are classified into Hotels, Guesthouses, Budgets and Hostels. The Hotels are further re-classified according to their star ratings to obtain homogenous energy use patterns. This is to ensure a realistic evaluation of the final energy demand for accommodation facilities.

The total final energy demand for Accommodation facilities is projected to increase from 33 ktoe in 2020 at an average annual growth rate of 6.3% to 60 ktoe in 2030 for the BaU scenario. For the AEG scenario, the total energy demand is projected to increase from 53 ktoe in 2020 at an average annual growth rate of 10.3% to 142 ktoe in 2030.

Table 3.15: Final Energy Demand Projection by Accommodation Establishment (ktoe)

Sub-Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Hotel	13	21	22	29	39	40	44	68	112
Budget	5.1	8.9	9.4	11.6	15.2	8.3	8.6	10.3	12.7
Guest House	0.7	0.6	0.6	0.7	0.9	1.6	1.7	2.4	3.6
Hostel	0.1	2.5	2.7	3.6	5.2	3.6	4.2	7.4	13.6
Total	19	33	35	45	60	53	59	88	142

Electricity would account for 83.4% of the energy demand for Accommodation Facilities for the BaU scenario in 2030. It is followed by LPG, which is projected to account for 15.5% of the total final energy demand, charcoal 1.1% and firewood 0.1%. Under the AEG scenario, electricity would account for 84.4% of the total final energy demand while LPG accounts for 14.9%, charcoal 0.7% and firewood 0.04% in 2030.

3.3.2.3 Final Energy Demand by Health Facilities

The total final energy demand for health facilities is evaluated by classifying health facilities into hospitals, poly-clinics, maternity homes, health centres and miscellaneous[47] health facilities. This was done to obtain homogenous energy use patterns to ensure a realistic assessment of the final energy demand for health facilities.

The total final energy demand for health facilities is projected to increase from 34 ktoe in 2020 at an average annual rate of 6.2% to 63 ktoe in 2030 under the BaU scenario and 93 ktoe in 2030 under the AEG scenario at an average annual growth rate of 7.8%.

The dominant energy demand sub-sector is hospitals, accounting for 72-80% of the total energy demand for health facilities in 2020 and is projected to increase to 77.1% and 87.2% in 2030 respectively for the BaU and the AEG scenarios. The increase in the share of energy demand by hospitals is due to an increase in the number of hospitals and an increase in the penetration of energy end-use equipment and appliances such as diagnostic, sanitising and storage equipment in hospitals. The final energy demand for health facilities according to the different sub-sectors is presented in Table 3.16.

[47] Classification from Ministry of Health

Table 3.16: Final Energy Demand Projection by Health Facilities (ktoe)

Sub-Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Hospitals	12	25	26	35	48	35	39	54	81
Poly_Clinics	3.2	4.8	5.0	5.9	7.6	4.6	4.8	5.7	7.2
MatHealth Centres	2.6	3.5	3.6	4.0	4.5	3.0	3.0	3.1	3.0
Others	2.4	1.2	1.3	1.6	2.2	1.0	1.1	1.3	1.6
Total	20	34	36	46	63	44	47	64	93

The dominant fuel for health facilities is electricity, the demand of which is projected to increase from 93.5-93.7% of the total energy demand in 2020 to 95.2% and 95.2% in 2030 for the BaU and AEG scenarios respectively.

3.3.2.4 Final Energy Demand by Educational Institutions

The total final energy demand for educational institutions[48] is projected to increase from 149-207 ktoe in 2020 at an average annual growth rate of about 4.5-7.5% to 232 ktoe and 428 ktoe in 2030 for the BaU and AEG scenarios respectively (see Table 3.17).

The tertiary institutions constitute the dominant energy demand sub-sector, accounting for 44-48% of the total energy demand for educational institutions in 2020 and expanding to 60.5% and 65.0% in 2030 for the BaU and AEG scenarios respectively.

Table 3.17: Final Energy Demand Projection by Educational Facility (ktoe)

Sub-Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Tertiary	21	65	71	98	141	99	111	171	278
Secondary	32	25	25	25	24	33	34	37	41
TechVoc	12	12	12	12	11	18	18	20	23
Basic	29	46	47	52	57	57	60	72	86
Special	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.0
Total	94	149	156	187	232	207	224	300	428

The demand for electricity, accounting for about 48-51% of the total final energy demand for educational facilities in 2020 would increase to 65.0% and 68.0% in 2030 for the BaU and AEG scenarios respectively.

[48] Classification from Ghana Education Service

The other significant fuels would be firewood and charcoal, the demand of which is projected to drop from about 26% and 21% respectively in 2020 to about 15% in 2030 for the BaU scenario and about 15% and 12% for the AEG scenario.

LPG is projected to increase from about 4% of the total final energy demand for educational institutions in 2020 to about 6% in 2030 for both BaU and AEG scenarios.

3.3.2.5 Energy Demand by Wholesale and Retail Outlets

The final energy demand for Wholesale & Retail outlets was classified under the following subsectors; large shopping malls (e.g. Accra Shopping mall, Junction mall, etc), other shopping facilities (A&C, Maxmart), supermarkets, cold-stores and others (e.g. stores, shops, etc).

The final energy demand for Wholesale & Retail outlets would increase from 83 ktoe in 2020 at an average annual growth rate of 9.1% to 197 ktoe in 2030 for the BaU scenario. For the AEG scenario, the total final energy demand would increase from 117 ktoe in 2020 at an average annual growth rate of 11.3% to 342 ktoe in 2030.

The most dominant energy demand sub-sector of the Wholesale and Retail outlet sector is Other Shopping Facilities. They account for about 62.21% of the total energy demand for the wholesale and retail outlets in 2020 for the BaU scenario, increasing to 73.55% in 2030. In the case of the AEG scenario, it would account for 66.56% of the total final energy demand in 2020 and increase to 76.5% in 2030. The share of large shopping malls would decrease from about 13-16% of the total final energy demand in 2020 to 7.0% in 2030 for the BaU scenario and to 5.6% in 2030 for the AEG scenario.

The share of the final energy demand for Supermarkets would be about 15% throughout the planning period for both scenarios (see Table 3.18).

Table 3.18: Final Energy Demand Projection by Wholesale and Retail Outlet (ktoe)

Sub-Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Large Shopping Mall	11	13	13	13	14	15	16	17	19
Other Shopping Malls	2	52	59	91	145	78	90	151	262
Supermarket	3	12	14	20	30	17	20	31	51
Cold stores	0.6	1.2	1.3	1.7	2.4	1.1	1.2	1.5	2.1
Others	4.0	4.9	5.0	5.4	6.0	5.6	5.8	6.6	7.6
Total	20	83	92	132	197	117	132	207	342

3.3.2.6 Final Energy Demand by Food Service Industry

The final energy demand for the Food Service Industry is classified into Restaurants and Eateries (or Chop Bars). The classification was done to ensure that each sub-sector has a homogenous energy use pattern (see Table 3.19).

The total final energy demand for Restaurants and Eateries is projected to increase from 65 ktoe in 2020 at an average annual growth rate of 5.8% to 114 ktoe in 2030 for the BaU scenario. For the AEG scenario, energy demand would rise at an average annual growth rate of 6.7% to 138 ktoe in 2030.

Final energy demand for restaurants accounts for 47% and 52% of the total final energy demand in 2020, which would increase to about 59% and 66% in 2030 for the BaU and AEG scenarios respectively.

Table 3.19: Final Energy Demand Projection by Restaurant and Eatery (ktoe)

Sub-Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Restaurants	9	30	33	46	67	37	41	60	92
Chop bars etc	26	35	36	40	47	35	36	40	46
Total	36	65	69	86	114	72	77	100	138

Electricity would account for about 41-42% of the total final demand in 2020, increasing to about 48% and 49% in 2030 respectively for the BaU and AEG scenarios. The next dominant fuel is charcoal, whose share would decrease from about 34% of the total final energy demand in 2020 to about 24% and 23% in 2030 respectively for the BaU and AEG scenarios.

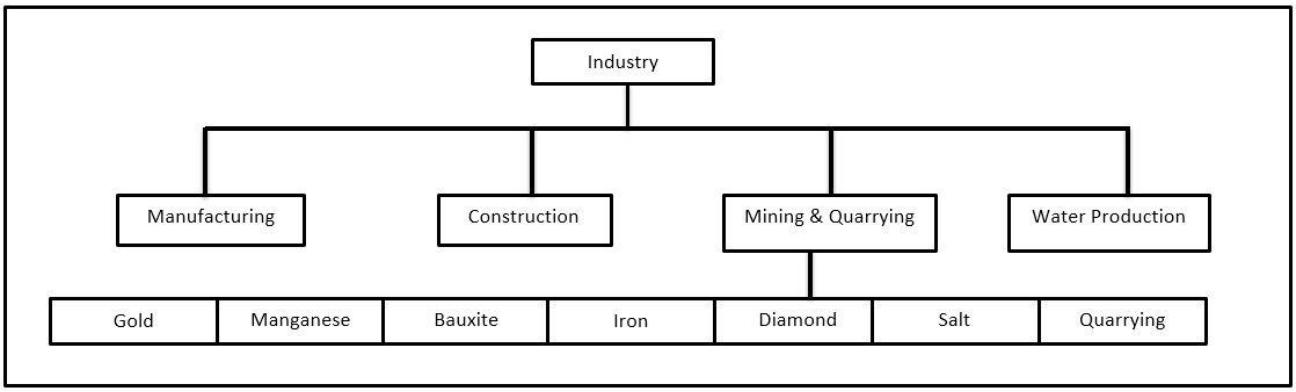
The share of firewood demand would also decrease from about 10% of the total final energy demand in 2020 to about 5% in 2030 respectively for the BaU and the AEG scenarios. The demand for LPG, on the other hand, would increase from about 14-15% of the total final energy demand in 2020 to 22.6% and 22.7% in 2030 respectively for the BaU and AEG scenarios.

3.3.2.7 Final Energy Demand by Street-lighting

The final energy demand for street-lighting is evaluated by considering all the electric street-lighting devices as one technology without any distinction. The total final energy demand for street-lighting is projected to increase from 55.9 ktoe (650 GWh) in 2020 at an average annual rate of 6.1% to 101.5 ktoe (1,180 GWh) in 2030 for the BaU scenario and also at average annual rate of 6.1% to 106.5 ktoe (1,239 GWh) in 2030 in the case of the AEG scenario due to the use of efficient lighting devices such as LED and more energy-saving lighting control systems.

3.4 Energy Demand by Industrial Sector

The country's industrial sector is classified mainly into manufacturing, construction, mining & quarrying and water production. The mining and quarrying sub-sector was further classified into gold mining, manganese mining, bauxite mining, diamond mining, quarrying and salt mining.



The evaluation of the final energy demand for the industrial sector was undertaken by classifying the industrial sector into the following:

(i) utilities (i.e. water production),
(ii) mining and quarrying activities,
(iii) construction activities, and
(iv) manufacturing activities.

3.4.1 Energy Demand of Industrial Sector by Sub-sector

The industrial sector's total final energy demand is projected to increase from 1,511 ktoe in 2020 at an average annual rate of 4.8% to 2,418 ktoe in 2030 for the BaU scenario. In the case of the AEG scenario, the total final energy demand is projected to increase from 1,650 ktoe in 2020 at an average annual rate of 14.7% to 6,451 ktoe in 2030.

The manufacturing sub-sector is the dominant sub-sector in terms of energy demand. In 2030, the manufacturing sub-sector is projected to account for 56.1% of the industrial sector's total final energy demand compared to 54.1% in 2020 for the BaU scenario. In the case of the AEG scenario, the manufacturing sub-sector would account for 78.9% of the industrial sector's total final energy in 2030 compared to 53.5% in 2020. The next dominant sub-sector would be the mining and quarrying sub-sector, which would account for 37.9% of the total final energy demand in 2030 compared to 38.2% in 2020 for the BaU scenario. The AEG scenario shows that the final energy demand for mining and

quarrying is projected to account for 18.5% of the industrial sector's total final energy demand in 2030 compared to 38.8% in 2020.

Table 3.20: Final Energy Demand of Industrial Sector by Sub-sector (ktoe)

Sub-sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Water production	15	39	42	52	63	45	48	59	74
Mining and Quarrying	356	578	605	729	916	632	667	880	1,194
Construction	71	76	77	79	82	81	82	86	91
Manufacturing	428	817	863	1,059	1,357	872	925	2,774	5,092
Total	869	1,511	1,587	1,919	2,418	1,630	1,722	3,799	6,451

The energy demand of the manufacturing sub-sector would increase from 817 ktoe in 2020 at an average annual rate of 5.2% to 1,357 ktoe for the BaU scenario and from 872 ktoe in 2020 at an average annual rate of 19.3% to 5,092 ktoe in 2030 for the AEG scenario. The higher final energy demand for the manufacturing sub-sector is due to the processing and refining of bauxite and iron integrated industries as a result of government's proposed programmes of Integrated Bauxite and Aluminum Industries, and Integrated Iron and Steel Industries. Energy demand for the mining and quarrying sub-sector would increase from 578 ktoe in 2020 at an average annual rate of 4.7% to 916 ktoe in 2030 for the BaU scenario. In the case of the AEG scenario, the final energy demand for mining and quarrying would increase from 632 ktoe in 2020 at an average annual rate of 6.6% to 1,194 ktoe.

3.4.1.1 Energy Demand by Fuel type

By 2030, the dominant fuels in the final energy mix of the industrial sector would be diesel and electricity for BaU scenario; but natural gas and electricity under AEG scenarios. Under the BaU scenario, diesel is projected to account for 31.3% of the industrial sector's total final energy demand in 2020 and will largely remain unchanged in 2030 whiles electricity would increase from 28.7% to 31.3%. In the case of the AEG scenario, the share of electricity is projected to decrease from 30.5% in 2020 to 22.8% in 2030, whiles natural gas share would increase from 4.2% to 42.2%.

The share of other petroleum products like RFO and LPG would be 5.6% and 1.8% of the total final energy demand respectively in 2020 compared to 6.6% and 2.4% in 2030 for the BaU scenario. Under the AEG scenario, the share of RFO and LPG in total energy demand would decrease from 6.0% and 1.9% respectively in 2020 to 4.1% and 1.0% in 2030.

The informal industrial sub-sector mostly demands firewood for the production of goods such as gari and pito. The share of firewood in the total final energy demand would decrease from 28.2% in 2020 to 23.6% in 2030 for the BaU scenario. In the case of the AEG scenario, the share would decrease from 26.2% in 2020 to 8.9% in 2030.

Table 3.21: Final Energy Demand of Industrial Sector by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	235	433	460	577	758	496	532	940	1,468
Diesel	306	473	494	590	737	506	531	852	1,359
Kerosene	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LPG	12	28	30	40	58	31	34	46	66
Residual Fuel Oil	40	84	91	117	160	98	106	166	263
Wood	275	426	440	500	571	427	442	503	572
Charcoal	1.8	2.3	2.3	2.3	2.3	2.3	2.3	2.4	2.3
Natural Gas	-	65	70	93	133	69	74	1,289	2,721
Total	869	1,511	1,587	1,919	2,418	1,630	1,722	3,799	6,451

The average annual growth rate of the various fuels used in the industrial sector from 2020 to 2030 shows growth for electricity demand to be 5.7% and 11.5% for the BaU and AEG scenarios respectively. Industrial demand for diesel would increase at an average annual rate of 4.5% and 10.4% for the BaU and AEG scenarios respectively whilst RFO demand increases at an average annual rate of 6.6% and 10.3% for the BaU and AEG scenarios respectively. In the case of the demand for wood, this would increase at an average annual rate of 3.0% for both scenarios. The results in ktoe are presented in Table 3.21.

3.4.2 Water Production

The Ghana Water Company Limited is a public utility with the mandate to provide potable and industrial water for the country. The final energy demand for the production and supply of water is evaluated by considering all the water production facilities of the Ghana Water Company as one system. The total electricity demand for water production would increase from 459 GWh and 520 GWh in 2020 respectively for the BaU and AEG scenarios at an average annual rate of 4.9% and 5.2% to 737 GWh and 860 GWh in 2030 (see Table 3.22).

Table 3.22: Electricity Demand for Water Production (GWh)

Sub-sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Water production	169	459	487	600	737	520	555	692	860

3.4.3 Mining and Quarrying

The assessment of the final energy demand for the mining and quarrying sub-sector is classified [49] into the following minerals and resources:

(i) gold,
(ii) manganese,
(iii) bauxite,
(iv) iron,
(v) diamond,
(vi) salt, and
(vii) quarry.

3.4.3.1 Energy Demand by Fuel-Type

The Mining and Quarrying sub-sector mostly utilises diesel and electricity for its operations. The diesel demand is projected to increase from 359 ktoe and 382 ktoe in 2020 at an average annual rate of 4.6 and 6.7% respectively to 561 ktoe and 727 ktoe in 2030 for the BaU and AEG scenarios respectively. The sector's electricity demand would increase from 219 ktoe and 250 ktoe in 2020 at an average annual rate of 4.9% and 6.4% respectively to 355 ktoe and 467 ktoe in 2030 for the BaU and AEG scenarios (see Table 3.23).

Table 3.23: Final Energy Demand by the Mining and Quarrying Sector by Fuel (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	134	219	230	279	355	250	266	343	467
Diesel	222	359	375	450	561	382	401	536	727
Total	356	578	605	729	916	632	667	880	1,194

The demand for diesel would be dominant in the Mining & Quarrying sub-sector's total final energy demand and would account for 61.3% of the total final energy demand in 2030 for the BaU scenario but would decline marginally to 60.9% for the AEG scenario.

3.4.3.2 Energy demand by sub-sectors

Table 4.24 presents the Mining & Quarrying sector's final energy demand by the various sub-sectors. Gold mining would remain the dominant mining activity (in terms of energy demand) accounting for over 80% of the total energy demand for mining and quarrying.

[49] Classification by Ghana Statistical Service

Table 3.24: Final Energy Demand by the Mining and Quarrying Sub-sectors (ktoe)

Sub-sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Gold	334	525	549	657	822	575	606	752	983
manganese	5.3	6.4	6.5	6.9	7.3	6.8	7.0	7.7	8.5
diamonds	0.3	0.5	0.6	0.8	1.0	0.6	0.7	0.9	1.2
bauxite	1.2	2.5	2.5	2.5	2.4	2.8	2.9	3.2	3.6
quarrying	15	44	46	62	83	47	50	70	98
salt	0	0	0	0	0	0	0	0	0
Iron	-	-	-	-	-	-	-	38	92
Limestone	-	-	-	-	-	-	-	7.6	7.6
Total	356	578	605	729	916	632	667	880	1,194

3.4.3.3 Final Energy Demand for Gold Mining

Four main factors influence gold production methods, particularly whether to opt for surface or underground mining. They are the (i) richness or concentration of the ore; (ii) world market price of gold, (iii) production cost and (iv) energy price.

The gold mining sub-sector has been classified into (i) underground mining and (ii) surface mining. For most surface mines in Ghana, the concentration of gold is between 2–3 gramme per tonne of ore, reducing to 1–2 gramme per tonne for workable tailings. For underground mining, concentration could go as high as 8–12 grammes per tonne of ore on the average in Obuasi underground but drops to a range of 3–5 gramme per tonne of ore in other areas of the country. In general, for any given mining area, the ore is richer as one goes underground[50].

The global market price averaged US$300-400 per ounce minimum in the 1990s but rose to the peak of US$3,000 per ounce during the last decade before dropping to the average range of US$1,200-1,400 per ounce since 2011.

As the global average price has gone up significantly, so also has the production cost. The total average production costs usually referred to AISC (All-in Sustaining Cost) has ranged from US$500-900 per ounce depending upon the quality of the ore and the depth, since the last decade compared to US$190–200 per ounce in the 1990s. Production cost beyond US$900[51] per ounce of gold is usually regarded as too high by the industry. In Ghana, however, it has ranged from about US$600-1,500[52]

[50] Reproduced from SNEP 2006-2020 released in 2006 and available at www.energycom.gov.gh/planning
[51] All-in Sustaining Cost (AISC).
[52] Ghana Chamber of Mines, Performance of the Mining Industry in 2016.

In terms of energy intensities, i.e., the electricity required to process one tonne of ore from underground gold mining range between 20-29 Gigawatt-hour per tonne of ore, depending upon the depth, followed by surface mining (below 11 Gigawatt-hour per tonne).

The demand for electricity would increase from 216 ktoe and 247 ktoe in 2020 respectively for BaU and the AEG scenarios at an average annual growth rate of 4.9% and 6.2% to 351 ktoe and 452 ktoe in 2030. Diesel demand for gold mining would increase from 308 ktoe and 327 ktoe in 2020 respectively for the BaU and the AEG scenarios at an average annual growth rate of 4.3% and 5.0% to 471 ktoe and 531 ktoe in 2030 (see Table 3.25).

Table 3.25: Final Energy Demand of Gold Mining by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	133	216	227	276	351	247	263	335	452
Diesel	201	308	322	381	471	327	344	417	531
Total	334	525	549	657	822	575	606	752	983

A. Final Energy Demand by Type of Mine

There are numerous economic and technical factors influencing preference for underground mining or surface mining. Some of the factors are price for the product, cost of production, quality and quantity of the deposit, volume of overburden to be removed per ton of the deposit, and feasibility of reclamation. Energy use is among factors influencing the cost of production. Underground mining requires more electricity than surface mining owing to more lighting needs, ventilation and space cooling whilst surface mining generally requires more diesel than electricity.

The final energy demand for underground gold mining would increase from 441 ktoe and 464 ktoe in 2020 respectively for the BaU and AEG scenarios at an average annual rate of 4.1% and 4.6% to 659 ktoe and 730 ktoe in 2030. Final energy demand for surface mining would increase from 84 ktoe and 110 ktoe respectively in 2020 for the BaU and the AEG scenarios at an average annual rate of 6.9% and 8.7% to 163 ktoe and 253 ktoe in 2030.

Table 3.26: Final Energy Demand by Gold Mining Sub-sectors (ktoe)

Sub-sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Surface gold	39	84	90	118	163	110	120	170	253
Underground gold	295	441	459	539	659	464	486	582	730
Total	334	525	549	657	822	575	606	752	983

3.4.3.4 Final Energy Demand by Manganese Mining

The final energy demand for manganese mining would increase from 6.4 ktoe and 6.8 ktoe in 2020 at an average annual growth rate of 1.3% and 2.3% respectively for the BaU and the AEG scenarios, to 7.3 ktoe and 8.5 ktoe in 2030.

Table 3.27: Final Energy Demand by Manganese Mining (ktoe)

Sub-sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Manganese	5.3	6.4	6.5	6.9	7.3	6.8	7.0	7.7	8.5

The dominant fuel used for manganese mining is diesel, which would account for about 75% of the total energy demand for both scenarios. Electricity would account for the rest of the demand.

3.4.3.5 Energy Demand by Bauxite Mining

The final energy demand for bauxite mining would increase from 2.5 ktoe in 2020 to 2.4 ktoe in 2030 for the BaU scenario. For the AEG scenario, the final energy demand would increase from 2.8 ktoe in 2020 at an annual average growth rate of 2.5% to 3.6 ktoe in 2030 (see Table 3.28). The expected demand increase for the AEG scenario is due to the government integrated bauxite and aluminium industrial plan.

Table 3.28: Final Energy Demand by Bauxite Mining (ktoe)

Sub-sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Bauxite	1.2	2.5	2.5	2.5	2.4	2.8	2.9	3.2	3.6

The main fuels used for mining bauxite are diesel and electricity. The demand for diesel would account for 75.0% of the total final energy demand for bauxite mining in 2030 compared to about 74% in 2020 for both scenarios.

3.4.3.6 Energy Demand by Iron Mining

Over 1.7 billion iron ore was discovered in the country, and with the passage of the Ghana Iron and Steel Development Corporation Act, 2019 (ACT 988) by Parliament, the sub-sector is expected to be vibrant. It was modelled under the AEG scenario and was assumed that mining would commence around 2023-2024.

The expected main fuels to be used are diesel and electricity. The final energy demand would be about 38 ktoe in 2025 to 92 ktoe by 2030, with diesel accounting for about 90% of the final energy demand.

3.4.3.7 Final Energy Demand by Diamond Mining

The final energy demand for diamond mining would increase from 0.5 ktoe in 2020 at an average annual growth rate of 6.1% to 1.0 ktoe in 2030 for the BaU scenario. In the case of the AEG scenario, it would increase at an annual average rate of 6.8% to 1.2 ktoe in 2030 (see Table 3.29).

Table 3.29: Final Energy Demand by Diamond Mining (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2
Diesel	0.3	0.5	0.5	0.6	0.8	0.5	0.6	0.8	1.0
Total	0.3	0.5	0.6	0.8	1.0	0.6	0.7	0.9	1.2

The fuels for mining diamonds are diesel and electricity. The dominant fuel is diesel, which would account for about 83% of the total final energy demand for diamond mining in both the BaU and AEG scenarios throughout the planning period.

3.4.3.8 Final Energy Demand by Stone Quarrying

The main fuels used for stone quarrying are diesel and electricity. Energy demand for stone quarrying would rise from 43.6 ktoe in 2020 at an average annual growth rate of 6.7% to 83.3 ktoe in 2030. In the case of the AEG scenario, the final energy would increase at an average annual rate of 7.6% from 46.9 ktoe to 97.5 ktoe in 2030. Share of diesel is projected to be about 97% for both scenarios.

3.4.3.9 Final Energy Demand by Salt Mining

Salt mining is currently undertaken by artisanal salt winning from lagoons during the dry season and by traditional pond production where solar thermal energy is used as evaporative power.

The main fuels for salt mining in future would be electricity and diesel for pumping and processing activities. The energy demand would increase from 0.1 ktoe in 2020 at an average annual rate of 8% to 0.2 ktoe in 2030 for the BaU scenario. For the AEG scenario, the final energy demand would increase at an annual average rate of 11% to 0.3 ktoe in 2030. The demand for diesel would account for 48.7% of the final energy demand in both the BaU and AEG scenarios in 2030, a slight increase from 48.5% in 2018.

3.4.4 Construction Sub-sector

The construction industry comprises the construction of new and the refurbishment of urban and rural buildings, Class I and II highways, expressways, bridges, urban paved areas, coastal works and general infrastructure development. It is classified into (i) building and (ii) road construction.

The total final energy demand for the construction industry would increase from 76 ktoe in 2020 at an average annual rate of 0.7% to 82 ktoe in 2030 for the BaU scenario and 91 ktoe in 2030 in the case of the AEG scenario, at an annual average growth rate of 1.2%.

3.4.5 Formal Manufacturing Sub-sector

The manufacturing sub-sector promotes technology transfer, provides revenue and employment and as such, is very critical to the economy. The manufacturing sub-sector comprises formal and informal entities.

The formal manufacturing sub-sector is classified into medium and large-scale manufacturing enterprises (MLME) and the micro and small-scale manufacturing enterprises (MSME).

The formal manufacturing sub-sector includes activities such as the production of cement[53], textiles, food and beverages, plastics, iron and steel, chemical and pharmaceutical products and the processing of wood lumber into other products.

The final energy demand for the formal manufacturing sub-sector is evaluated by classifying the formal manufacturing sub-sector into the following industrial activities: iron and steel production, cement production, food processing, production of beverages, plastics, textiles, wood processing, paper and paper products, chemical and chemical products, lubricating oils, fabrication of metals and miscellaneous products.

3.4.5.1 Final Energy Demand by Fuel

The total final energy demand for the formal manufacturing sub-sector would increase from 385 and 439 ktoe in 2020 at an annual growth rate of 7.2% to 775 ktoe in 2030 for the BaU scenario and to 4,510 ktoe in 2030 at an average annual rate of 26.2% in the case of the AEG scenario (see Table 3.30).

[53] Milling of clinker and gypsum

Table 3.30: Final Energy Demand of Formal Manufacturing Sub-sector by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	86	175	188	246	340	201	218	538	927
Diesel	14	38	42	61	94	43	48	230	541
LPG	10	23	26	34	49	27	30	40	57
Residual Fuel Oil	40	84	91	117	160	98	106	166	263
Wood	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04
Natural Gas	-	65	70	93	133	69	74	1,289	2,721
Total	150	385	416	551	775	439	477	2,262	4,510

Electricity would remain the dominant fuel for the manufacturing sub-sector under BaU scenario whilst the AEG scenario natural gas would displace electricity as the dominant fuel. The share of electricity accounting for about 45% in 2020 is expected to decrease to 44% in 2030 for BaU and to about 20% under the AEG scenario should the relatively high electricity tariff remains unchanged while residential access estimated to be over 83% in 2019 continues to expand[54].

Demand for natural gas as final energy use is driven mainly by the expected processing of extractive minerals such as iron to pig iron, limestone to clinker and bauxite to alumina. These expected activities considered under the AEG scenario would cause the share of natural gas to increase from 17% to 60% in 2030, becoming the dominant fuel.

3.4.5.2 Final Energy Demand by End-use

Table 3.31 presents the final energy demand for the Manufacturing sub-sector according to the various manufacturing activities. The final energy demand for food processing is projected to increase at an annual average growth rate of 8% from 80 ktoe in 2020 to 173 ktoe in 2030 for the BaU scenario, and from 94 ktoe to 203 ktoe for the AEG scenario. Food processing would be the most dominant identifiable energy demand activity accounting for about 21% of the final energy demand share for BaU scenario. Its dominance would be displaced by pig iron and steel production under the AEG scenario.

[54] Ministry of Power estimated universal access to grid electricity to about 84% by close of 2018.

Table 3.31: Final Manufacturing Energy Demand by Sub-sector (ktoe)

Sub-sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Pig Iron Production	-	-	-	-	-	-	-	1,063	2,559
Steel Production	-	-	-	-	-	-	-	186	469
Steel Milling	3	7	8	12	19	9	10	125	311
Clinker Production	-	-	-	-	-	-	-	110	110
Cement Milling	12	30	33	43	55	43	48	66	88
Alumina Production	-	-	-	-	-	-	-	153	170
Textiles	12	26	28	36	47	31	34	44	57
Plastics	8	9	9	9	9	9	9	9	10
Wood processing	8	13	14	18	24	15	16	21	29
Beverages	18	38	41	54	76	44	48	63	89
Food processing	33	80	88	118	173	94	103	138	203
Paper and Paper Products	3	7	8	11	16	8	9	12	18
Chemicals & chemical products	6	12	13	19	27	14	16	22	32
Lubricating oils	0.1	0.2	0.2	0.3	0.5	0.2	0.3	0.4	0.6
Fabrication of metals	7	14	15	19	24	15	16	20	26
Other	41	148	159	212	304	157	169	231	339
Total	150	385	416	551	775	439	477	2,262	4,510

3.4.5.3 Final Energy Demand by Cement Production

The major cement plants in the country produce mainly Portland cement. Imported clinker and gypsum are ground into Portland cement at Tema, Takoradi and Aflao. Another plant, the Savanna Diamond Cement started cement production in 2011 and produces clinker from limestone deposit at Buipe in the Northern region. It is then milled with imported gypsum into Portland cement. There is another plant near Konongo on the Konongo-Kumasi road.

The final energy demand for cement production is evaluated by classifying cement production into clinker production phase and milling phase (such as Ghacem and Diamond).

The final energy demand for cement production is projected to increase from 34 ktoe in 2018 at an average annual growth rate of 10.2% to 109 ktoe in 2030 for the BaU scenario. For the AEG scenario, the final energy demand would increase at an average annual rate of 10.9% to 139 ktoe in 2030. The results, according to fuels, are presented in Table 3.32.

Table 3.32: Final Energy Demand by Cement Production by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	12	30	32	42	54	42	47	86	108
Diesel	0	1	1	1	1	1	1	101	101
Natural Gas	-	0.0	0.0	0.0	0.0	0.0	0.0	99.4	99.4
Total	12	30	33	43	55	43	48	287	308

Though the demand for electricity would increase, its share of 98% in 2020 (for both scenarios) is expected to remain the same for BaU scenario but would decrease to 35% in 2030 for the AEG scenario. Share of demand for natural gas (modelled to replace Residual Fuel Oil) would increase to about 32% AEG as a result of energy-intensive integrated cement production starting from the sintering of clinker.

3.4.5.4 Final Energy Demand by Steel Industry

The steel production plants in the country employ the Electric Arc Furnace technology to produce steel using scrap metals as feedstock. The total final energy demand for steel production is projected to increase from 7-9 ktoe in 2020 at an average annual growth rate of 8.1% to 19 ktoe and 57% to 780 ktoe in 2030 for the BaU and AEG scenarios respectively (see Table 3.33).

Table 3.33: Final Energy Demand Projection for Steel Production by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	1.5	3.4	3.7	5.0	7.5	4.0	4.4	174.4	413.1
Diesel	1.1	3.4	3.9	5.9	10.3	4.0	4.5	115.9	315.2
Residual Fuel Oil	0.2	0.6	0.7	1.0	1.7	0.7	0.8	20.0	51.8
Total	2.9	7.4	8.3	12.0	19.4	8.7	9.7	310.2	780.0

Electricity is projected to account for about 38% of the final energy demand for steel production whilst diesel accounts for 53% and RFO 9% for BaU scenario. Meanwhile, electricity, diesel and RFO respectively account for 53%, 40% and 7% under AEG scenario by 2030.

3.4.5.5 Final Energy Demand by the Plastic Industry

The plastic industries produce polymer materials and intermediate products for the building and construction industry, electronics, chemicals, packaging and transportation industries. It is one of the fastest-growing industries in the country.

The final energy demand of the plastic industry is projected to increase from 8.6 ktoe in 2020 at an average annual rate of 0.6% to 9.2 ktoe in 2030 for the BaU scenario. Under the AEG scenario, final energy demand is projected to increase from 9.0 ktoe in 2020 at an average annual rate of 1.0% to 10 ktoe in 2030. These results are presented in Table 3.34.

Table 3.34: Final Energy Demand of Plastic Industry by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	4.8	5.1	5.1	5.3	5.4	5.3	5.4	5.6	5.9
Diesel	3.3	3.5	3.5	3.6	3.7	3.6	3.6	3.8	4.0
LPG	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
Residual Fuel Oil	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Total	8.1	8.6	8.7	8.9	9.2	9.0	9.1	9.5	10.0

The demand for electricity is projected to account for 59% of the final energy demand for plastics production whilst diesel accounts for 40%, and LPG and RFO would have the remaining 1% for both the BaU and AEG scenarios.

3.4.5.6 Final Energy Demand by Food Processing Industry

The food processing industry annually accounts for about 15% of the total output of the manufacturing sector[55]. This industry comprises the large-scale processing of raw cocoa beans and oil-palm fruits into semi-finished and finished products, the manufacture of animal feeds, canned products, dairy products, food products, e.g. pasta, noodles etc. and grain mill products, e.g. wheat flour.

The total final energy demand of the food processing industry is projected to increase from 80-94 ktoe in 2020 at an average annual rate of about 8.0% to 173 ktoe and 203 ktoe in 2030 for the BaU and AEG scenarios respectively (see Table 3.35).

Table 3.35: Final Energy Demand by Food Processing (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	8	19	20	27	38	22	24	31	44
Diesel	1	5	6	11	19	6	7	12	22
LPG	9	21	23	30	44	25	27	36	51
Residual Fuel Oil	15.2	35.2	38.2	50.3	72.1	41.2	44.8	59.0	84.4
Total	33	80	88	118	173	94	103	138	203

[55] Ghana Statistical Service: "Value Added Estimates of Sub-sectors of Manufacturing in the Revised 2011 GDP"

Demand for RFO, used in the formal food industry, would account for 42% of the final energy demand for food processing whilst electricity demand would account for 22%, diesel about 11% and LPG about 25% in 2030 for both BaU and AEG scenarios.

3.4.5.7 Final Energy Demand by Beverage Industry

The beverage industry includes the large-scale manufacture of alcoholic (i.e. hard liquors, wines and beers) and non-alcoholic (i.e. carbonated drinks, fruit juices and water (sachet and bottled) drinks.

The total final energy demand of the beverage industry would increase from 38-44 ktoe in 2020 at an average annual growth rate of 7.2% to 76 ktoe and 89 ktoe in 2030 for the BaU and AEG scenarios respectively (see Table 3.36).

Table 3.36: Final Energy Demand by the Beverage Industry (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	3.6	6.9	7.4	9.3	12.6	8.1	8.6	10.9	14.8
Diesel	0.8	5.5	6.4	10.1	17.3	6.5	7.4	11.9	20.3
LPG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residual Fuel Oil	13.3	25.4	27.2	34.2	46.1	29.8	31.9	40.1	54.0
Total	17.6	37.9	40.9	53.7	76.0	44.4	47.9	62.9	89.0

Residual fuel oil would account for 60.6% of the final energy demand whilst electricity, and diesel would account for 16.6% and 22.8% in 2030, respectively for both BaU and AEG scenarios.

3.4.5.8 Final Energy Demand by Textile Industry

The final energy demand for the textile industry is projected to increase from 26-31 ktoe in 2020 at an average annual rate of 6.0% and 6.3% respectively to 47 ktoe and 57 ktoe in 2030 for the BaU and AEG scenarios (see Table 3.37).

Table 3.37: Final Energy Demand by the Textile Industry (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	3.0	6.6	7.2	9.3	12.0	8.0	8.6	11.3	14.7
Diesel	0.4	2.0	2.2	3.6	5.8	2.5	2.9	4.8	8.0
Residual Fuel Oil	8.5	17.3	18.5	23.3	28.8	20.5	22.0	27.8	34.4
Total	12.0	25.9	28.0	36.2	46.6	31.0	33.6	43.9	57.0

RFO would be the dominant fuel in the final energy mix of the textile industry. Nonetheless, its share would drop from about 70% in 2020 to 62% and 60% respectively for the BaU and AEG scenarios. The share of electricity would, however, remain about the same at 26-27% for both scenarios. The share of diesel would increase from about 8% in 2020 to 12-14% in 2030 for both BaU and AEG scenarios.

3.4.5.9 Final Energy Demand by Chemical Industry

The chemical industry involves the production of a wide range of products such as consumer goods (soap and toiletries, health care and hair products, pharmaceuticals), paints and fertilisers.

The final energy demand for the chemical industry is projected to increase from 12-14 ktoe at an average annual growth rate of 8.4% to 27 ktoe and 32 ktoe respectively in 2030 according to the BaU and AEG scenarios.

In 2030, electricity share of the total final energy demand would remain about the same as about 54% in 2020 for both scenarios. RFO and diesel shares of about 18% and 28% respectively are also expected to remain about the same for both the BaU and AEG scenarios (see Table 3.38).

Table 3.38: Final Energy Demand by Chemical Industry (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	3.0	6.5	7.2	10.1	14.5	7.6	8.4	11.9	17.0
Diesel	1.6	3.4	3.8	5.3	7.6	4.0	4.4	6.3	9.0
Residual Fuel Oil	1.0	2.2	2.5	3.5	5.0	2.6	2.9	4.1	5.8
Total	5.7	12.1	13.4	18.9	27.1	14.1	15.8	22.2	31.8

3.4.5.10 Final Energy Demand by Metal Fabrication Industry

The metal fabrication industry includes the manufacturing of a wide range of aluminium and steel products (e.g. steel tanks and reservoirs, LPG cylinders, gas stoves, metal chairs, cables and cabling systems) on a large-scale.

The energy demand was projected to increase from about 14-15 ktoe in 2020 at an average annual growth rate of 5.6% and 5.7% respectively to 24 ktoe and 26 ktoe in 2030 for the BaU and AEG scenarios (see Table 3.39)

Table 3.39: Final Energy Demand by Metal Fabrication (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	2.2	4.5	4.8	6.1	7.9	4.7	5.0	6.4	8.3
Diesel	3.8	8.2	8.7	11.0	14.2	8.6	9.1	11.6	15.1
LPG	0.1	0.4	0.4	0.6	0.9	0.4	0.4	0.6	0.9
Residual Fuel Oil	0.7	1.0	1.0	1.1	1.3	1.0	1.0	1.1	1.3
Total	6.8	14.1	15.0	18.8	24.3	14.7	15.6	19.7	25.6

Electricity share of the energy demand for both scenarios is expected to remain about the same of about 32% in 2030 as in 2020 for both scenarios.

3.4.5.11 Final Energy Demand by Paper Products Manufacture and Printing

The paper and printing industry in the country is based on processing imported rolls of paper and the recycling of waste paper. The main products are corrugated packaging boxes and paper products.

The final energy demand of the paper products and printing industry would increase from 7-8 ktoe in 2020 at an average annual growth rate of 8.3-8.5% to 16-18 ktoe in 2030 for both BaU and AEG scenarios (see Table 3.40).

Table 3.40: Final Energy Demand by the Paper and Printing Industry (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	1.9	4.1	4.6	6.5	9.3	4.5	5.0	7.1	10.4
Diesel	0.5	1.1	1.2	1.7	2.4	1.2	1.3	1.9	2.7
LPG	1.0	2.1	2.3	3.2	4.5	2.3	2.5	3.5	5.1
Total	3.5	7.3	8.1	11.4	16.2	8.0	8.9	12.4	18.2

Electricity would account for 57% of the final energy demand in 2030, LPG 28% and diesel 15% for both scenarios.

3.4.5.12 Final Energy Demand by Wood Processing Industry

Formal wood processing industries were classified into three categories (i) primary – logging; (ii) secondary – sawmilling and (iii) tertiary – panel production and furniture. The wood processing industry employs different processing techniques to produce varied products e.g. dried timber, sawn wood, particleboard, plywood and veneer.

The final energy demand for the wood processing industry would increase from 13 ktoe and 15 ktoe in 2020 respectively for the BaU and AEG scenarios at an average annual growth rate of 6.4-6.6% to 25 ktoe and 29 ktoe in 2030.

Table 3.41: Final Energy Demand by the Wood Processing Industry (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	6.7	8.3	8.6	9.9	12.2	9.6	10.0	11.5	14.3
Diesel	1.0	4.8	5.3	7.7	12.2	5.5	6.1	9.0	14.3
Wood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	7.8	13.1	14.0	17.6	24.5	15.1	16.1	20.6	28.7

Electricity and diesel would account for about 50% each of the final energy demand in the wood processing industry in 2030.

3.4.6 Informal Manufacturing Sub-sector

According to Ghana Statistical Service, the informal or traditional manufacturing sub-sector consists of micro and small-scale enterprises which are not registered with the Registrar-General's Department (RGD) and do not keep formal accounts.

The final energy use for the informal or traditional manufacturing sector was evaluated by classifying the sector into the production of textiles (*batik*, *adinkra*, *tie & dye*, etc.), local soap, beverages (brewing of *pito* and distillation of *akpeteshie*), food (*gari*, bread, smoked fish and vegetable oil), ceramics (pottery and clay products, bricks and tiles).

The final energy demand for the informal manufacturing sub-sector would increase from 432 ktoe in 2020 at an average annual growth rate of 3.0% to 581 ktoe and 583 ktoe in 2030 for BaU and AEG scenarios respectively. The results, according to the sub-sectors, are presented in Table 3.42.

Table 3.42: Final Energy Demand by Informal Manufacturing Sector (ktoe)

Sub-sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Textiles	26	40	42	47	54	40	42	47	54
Soap Production	28	35	35	39	43	35	35	39	43
Beverages	35	54	56	63	73	54	56	64	73
Food Processing	163	264	274	313	358	265	275	316	360
Ceramics and Lime	26	39	41	46	53	40	41	47	53
Total	278	432	447	508	581	433	448	512	583

Energy demand for food processing would be dominant in terms of the final energy demand, though the share would increase marginally from about 61% in 2020 to 62% in 2030 for both scenarios. The production of beverages would be the next dominant energy end-use activity accounting for about 12% of the energy demand and increasing marginally to 13% for both scenarios.

3.4.7 Aluminium Smeltering

The evaluation of the final energy demand for the aluminium smelter was undertaken by considering the smelter as a separate demand sector different from the activities under the manufacturing sub-sector, owing to the unique energy use pattern of the smelter. The operation of the smelter is based on the government's strategy to allocate legacy hydropower generation to strategic industries, which include the smelter.

Primary aluminium production, in general, is energy-intensive, although, lower than gold mining. The significant improvement has however been with its electricity consumption efficiency which has improved so far from 16.2 Megawatt-hour per tonne to about 14.5 Megawatt-hour per tonne and thus falling within the global standard of 14–15 Megawatt-hours of electricity per tonne.

Aluminium smelting worldwide is still very sensitive to electricity pricing. VRA bulk electricity tariff to VALCO was 1.65–1.80 US cents per unit of electricity in the 1990s to the middle of the last decade and based on dedicated hydro-power from the Akosombo generating station. The tariff went up to about 4 US cents per unit of electricity in the early 2000s, based on a generation mix of hydro and thermal. In 2018, an all-inclusive tariff of US Cents 3.5 was reached.

Alumina, electricity and carbon (anodes) costs represent the three major cost factors of every smelter. While alumina and carbon costs are mostly similar for smelters, electricity and labour costs significantly vary from region to region.

Production costs for smelters globally have decreased significantly since 2012. Reasons include falling alumina prices (about 35 % since), lower prices on the electricity market[56] and lower oil prices (falling from nearly US$ 100/bbl in 2012 to below US$ 40/bbl in 2017, then rising to about US$ 70/bbl in 2018). Others include new and cheaper technologies with lower electricity consumption and higher efficiency, either in entirely new low-cost capacities or through the replacement of high-cost old technologies[57].

Aluminium production levels and electricity pricing are still highly correlated. The higher the production, the higher the tariff regime it can take. Typical smelters of similar capacities as VALCO

[56] Some smelters have built their own power plants or switched suppliers to get lower prices.
[57] This trend has been especially strong in China.

operate at average power prices of 2.5 US cent per unit of electricity in the Middle East, but higher production plants operate averagely in the range of 3.5-4 US cents per unit of electricity in the United States and Europe. As the production cost falls, the global price of aluminium is estimated to average US$2,000 per tonne between 2017 and 2020. Even at the prevailing average world market price of US$1,800 per tonne of aluminium, plants of over 250,000 tonnes capacity could operate profitably at tariffs as high as 5 US cents per kWh. Thus, the economic viability of an aluminium smelter depends on the supply of relatively low priced electricity.

Even at the 4 US cents per kWh and at production levels between 60,000 and 65,000 tonnes per annum, VALCO production costs still fall within the global range of US$1,400-1,600 per tonne but towards the high-side. However, any further increase in the electricity tariff without corresponding increase in production to at least three potlines would move the production cost beyond the maximum average ceiling to approach or go beyond U$1,800 which is regarded as global highest.

Expanding VALCO to about 250,000-tonne smelting capacity, however, would require 500,000-520,000 tonnes of alumina per annum and consequently 1–1.5 million tonnes of bauxite every year.

Processing of bauxite into alumina requires less electricity. Such a refinery would require just about 5–6 percent of VALCO's power demand to produce the alumina needs of the VALCO smelter. Ghana's proven bauxite reserves, at an average mining rate of 3 million tonnes a year, are estimated to last 30 years. At 1.5 million tonnes per year, such an alumina refinery can be assured of feedstock for 60 years. Expanding the bauxite industry and building a refinery to produce alumina to feed the future VALCO would close the bauxite-aluminium industrial loop. A more efficient mode of transport, however, would be required to haul the bauxite from new fields yet to be developed.

VALCO is assumed to operate on two pot-lines, under the BaU scenario but, would increase from two pot-lines to five pot-lines for the AEG scenario. The final energy demand for the smelter would, therefore, increase from 186 ktoe in 2020 for the BaU and the AEG scenarios, to 185 ktoe and 303[58] ktoe in 2030 depending on the long term competitiveness of the electricity tariff.

Table 3.43: Final Energy Demand by Aluminium Smeltering (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Diesel	0.0	2.4	2.4	2.4	2.4	2.4	3.2	4.0	3.9
LPG	0.0	1.0	0.9	0.9	0.9	1.0	1.3	1.6	1.6
Residual Fuel Oil	0.1	16.8	16.8	16.7	16.6	16.8	22.3	27.8	27.7
Electricity bulk	1	166	166	165	165	166	221	276	274
Total	1	186	186	185	185	186	248	309	308

[58] It is projected that more agreesive efficiency measures would be instituted thereby reducing the energy intensity under AEG scenario

Electricity would account for 89.2% of the final energy demand in 2030 while RFO accounts for 9.0%, diesel 1.3% and LPG 0.5%.

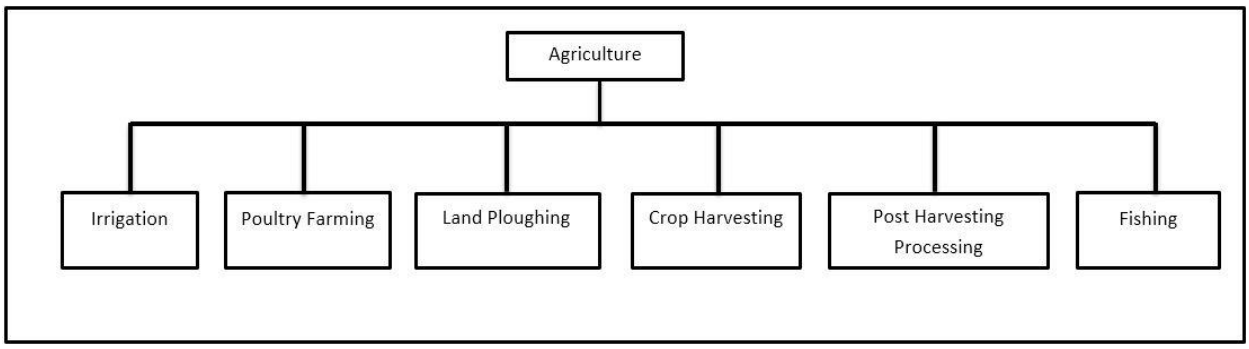
3.4.8 Pig Iron and Alumina Production

The production of pig iron and alumina are dependent on the successful mining of iron ore and bauxite, respectively. With the government's plan of halting exportation of raw materials, steel and aluminium industries are expected to significantly contribute to the country's economic growth through their respective value chains. An analysis of the energy demand for pig iron and alumina production was modelled to commence from 2025.

The total final energy demand for pig iron and alumina production would be about 1,089 ktoe in 2025, increasing to 2,473 ktoe in 2030. Natural gas would be the dominant fuel accounting for about 90% of their total energy demand. About 90% of the natural gas demand would be used in the production of pig iron, while the remaining 10% would be used in alumina production.

3.5 Energy Demand by Agricultural Sector

The agricultural sector provides staple crops and industrial raw materials for sugar, textiles, food processing and beverage industries. It also provides cash crops, e.g. cocoa and timber for export and the cultivation or harvesting of fish and livestock.



The country's agricultural sector is classified into crops, fishing, livestock, forestry and logging[59]. Food and Agriculture Sector Development Policy (FASDP)[60] was developed in 2002 and reviewed in 2007 to boost agricultural productivity and transform the country's agricultural sector from small-size farm holdings into a modern and commercially oriented one. The objective is to employ large-scale

[59] Classification is from Ghana Statistical Service, National Accounts Statistics, Gross Domestic Product 2012, April 2013

[60] Food and Agriculture Sector Development Policy (FASDP) was based on Accelerated Agricultural Growth and Development Strategy developed in 1996

use of advanced farming techniques such as irrigation, mechanised land-ploughing and crop harvesting. This approach would provide the impetus for an agro-based industrialisation strategy, value-addition and job creation.

The final energy demand for the Agricultural sector is evaluated by classifying the agricultural sector into irrigation, poultry, land-ploughing, crop-harvesting, post-harvest processing and fishing.

It is projected to increase from 185 ktoe and 200 ktoe in 2020 for the BaU and the AEG scenarios respectively at an average annual rate of 9.0% and 9.3% to 437 ktoe and 489 ktoe in 2030 (see Table 3.44).

Table 3.44: Final Energy Demand of Agricultural Sector by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	0.1	1.2	1.3	1.8	2.4	4.4	5.4	10.1	17.4
Diesel	40	100	109	155	241	114	125	181	282
Gasoline premix	35	83	91	127	193	82	90	125	190
Total	76	185	201	284	437	200	220	316	489

Diesel would be the dominant fuel in the Agricultural sector with its share of the total final energy demand increasing from 54-56% in 2020 to about 55% and 58% in 2030 for the BaU and AEG scenarios respectively. Share of the next dominant fuel, premix, would decrease from 41-45% in 2020 to 44% for the BaU and 39% for the AEG scenarios in 2030.

The final energy demand for the agricultural sector, according to the sub-sectors are presented in Table 3.45.

Table 3.45: Sub-sectoral shares of Agricultural sector final energy demand (ktoe)

Sub-sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Irrigation	0.1	2.3	2.5	3.2	4.3	9.1	10.9	18.3	27.5
Poultry farms	0.1	0.4	0.4	0.6	0.8	0.5	0.5	0.8	1.0
Land ploughing	19	29	30	35	43	33	35	44	58
Crop harvesting	2	10	10	14	17	12	14	18	23
Post harvest processin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fishing	54	144	158	232	372	145	160	235	379
Total	76	185	201	284	437	200	220	316	489

The share of fishing, the dominant energy demand sub-sector would increase marginally from about 78% in 2020 to 85% and 73% to 78% in 2030 respectively for the BaU and AEG scenarios.

3.5.1 Energy Demand for Irrigation

Irrigation schemes in the country use sprinkler and pump, sprinkler and gravity or gravity systems of irrigation. The total area under irrigation in 2012 was estimated at 30,345 ha or 0.4% of the total land area cultivated in the country. However, the technically feasible irrigation potential is 1.9 million[61] ha of land. The economically viable irrigation potential was estimated at 500,000 ha[62].

The total final energy demand for irrigation would increase from 2.3 ktoe in 2020 at an annual average growth rate of 16% to 4.3 ktoe in 2030 for the BaU scenario. In the case of the AEG scenario, the final energy demand would increase from 9.1 ktoe in 2020 at an annual growth rate of 17.7% to 27.5 ktoe in 2030 (see Table 3.46).

Table 3.46: Final Energy Demand by Irrigation (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electric pumps	0.05	0.86	0.93	1.22	1.65	3.92	4.89	9.41	16.40
Diesel pumps	0.09	1.45	1.56	2.02	2.67	5.17	6.04	8.92	11.15
Total	0.14	2.31	2.49	3.24	4.32	9.08	10.94	18.33	27.54

Analysis of the energy demand for irrigation shows that electricity would displace the use of diesel-powered pumps for irrigation. The phasing out of these high-cost diesel pumps is dependent on approved and implemented concessionary tariff being proposed for grid electricity-powered irrigation. Also, solar-powered irrigation systems will play a significant role.

3.5.2 Energy Demand for Land Ploughing

Land ploughing in the country is undertaken by using mechanical tractors and animal traction. The government has established the Agriculture Mechanization Service Centres (AMSEC) to provide tractor services in the country as part of the Ghana Commercial Agriculture Project. This initiative is in addition to tractor services provided by private individuals who are not affiliated with the AMSEC.

Diesel is the main fuel for land ploughing tractors. The final energy demand for land ploughing is projected to increase from 29-33 ktoe in 2020 at an average annual growth rate of 4.1% and 5.7% respectively for the BaU and AEG scenarios to 43 ktoe and 58 ktoe in 2030.

[61] Ghana Strategy Support Program, Irrigation Development in Ghana: Past experiences, emerging opportunities and future directions, GSSP Working Paper No. 27, March 2011
[62] Ministry of Food and Agriculture, National Irrigation Policy, Strategies and Regulatory Measures, 2011

3.5.3 Energy Demand for Crop Harvesting

As part of the Ghana Commercial Agriculture Project, the government has imported and deployed combine harvesters to farmers in the country[63] to improve rice and maize harvesting.

The main fuel for crop-harvesting is diesel. The total final energy demand for crop harvesting is projected to increase from 10-12 ktoe in 2020 at an average annual growth rate of 6.1-6.4% to 17 ktoe and 23 ktoe in 2030 respectively for the BaU and AEG scenarios.

3.5.4 Energy Demand for Post-Harvest Processing

The country loses between 20% and 50% of all vegetables, fruits, roots and tubers harvested annually and about 20 – 30% of cereals and legumes[64].

Some agricultural produce such as fish, tomatoes and vegetables deteriorate relatively quickly after harvest. Consequently, in the informal sub-sector, these produce are quickly processed upon harvest through processes such as smoking, salting and drying of fish, processing cassava into gari. Sun- and air-drying are employed to preserve some grains and vegetables.

The total final energy demand for post-harvest processing in the form of drying of grains is projected to increase from 7-8 ktoe in 2020 at an average growth rate of 5-6% to 12 ktoe and 14 ktoe in 2030 respectively for the BaU and the AEG scenarios.

3.5.5 Energy Demand for Poultry Industry

The poultry industry was classified into (i) 380 large-scale poultry farms with over 10,000 birds and (ii) about 1,000 small to medium-scale poultry farms with 50 to 10,000 birds. Backyard poultry, part of the small scale poultry farms, accounts for about 60–80% of the country's poultry stock. A small number of the large poultry farms have their hatcheries (which produce day-old chicks), feed-mills (to produce poultry feed), and slaughter-houses (to process birds into poultry parts and other products).

Electricity and diesel are the main forms of energy used in the poultry industry. The final energy demand for the poultry industry is projected to increase from 0.4-0.5 ktoe in 2020 at an average annual growth rate of about 8-9% to 0.8-1 ktoe in 2030 for both the BaU and AEG scenarios (see Table 3.47).

63 Institute of Statistical, Social and Economic Research: "The State of Ghanaian Economy in 2012", August 2013
64 http://www.ghanaweb.com/GhanaHomePage/NewsArchive/Ghana-s-post-harvest-losses-hit-GH-700-000-annually-185268

Table 3.47 Final Energy Demand by the Poultry Industry (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	0.08	0.33	0.37	0.52	0.72	0.43	0.48	0.69	0.96
Diesel	0.01	0.03	0.03	0.04	0.06	0.03	0.04	0.06	0.09
Total	0.09	0.36	0.40	0.57	0.78	0.46	0.52	0.75	1.05

The share of electricity in the final energy demand would be about 92% in 2020 and is expected to remain the same in 2030 for both BaU and AEG scenarios.

3.5.6 Energy Demand for Fishing Industry

The country has about 550 km of coastline and 11.0 million ha area of inland water-body, which supports the fishing industry. The main types of fish production in the country are (i) Captured fisheries (industrial, semi-industrial, artisanal/canoe fisheries) and (ii) Aquaculture (intensive, semi-intensive and extensive). The artisanal sub-sector provides over 70% of the total fish requirements of the country.

The final energy demand for the fishing industry is evaluated by classifying the fishing industry into marine and inland fishing. The marine fishing is further classified into fishing by trawlers and by canoes using outboard motors. Inland fishing is only by canoes fitted with outboard motors.

Table 3.48 Final Energy Demand by the Fishing industry (ktoe)

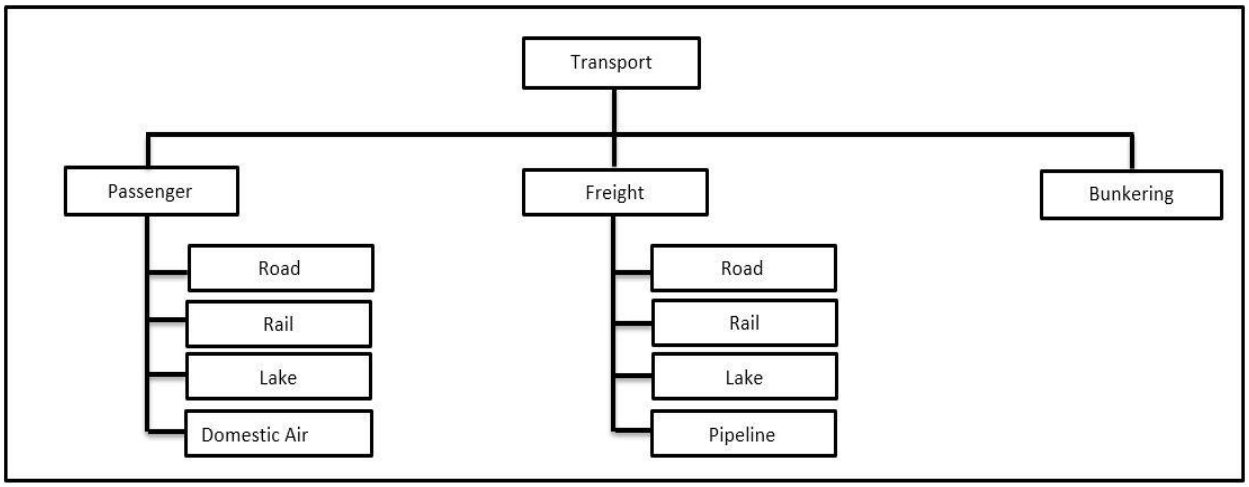
Sub-sector	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Marine	43	119	132	196	318	123	137	205	338
Inland	11	24	26	36	54	22	23	30	41
Total	54	144	158	232	372	145	160	235	379

The total final energy demand for the fishing industry would increase from about 144-145 ktoe in 2020 at an average annual growth rate of 10% to 372 ktoe and 379 ktoe in 2030 respectively for the BaU and AEG scenarios (see Table 3.48).

The dominant fuel in 2030, diesel, would increase from about 83% and 85% in 2020 to about 86% and 89% in 2030 for the BaU and AEG scenarios respectively.

3.6 Energy Demand by Transport Sector

The transport sector provides for the movement of goods and persons. The final energy demand for the transport sector is evaluated by classifying the transport sector into passenger and freight transportation. The passenger and freight transportation sub-sectors are further classified according to modes of transport. The road passenger transport is classified into intra-city and inter-city passenger transport whilst freight transport is classified into local or urban and long-distance freight transportation.



The total final energy demand for the transport sector is projected to increase from 3,950 ktoe and 4,301 ktoe in 2020 at an average annual rate of 7.2% and 8.5% to 7,926 ktoe and 9,751 ktoe in 2030 respectively for the BaU and AEG scenarios.

3.6.1 Energy Demand by Transport Sector

The results of the total final energy demand by the sub-sectors of the transport sector for the BaU and AEG scenarios are presented in Table 3.49.

Table 3.49: Transport Sector Energy Demand by the sub-sectors (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Passenger	1,761	3,059	3,253	4,169	5,703	3,285	3,541	4,740	6,826
Freight	209	643	717	1,095	1,802	745	846	1,372	2,423
Bunkering	147	248	261	323	421	271	288	368	502
Total	2,116	3,950	4,232	5,587	7,926	4,301	4,674	6,480	9,751

The share of Passenger transportation of about 70-72% in 2020 is not expected to change in 2030 for both BaU and AEG scenarios.

The share of final energy demand for freight transportation of 16-17% in 2020 is also not expected to change significantly in 2030 for both BaU and AEG scenarios. Share of energy demand for bunkering would drop marginally from 6% in 2020 to about 5% in 2030 for both scenarios.

3.6.2 Energy Demand by Modes of Transport

The results of the total final energy demand in terms of modes of transportation are presented in Table 3.50.

Table 3.50: Final Energy Demand by Modes of Transport (ktoe)

Modes	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Road	1,953	2,931	3,080	3,769	4,892	2,949	3,120	3,883	5,119
Rail	2	739	857	1,448	2,544	1,016	1,192	2,111	3,929
Inland lake	1	1	2	2	2	2	2	2	3
Domestic Air	13	29	31	43	64	61	69	109	186
Pipeline	0	1	1	2	4	3	4	6	12
Bunkering_Air	106	186	197	247	328	205	219	285	395
Buntering_Marin	41	62	64	76	93	66	69	84	106
Total	2,116	3,950	4,232	5,587	7,926	4,301	4,674	6,480	9,751

From the results, road transport share of the transport sector's total final energy demand would drop from 74.2% and 68.6% in 2020 respectively to 61.7% and 52.5% for the BaU and the AEG scenarios.

The final energy demand for rail transportation would, however, rise from 18.7% and 23.6% in 2020 respectively to 32.1% and 40.3% in 2030 for the BaU and AEG scenarios. The rapid increase in the share of final energy demand for rail transportation is attributable to the government's policy to refurbish the country's railway sector. The total final energy demand for domestic air transportation would also increase but marginally from 0.7% and 1.4% in 2020 respectively to 0.8% and 1.9% in 2030 for the BaU and AEG scenarios.

3.6.3 Energy Demand by Fuel type

Demand for diesel accounting for about 57-60% of the total final energy demand for the transport sector in 2020 would increase to 63% and 68% in 2030 respectively for the BaU and AEG scenarios.

Demand for gasoline would, however, drop from 33-35% of the final energy demand for the transportation sector in 2020 to about 31% and 24% for BaU and AEG scenarios respectively (see Table 3.51).

Table 3.51: Final Transportation Energy Demand by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	0	1	1	2	4	6	7	30	80
Diesel	1,106	2,270	2,460	3,384	5,014	2,567	2,829	4,150	6,629
Gasoline	839	1,399	1,476	1,837	2,434	1,399	1,484	1,830	2,371
Gasoline premix	0.001	0.002	0.002	0.003	0.004	0.003	0.003	0.004	0.007
Jet Kerosene	119	215	229	290	391	266	287	394	581
LPG	52	64	66	73	83	64	67	77	90
Total	2,116	3,950	4,232	5,587	7,926	4,301	4,674	6,480	9,751

The introduction of electric vehicles will definitely increase the electricity demand and displace some amount of gasoline.

3.6.4 Effect of Electric Vehicles (EVs) on Electricity Demand

Electric vehicles (EVs) can achieve above 90% efficiency, which is 3-4 times more than similar internal combustion engine-powered vehicles (ICE)[65]. Unfortunately, EVs currently have challenges including high investment cost[66], lower energy density of batteries (energy) compared to gasoline and diesel, lack of charging infrastructure, comparatively longer refuelling (charging) time[67].

Nonetheless, the global share of EVs in automobile stock is rising owing to reasons such as rise in research in battery technologies, improvement in drive range, purchase incentives such as rebates and reduction in charging time[68]. With a reduction in battery cost and other solutions to current challenges, sales of EVs is projected to be between 15% to 25% of the automobile market share by 2030[69].

[65] Grid Electrified Vehicles - Performance, Design and Environmental Impacts: Real Life Comparison Between Diesel and Electric Car Energy Consumption". Chapter 10; 2013
[66] The higher initial investment cost on EV is averagely the net sum of battery cost (current average of US$(320-380) per kWh) and about US$2000 savings from eliminating the ICE engine/drive train and replacing with a motor system.
[67] International Renewable Energy Agency: "Electric Vehicles Technology Brief" 2017
[68] International Energy Agency: "Global EV Outlook 2017" 2017
[69] International Energy Agency: "Global EV Outlook 2017" 2017

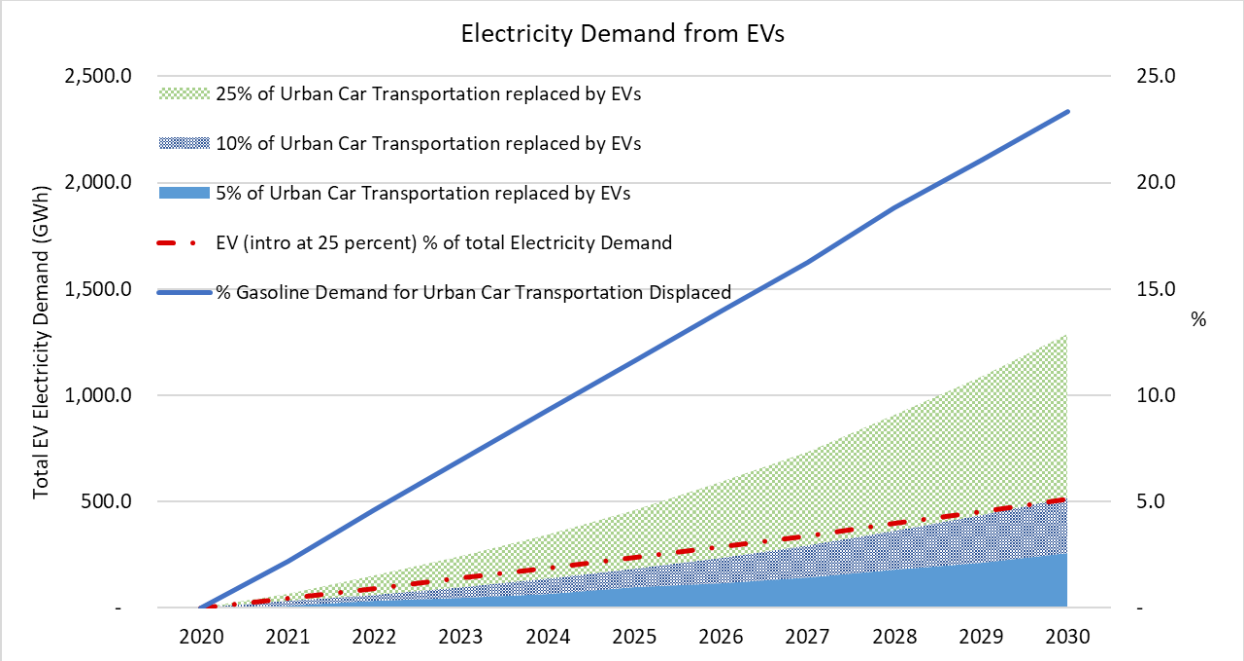


Figure 3.1: Prospects of Electric Vehicle Use and it's Effect on Electricity and Gasoline Demands

Introduction of EVs to displace 5-25% of ICE-powered cars in urban areas for passenger transportation by 2030 was assessed. This has the potential of reducing about 5-23% of gasoline demand for urban passenger transportation using cars. The resultant increment in electricity demand is projected to be about 1-5% of Ghana's electricity demand.

3.6.5 Energy Demand by Passenger Transportation

The final energy demand for passenger transportation is projected to increase from 3,059 ktoe and 3,285 ktoe in 2020 at an average annual rate of 7.3% and 8.7% to 5,703 ktoe and 6,826 ktoe respectively in 2030 for the BaU and AEG scenarios.

3.6.5.1 Final Energy Demand by Modes of Transportation

Share of the total final energy demand for passenger transportation by road is expected to drop from 79-84% in 2020 to 64-74% in 2030 for both the BaU and AEG scenarios.

The final energy demand of Passenger transportation by rail, on the other hand, would expand from 15% and 19.6% in 2020 to 25.5% and 33.8% in 2030 respectively for the BaU and AEG scenarios.

Share of Domestic Air passenger of the total final energy demand for passenger transportation would increase marginally from 0.9% and 1.9% in 2020 respectively to 1.1% and 2.7% in 2030 for the BaU and AEG scenarios (see Table 3.52).

Table 3.52: Final Energy Demand of Passenger Transportation by modes (ktoe)

Modes	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Road	1,746	2,569	2,693	3,262	4,183	2,580	2,722	3,344	4,334
Rail	1	460	528	863	1,455	644	749	1,286	2,305
Lake	0.7	0.7	0.7	0.7	0.7	0.9	0.9	1.1	1.4
Domestic Air	13	29	31	43	64	61	69	109	186
Total	1,761	3,059	3,253	4,169	5,703	3,285	3,541	4,740	6,826

3.6.5.2 Final Energy Demand by Fuel-Types

Diesel share of the final energy demand for passenger transportation would expand from 51.2% and 53.5% in 2020 to 54.8% and 60.2% in 2030 respectively for the BaU and AEG scenarios.

Gasoline share of the final energy demand for passenger transportation, however, would decrease from almost 46% and 43% in 2020 to about 43% and 35% respectively in 2030 for the BAU and AEG scenarios (see Table 3.53).

Electricity demand for passenger transportation would increase from 0.09% in 2020 to 1.0% in 2030 in the AEG scenario. We do not expect the use of electric vehicles under the BaU scenario unless incentives such as tax rebate are introduced to reduce the effective purchasing price.

The introduction of compressed natural gas (CNG) and liquefied natural gas (LNG) as automotive fuel (if adequately promoted) could lead to further diversification of fuel types for auto transport.

Table 3.53: Final Energy Demand by Fuels for Passenger Transportation (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	-	-	-	-	-	3	4	23	68
Diesel	856	1,567	1,680	2,216	3,122	1,758	1,918	2,701	4,111
Gasoline	839	1,399	1,476	1,837	2,434	1,399	1,484	1,830	2,371
Gasoline premix	0.000	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.004
Jet Kerosene	13	29	31	43	64	61	69	109	186
LPG	52	64	66	73	83	64	67	77	90
Total	1,761	3,059	3,253	4,169	5,703	3,285	3,541	4,740	6,826

3.6.5.3 Final Energy Demand for Road Passenger Transportation

The final energy demand for passenger traffic by road is evaluated by classifying the passenger traffic by road into intracity or urban passenger traffic and intercity passenger traffic.

Final energy demand for road passenger transportation is projected to increase from 2,569 ktoe in 2020 at an average annual rate of 5.0% to 4,183 ktoe in 2030 for the BaU scenario. Under the AEG scenario, final energy demand for road passenger transportation is projected to increase from 4,183 ktoe in 2020 at an average annual rate of 5.3% to 4,334 ktoe in 2030 (Table 3.54).

Table 3.54: Final Energy Demand of Road Passenger Transportation by Sub-Sectors (ktoe)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Intra-city	709	1,309	1,391	1,777	2,418	1,312	1,402	1,790	2,421
Inter-city	1,036	1,260	1,301	1,486	1,765	1,269	1,321	1,554	1,913
Total	1,746	2,569	2,693	3,262	4,183	2,580	2,722	3,344	4,334

Intra-city or urban passenger transportation is projected to account for 58% of the final energy demand for road passenger transportation in 2030 compared with 51% in 2020 for the BaU scenario and 56% of the final energy demand for road passenger transportation in 2030 compared to 51% in 2020 under the AEG scenario.

In terms of fuel, the results show that diesel demand is projected to account for 39.8% of the final road passenger transportation energy demand in 2030 compared to 43.1% in 2020 for the BaU scenario. Under the AEG scenario, diesel demand is projected to account for 41.7% of the total final road passenger transportation energy demand in 2030 compared to 43.2% in 2020.

Gasoline is projected to account for 58% and 55% of the final road passenger transportation energy demand in 2030 for the BaU and AEG scenarios respectively compared to about 43% in 2020 for both scenarios (see Table 3.55).

Table 3.55: Final Energy Demand of Road Passenger Transportation by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	-	-	-	-	-	3	4	23	68
Diesel	854	1,106	1,151	1,352	1,666	1,114	1,168	1,415	1,805
Gasoline	839	1,399	1,476	1,837	2,434	1,399	1,484	1,830	2,371
LPG	52	64	66	73	83	64	67	77	90
Total	1,746	2,569	2,693	3,262	4,183	2,580	2,722	3,344	4,334

3.6.5.4 Final Energy Demand for Urban Road Passenger Transportation

The final energy demand for urban passenger transportation by road is evaluated based on vehicle types, e.g. motorcycles, private cars, taxi, etc. and fuels used, e.g. gasoline, diesel and LPG.

Final energy demand for urban road passenger transportation is projected to increase from 1,309 ktoe and 1,312 ktoe in 2020 for BaU to 2,418 ktoe and 2,421 ktoe in 2030 for AEG scenario, at an average annual rate of 6.3% for both scenarios. The results are presented in Table 3.56.

Table 3.56: Final Energy Demand by Urban Road Passenger Transportation (ktoe)

Vehicle type	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Motor cycles	51	72	76	91	113	73	77	95	122
Private cars	292	814	870	1,135	1,583	822	873	1,123	1,534
Taxis	196	173	183	227	297	165	184	232	305
Mini & Midi Bus	84	103	106	118	131	104	108	123	142
Big Buses	87	137	145	182	242	138	147	190	262
High Occupancy	-	10	12	26	52	10	12	27	56
Total	709	1,309	1,391	1,777	2,418	1,312	1,402	1,790	2,421

The share of the energy demand by private cars is expected to increase from 62.2% in 2020 for both scenarios to 65.5% and 63.4% in 2030 respectively for Bau and AEG scenarios.

Energy demand by Taxis, however, would be about 13% in 2020 and would remain the same in 2030 for both scenarios. Meanwhile, *trotros* (i.e. urban mini and midi buses) energy demand would decrease marginally from about 8% in 2020 to about 6% in 2030 for both scenarios.

The energy demand by big buses for urban transportation (e.g. Metro) is also expected to remain the same, about 10% for BaU scenario and 11% for AEG scenario. The BRT system, which commenced operation in 2016, would account for 2.1% of the total final energy demand for urban road passenger transportation in 2030 for the BaU scenario provided it is sustained. In the AEG scenario, the energy demand for the BRT system is expected to account for 2.3% of final energy demand for urban road passenger transportation in 2030.

In terms of fuel, diesel share of energy demand for urban road passenger transportation would remain the same at about 20-21% of the total final energy demand throughout the planning period for both scenarios.

Gasoline share of the energy demand, however, would increase from about 75% in 2020 to about 77% for BaU but would decrease under AEG scenario to 73%.

Share of LPG in the energy demand for urban road passenger transportation, on the other hand, would fall from about 5% in 2020 to about 4% in 2030.

The results of the final energy demand for urban road passenger transportation by fuels for the BaU and the AEG scenarios are shown in Table 3.57.

Table 3.57: Final Energy Demand of Urban Road Passenger Transportation by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	-	-	-	-	-	3	4	23	68
Diesel	176	266	281	352	467	268	286	369	507
Gasoline	481	979	1,044	1,351	1,868	976	1,046	1,321	1,757
LPG	52	64	66	73	83	64	67	77	90
Total	709	1,309	1,391	1,777	2,418	1,312	1,402	1,790	2,421

A. Effect of BRT system on the Energy Demand for Urban Transportation

The impact of the implementation of the government policy of introducing BRT as part of the urban transportation system is evaluated by comparing the results of the total energy demand projections for urban transport with and without the introduction of the BRT system (see Figure 3.2).

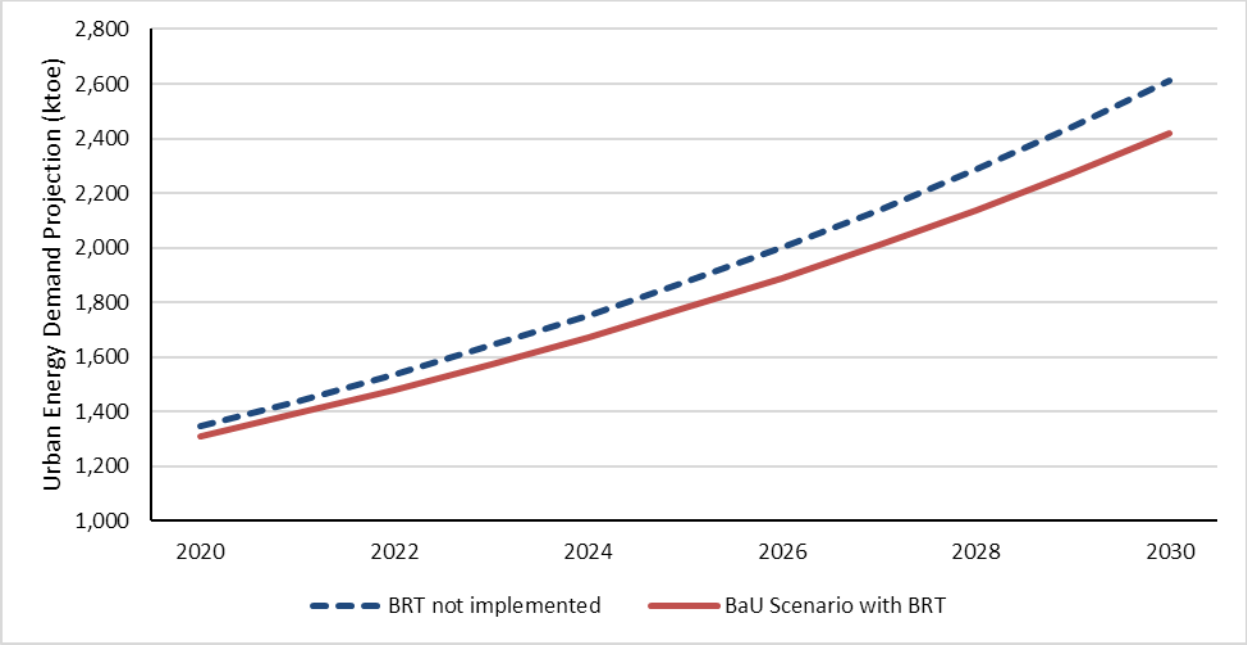


Figure 3.2: Effect of the BRT System on Urban Transport under the BaU Scenario

Figure 3.2 shows that the implementation of the BRT system in the country, which is expected to account for about 2% of the total urban traffic in 2030, would decrease the total energy demand for urban transport by about 7% by 2030. The main bottleneck would be the availability of dedicated lanes for the BRT.

3.6.5.5 Final Energy Demand for Intercity Road Passenger Transport

The final energy demand for intercity passenger transportation by road is evaluated based on vehicle types (e.g. motorcycles, private cars, taxis, etc.) and fuel type used (e.g. gasoline and diesel).

Final energy demand for intercity road passenger transportation for the BaU and AEG scenarios is projected to increase from 1,260 ktoe and 1,269 ktoe in 2020 at an average annual rate of 3.4% and 4.2% to 1,765 ktoe and 1,913 ktoe in 2030 (see Table 3.58).

Table 3.58: Final Energy Demand by Intercity Road Passenger Transportation (ktoe)

Vehicle type	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Motor cycles	52	33	32	22	6	34	32	23	7
Private cars	101	163	172	215	282	164	175	225	306
Taxis	205	242	249	280	327	243	252	293	355
Mini & Midi Bus	389	436	447	493	560	439	453	516	607
Big Buses	289	386	402	475	589	389	408	497	638
Total	1,036	1,260	1,301	1,486	1,765	1,269	1,321	1,554	1,913

Share of energy demand for inter-city road passenger transportation by private cars would increase from about 13% in 2020 to about 16 % in 2030 for both scenarios. The share of energy demand by Taxis, on the other hand, would remain about the same throughout at about 19% for both scenarios. Similarly, the share of energy demand by minibuses would drop from about 35% in 2020 to about 32% in 2030, while that of the Big Buses would increase from about 30% in 2020 to about 33% in 2030.

Share of diesel in final energy demand for intercity road passenger transportation is expected to increase slightly from about 67% in 2020 to about 68% in 2030. The share of demand for gasoline, on the other hand, would drop slightly from about 33% to about 32% in 2030 for both scenarios. The results of the final energy demand for inter-city road passenger transportation by fuels for the BaU and the AEG scenarios are shown in Table 3.59.

Table 3.59: Final Energy Demand by Intercity Road Passenger Transportation by Fuels (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Diesel	678	840	869	1,000	1,199	846	882	1,046	1,299
Gasoline	358	420	432	486	567	423	438	508	614
Total	1,036	1,260	1,301	1,486	1,765	1,269	1,321	1,554	1,913

3.6.5.6 Final Energy Demand for Rail Passenger Transportation

The final energy demand for intercity rail passenger transportation was evaluated by considering all passenger train services (including the suburban train service from Accra to Tema) as intercity passenger transportation. Diesel is likely to be the main fuel for rail transportation.

The final energy demand for intercity rail passenger transportation is expected to increase from 451 ktonne and 631 ktonne in 2020 to about 1,427 ktonne and 2,259 ktonne in 2030 respectively for the BaU and AEG scenarios (see Table 3.60).

Table 3.60: Final Energy Demand by Intercity Rail Passenger Transportation (ktonne)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Diesel Train	1	451	518	846	1,427	631	734	1,260	2,259

3.6.5.7 Final Energy Demand for Lake and Marine Transportation

The final energy demand for passenger transportation by inland lake and marine is evaluated by attributing passenger transportation on the inland lake to Cross-Lake ferry services, which account for over 95% of passenger movement on the lake.

Final energy demand for inland lake and marine passenger transportation is expected to increase from 711 toe and 889 toe in 2020 at an average annual rate of 0.4% and 4.3% respectively to 742 toe and 1,353 toe in 2030 for the BaU and AEG scenarios (see Table 3.61).

Table 3.61: Final Energy Demand by Inland Lake and Marine Passenger Transportation (toe)

Vehicle type	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Ferries	713	709	714	723	740	887	924	1,092	1,348
Motor boat	0	1	1	2	2	2	2	3	4
Total	714	711	715	725	742	889	926	1,095	1,353

Inland lake and marine transportation would continue to be by ferries and the latter mainly fuelled by diesel. The demand for premix would account for less than one percent of the energy share.

3.6.5.8 Final Energy Demand for Domestic Air Transportation

The main fuel for domestic air transportation is Aviation Turbine Kerosene (ATK). Final energy demand for domestic air transportation is expected to increase from 28 ktonne and 59 ktonne in 2020

at an average annual rate of 8.2% and 11.8% respectively to 62 ktonne and 180 ktonne in 2030 for the BaU and AEG scenarios (see Table 3.62).

Table 3.62: Final Energy Demand by Domestic Air Passenger Transportation (ktonne)

Vehicle type	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Small Plane	13	28	30	42	62	59	67	106	180

3.6.6 Energy Demand by Freight Transport

Freight transportation is undertaken by the following modes of transport:

(i) Road,
(ii) Rail,
(iii) inland lake & marine, and
(iv) pipeline.

The main technologies used for freight transport are trucks for freight transportation by road, trains for freight transportation by rail, barges for freight transportation by inland lake & marine and pipelines for the transportation of crude oil and petroleum products from the jetty or Single Buoy Mooring (SBM)/Combine Buoy Mooring (CBM) to the refinery or bulk depots.

3.6.6.1 Final Energy Demand for Freight Transportation

The final energy demand for freight transportation is evaluated by classifying the freight transport sector into the following sub-sectors: road, rail, inland lake and pipelines.

The final energy demand for freight transportation is projected to increase from 643 ktoe and 745 ktoe 2020 at an average annual rate of 10.9% and 12.5% respectively to 1,095 ktoe and 2,423 ktoe in 2030 for the BaU and AEG scenarios (see Table 3.63).

Table 3.63: Final Energy Demand by Freight Transportation (ktoe)

Mode	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Road	207	362	387	507	709	369	398	539	785
Rail	1	279	328	585	1,089	373	443	825	1,625
Lake	0.5	0.8	0.8	1.0	1.4	0.9	0.9	1.3	1.9
Pipelines	0.2	1.1	1.3	2.1	3.7	3.0	3.5	6.4	12.2
Total	209	643	717	1,095	1,802	745	846	1,372	2,423

Energy share of freight transportation by road would account for 50-56% in 2020 for both scenarios but will reduce to 32-40% by 2030. Freight transportation by rail accounting for about 43-50% in 2020 would, however, expand to 60-67% of the total energy demand in 2030 for both scenarios.

Diesel would continue to be the main fuel used for road, rail and lake freight transportation, whilst electricity would be used for operating pumps for pipeline transportation of crude oil and petroleum products from the oil jetty to the refinery and SBM/CBM to the fuel depots. Table 3.64 shows the projected demand for diesel and electricity for freight transportation for the two scenarios.

Table 3.64: Final Energy Demand for Freight Transportation by Fuel type (ktoe)

Fuels	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Electricity	0.2	1.1	1.3	2.1	3.7	3.0	3.5	6.4	12.2
Diesel	209	642	716	1,093	1,799	742	842	1,365	2,411
Gasoline premix	0.000	0.001	0.001	0.001	0.002	0.001	0.001	0.002	0.003
Total	209	643	717	1,095	1,802	745	846	1,372	2,423

Diesel would account for over 98% of the total final energy demand for freight transportation from 2020 to 2030 for both scenarios.

3.6.6.2 Final Energy Demand for Freight by Road

Freight transportation by road was classified into urban or local freight transportation and long-distance freight transportation.

Urban or local freight transportation by road involves the movement of goods in urban localities such as from ports to factories and warehouses, from warehouses to retail outlets and restaurants. It also involves the collection of trash produced in homes, institutions and industries. The main vehicles used for local freight transportation by road are delivery vans, pick-ups, rigid cargo and trucks.

Long-distance freight transportation by road involves the bulk movement of agricultural produce and charcoal from rural localities to urban market centres. This also involves the movement of cocoa, timber and other agricultural produce to the harbour for export and the movement of imported goods from the harbour to major towns in the country. The vehicles used for long-distance freight transportation by road are vans, rigid cargo and articulated trucks.

The total final energy demand for freight transportation by road was evaluated by classifying freight transportation by road into:

(i) urban or local freight, and
(ii) long-distance freight transportation.

Final energy demand for freight by road transportation is projected to increase from 362 ktoe and 369 ktoe in 2020 at an average annual rate of 7.0% and 7.8% respectively to about 709 ktoe and 785 ktoe in 2030 for the BaU and AEG scenarios (see Table 3.65).

Table 3.65: Final Energy Demand for Freight by Road Transportation (ktoe)

Sector	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Urban or Local	57	130	143	202	308	133	147	215	342
Long distance	151	231	244	304	400	236	251	324	443
Total	207	362	387	507	709	369	398	539	785

The main fuel for freight by road transportation is diesel for powering trucks. Table 3.65 shows that share for urban or local freight transportation by road would increase from 36% in 2020 to 44% of the total energy demand for freight transportation by road in 2030 for BaU and AEG scenarios.

On the other hand, though the energy demand for long-distance freight transportation by road would increase, its share would drop from 64% to 56% in 2030 for BaU and AEG scenarios.

3.6.6.3 Final Energy Demand for Freight by Rail

The Ghana Railway Company Ltd. provides freight transport services for the bulk haulage of bauxite and manganese and other miscellaneous items to the Takoradi harbour for export as well as from the port to other parts of the country. The final energy demand for freight transportation by rail was evaluated by taking into account only freight train services in the country.

Final energy demand is expected to increase from 274 ktonne and 365 ktonne in 2020 at an average annual rate of 14.6% and 15.9% respectively to 1,067 ktonne and 1,593 ktonne in 2030 for the BaU and AEG scenarios.

The projected increase in the final energy demand for freight transportation by rail would be as a result of the government's policy to revamp the country's rail transportation system and complete the Boankra inland port. The final energy demand for freight transportation by rail for BaU and AEG scenarios are presented in Table 3.66.

Table 3.66: Final Energy Demand by Intercity Rail Freight Transportation (ktonne)

Vehicle type	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Diesel Train	1	274	322	573	1,067	365	434	809	1,593

3.6.6.4 Freight Inland Lake Transport

The Volta Lake Transport Company (VLTC) Ltd. provides freight transport services for the movement of cargo such as liquids (e.g. petroleum products), cement, foodstuffs and other miscellaneous items from the port at Akosombo along the Volta Lake to Buipe in the northern region. The VLTC mainly uses barges for freight transportation. Final energy demand for freight transportation by the inland lake was evaluated by classifying freight transport on the lake into barge and ferry services. Boats are also used to transport charcoal, and other agriculture produce along the inland lake.

Final energy demand for freight transportation by the inland lake is likely to increase from 776 toe and 862 toe in 2020 at an average annual rate of 3.2% and 4.7% respectively to 1,399 ktoe and 1,856 ktoe in 2030 for the BaU and AEG scenarios. Table 3.67 shows the results for the two scenarios.

Table 3.67: Final Energy Demand for Freight by Inland Lake Transportation (toe)

Vehicle type	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Barge	459	725	769	971	1,298	806	869	1,178	1,722
Ferries	28	50	53	71	99	55	60	86	132
Motor boat	0.4	0.8	0.9	1.3	1.9	0.9	1.0	1.5	2.5
Total	487	776	823	1,043	1,399	862	931	1,265	1,856

3.6.6.5 Final Energy Demand for Pipeline Transportation

The final energy demand for pipeline transportation was evaluated by classifying the pipelines into:

(i) crude oil, and
(ii) petroleum products.

The main fuel is electricity. The final energy demand for pipeline transportation would increase from 13.3 GWh and 35 GWh in 2020 at an average annual rate of 12.4% and 15.0% respectively to 43 GWh and 142 GWh in 2030 for the BaU and AEG scenarios (see Table 3.68).

Table 3.68: Final Energy Demand by Pipeline Transportation (GWh)

Type	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Crude oil Pipeline	0.4	1.7	1.9	3.0	4.9	4.5	5.2	9.0	16.2
Petroleum products pipeline	2.4	11.6	13.2	21.5	37.7	30.5	35.9	65.0	125.8
Total	2.8	13.3	15.1	24.5	42.6	35.0	41.1	73.9	142.0

Table 3.68 shows that the final energy demand for the pipeline transportation of petroleum products is expected to account for over 80% of the total final energy demand for pipeline transportation from 2020 to 2030.

3.6.7 Energy Demand for Bunkering

The final energy demand for bunkering is expected to increase from 248-271 ktoe in 2020 at an average annual rate of 5.4% and 6.4% respectively to 421 ktoe and 502 ktoe in 2030 for the BaU and AEG scenarios. Table 3.69 shows the results of the energy demand projections.

Table 3.69: Final Energy Demand for Bunkering (ktoe)

Sector	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Air	106	186	197	247	328	205	219	285	395
Marine	41	62	64	76	93	66	69	84	106
Total	147	248	261	323	421	271	288	368	502

From Table 3.69, international air transportation would expand from about 75% of the final energy demand for aviation and marine bunkering in 2020 to between 78-79% by 2030 for both scenarios. The rest of the final energy demand for bunkering would be attributed to international marine transportation.

Table 3.70: Shares of Final Energy Demand for Bunkering (%)

Fuel	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
ATK	72.2	75.1	75.4	76.5	77.9	75.6	76.0	77.3	78.8
Marine diesel	27.8	24.9	24.6	23.5	22.1	24.4	24.0	22.7	21.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

From Table 3.70, ATK is expected to account for over 70% of the final energy demand for bunkering over the planning period.

Chapter Four: Energy Demand Projections by Fuel Types

4.0 Introduction

This chapter presents energy demand projections by fuels. The fuels considered in this analysis are electricity, solar PV, LPG, kerosene, aviation turbine kerosene, premix, gasoline, diesel, residual fuel oil, charcoal, fire-wood and crop residue.

4.1 Electricity Demand

The final electricity demand of the following sectors: household, commerce and service, industry, the aluminium smelter and agriculture are presented. The main national policies and programmes that would influence the electricity demand are:

(i) Achieving universal electrification by 2020 through the National Electrification Scheme.
(ii) Aluminium smelter operating two pot-lines from 2016 to 2019, and three pot-lines from 2020 for the rest of the planning period for BaU scenario. For AEG, it would operate on three pot-lines in 2020 with annual increment of one-pot line to reach five pot-lines in 2022 and remain the same up to 2030.
(iii) Plans to sustain energy efficiency programmes.
(iv) Plans for accelerated industrialisation (such as one-district one-factory) throughout the country.

Final electricity required is projected to increase from 18,542 GWh (1,594 ktoe) and 21,971 GWh (1,889 ktoe) in 2020 respectively for the BaU and the AEG scenarios at an average annual rate of 5.1% and 8.1% to 30,570 GWh (2,629 ktoe) and 47,926 GWh (4,121 ktoe) in 2030 respectively (Figure 4.1).

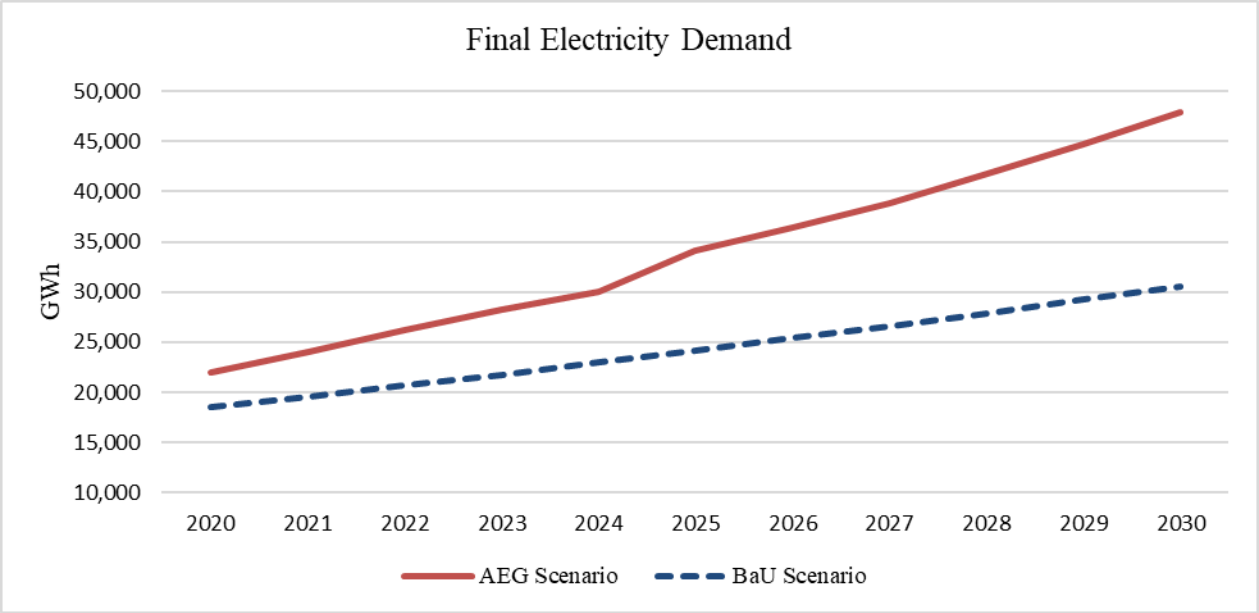


Figure 4.1: Final Electricity Demand Projection from 2020 to 2030

4.1.1 Electricity Use per capita

The electricity demand per capita was projected to increase from 599 kWh and 713 kWh in 2020 at an average annual rate of 3.0% and 6.04% respectively to 804.8 kWh and 1,282.3 kWh in 2030 for the BaU and AEG scenarios. The electricity demand per capita in 2020 for the BaU scenario is lower than the average of 704 kWh for Lower Middle-Income countries. The low per capita electricity usage in the country is attributable to the low level of industrial activity, high level of suppressed demand, curtailment of operations of the aluminium smelter and higher uptake of energy efficiency/demand-side management.

4.1.2 Electricity Use Intensity

The intensity of electricity demand was projected to drop from 0.29-0.31 kWh/USD of GDP in 2020 to 0.24-0.30 kWh/USD of GDP in 2030 for both the BaU and AEG scenarios. The general decrease in the intensity of electricity demand would be as a result of sustained and projected energy efficiency initiatives and increase in service activities during the planning period.

4.1.3 Electricity Demand by Sector

The Household sector share of the total final electricity demand in 2020 was projected to drop from about 41% to about 39% and 29% in 2030 for BaU and AEG scenarios respectively. The next dominant electricity demand sector is Industry accounting for 26-27% of the total electricity demand in 2020

but would drop to about 29-36% in 2030 whilst the Services sector would increase its share from 21-24% in 2020 to 25-27% in 2030 thereby displacing Industry as the second dominant sector (see Table 4.1)

Table 4.1: Final Electricity Demand by Sector (GWh)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Households	3,747	7,597	8,018	9,842	11,977	8,954	9,376	11,204	13,843
Urban	3,096	5,833	6,115	7,329	8,906	6,605	6,959	8,511	10,754
Rural	651	1,764	1,903	2,513	3,071	2,348	2,417	2,693	3,090
Services	1,719	3,948	4,255	5,641	7,796	5,193	5,720	8,262	12,683
Formal	1,719	3,948	4,255	5,641	7,796	5,193	5,720	8,262	12,683
Informal	-	-	-	-	-	-	-	-	-
Industry	2,728	5,039	5,348	6,705	8,812	5,772	6,186	10,938	17,073
Water production	169	459	487	600	737	520	555	692	860
Mining and Quarrying	1,560	2,548	2,675	3,245	4,125	2,910	3,092	3,992	5,427
Manufacturing	997.5	2,030.4	2,185.0	2,859.6	3,948.7	2,341.6	2,538.5	6,252.9	10,784.2
Construction	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.2
VALCo	7	1,931	1,929	1,923	1,915	1,931	2,572	3,205	3,192
Electricity for smelting	7	1,931	1,929	1,923	1,915	1,931	2,572	3,205	3,192
Agriculture	2	14	15	20	28	51	63	118	202
Irrigation	1	10	11	14	19	46	57	109	191
Poultry farms	1	4	4	6	8	5	6	8	11
Post harvest processing	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Transport	3	13	15	24	43	70	83	345	933
Passenger	-	-	-	-	-	35	42	271	791
Freight	3	13	15	24	43	35	41	74	142
Total	8,205	18,542	19,581	24,156	30,570	21,971	24,001	34,072	47,926

Share of electricity demand by aluminium smelter accounting for 8-10% of the total electricity demand in 2020 is expected to reduce to 6.3% and 6.6% in 2030 for the BaU scenario and AEG scenario respectively, should the average electricity tariff remain high.

4.1.4 Electricity Demand per Household

The average electricity demand per household would increase from 1,128 kWh and 1,177 kWh in 2020 to 1,227 kWh and 1,441 kWh in 2030 respectively for the BaU and AEG scenarios. The higher average electricity demand per household in 2030 compared to 2020 is attributed to the increased penetration and usage of electrical appliances. Nonetheless, the projected electricity demand per household in 2030 is still lower than the 2010 world average of about 3,500 kWh. The higher penetration of energy-efficient and super energy-efficient appliances would drive demand reductions.

4.1.5 Electricity Demand by Services Sector

The Services sector's demand for electricity was projected to increase from 3,948 GWh (339 ktoe) and 5,193 GWh (447 ktoe) at an average annual rate of 7.0% and 9.3% to 7,796 GWh (670 ktoe) and 12,683 GWh (1,090 ktoe) in 2030 for the BaU and AEG scenarios respectively (see Table 4.2).

Table 4.2: Final Electricity Demand by Services Sector (GWh)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Offices	239	370	386	458	565	438	465	589	789
Lodging	190	325	345	438	585	533	588	869	1,397
Health Facilities	195	372	396	509	693	478	518	708	1,024
Educational facilities	314	837	908	1,234	1,754	1,232	1,376	2,092	3,385
Retail Facilities	219	948	1,049	1,517	2,277	1,340	1,516	2,386	3,948
Restaurants and Eateries	141	312	336	447	631	353	383	531	782
Others	156	134	132	123	112	137	135	127	117
Street lighting	264	650	703	915	1,180	682	738	961	1,239
Total	1,719	3,948	4,255	5,641	7,796	5,193	5,720	8,262	12,683

Analysis of the Service sector's electricity demand shows that the Wholesale & retail sub-sector would account for about 24% and 26% of the total electricity demand of the Services sector in 2020 respectively for the BaU and AEG scenarios and would increase to 29% and 31% in 2030. The other dominant energy demand sub-sector is Education, which accounts for about 21-24% of the Services sector's total electricity demand in 2020 and would increase to 23% and 27% in 2030 for the BaU and AEG scenarios respectively.

4.1.6 Electricity Demand by Industrial Sector

Electricity demand for the Industrial sector was projected to increase from 6,969 GWh (599 ktoe) and 7,703 GWh (662 ktoe) in 2020 respectively for the BaU and AEG scenarios at an average annual growth rate of 4.4% and 10.2% to 10,727 GWh (922 ktoe) and 20,265 GWh (1,742 ktoe) in 2030 respectively (see Table 4.3).

Table 4.3: Final Electricity Demand by Industrial Sector (GWh)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Water production	169	459	487	600	737	520	555	692	860
Mining and Quarrying	1,560	2,548	2,675	3,245	4,125	2,910	3,092	3,992	5,427
Construction	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.2
Manufacturing	998	2,030	2,185	2,860	3,949	2,342	2,538	6,253	10,784
VALCo	7	1,931	1,929	1,923	1,915	1,931	2,572	3,205	3,192
Total	2,735	6,969	7,277	8,628	10,727	7,703	8,759	14,143	20,265

Mining and quarrying sub-sector would be the dominant electricity demand sub-sector in 2030 under BaU scenarios, accounting for about 38% of the total electricity demand by the industrial sector from about 37% in 2020. Manufacturing sub-sector in 2030 would be accounting for about 37% of the total electricity demand by the industrial sector from about 29% in 2020 under BaU scenario. However, under AEG scenarios, manufacturing in 2030 is expected to account for about 53% of the total electricity demand by the industrial sector from about 30% in 2020. Manufacturing sub-sector, under AEG scenario, is expected to dominate owing to reasons such as government's Integrated Aluminium Industry policy.

4.1.7 Electricity Demand by Agricultural Sector

The total electricity demand for the agricultural sector for the BaU scenario is projected to increase from 13.9 GWh (1.2 ktoe) in 2020 at an annual rate of 7.1% to 27.7 GWh (2.4 ktoe) in 2030. In the case of the AEG scenario, it is projected to increase from 50.6 GWh (4.4 ktoe) in 2020 at an average annual growth rate of 14.8% to 202 GWh (17.4 ktoe) in 2030. The fast growth in demand for electricity in the agricultural sector would be due to increased irrigation. The results of the electricity demand and the electricity demand projections for the various sub-sectors are presented in Table 4.4.

Table 4.4: Final Electricity Demand by Agricultural Sector (GWh)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Irrigation	0.6	10.0	10.8	14.2	19.2	45.5	56.9	109.4	190.7
poultry farms	1.0	3.8	4.3	6.1	8.3	5.0	5.6	8.0	11.2
post harvest processing	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Total	1.6	13.9	15.1	20.4	27.7	50.6	62.6	117.6	202.1

Poultry farms and Irrigation would remain the dominant electricity demand sub-sectors. Electricity demand for poultry farms and irrigation account for 27.7% and 71.7% respectively of the total electricity demand by the Agricultural and fisheries in 2020 and would change to 30.2% and 69.3% in 2030 for the BaU scenario. In the case of the AEG scenario, electricity demand for Poultry farms and Irrigation would drop from about 9.8% and 90.0% respectively in 2020 to about 5.5% and 94.4% in 2030.

4.1.8 Electricity Demand by Transport Sector

The electricity demand for both the transportation of crude oil and petroleum products through pipelines and expected road passenger transport in the country is expected to increase. It would increase from 13.3 GWh (1.1 ktoe) and 70.5 GWh (6.1 ktoe) in 2020 at an average annual growth rate

of 12.4% and 29.5% to 42.6 GWh (3.7 ktoe) and 933 GWh (80.2 ktoe) in 2030 for the BaU and AEG scenarios respectively.

Table 4.5: Final Electricity Demand by Transport Sector (GWh)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Passenger	-	-	-	-	-	35.5	41.7	271.5	791.3
Freight	2.8	13.3	15.1	24.5	42.6	35.0	41.1	73.9	142.0
Total	2.8	13.3	15.1	24.5	42.6	70.5	82.8	345.4	933.3

4.2 Petroleum Products and Natural Gas Demand

The total demand for petroleum products would increase from 4,831 ktonne and 5,272 ktonne in 2020 respectively at an average annual rate of 6.9% and 8.6% to 9,458 ktonne and 12,077 ktonne in 2030 for the BaU and AEG scenarios. Table 4.6 presents the results of these projections.

Table 4.6: Final Demand for Petroleum Products (ktonne)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Diesel	1,424	2,790	3,006	4,051	5,877	3,126	3,420	5,085	8,111
Gasoline	799	1,332	1,406	1,750	2,318	1,332	1,413	1,743	2,258
Gasoline premix	33	79	86	121	184	78	85	119	181
Jet Kerosene	116	209	222	282	380	258	279	382	564
Kerosene	48	3	2	0	0	0	0	0	0
LPG	168	313	331	408	516	358	384	495	662
Residual Fuel Oil	42	104	111	138	182	119	132	200	299
Total	2,629	4,831	5,164	6,750	9,458	5,272	5,714	8,025	12,077
Natural Gas (MMSCF)	-	2,498	2,683	3,569	5,100	2,641	2,852	49,583	104,654

From Table 4.6, diesel is the dominant fuel in both the BaU and AEG scenarios. It accounts for 58-59% in 2020 and increasing to 62-67% of the total demand for petroleum products in 2030.Gasoline share is expected to reduce from about 28% in 2020 to about 25% by 2030 for BaU scenario but expected to drop from about 25% in 2020 to about 19% by 2030 for AEG scenario. The demand for LPG would also drop from about 6% in 2020 to about 5% of the total demand for petroleum products by 2030.

4.2.1 LPG Demand Projections

The demand for LPG would increase from 313 ktonne and 358 ktonne in 2020 at an average annual rate of 5.2% and 6.4% respectively to 516 ktonne and 662 ktonne in 2030 for the BaU and AEG scenarios (see Table 4.7).

Table 4.7: LPG Demand by Sector (ktonne)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Households	101	207	219	271	338	243	260	337	445
Urban	91	184	194	235	289	213	228	295	389
Rural	11	23	25	36	48	30	32	42	56
Services\Formal	7	20	22	31	47	26	29	44	72
Industry	11	26	29	38	54	30	33	44	63
Manufacturing	11	25	28	37	54	29	32	42	61
VALCo	0.0	0.9	0.9	0.9	0.9	0.9	1.2	1.5	1.5
Transport	48	59	61	68	77	60	62	71	83
Total	168	313	331	408	516	358	384	495	662

Share of LPG for household cooking, in total LPG demand, would decrease from about 38-39% in 2020 to about 37-38% in 2030 for both scenarios. LPG for transportation, however, would decrease from about 9-11% to 7-8% of the total LPG demand in 2030.

The LPG demand for the Services sector would also expand from about 4% in 2020 to 5% and 6% by 2030 for BaU and AEG scenarios respectively.

4.2.1.1 Future penetration of LPG Use in Households

LPG demand projection for cooking shows that for the BaU scenario, 29.5% of the total households would be using LPG as their main fuel for cooking in 2020, which is projected to increase to 38.6% in 2030.

The penetration of LPG use in urban households would be 40.8% and 41.6% in 2020 and 48.2% and 51.2% in 2030 respectively for the BaU and the AEG scenarios, whilst that for rural households would be 9.9% and 13.4% by 2020, and 18.6% and 22.6% by 2030 respectively.

In order to achieve the Government policy target of 50% of households using LPG as the main cooking fuel by 2030, the demand for LPG in households would have to increase by over two-folds from an estimate of 224 ktoe (207 ktonne) in 2020 to 483 ktoe (448 ktonne) by the end of 2030.

4.2.1.2 LPG Demand per capita

The average LPG demand per capita would increase from about 10-12 kg in 2020 to about 14 kg and 18 kg in 2030 respectively for the BaU and the AEG scenarios. The increasing trend of the average LPG demand per capita is as a result of increasing household disposable income, the government's policy to achieve 50% household penetration of LPG in 2030 and the Rural LPG promotion programme under the SE4ALL.

4.2.2 Diesel Demand Projections

Demand for diesel is projected to increase from 2,790 ktonne in 2020 at an average annual rate of 7.4% to 5,877 ktonne in 2030 in the BaU scenario. In the case of the AEG scenario, the demand for diesel is projected to increase from 3,126 ktonne at an average annual rate of 8.7% to 8,111 ktonne in 2030 (see Table 4.8).

The transport sector accounts for 79.8% of the total diesel demand in 2020 and 83.6% in 2030 under the BaU scenario. The industry sector's demand for diesel is projected to account for 12.3% of the total diesel demand in 2030 compared to 16.7% in 2020.

Table 4.8: Diesel Demand by Sectors (ktonne)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Industry	300	466	487	581	725	498	524	839	1,336
Mining and Quarrying	217	352	368	441	550	374	393	526	713
Construction	70	75	75	78	80	79	80	84	89
Manufacturing	13	37	41	60	92	43	47	225	530
VALCo	0	2	2	2	2	2	3	4	4
Agriculture	40	98	107	152	236	111	122	177	277
Irrigation	0.1	1.4	1.5	2.0	2.6	5.1	5.9	8.7	10.9
poultry farms	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1
Land ploughing	19	28	29	34	42	33	35	43	57
Crop harvesting	2	9	10	13	17	12	13	17	23
Fishing	19	59	66	103	175	61	69	108	186
Transport	1,084	2,226	2,412	3,318	4,916	2,516	2,773	4,069	6,499
Passenger	839	1,536	1,647	2,172	3,061	1,724	1,880	2,648	4,031
Freight	204	629	702	1,071	1,764	728	825	1,339	2,364
Bunkering	40	60	63	74	91	65	68	82	104
Total	1,424	2,790	3,006	4,051	5,877	3,126	3,420	5,085	8,111

The diesel demand for industry is projected to account for 16.5% of the total diesel demand in 2030 compared to 15.9% in 2020 for the AEG scenario.

4.2.2.1 Diesel Demand per capita

The average diesel demand per capita would increase from 90 kg in 2020 to 155 kg by 2030 for the BaU, which is about 48.2% higher than the World average diesel use per capita of 114 kg in 2010[70].

Under the AEG scenario, the average diesel demand per capita would increase from 101 kg in 2020 to 217 kg in 2030. The high average diesel demand per capita is owing to the projected increase in surface mining, motorisation, passenger and freight traffic.

4.2.3 Gasoline Demand Projections

Gasoline demand is primarily for road transportation. However, some amount of gasoline would be demanded for electricity generation in events of power outages.

The demand for gasoline is expected to increase from 1,332 ktonne in 2020 at an average annual rate of 5.7% and 5.4% respectively to 2,318 ktonne and 2,258 ktonne by 2030 under the BaU scenario and AEG scenarios (see Table 4.9).

Table 4.9: Gasoline Demand (ktonne)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Transport	799	1,332	1,406	1,750	2,318	1,332	1,413	1,743	2,258

4.2.3.1 Gasoline Demand per capita

The average gasoline demand per capita would increase from about 43 kg in 2020 to 61 kg in 2030 for the BaU scenario whiles AEG scenario would increase marginally from 43.2 kg to 54.3 kg in 2030 owing to expected more effective mass transportation and higher penetration of EVs within cities.

4.2.4 Premix Fuel Demand Projections

The demand for premix[71] is expected to increase from 79 and 78 ktonne in 2020 at an average annual rate of 8.8% and 8.7% respectively to about 184 ktonne and 181 ktonne in 2030 under the BaU and the AEG scenarios. Table 4.10 presents the results.

[70] World Bank, Open Access World Bank Database, Website: http://databank.worldbank.org/data/home.aspx
[71] Premix fuel is a blend of gasoline to marine mix (a residue from lubricating oil) in a ratio of 29:1 by weight. It is primarily blended for fishermen to be used in their outboard motors. It is also used for the operation of sparying machines in cocoa growing areas.

Table 4.10: Premix Demand (ktonne)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Agriculture	33	79	86	121	184	78	85	119	181
Lake Transport	0.0007	0.0020	0.0022	0.0029	0.0040	0.0024	0.0027	0.0041	0.0066
Total	33	79	86	121	184	78	85	119	181

4.2.5 ATK Demand Projections

The demand for ATK would increase from 209 ktonne and 258 ktonne in 2020 at an average annual rate of 6.2% and 8.2% respectively to 380 ktonne and 564 ktonne in 2030 for the BaU and AEG scenarios (see Table 4.11).

Table 4.11: ATK Demand (ktonne)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Transport\Passenger	13	28	30	42	62	59	67	106	180
Transport\Bunkering	103	181	191	240	318	199	212	276	384
Total	116	209	222	282	380	258	279	382	564

Table 4.11 suggests that domestic air passenger transportation would account for 13.4% and 22.9% of total ATK demand in 2020 respectively in 2030 under the BaU and AEG scenarios, and would increase to 16.3% and 32.0%.

Share of ATK demand for international air travel or bunkering would reduce from about 87% and 77% in 2020 to around 84% and 68% in 2030 respectively for the BaU and AEG scenarios.

4.2.6 Kerosene Demand Projections

The demand for kerosene would continue to decrease from about 2.9 ktonne and 0.1 ktonne in 2020 to 0.1 ktonne in 2030 for both BaU to AEG scenarios (see Table 4.12).

Table 4.12: Kerosene Demand (ktonne)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Household	47.9	2.9	2.2	0.5	0.1	0.1	0.1	0.1	0.1
Urban	5.9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Rural	42.0	2.8	2.2	0.4	0.0	0.0	0.0	0.0	0.0
Manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	47.9	2.9	2.2	0.5	0.1	0.1	0.1	0.1	0.1

Consequently, the rural sector will account for over 96% of the kerosene demand under BaU scenario. The share of its use in the manufacturing sector would be zero by 2030 under AEG scenario.

4.2.7 RFO Demand Projections

In the BaU scenario, the demand for RFO is projected to increase from 104 ktonne in 2020 at an average annual rate of 5.7% to about 182 ktonne in 2030. In the case of the AEG scenario, the demand for RFO is projected to increase from 119 ktonne at an average annual rate of 9.7% to 299 ktonne in 2030 (Table 4.13).

Table 4.13: RFO Demand (ktonne)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Manufacturing	41	87	94	121	165	101	109	171	271
VALCo	0	17	17	17	17	17	23	29	29
Total	42	104	111	138	182	119	132	200	299

The RFO demand of the Manufacturing sub-sector would increase from 87 tonnes in 2020 (83% of 2020 demand) to 165 tonnes in 2030 (i.e. about 91% of 2030 demand) for the BAU scenario. That of the AEG scenario is expected increase from 101 tonnes in 2020 to 299 tonnes in 2030, with a corresponding share increase of 85% to 90% respectively.

The aluminium smelter's demand for RFO remains unchanged for the BAU scenario but its share would, on the other hand, reduce from about 17% in 2020 to 9% in 2030. The share for the AEG scenario decreases from 15% in 2020 to 10% in 2030. This reduction is due to expected improvements in efficiency measures.

4.2.8 Natural Gas Demand Projections

The use of natural gas as final energy (not for electricity generation and other transformation purposes) commenced in 2016-2017 and has the potential of displacing RFO and diesel as heating fuels used in industrial processes. It is projected to be the main fuel for heating for production of pig iron and sintering of alumina (which are energy-intensive). For this study, the use of natural gas as a chemical feedstock, in the manufacture of plastics and other chemicals, was not considered.

Table 4.14: Natural Gas Demand (mmscf)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Manufacturing	-	2,498	2,683	3,569	5,100	2,641	2,852	49,583	104,654

Demand for natural gas would increase from 2,498 mmscf and 2,641 mmscf in 2020 at an annual average rate of 7.4% and 44.5% respectively to 5,100 mmscf and 104,654 mmscf in 2030 for BaU and AEG scenarios (Table 4.14). The relatively high demand growth rate for the AEG scenario is due to the expected commencement of production of the metals mentioned above.

4.3 Wood-fuel Demand

The demand for woodfuel is expected to reduce from about 3,104 ktoe and 2,918 ktoe in 2020 at an annual average rate of 0.2% and 0.3% respectively to 3,041 ktoe and 2,824 ktoe by 2030 under the BaU and AEG scenarios. The total demand projections for woodfuel and according to the various sectors are presented in Table 4.15.

Table 4.15: Wood-fuel Demand (ktoe)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Residential	2,659	2,575	2,559	2,461	2,364	2,362	2,344	2,251	2,091
Services	90	101	103	105	104	127	131	146	159
Industry	277	428	442	502	573	429	444	506	574
Total	3,026	3,104	3,104	3,068	3,041	2,918	2,920	2,903	2,824

Table 4.15 indicates that the share of woodfuel demand for households would drop from about 83% to 78% for the BAU scenario. That of the AEG scenario will drop from 81% -74%.

4.3.1 Firewood Demand Projections

The demand for firewood is projected to reduce from 2,272 ktoe and 2,068 ktoe in 2020 at an average annual rate of 0.9% and 1.1% respectively to 2,070 ktoe and 1,845 ktoe in 2030 for the BaU and AEG scenarios (see Table 4.16).

Table 4.16: Firewood Demand (ktoe)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Households	2,064	1,801	1,768	1,609	1,459	1,580	1,548	1,402	1,202
Urban	371	140	142	146	145	140	141	145	144
Rural	1,694	1,661	1,627	1,464	1,314	1,441	1,407	1,257	1,058
Services	45	45	45	43	40	61	62	67	71
Industry	275	426	440	500	571	427	442	503	572
Total	2,385	2,272	2,253	2,153	2,070	2,068	2,053	1,972	1,845

Share of Household firewood in the total firewood demand would drop from about 76% in 2020 to around 65% in 2030 for both scenarios.

The share of firewood demand for rural households would also decrease from about 91% in 2020 to about 88-90% by 2030 for both scenarios.

Share of firewood demand by industry, however, would increase from about 18% in 2020 to 27-31% in 2030 for both scenarios.

4.3.2 Firewood Demand per Household

For households depending on firewood as main fuel for cooking, the average demand for firewood per household is expected to remain almost about the same as in 2020; 2,738 - 2,757 kg in 2020 to 2,571-2,640 kg in 2030. The marginal change in household demand for firewood would be as a result of the minimal change in rural household size.

4.3.3 Charcoal Demand

The demand for charcoal would change from 832 ktoe and 850 ktoe in 2020 at an average annual rate of 1.6% and 1.4% respectively to 971 ktoe and 978 ktoe in 2030 for the BaU and AEG scenarios (see Table 4.17).

Table 4.17: Charcoal Demand by Sectors (ktoe)

Sectors	Actual	Projection							
	Base Year	Business as Usual				Accelerated Economic Growth			
	2010	2020	2021	2025	2030	2020	2021	2025	2030
Households	595	773	790	851	905	781	796	849	888
Urban	438	664	678	735	789	670	684	738	775
Rural	157	109	112	117	116	111	111	112	113
Services	44	56	58	62	64	66	69	79	88
Industry	2	2	2	2	2	2	2	2	2
Total	641	832	850	915	971	850	867	931	978

Table 4.17 suggests that the share of the household sector of the total charcoal demand, which would be about 93% in 2020 would remain about the same by 2030 for the BaU scenario. Shares change, under the AEG scenario, from 91.9% in 2020 to 90.8% in 2030.

4.3.4 Charcoal Demand per Household

For households using charcoal, the average charcoal demand per household is expected to fall from 341 kg in 2020 to 308 kg in 2030 for the BaU scenario. In the case of the AEG scenario, the average demand for charcoal per household would reduce from 337 kg to 312 kg in 2030.

Since charcoal would be demanded mainly by urban households, the decrease in the average demand for charcoal per household (that depends on charcoal as the main fuel for cooking), is as a result of more penetration of LPG.

4.3.5 Effect of Improved Cook-stoves on Wood-fuel

Introduction of improved cookstoves has the potential to reduce woodfuel consumption. If government's target of promotion and adoption of 2 million improved woodfuel is achieved, then penetration of improved cookstoves would increase from about 19% of the total number of households in 2020 to 25.4% by 2030. This would decrease the demand for woodfuel by 15.0% in 2030 and subsequently increased the share of improved cookstoves among households using woodfuel from about 32% in 2020 to 48% in 2030. (see Figure 4.2).

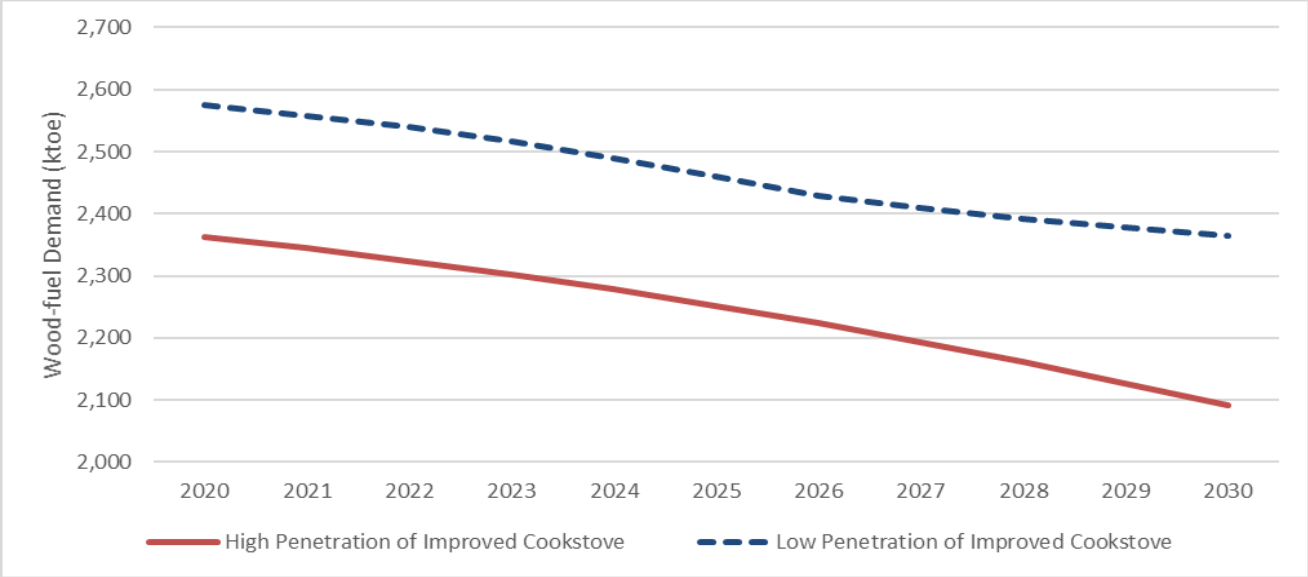


Figure 4.2: Projected Savings on Wood-fuel Owing to the Penetration of Improved Cook-stoves

Chapter Five: Conclusions and Recommendations

Ghana's energy demand has been projected from 2020 to 2030 for two scenarios using the Long-Range Energy Alternatives Planning (LEAP) model. The two scenarios under which the projections were made are Business as Usual (BaU) and Accelerated Economic Growth (AEG) scenarios.

Under the BaU scenario, population would increase from 24.7 million in 2010 to 38 million in 2030 at an average annual growth rate of 2.17%. Urbanization rate was projected to increase from 50.9% in 2010 to 65.0% in 2030 at an average annual rate of 1.2%. Also, Gross Domestic Product (GDP) was projected to increase from US$ 32.2 billion (in current prices) in 2010 at an average annual rate of 7.1% to US$ 126.9 billion (current prices) in 2030.

For the AEG scenario, the population was projected to increase from 24.7 million in 2010 at an average annual rate of 2.09% to 37.4 million in 2030. Urbanization rate was projected to increase from 50.9% in 2010 to 66.0% in 2030 at an average annual rate of 1.3%. GDP was projected to increase from US$ 32.2 billion (current prices) in 2010 at an average annual rate of 8.3% to US$ 158.6 billion (current prices) in 2030.

The predictions are as follows:

i) Total energy demand would increase by about 60% from 9,753 ktoe in 2020 to 15,552 ktoe in 2030.

ii) The dominant energy demand sector would be transport instead of the household sector, which was dominant for the year 2010. The transport sector would account for 51% of the total final energy demand for the BaU scenario and 53% for the AEG scenario in 2030.

iii) The share of energy for freight transport of total energy demand could remain low due to relatively low industrial activity from 2020 to 2030. as a result of relatively high and uncompetitive industrial electricity tariffs. Freight transport's share of total energy demand for transportation would nonetheless increase marginally from about 16-17% in 2020 to 22.7% and 24.9% respectively in 2030 for the BaU and AEG scenarios.

iv) As a result of the increase in population and per capita income, the demand for passenger traffic is expected to increase rapidly. This would lead to an increase in the energy demand for passenger transportation at an average annual rate of 6.4% for the BaU scenario and 7.6% for the AEG scenario. The high-energy demand for transportation is likely to lead to an increase in vehicular emissions and local pollution, especially in the cities.

v) Due to the increasing penetration of electrical appliances in the household and service sectors and the electricity-intensive nature of industrial processes, electricity demand would increase at an annual rate of 5-8% for both BaU and AEG scenarios. The electricity demand per household would increase by 58% for the BaU scenario and 55% for the AEG scenario from 2020 to 2030.

vi) The government's policy objective is to increase the penetration of LPG used for cooking to 50% of households by 2030. However, the results of the LPG demand projection show that for both scenarios, only about 39-42% of total households would have access to LPG as their main fuel for cooking in 2030 compared to government's penetration target of 50%. To achieve the 50% target, the demand for LPG would have to increase by about two-folds, from 224 ktoe (207 ktonne) in 2020 to 483 ktoe (448 ktonne) by the end of 2030.

vii) Although the country would use energy more efficiently by the year 2030, there would be a higher energy demand, which would be driven by population and economic growth. Keeping pace with the energy demand growth would require unprecedented levels of investment and the pursuit of all energy sources that are economically viable.

viii) The promotion, adoption and use of efficient electric drives and motors, will undoubtedly, reduce energy consumption, especially in the industrial sector.

ix) More thorough surveys on energy use patterns and statistical analysis must be carried out to generate new data sources to improve the quality of future energy demand projections.

x) The government's policy objective of achieving universal electrification by 2020 is not practically possible under the BaU scenario.

Given these findings, we make the following recommendations to the Government and other stakeholders:

1. Promoting the use of LPG in households must be more aggressive to achieve the government's policy objective of increasing the penetration of LPG used for cooking in households to 50% by the end of 2030.

2. High demand for firewood would continue to persist in rural households with a potential threat of deforestation and the associated effects of indoor air pollution. Efficiency gains through energy-saving practices and sustained introduction and promotion of improved kilns and cookstove technologies, as well as sustainable forest management practices such as woodlot plantations, would significantly reduce demand growth and curb GHG and particulate pollutant-emissions. Intensify promotion and adoption of improved cookstoves of fuel savings potential of at least 15%.

3. The growth in the demand for electricity implies that the chronic power outages experienced in the past are to be expected and could be at a more frequent rate unless generation capacity needed is provided and the efficiency of the power infrastructure as well as electricity end-uses industrial processes are drastically improved.

4. Provide special interventions to boost manufacturing to create jobs and in turn, increase productive energy consumption.

5. The government, in partnership with the private sector, should establish accredited electric drives and motor service centres. Energy Commission in partnership with relevant agencies should certify the service centres.

6. Government should place a ban on the importation of capacity specific used electric drive and motors. Determination of the specific capacities should be based on studies into the efficiency drop, economic and environmental cost of repairing electric motors in Ghana. Subsequently, a gradual ban on the use of inefficient electric drives and motors should be introduced.

7. Besides introducing vehicular emission controls, there would be the need to implement other measures such as improved public transport infrastructure and a modal shift from the road to other efficient modes of transport such as rail, sea, etc. This recommendation was made in SNEP I but never implemented.

8. Introduction of Compressed Natural Gas (CNG) and Liquified Natural Gas (LNG) as automotive fuel, if properly promoted, could lead to further diversification of fuel types for auto transport.

9. The use of electric vehicles could further diversify fuel use for auto transport and has the potential of lowering emission from the transport sector depending on electricity generation options

10. Provision of dedicated lanes to urban BRT would increase patronage and utilisation of the transport system.

11. Since universal electrification cannot be achieved in 2020, the target should be reviewed from 2020 to 2025. In addition, the Ministry of Energy should implement plans on distributed or decentralised electricity systems like mini-grids for hard-to-reach off-grid communities in order to attain the new target.

Annex 1 Sectoral Energy Demand Projection

Table A1.1: Final Energy Demand by Sectors (ktoe)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Households	3,458.8	3,490.8	3,521.1	3,549.7	3,576.7	3,602.0	3,623.5	3,653.5	3,685.8	3,723.6	3,760.5
Services	462.8	492.4	523.3	555.5	589.2	624.3	661.1	699.5	739.7	781.7	825.8
Industry	1,511.0	1,587.0	1,665.2	1,747.3	1,831.8	1,918.9	2,012.7	2,109.4	2,209.1	2,312.0	2,418.1
VALCo	186.1	186.0	185.8	185.7	185.5	185.4	185.2	185.1	184.9	184.8	184.6
Agriculture	184.6	201.3	219.4	239.1	260.6	284.0	309.5	337.3	367.6	400.7	436.7
Transport	3,949.6	4,232.0	4,535.4	4,861.2	5,211.1	5,586.9	5,990.5	6,423.9	6,889.3	7,389.2	7,925.9
Total	9,752.9	10,189.5	10,650.3	11,138.5	11,654.8	12,201.4	12,782.5	13,408.7	14,076.5	14,791.8	15,551.6

Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Households	3,394.9	3,432.3	3,469.5	3,506.5	3,543.4	3,580.4	3,617.8	3,655.0	3,692.1	3,728.8	3,765.4
Services	601.7	654.4	710.6	770.7	835.0	903.7	977.2	1,055.9	1,140.1	1,230.2	1,326.7
Industry	1,629.7	1,721.8	1,817.1	2,064.3	2,290.3	3,799.3	4,203.5	4,613.6	5,218.1	5,830.4	6,450.8
VALCo	186.1	248.0	309.7	309.5	309.2	309.0	308.7	308.5	308.2	308.0	307.7
Agriculture	200.3	220.0	241.2	264.2	289.0	316.0	345.2	376.9	411.4	448.8	489.4
Transport	4,301.4	4,674.3	5,071.8	5,503.3	5,971.8	6,480.4	7,032.7	7,632.1	8,280.3	8,986.9	9,750.9
Total	10,314.1	10,950.7	11,619.9	12,418.5	13,238.7	15,388.8	16,485.1	17,642.0	19,050.1	20,533.0	22,091.1

Table A1.2: Final Energy Demand (excluding biomass) (ktoe)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Households	884.1	932.2	982.0	1,033.4	1,086.6	1,141.4	1,194.6	1,244.9	1,294.0	1,344.9	1,396.9
Services	361.4	389.9	419.8	451.2	484.3	519.0	555.6	594.0	634.4	676.8	721.5
Industry	1,083.1	1,144.5	1,207.9	1,275.1	1,344.6	1,416.5	1,496.3	1,578.9	1,664.5	1,753.2	1,845.2
VALCo	186.1	186.0	185.8	185.7	185.5	185.4	185.2	185.1	184.9	184.8	184.6
Agriculture	184.6	201.3	219.4	239.1	260.6	284.0	309.5	337.3	367.6	400.7	436.7
Transport	3,949.6	4,232.0	4,535.4	4,861.2	5,211.1	5,586.9	5,990.5	6,423.9	6,889.3	7,389.2	7,925.9
Total	6,649.0	7,085.9	7,550.3	8,045.7	8,572.6	9,133.2	9,731.7	10,364.0	11,034.7	11,749.4	12,510.8
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Households	1,033.2	1,088.2	1,145.3	1,204.4	1,265.7	1,329.1	1,394.2	1,461.3	1,530.5	1,601.6	1,674.8
Services	474.4	522.9	575.3	631.6	692.3	757.7	828.1	904.0	985.6	1,073.5	1,168.1
Industry	1,200.7	1,277.8	1,357.9	1,589.7	1,800.1	3,293.5	3,684.0	4,080.4	4,671.2	5,269.7	5,876.5
VALCo	186.1	248.0	309.7	309.5	309.2	309.0	308.7	308.5	308.2	308.0	307.7
Agriculture	200.3	220.0	241.2	264.2	289.0	316.0	345.2	376.9	411.4	448.8	489.4
Transport	4,301.4	4,674.3	5,071.8	5,503.3	5,971.8	6,480.4	7,032.7	7,632.1	8,280.3	8,986.9	9,750.9
Total	7,396.1	8,031.2	8,701.1	9,502.7	10,328.1	12,485.7	13,592.9	14,763.2	16,187.1	17,688.4	19,267.4

Annex 2 Household Sector Energy Demand Projection

Table A2.1: Final Energy in Household (ktoe)

Fuels	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	653.2	689.5	726.9	765.5	805.3	846.3	885.9	922.2	956.8	992.9	1,029.9
Kerosene	2.9	2.3	1.7	1.3	0.8	0.5	0.2	0.1	0.1	0.1	0.1
LPG	223.6	236.5	249.7	263.5	277.7	292.3	306.8	321.0	335.5	350.0	364.9
Wood	1,801.3	1,768.2	1,732.4	1,693.9	1,652.9	1,609.3	1,566.2	1,535.3	1,508.2	1,484.3	1,458.8
Charcoal	773.3	790.4	806.7	822.3	837.2	851.3	862.6	873.3	883.6	894.4	904.8
Solar	4.3	4.0	3.7	3.3	2.8	2.3	1.8	1.6	1.6	1.8	2.1
Total	3,458.8	3,490.8	3,521.1	3,549.7	3,576.7	3,602.0	3,623.5	3,653.5	3,685.8	3,723.6	3,760.5
Fuels	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	769.9	806.2	843.7	882.4	922.3	963.4	1,006.5	1,050.8	1,096.3	1,142.7	1,190.3
Kerosene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
LPG	262.5	280.9	300.3	320.5	341.7	363.8	385.4	407.9	431.2	455.5	480.6
Wood	1,580.4	1,548.4	1,514.5	1,478.7	1,441.2	1,401.8	1,365.2	1,326.9	1,287.0	1,245.4	1,202.2
Charcoal	781.3	795.7	809.7	823.4	836.6	849.4	858.4	866.8	874.6	881.8	888.4
Solar	0.8	1.0	1.2	1.4	1.6	1.9	2.2	2.5	2.9	3.3	3.8
Total	3,394.9	3,432.3	3,469.5	3,506.5	3,543.4	3,580.4	3,617.8	3,655.0	3,692.1	3,728.8	3,765.4

Table A2.2: Final Energy Use per Activity in Household Final Energy Demand (ktoe)

Energy End-uses	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cooking	2,801.4	2,798.2	2,792.1	2,783.0	2,771.0	2,756.1	2,738.9	2,732.9	2,730.7	2,732.1	2,731.9
Lighting	237.6	245.1	252.5	259.9	267.2	274.4	279.8	283.2	285.4	289.1	292.8
Refrigeration	159.8	170.3	181.4	193.0	205.0	217.6	230.3	243.0	255.9	269.1	282.6
Space cooling	19.4	21.3	23.2	25.2	27.4	29.6	31.9	34.2	36.6	39.0	41.6
Water heating	3.1	3.4	3.7	4.0	4.4	4.8	5.2	5.6	6.0	6.5	6.9
Clothes Washing	2.5	2.7	3.0	3.2	3.5	3.8	4.1	4.4	4.7	5.0	5.3
Dish Washing	0.6	0.7	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
Air circulation	71.1	75.4	79.9	84.6	89.5	94.5	99.7	104.5	109.0	113.3	117.7
TV	41.2	43.9	46.7	49.6	52.7	55.8	59.1	62.1	65.0	67.8	70.7
Miscellaneous	122.2	129.9	138.0	146.4	155.2	164.3	173.4	182.4	191.3	200.4	209.7
Total	3,458.8	3,490.8	3,521.1	3,549.7	3,576.7	3,602.0	3,623.5	3,653.5	3,685.8	3,723.6	3,760.5
Energy End-uses	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cooking	2,627.7	2,628.6	2,628.1	2,626.2	2,623.0	2,618.7	2,612.6	2,605.2	2,596.4	2,586.3	2,575.0
Lighting	262.1	263.3	264.2	264.9	265.3	265.4	268.3	271.1	273.8	276.5	279.1
Refrigeration	184.7	198.0	211.9	226.5	241.5	257.2	272.8	288.8	305.4	322.4	339.8
Space cooling	32.6	36.3	40.2	44.3	48.6	53.1	57.6	62.3	67.3	72.4	77.7
Water heating	4.8	5.4	6.0	6.7	7.4	8.1	8.8	9.6	10.4	11.3	12.2
Clothes Washing	3.7	4.0	4.5	4.9	5.4	5.9	6.4	6.9	7.4	7.9	8.5
Dish Washing	1.9	2.2	2.4	2.7	3.0	3.4	3.7	4.0	4.4	4.8	5.2
Air circulation	82.5	86.7	90.9	95.2	99.5	104.0	108.3	112.7	117.1	121.6	126.2
TV	44.6	47.1	49.6	52.1	54.8	57.4	60.1	62.7	65.4	67.9	70.4
Miscellaneous	150.2	160.7	171.6	183.0	194.9	207.2	219.2	231.6	244.5	257.7	271.4
Total	3,394.9	3,432.3	3,469.5	3,506.5	3,543.4	3,580.4	3,617.8	3,655.0	3,692.1	3,728.8	3,765.4

Table A2.3: Final Energy Use per Sector in Household Final Energy demand (ktoe)

Sub-Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Urban	1,505.6	1,555.9	1,607.1	1,659.0	1,711.7	1,765.3	1,813.1	1,861.4	1,910.2	1,962.1	2,014.7
Rural	1,953.2	1,934.9	1,914.0	1,890.7	1,864.9	1,836.7	1,810.4	1,792.1	1,775.6	1,761.4	1,745.8
Total	3,458.8	3,490.8	3,521.1	3,549.7	3,576.7	3,602.0	3,623.5	3,653.5	3,685.8	3,723.6	3,760.5
Sub-Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Urban	1,608.8	1,670.7	1,734.2	1,799.3	1,866.1	1,934.5	1,998.6	2,064.1	2,131.0	2,198.9	2,268.3
Rural	1,786.1	1,761.6	1,735.3	1,707.2	1,677.4	1,645.8	1,619.1	1,590.9	1,561.1	1,529.9	1,497.2
Total	3,394.9	3,432.3	3,469.5	3,506.5	3,543.4	3,580.4	3,617.8	3,655.0	3,692.1	3,728.8	3,765.4

Table A2.4: Urban Household Energy Demand (ktoe)

Sub-Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Metro Urban	623.8	647.9	672.6	697.7	723.4	749.6	773.7	798.2	823.0	850.9	879.3
Other Urban	881.8	908.0	934.5	961.3	988.4	1,015.7	1,039.4	1,063.2	1,087.2	1,111.2	1,135.3
Total	1,505.6	1,555.9	1,607.1	1,659.0	1,711.7	1,765.3	1,813.1	1,861.4	1,910.2	1,962.1	2,014.7
Sub-Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Metro Urban	669.1	697.8	727.4	757.9	789.3	821.6	854.2	887.6	921.9	956.7	992.5
Other Urban	939.7	972.8	1,006.7	1,041.4	1,076.8	1,112.9	1,144.5	1,176.5	1,209.1	1,242.2	1,275.8
Total	1,608.8	1,670.7	1,734.2	1,799.3	1,866.1	1,934.5	1,998.6	2,064.1	2,131.0	2,198.9	2,268.3

Table A2.5: Final Energy Demand by End-use activities of Urban Households (ktoe)

Energy End-uses	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cooking	1,005.7	1,031.7	1,057.7	1,083.7	1,109.8	1,135.9	1,158.7	1,181.4	1,204.0	1,226.4	1,248.7
Lighting	134.7	137.8	140.8	143.8	146.6	149.4	150.1	150.6	151.0	153.8	156.6
Refrigeration	150.1	159.4	169.0	179.0	189.4	200.2	210.9	222.0	233.4	245.1	257.2
Space cooling	18.1	19.7	21.5	23.3	25.3	27.3	29.3	31.4	33.6	35.9	38.3
Water heating	3.1	3.4	3.7	4.0	4.4	4.8	5.2	5.6	6.0	6.5	6.9
Clothes Washing	2.5	2.7	3.0	3.2	3.5	3.8	4.1	4.4	4.7	5.0	5.3
Dish Washing	0.6	0.7	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
Air circulation	52.8	54.9	57.1	59.4	61.7	64.1	66.3	68.6	71.0	73.4	75.8
TV	30.9	32.4	33.9	35.4	37.0	38.6	40.2	41.8	43.5	45.2	46.9
Miscellaneous	107.1	113.3	119.7	126.3	133.1	140.3	147.2	154.4	161.8	169.5	177.3
Total	1,505.6	1,555.9	1,607.1	1,659.0	1,711.7	1,765.3	1,813.1	1,861.4	1,910.2	1,962.1	2,014.7
Energy End-uses	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cooking	1,042.1	1,073.4	1,105.2	1,137.3	1,169.9	1,203.0	1,230.4	1,258.0	1,285.8	1,313.8	1,342.0
Lighting	139.8	140.9	141.8	142.6	143.2	143.6	146.3	149.1	151.8	154.6	157.3
Refrigeration	170.0	181.9	194.3	207.3	220.9	235.0	249.0	263.4	278.3	293.7	309.6
Space cooling	31.4	35.0	38.8	42.8	47.0	51.5	55.9	60.6	65.4	70.4	75.7
Water heating	4.8	5.4	6.0	6.7	7.4	8.1	8.8	9.6	10.4	11.3	12.2
Clothes Washing	3.7	4.0	4.5	4.9	5.4	5.9	6.4	6.9	7.4	7.9	8.5
Dish Washing	1.9	2.2	2.4	2.7	3.0	3.4	3.7	4.0	4.4	4.8	5.2
Air circulation	58.3	60.7	63.2	65.8	68.5	71.2	73.6	76.1	78.7	81.3	83.9
TV	31.2	32.7	34.3	35.9	37.6	39.4	41.0	42.6	44.3	45.7	47.2
Miscellaneous	125.6	134.4	143.6	153.2	163.2	173.6	183.5	193.8	204.4	215.4	226.8
Total	1,608.8	1,670.7	1,734.2	1,799.3	1,866.1	1,934.5	1,998.6	2,064.1	2,131.0	2,198.9	2,268.3

Table A2.6: Urban Household Final Energy Demand (excluding energy use for transport) by fuel type (ktoe)

Fuels	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	501.5	525.8	550.8	576.5	603.0	630.2	655.0	680.5	706.5	735.7	765.8
Kerosene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
LPG	199.2	209.4	219.9	230.7	242.0	253.5	264.7	276.2	288.1	300.2	312.7
Wood	140.3	141.7	142.9	144.0	145.0	145.8	146.0	146.1	146.0	145.7	145.3
Charcoal	664.1	678.5	692.8	706.9	720.9	734.6	746.0	757.2	768.0	778.6	788.8
Solar	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.1
Total	1,505.6	1,555.9	1,607.1	1,659.0	1,711.7	1,765.3	1,813.1	1,861.4	1,910.2	1,962.1	2,014.7
Fuels	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	568.0	598.4	630.0	662.7	696.7	731.8	768.2	805.7	844.4	883.9	924.7
Kerosene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
LPG	230.1	246.0	262.7	280.3	298.8	318.2	336.9	356.5	376.8	398.1	420.2
Wood	139.7	141.1	142.3	143.4	144.3	145.0	145.2	145.1	144.9	144.6	144.1
Charcoal	670.2	684.2	698.0	711.5	724.7	737.5	746.1	754.2	761.8	768.9	775.5
Solar	0.8	1.0	1.2	1.4	1.6	1.9	2.2	2.5	2.9	3.3	3.8
Total	1,608.8	1,670.7	1,734.2	1,799.3	1,866.1	1,934.5	1,998.6	2,064.1	2,131.0	2,198.9	2,268.3

Table A2.7: Final Energy Demand of Rural Household (ktoe)

Sub-Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Coastal	357.9	355.6	352.9	349.7	346.1	342.0	338.3	334.2	329.7	328.6	327.3
Forest	891.8	878.0	863.1	847.1	830.0	811.8	794.4	786.4	777.6	768.2	758.1
Savanna	703.5	701.2	698.0	693.9	688.9	682.9	677.7	671.5	668.3	664.7	660.5
Total	1,953.2	1,934.9	1,914.0	1,890.7	1,864.9	1,836.7	1,810.4	1,792.1	1,775.6	1,761.4	1,745.8
Sub-Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Coastal	329.1	327.0	324.6	321.7	318.5	315.0	312.3	309.2	305.9	302.2	298.2
Forest	793.7	780.3	766.2	751.4	735.9	719.8	705.9	691.4	676.3	660.7	644.6
Savanna	663.3	654.3	644.5	634.1	622.9	611.1	601.0	590.3	578.9	567.0	554.4
Total	1,786.1	1,761.6	1,735.3	1,707.2	1,677.4	1,645.8	1,619.1	1,590.9	1,561.1	1,529.9	1,497.2

Table A2.8: Final Energy End-use activities of Rural Households (ktoe)

Energy End-uses	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cooking	1,795.7	1,766.5	1,734.4	1,699.3	1,661.2	1,620.2	1,580.2	1,551.5	1,526.7	1,505.6	1,483.1
Lighting	102.9	107.3	111.7	116.1	120.5	125.0	129.7	132.6	134.4	135.3	136.2
Refrigeration	9.6	11.0	12.4	14.0	15.7	17.5	19.4	21.1	22.6	24.0	25.3
Air conditioning	1.3	1.5	1.7	1.9	2.1	2.3	2.6	2.8	2.9	3.1	3.3
Air circulation	18.3	20.4	22.7	25.2	27.7	30.5	33.4	35.8	38.0	39.9	41.8
TV	10.3	11.5	12.8	14.2	15.7	17.2	18.9	20.3	21.5	22.6	23.7
Other	15.0	16.6	18.3	20.1	22.0	24.0	26.2	27.9	29.5	30.9	32.3
Total	1,953.2	1,934.9	1,914.0	1,890.7	1,864.9	1,836.7	1,810.4	1,792.1	1,775.6	1,761.4	1,745.8
Energy End-uses	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cooking	1,585.6	1,555.2	1,522.9	1,488.9	1,453.1	1,415.7	1,382.2	1,347.2	1,310.6	1,272.5	1,233.0
Lighting	122.3	122.4	122.4	122.3	122.1	121.8	122.0	122.0	122.0	121.9	121.8
Refrigeration	14.7	16.1	17.6	19.1	20.6	22.2	23.8	25.4	27.1	28.7	30.2
Air conditioning	1.3	1.3	1.4	1.5	1.6	1.6	1.7	1.8	1.9	2.0	2.0
Air circulation	24.3	26.0	27.7	29.4	31.1	32.8	34.7	36.5	38.4	40.3	42.2
TV	13.4	14.4	15.3	16.2	17.1	18.1	19.1	20.1	21.1	22.2	23.2
Other	24.6	26.3	28.0	29.9	31.7	33.6	35.7	37.8	40.0	42.3	44.7
Total	1,786.1	1,761.6	1,735.3	1,707.2	1,677.4	1,645.8	1,619.1	1,590.9	1,561.1	1,529.9	1,497.2

Table A2.9: Final Energy Demand by fuel type in Rural Households (ktoe)

Fuels	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	151.7	163.7	176.1	188.9	202.3	216.1	230.8	241.7	250.3	257.2	264.1
Kerosene	2.9	2.2	1.7	1.2	0.8	0.4	0.2	0.0	0.0	0.0	0.0
LPG	24.5	27.1	29.9	32.7	35.7	38.8	42.0	44.8	47.4	49.8	52.2
Wood	1,661.0	1,626.5	1,589.5	1,549.9	1,507.9	1,463.5	1,420.2	1,389.3	1,362.2	1,338.6	1,313.6
Charcoal	109.3	111.9	113.9	115.4	116.3	116.6	116.6	116.1	115.6	115.8	116.0
Solar	3.9	3.5	3.0	2.5	1.9	1.3	0.6	0.2	-	-	-
Total	1,953.2	1,934.9	1,914.0	1,890.7	1,864.9	1,836.7	1,810.4	1,792.1	1,775.6	1,761.4	1,745.8

Fuels	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	201.9	207.8	213.8	219.7	225.6	231.5	238.3	245.1	252.0	258.8	265.7
Kerosene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LPG	32.4	35.0	37.6	40.2	42.9	45.6	48.5	51.4	54.4	57.4	60.4
Wood	1,440.7	1,407.4	1,372.2	1,335.4	1,296.9	1,256.8	1,220.1	1,181.8	1,142.0	1,100.8	1,058.1
Charcoal	111.1	111.4	111.7	111.8	111.9	111.9	112.2	112.5	112.7	112.9	113.0
Solar	-	-	-	-	-	-	-	-	-	-	-
Total	1,786.1	1,761.6	1,735.3	1,707.2	1,677.4	1,645.8	1,619.1	1,590.9	1,561.1	1,529.9	1,497.2

Annex 3 Services Sector Energy Demand Projection

Table A3.1: Final Energy Demand by fuel type in Service Sector (ktoe)

Fuels	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	339.5	365.9	393.5	422.6	453.1	485.0	518.6	553.8	590.8	629.6	670.3
LPG	21.9	24.0	26.2	28.6	31.2	34.0	37.0	40.1	43.6	47.2	51.2
Wood	45.3	45.0	44.7	44.4	44.0	43.5	43.0	42.4	41.8	41.2	40.4
Charcoal	56.1	57.5	58.8	59.9	60.9	61.8	62.5	63.1	63.5	63.8	63.8
Total	462.8	492.4	523.3	555.5	589.2	624.3	661.1	699.5	739.7	781.7	825.8
Fuels	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	446.5	491.9	540.7	593.2	649.6	710.4	775.8	846.1	921.7	1,003.1	1,090.5
LPG	27.8	31.1	34.6	38.5	42.7	47.3	52.4	57.9	63.9	70.4	77.6
Wood	61.0	62.4	63.7	64.9	66.0	67.1	68.1	69.0	69.8	70.5	71.1
Charcoal	66.3	69.1	71.7	74.2	76.6	78.9	81.0	82.9	84.7	86.2	87.5
Total	601.7	654.4	710.6	770.7	835.0	903.7	977.2	1,055.9	1,140.1	1,230.2	1,326.7

Table A3.2: Final Energy Demand for Service Sector (ktoe)

Facilities	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Offices	31.8	33.2	34.7	36.2	37.8	39.4	41.1	42.8	44.7	46.6	48.6
Lodging	32.9	35.0	37.2	39.6	42.0	44.7	47.5	50.4	53.5	56.8	60.3
Health Facilities	34.2	36.3	38.6	41.0	43.5	46.2	49.1	52.2	55.5	58.9	62.6
Educational facilities	148.9	155.9	163.2	170.8	178.6	186.7	195.1	203.8	212.8	222.2	232.0
Retail Facilities	82.8	91.5	100.7	110.5	120.9	131.9	143.5	155.8	168.9	182.7	197.3
Restaurants and Eaterie	64.9	68.7	72.8	77.0	81.5	86.2	91.2	96.4	102.0	107.8	114.0
Others	11.5	11.3	11.1	10.9	10.8	10.6	10.4	10.2	10.0	9.8	9.6
Street lighting	55.9	60.4	65.0	69.6	74.1	78.7	83.2	87.8	92.3	96.9	101.5
Total	462.8	492.4	523.3	555.5	589.2	624.3	661.1	699.5	739.7	781.7	825.8
Facilities	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Offices	37.7	40.0	42.4	45.0	47.8	50.7	53.7	57.0	60.4	64.0	67.8
Lodging	53.3	59.0	65.2	72.0	79.5	87.8	96.8	106.7	117.5	129.4	142.3
Health Facilities	43.8	47.4	51.2	55.3	59.6	64.3	69.2	74.5	80.2	86.2	92.5
Educational facilities	207.2	223.6	241.0	259.4	279.1	300.1	322.5	346.3	371.7	398.9	427.8
Retail Facilities	116.8	132.0	148.5	166.4	185.9	207.0	229.8	254.6	281.3	310.3	341.6
Restaurants and Eaterie	72.3	77.3	82.6	88.2	94.1	100.4	107.0	114.1	121.6	129.5	138.0
Others	11.8	11.6	11.4	11.3	11.1	10.9	10.8	10.6	10.4	10.3	10.1
Street lighting	58.7	63.5	68.3	73.0	77.8	82.6	87.4	92.2	97.0	101.7	106.5
Total	601.7	654.4	710.6	770.7	835.0	903.7	977.2	1,055.9	1,140.1	1,230.2	1,326.7

Table A3.3: Final Energy Demand for Office Buildings by type of ownership (ktoe)

Type of Ownship	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Government	11.9	12.4	13.0	13.6	14.2	14.9	15.5	16.2	16.9	17.7	18.4
Private	20.0	20.8	21.7	22.6	23.5	24.5	25.6	26.6	27.7	28.9	30.1
Total	31.8	33.2	34.7	36.2	37.8	39.4	41.1	42.8	44.7	46.6	48.6
Type of Ownship	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Government	13.5	14.3	15.2	16.1	17.0	18.0	19.0	20.1	21.2	22.4	23.6
Private	24.2	25.7	27.3	29.0	30.8	32.7	34.7	36.9	39.2	41.6	44.2
Total	37.7	40.0	42.4	45.0	47.8	50.7	53.7	57.0	60.4	64.0	67.8

Table A3.4: Final Energy Demand for Accommodation Establishments (ktoe)

Accommodation	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Hotels	20.9	22.3	23.8	25.3	27.0	28.7	30.5	32.5	34.5	36.7	39.0
Budgets	8.9	9.4	9.9	10.4	11.0	11.6	12.3	13.0	13.7	14.4	15.2
Guest Houses	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.9
Hostels	2.5	2.7	2.9	3.1	3.4	3.6	3.9	4.2	4.5	4.8	5.2
Total	32.9	35.0	37.2	39.6	42.0	44.7	47.5	50.4	53.5	56.8	60.3
Accommodation	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Hotels	39.9	44.5	49.5	55.0	61.0	67.7	75.0	83.1	92.0	101.7	112.4
Budgets	8.3	8.6	9.0	9.5	9.9	10.3	10.8	11.3	11.7	12.2	12.7
Guest Houses	1.6	1.7	1.8	2.0	2.2	2.4	2.6	2.8	3.1	3.3	3.6
Hostels	3.6	4.2	4.9	5.6	6.5	7.4	8.4	9.5	10.7	12.1	13.6
Total	53.3	59.0	65.2	72.0	79.5	87.8	96.8	106.7	117.5	129.4	142.3

Table A3.5: Final Energy Demand for Health Sector (ktoe)

Facility	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Hospitals	24.7	26.5	28.4	30.3	32.5	34.7	37.1	39.6	42.3	45.2	48.2
Poly_Clinics	4.8	5.0	5.2	5.4	5.7	5.9	6.2	6.5	6.9	7.2	7.6
MatHealth Centres	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5
Others	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.1	2.2
Total	34.2	36.3	38.6	41.0	43.5	46.2	49.1	52.2	55.5	58.9	62.6

Facility	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Hospitals	35.2	38.5	42.1	45.9	49.9	54.3	58.9	63.8	69.1	74.7	80.7
Poly_Clinics	4.6	4.8	5.0	5.2	5.4	5.7	6.0	6.3	6.6	6.9	7.2
MatHealth Centres	3.0	3.0	3.0	3.0	3.0	3.1	3.1	3.1	3.1	3.0	3.0
Others	1.0	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.5	1.5	1.6
Total	43.8	47.4	51.2	55.3	59.6	64.3	69.2	74.5	80.2	86.2	92.5

Table A3.6: Final Energy Demand for Educational Sector (ktoe)

Facility	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Tertiary	65.2	71.1	77.3	83.8	90.7	98.0	105.6	113.7	122.2	131.1	140.5
Secondary	25.4	25.2	25.1	25.0	24.8	24.7	24.5	24.3	24.2	24.0	23.8
TechVoc	12.1	12.0	12.0	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.1
Basic	46.1	47.5	48.8	50.0	51.1	52.2	53.2	54.2	55.0	55.8	56.5
Special	0.054	0.052	0.051	0.049	0.047	0.046	0.044	0.043	0.041	0.039	0.038
Total	148.9	155.9	163.2	170.8	178.6	186.7	195.1	203.8	212.8	222.2	232.0

Facility	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Tertiary	99.0	111.1	124.3	138.5	154.0	170.8	189.0	208.6	229.9	253.0	277.9
Secondary	33.5	34.2	35.0	35.7	36.5	37.3	38.0	38.8	39.6	40.3	41.1
TechVoc	17.7	18.3	18.8	19.3	19.8	20.3	20.8	21.2	21.7	22.1	22.5
Basic	57.0	59.9	62.9	65.8	68.8	71.7	74.6	77.6	80.5	83.4	86.3
Special	0.061	0.060	0.059	0.058	0.056	0.055	0.054	0.053	0.051	0.050	0.048
Total	207.2	223.6	241.0	259.4	279.1	300.1	322.5	346.3	371.7	398.9	427.8

Table A3.7: Final Energy Demand for Wholesale and Retail Outlets (ktoe)

Facility	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Larger Shopping Mall	12.8	13.0	13.1	13.2	13.4	13.5	13.6	13.7	13.7	13.8	13.8
Other Shopping Malls	51.5	58.5	66.0	73.9	82.4	91.4	100.9	111.0	121.7	133.1	145.1
Supermarket	12.3	13.6	15.0	16.6	18.2	19.8	21.6	23.6	25.6	27.7	30.0
Cold stores	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.1	2.3	2.4
Others	4.9	5.0	5.1	5.2	5.3	5.4	5.6	5.7	5.8	5.9	6.0
Total	82.8	91.5	100.7	110.5	120.9	131.9	143.5	155.8	168.9	182.7	197.3

Facility	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Larger Shopping Mall	15.1	15.6	16.0	16.4	16.8	17.2	17.6	18.0	18.4	18.8	19.1
Other Shopping Malls	77.8	90.0	103.3	117.8	133.6	150.8	169.5	189.8	211.8	235.6	261.5
Supermarket	17.2	19.5	22.0	24.7	27.6	30.8	34.3	38.0	42.1	46.5	51.3
Cold stores	1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.1
Others	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6
Total	116.8	132.0	148.5	166.4	185.9	207.0	229.8	254.6	281.3	310.3	341.6

Table A3.8: Final Energy Demand for Restaurants and Eateries (ktoe)

Facility	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Restaurants	30.2	33.0	36.0	39.1	42.5	46.0	49.8	53.8	58.0	62.5	67.3
Chop bars etc	34.7	35.7	36.8	37.9	39.0	40.2	41.4	42.7	44.0	45.3	46.7
Total	64.9	68.7	72.8	77.0	81.5	86.2	91.2	96.4	102.0	107.8	114.0

Facility	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Restaurants	37.4	41.3	45.5	50.1	54.9	60.0	65.5	71.4	77.7	84.4	91.6
Chop bars etc	35.0	36.0	37.0	38.1	39.2	40.4	41.5	42.7	43.9	45.1	46.3
Total	72.3	77.3	82.6	88.2	94.1	100.4	107.0	114.1	121.6	129.5	138.0

Annex 4 Industrial Sector Energy Demand Projection

Table A4.1: Industrial Final Energy Demand by sub-sectors (ktoe)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Water production	39.4	41.9	44.3	46.7	49.1	51.6	53.9	56.3	58.7	61.1	63.4
Mining and Quarrying	577.8	605.0	633.2	664.0	695.9	729.2	763.7	799.6	836.9	875.6	916.0
Construction	76.5	77.0	77.6	78.1	78.7	79.2	79.8	80.3	80.8	81.4	81.9
Manufacturing	817.2	863.1	910.2	958.5	1,008.1	1,059.0	1,115.4	1,173.3	1,232.7	1,293.9	1,356.8
Total	1,511.0	1,587.0	1,665.2	1,747.3	1,831.8	1,918.9	2,012.7	2,109.4	2,209.1	2,312.0	2,418.1

Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Water production	44.7	47.7	50.6	53.6	56.5	59.5	62.4	65.3	68.2	71.1	74.0
Mining and Quarrying	631.8	667.1	704.2	745.4	796.2	879.6	934.6	991.8	1,056.5	1,123.7	1,193.5
Construction	81.0	82.0	83.0	84.0	85.0	86.0	87.0	88.0	89.0	90.0	91.0
Manufacturing	872.1	925.0	979.3	1,181.3	1,352.6	2,774.3	3,119.6	3,468.6	4,004.4	4,545.6	5,092.4
Total	1,629.7	1,721.8	1,817.1	2,064.3	2,290.3	3,799.3	4,203.5	4,613.6	5,218.1	5,830.4	6,450.8

Table A4.2: Industrial Final Energy Demand by Fuel type (ktoe)

Sectors	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	433.2	459.8	487.4	516.0	545.7	576.5	610.0	644.8	680.9	718.5	757.7
Diesel	473.3	494.2	515.9	539.7	564.5	590.0	617.4	645.8	675.2	705.7	737.3
Kerosene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LPG	27.5	30.0	32.5	35.0	37.6	40.2	43.7	47.2	50.7	54.3	57.9
Residual Fuel Oil	84.2	90.7	97.3	103.9	110.4	117.0	125.6	134.1	142.7	151.2	159.8
Wood	425.6	440.2	455.0	469.9	484.9	500.0	514.1	528.2	542.3	556.4	570.6
Charcoal	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Natural Gas	64.9	69.7	74.9	80.5	86.4	92.8	99.7	107.0	115.0	123.5	132.6
Total	1,511.0	1,587.0	1,665.2	1,747.3	1,831.8	1,918.9	2,012.7	2,109.4	2,209.1	2,312.0	2,418.1

Sectors	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	496.3	531.9	569.0	650.1	703.2	940.5	1,026.1	1,113.7	1,229.5	1,347.5	1,468.0
Diesel	506.0	531.4	557.9	587.8	625.8	852.2	930.1	1,011.0	1,122.5	1,238.3	1,358.7
Kerosene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LPG	31.3	34.1	37.0	39.9	42.8	45.8	49.7	53.8	57.8	61.9	66.0
Residual Fuel Oil	98.4	106.2	113.9	121.6	129.4	166.0	182.4	199.1	219.9	241.2	262.8
Wood	426.7	441.7	456.9	472.3	487.8	503.5	517.2	530.9	544.6	558.3	572.1
Charcoal	2.3	2.3	2.3	2.3	2.3	2.4	2.4	2.4	2.3	2.3	2.3
Natural Gas	68.7	74.2	80.1	190.3	299.0	1,289.1	1,495.7	1,702.9	2,041.5	2,380.8	2,721.0
Total	1,629.7	1,721.8	1,817.1	2,064.3	2,290.3	3,799.3	4,203.5	4,613.6	5,218.1	5,830.4	6,450.8

Table A4.3: Final Electricity Demand for Water Production (GWh)

Scenarios	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BaU	458.7	487.1	515.4	543.6	571.6	599.5	627.3	655.0	682.6	710.0	737.4
AEG	520.1	554.6	589.0	623.3	657.5	691.6	725.5	759.4	793.1	826.8	860.3

Table A4.4: Mining and Quarrying Final Energy Demand by fuel type (ktoe)

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	219.1	230.0	241.4	253.3	265.9	279.0	292.7	307.2	322.3	338.1	354.7
Diesel	358.7	375.0	391.8	410.6	430.1	450.2	470.9	492.4	514.6	537.6	561.3
Total	577.8	605.0	633.2	664.0	695.9	729.2	763.7	799.6	836.9	875.6	916.0
Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	250.2	265.9	282.5	300.2	319.6	343.3	365.0	388.0	412.8	439.0	466.6
Diesel	381.6	401.2	421.6	445.2	476.5	536.4	569.6	603.8	643.7	684.7	726.9
Total	631.8	667.1	704.2	745.4	796.2	879.6	934.6	991.8	1,056.5	1,123.7	1,193.5

Table A4.5: Mining and Quarrying Final Energy Demand by sub-sectors (ktoe)

Sectors	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gold	524.7	548.8	574.1	600.5	628.0	656.9	687.0	718.5	751.4	785.8	821.8
manganese	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.0	7.1	7.2	7.3
diamonds	0.55	0.59	0.63	0.67	0.71	0.76	0.80	0.85	0.89	0.94	0.99
bauxite	2.48	2.48	2.47	2.47	2.46	2.45	2.45	2.44	2.44	2.43	2.42
quarrying	43.59	46.44	49.28	53.57	57.85	62.12	66.37	70.62	74.86	79.08	83.30
salt	0.07	0.08	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16
Iron	-	-	-	-	-	-	-	-	-	-	-
Limestone	-	-	-	-	-	-	-	-	-	-	-
Total	577.8	605.0	633.2	664.0	695.9	729.2	763.7	799.6	836.9	875.6	916.0

Sectors	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gold	574.5	606.3	639.9	675.2	712.5	751.8	793.2	836.9	882.9	931.5	982.6
manganese	6.8	7.0	7.2	7.3	7.5	7.7	7.9	8.0	8.2	8.4	8.5
diamonds	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.0	1.1	1.2	1.2
bauxite	2.8	2.9	3.0	3.0	3.1	3.2	3.3	3.4	3.4	3.5	3.6
quarrying	46.94	50.12	53.29	58.87	64.43	69.98	75.51	81.03	86.54	92.03	97.51
salt	0.10	0.11	0.12	0.14	0.15	0.17	0.19	0.21	0.23	0.26	0.29
Iron	-	-	-	-	-	38.3	46.0	53.7	66.5	79.3	92.2
Limestone	-	-	-	-	7.58	7.58	7.57	7.57	7.57	7.57	7.57
Total	631.8	667.1	704.2	745.4	796.2	879.6	934.6	991.8	1,056.5	1,123.7	1,193.5

Table A4.6: Final Energy Demand for Formal Manufacturing (ktoe)

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	174.6	187.9	201.6	215.8	230.6	245.9	263.2	281.2	299.9	319.3	339.5
Diesel	38.2	42.3	46.6	51.1	55.8	60.7	66.8	73.2	79.8	86.8	94.1
LPG	23.5	25.6	27.7	29.9	32.0	34.2	37.2	40.2	43.3	46.3	49.4
Residual Fuel Oil	84.2	90.7	97.3	103.9	110.4	117.0	125.6	134.1	142.7	151.2	159.8
Wood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas	64.9	69.7	74.9	80.5	86.4	92.8	99.7	107.0	115.0	123.5	132.6
Total	385.3	416.3	448.2	481.2	515.3	550.6	592.5	635.8	680.7	727.2	775.4

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	201.3	218.3	235.7	296.2	326.9	537.7	598.6	660.3	748.3	837.3	927.3
Diesel	43.4	48.3	53.4	58.8	64.4	229.9	273.6	319.3	389.9	463.7	541.0
LPG	27.3	29.7	32.2	34.7	37.2	39.7	43.2	46.8	50.3	53.9	57.5
Residual Fuel Oil	98.4	106.2	113.9	121.6	129.4	166.0	182.4	199.1	219.9	241.2	262.8
Wood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas	68.7	74.2	80.1	190.3	299.0	1,289.1	1,495.7	1,702.9	2,041.5	2,380.8	2,721.0
Total	439.2	476.7	515.4	701.6	856.9	2,262.4	2,593.6	2,928.4	3,450.0	3,977.0	4,509.5

Table A4.7: Final Energy Demand for Manufacturing Sub-sectors (ktoe)

Sectors	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Pig Iron Production	-	-	-	-	-	-	-	-	-	-	-
Steel Production	-	-	-	-	-	-	-	-	-	-	-
Steel Milling	7.4	8.3	9.2	10.1	11.0	12.0	13.4	14.8	16.3	17.9	19.4
Clinker Production	-	-	-	-	-	-	-	-	-	-	-
Cement Milling	30.4	32.9	35.4	37.9	40.4	42.9	45.4	47.8	50.3	52.7	55.2
Alumina Production	-	-	-	-	-	-	-	-	-	-	-
Textiles	25.9	28.0	30.0	32.1	34.1	36.2	38.3	40.3	42.4	44.5	46.6
Plastics	8.6	8.7	8.7	8.8	8.9	8.9	9.0	9.0	9.1	9.1	9.2
Wood processing	13.1	14.0	14.8	15.7	16.6	17.6	18.9	20.2	21.6	23.0	24.5
Beverages	37.9	40.9	44.0	47.2	50.4	53.7	58.0	62.4	66.9	71.4	76.0
Food processing	80.2	87.6	95.0	102.6	110.1	117.8	128.7	139.6	150.6	161.8	173.0
Paper and Paper Products	7.3	8.1	9.0	9.8	10.6	11.4	12.4	13.3	14.3	15.2	16.2
Chemicals and chemical p	12.1	13.4	14.8	16.2	17.6	18.9	20.6	22.2	23.9	25.5	27.1
Lubricating oils	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5
Fabrication of metals	14.10	14.98	15.89	16.83	17.79	18.79	19.82	20.89	21.99	23.13	24.31
Other	148.17	159.19	171.02	183.74	197.39	212.07	227.83	244.77	262.96	282.51	303.51
Total	385.3	416.3	448.2	481.2	515.3	550.6	592.5	635.8	680.7	727.2	775.4

Sectors	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Pig Iron Production	-	-	-	-	-	1,063.0	1,276.3	1,489.9	1,845.8	2,202.0	2,558.7
Steel Production	-	-	-	-	-	185.6	224.9	265.0	331.5	399.3	468.6
Steel Milling	8.7	9.7	10.8	11.8	12.9	124.6	150.6	177.4	220.6	265.3	311.4
Clinker Production	-	-	-	-	110.4	110.4	110.4	110.4	110.4	110.4	110.4
Cement Milling	43.4	47.9	52.4	56.8	61.3	65.7	70.1	74.5	78.8	83.2	87.6
Alumina Production	-	-	-	146.2	149.6	153.0	156.5	159.9	163.3	166.8	170.2
Textiles	31.0	33.6	36.1	38.7	41.3	43.9	46.5	49.1	51.7	54.3	57.0
Plastics	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0
Wood processing	15.1	16.1	17.2	18.3	19.4	20.6	22.1	23.7	25.3	27.0	28.7
Beverages	44.4	47.9	51.6	55.3	59.1	62.9	68.0	73.1	78.3	83.7	89.0
Food processing	93.9	102.5	111.3	120.1	129.0	137.9	150.6	163.4	176.4	189.4	202.5
Paper and Paper Products	8.0	8.9	9.8	10.7	11.5	12.4	13.6	14.7	15.9	17.0	18.2
Chemicals and chemical p	14.1	15.8	17.4	19.0	20.6	22.2	24.1	26.0	28.0	29.9	31.8
Lubricating oils	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6
Fabrication of metals	14.67	15.62	16.60	17.61	18.65	19.71	20.81	21.95	23.12	24.33	25.58
Other	156.66	169.25	182.85	197.54	213.41	230.55	249.07	269.08	290.70	314.05	339.29
Total	439.2	476.7	515.4	701.6	856.9	2,262.4	2,593.6	2,928.4	3,450.0	3,977.0	4,509.5

Table A4.8: Final Energy Demand for Cement Production by fuel type (ktoe)

Fuels	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	29.7	32.2	34.7	37.1	39.5	42.0	44.4	46.8	49.2	51.6	53.9
Diesel	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.2	1.2
Natural Gas	-	-	-	-	-	-	-	-	-	-	-
Total	30.4	32.9	35.4	37.9	40.4	42.9	45.4	47.8	50.3	52.7	55.2

Fuels	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	42.4	46.8	51.2	55.6	70.9	75.3	79.6	83.8	88.1	92.4	96.6
Diesel	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Natural Gas	-	-	-	-	99.4	99.4	99.4	99.4	99.4	99.4	99.4
Total	43.4	47.9	52.4	56.8	171.7	176.1	180.5	184.9	189.3	193.6	198.0

Table A4.9: Final Energy Demand for Steel Production by fuel type (ktoe)

Fuels	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	3.4	3.7	4.0	4.4	4.7	5.0	5.5	6.0	6.5	7.0	7.5
Diesel	3.4	3.9	4.4	4.9	5.4	5.9	6.7	7.6	8.4	9.3	10.3
Residual Fuel Oil	0.6	0.7	0.8	0.9	0.9	1.0	1.1	1.3	1.4	1.5	1.7
Total	7.4	8.3	9.2	10.1	11.0	12.0	13.4	14.8	16.3	17.9	19.4

Fuels	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	4.0	4.4	4.8	5.2	5.6	174.4	208.6	242.9	299.6	356.4	413.1
Diesel	4.0	4.5	5.1	5.7	6.3	115.9	142.5	170.6	216.2	264.3	315.2
Residual Fuel Oil	0.7	0.8	0.9	1.0	1.1	20.0	24.3	28.9	36.2	43.8	51.8
Total	8.7	9.7	10.8	11.8	12.9	310.2	375.5	442.4	552.1	664.6	780.0

Table A4.10: Final Energy Demand for Plastic Industry (ktoe)

Fuels	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	5.1	5.1	5.2	5.2	5.2	5.3	5.3	5.3	5.4	5.4	5.4
Diesel	3.5	3.5	3.5	3.5	3.6	3.6	3.6	3.6	3.6	3.7	3.7
LPG	0.042	0.042	0.043	0.043	0.043	0.044	0.044	0.044	0.044	0.045	0.045
Residual Fuel Oil	0.025	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.026	0.026	0.026
Total	8.6	8.7	8.7	8.8	8.9	8.9	9.0	9.0	9.1	9.1	9.2

Fuels	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	5.3	5.4	5.4	5.5	5.5	5.6	5.6	5.7	5.8	5.8	5.9
Diesel	3.6	3.6	3.7	3.7	3.8	3.8	3.8	3.9	3.9	4.0	4.0
LPG	0.044	0.044	0.045	0.045	0.046	0.046	0.047	0.047	0.048	0.048	0.049
Residual Fuel Oil	0.026	0.026	0.026	0.027	0.027	0.027	0.027	0.028	0.028	0.028	0.029
Total	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0

Table A4.11: Final Energy Demand for Food Processing (ktoe)

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	18.5	20.2	21.8	23.4	25.0	26.6	28.9	31.2	33.5	35.8	38.1
Diesel	5.5	6.3	7.3	8.3	9.4	10.5	12.0	13.6	15.3	17.0	18.9
LPG	21.0	22.8	24.7	26.6	28.5	30.3	33.0	35.7	38.5	41.2	43.9
Residual Fuel Oil	35.2	38.2	41.3	44.3	47.3	50.3	54.7	59.0	63.4	67.7	72.1
Total	80.2	87.6	95.0	102.6	110.1	117.8	128.7	139.6	150.6	161.8	173.0

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	21.7	23.6	25.4	27.3	29.2	31.1	33.7	36.4	39.1	41.8	44.5
Diesel	6.4	7.4	8.5	9.7	11.0	12.3	14.1	15.9	17.9	20.0	22.2
LPG	24.6	26.8	29.0	31.1	33.4	35.6	38.7	41.9	45.1	48.3	51.5
Residual Fuel Oil	41.2	44.8	48.3	51.9	55.5	59.0	64.1	69.2	74.3	79.4	84.4
Total	93.9	102.5	111.3	120.1	129.0	137.9	150.6	163.4	176.4	189.4	202.5

Table A4.12: Final Energy Demand for Beverage Industry (ktoe)

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	6.9	7.4	7.9	8.4	8.8	9.3	10.0	10.6	11.3	11.9	12.6
Diesel	5.5	6.4	7.2	8.1	9.1	10.1	11.4	12.8	14.2	15.7	17.3
LPG	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0007	0.0007
Residual Fuel Oil	25.4	27.2	28.9	30.7	32.5	34.2	36.6	39.0	41.3	43.7	46.1
Total	37.9	40.9	44.0	47.2	50.4	53.7	58.0	62.4	66.9	71.4	76.0

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	8.1	8.6	9.2	9.8	10.4	10.9	11.7	12.5	13.2	14.0	14.8
Diesel	6.5	7.4	8.5	9.5	10.7	11.9	13.4	15.0	16.7	18.4	20.3
LPG	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0008	0.0008
Residual Fuel Oil	29.8	31.9	33.9	36.0	38.0	40.1	42.9	45.7	48.5	51.2	54.0
Total	44.4	47.9	51.6	55.3	59.1	62.9	68.0	73.1	78.3	83.7	89.0

Table A4.13: Final Energy Demand for Textile Industry (ktoe)

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	6.6	7.2	7.7	8.2	8.8	9.3	9.9	10.4	10.9	11.5	12.0
Diesel	2.0	2.2	2.5	2.9	3.2	3.6	4.0	4.4	4.8	5.3	5.8
Residual Fuel Oil	17.3	18.5	19.8	21.0	22.1	23.3	24.4	25.6	26.7	27.7	28.8
Total	25.9	28.0	30.0	32.1	34.1	36.2	38.3	40.3	42.4	44.5	46.6

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	8.0	8.6	9.3	10.0	10.6	11.3	12.0	12.7	13.3	14.0	14.7
Diesel	2.5	2.9	3.3	3.8	4.3	4.8	5.4	5.9	6.6	7.2	8.0
Residual Fuel Oil	20.5	22.0	23.5	24.9	26.4	27.8	29.1	30.5	31.8	33.1	34.4
Total	31.0	33.6	36.1	38.7	41.3	43.9	46.5	49.1	51.7	54.3	57.0

Table A4.14: Final Energy Demand for Chemical Industry (ktoe)

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	6.5	7.2	7.9	8.7	9.4	10.1	11.0	11.9	12.8	13.6	14.5
Diesel	3.4	3.8	4.2	4.6	4.9	5.3	5.8	6.3	6.7	7.2	7.6
Residual Fuel Oil	2.2	2.5	2.7	3.0	3.2	3.5	3.8	4.1	4.4	4.7	5.0
Total	12.1	13.4	14.8	16.2	17.6	18.9	20.6	22.2	23.9	25.5	27.1

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	7.6	8.4	9.3	10.2	11.0	11.9	12.9	13.9	15.0	16.0	17.0
Diesel	4.0	4.4	4.9	5.3	5.8	6.3	6.8	7.3	7.9	8.4	9.0
Residual Fuel Oil	2.6	2.9	3.2	3.5	3.8	4.1	4.4	4.8	5.1	5.5	5.8
Total	14.1	15.8	17.4	19.0	20.6	22.2	24.1	26.0	28.0	29.9	31.8

Table A4.15: Final Energy Demand for Metal Fabrication (ktoe)

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	4.5	4.8	5.1	5.4	5.7	6.1	6.4	6.7	7.1	7.5	7.9
Diesel	8.2	8.7	9.3	9.8	10.4	11.0	11.6	12.2	12.9	13.6	14.2
LPG	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9
Residual Fuel Oil	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3
Total	14.1	15.0	15.9	16.8	17.8	18.8	19.8	20.9	22.0	23.1	24.3

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	4.7	5.0	5.4	5.7	6.0	6.4	6.7	7.1	7.5	7.9	8.3
Diesel	8.6	9.1	9.7	10.3	11.0	11.6	12.3	12.9	13.6	14.3	15.1
LPG	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9
Residual Fuel Oil	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3
Total	14.7	15.6	16.6	17.6	18.6	19.7	20.8	21.9	23.1	24.3	25.6

Table A4.16: Final Energy Demand for Paper and Printing Industry (ktoe)

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	4.1	4.6	5.1	5.5	6.0	6.5	7.0	7.6	8.2	8.7	9.3
Diesel	1.1	1.2	1.4	1.5	1.6	1.7	1.9	2.0	2.1	2.3	2.4
LPG	2.1	2.3	2.5	2.8	3.0	3.2	3.5	3.7	4.0	4.2	4.5
Total	7.3	8.1	9.0	9.8	10.6	11.4	12.4	13.3	14.3	15.2	16.2

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	4.5	5.0	5.5	6.0	6.6	7.1	7.7	8.4	9.1	9.8	10.4
Diesel	1.2	1.3	1.5	1.6	1.7	1.9	2.0	2.2	2.4	2.5	2.7
LPG	2.3	2.5	2.8	3.0	3.2	3.5	3.8	4.1	4.4	4.8	5.1
Total	8.0	8.9	9.8	10.7	11.5	12.4	13.6	14.7	15.9	17.0	18.2

Table A4.17: Final Energy Demand for Wood Processing Industry (ktoe)

Fuels	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	8.3	8.6	8.9	9.2	9.5	9.9	10.3	10.8	11.3	11.7	12.2
Diesel	4.8	5.3	5.9	6.5	7.1	7.7	8.5	9.4	10.3	11.2	12.2
Wood	0.022	0.023	0.023	0.024	0.025	0.026	0.027	0.028	0.030	0.031	0.032
Total	13.1	14.0	14.8	15.7	16.6	17.6	18.9	20.2	21.6	23.0	24.5

Fuels	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	9.6	10.0	10.4	10.8	11.2	11.5	12.1	12.7	13.2	13.8	14.3
Diesel	5.5	6.1	6.8	7.5	8.3	9.0	10.0	11.0	12.1	13.1	14.3
Wood	0.025	0.026	0.027	0.028	0.029	0.030	0.032	0.033	0.035	0.036	0.038
Total	15.1	16.1	17.2	18.3	19.4	20.6	22.1	23.7	25.3	27.0	28.7

Table A4.18: Final Energy Demand for Informal Manufacturing Sector (ktoe)

Fuels	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Textiles	40.2	41.6	42.9	44.3	45.7	47.0	48.4	49.8	51.1	52.5	53.8
Soap Production	34.6	35.4	36.1	36.9	37.7	38.6	39.4	40.3	41.1	42.0	43.0
Beverages	53.7	55.6	57.5	59.4	61.4	63.4	65.2	67.1	69.0	71.0	72.9
Food Processing	263.8	273.5	283.3	293.1	303.0	313.0	322.1	331.2	340.3	349.4	358.5
Ceramics and Lime	39.5	40.8	42.2	43.5	45.0	46.4	47.7	49.1	50.4	51.8	53.2
Total	431.9	446.9	462.0	477.3	492.8	508.4	522.9	537.4	552.1	566.7	581.4

Fuels	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Textiles	40.2	41.6	42.9	44.3	45.7	47.0	48.4	49.8	51.1	52.5	53.8
Soap Production	34.6	35.4	36.1	36.9	37.7	38.6	39.4	40.3	41.1	42.0	43.0
Beverages	53.9	55.8	57.8	59.8	61.8	63.9	65.7	67.5	69.4	71.3	73.2
Food Processing	264.7	274.6	284.7	294.9	305.2	315.6	324.4	333.3	342.1	350.8	359.6
Ceramics and Lime	39.6	41.0	42.4	43.8	45.3	46.8	48.1	49.4	50.7	52.0	53.4
Total	433.0	448.4	464.0	479.7	495.7	511.8	526.0	540.2	554.4	568.6	582.9

Table A4.19: Final Energy Demand for Aluminum Smeltering (ktoe)

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity bulk	166.0	165.9	165.8	165.6	165.5	165.4	165.2	165.1	165.0	164.8	164.7
Residual Fuel Oil	16.8	16.8	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.6
Diesel	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
LPG	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Total	186.1	186.0	185.8	185.7	185.5	185.4	185.2	185.1	184.9	184.8	184.6

Fuels											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity bulk	166.0	221.2	276.3	276.0	275.8	275.6	275.4	275.1	274.9	274.7	274.5
Residual Fuel Oil	16.8	22.3	27.9	27.9	27.9	27.8	27.8	27.8	27.8	27.8	27.7
Diesel	2.4	3.2	4.0	4.0	4.0	4.0	3.9	3.9	3.9	3.9	3.9
LPG	1.0	1.3	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Total	186.1	248.0	309.7	309.5	309.2	309.0	308.7	308.5	308.2	308.0	307.7

Annex 5 Agricultural Sector Energy Demand Projection

Table A5.1: Agricultural Final Energy Demand by fuel type (ktoe)

Fuel	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.2	2.4
Diesel	100.2	109.4	119.4	130.2	142.1	155.1	169.3	184.9	201.9	220.5	241.0
Gasoline premix	83.2	90.6	98.6	107.4	116.8	127.1	138.3	150.4	163.6	177.9	193.4
Total	184.6	201.3	219.4	239.1	260.6	284.0	309.5	337.3	367.6	400.7	436.7
Fuel	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	4.4	5.4	6.5	7.6	8.8	10.1	11.4	12.8	14.3	15.8	17.4
Diesel	113.6	124.9	137.2	150.5	164.9	180.6	197.6	216.0	236.2	258.2	282.2
Gasoline premix	82.4	89.6	97.5	106.0	115.3	125.3	136.2	148.0	160.9	174.8	189.9
Total	200.3	220.0	241.2	264.2	289.0	316.0	345.2	376.9	411.4	448.8	489.4

Table A5.2: Agricultural Final Energy Demand by sub-sector (ktoe)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Irrigation	2.3	2.5	2.7	2.9	3.0	3.2	3.4	3.7	3.9	4.1	4.3
poultry farms	0.358	0.399	0.440	0.482	0.524	0.566	0.609	0.652	0.695	0.738	0.781
Land ploughing	28.6	29.7	30.9	32.2	33.5	34.9	36.3	37.8	39.3	40.9	42.6
Crop harvesting	9.7	10.4	11.2	12.0	12.8	13.5	14.3	15.1	15.9	16.7	17.5
Post harvest pro	0.007	0.008	0.008	0.008	0.009	0.009	0.010	0.010	0.011	0.011	0.012
Fishing	143.7	158.2	174.1	191.6	210.7	231.8	254.8	280.1	307.8	338.2	371.5
Total	184.6	201.3	219.4	239.1	260.6	284.0	309.5	337.3	367.6	400.7	436.7
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Irrigation	9.1	10.9	12.8	14.6	16.5	18.3	20.2	22.0	23.9	25.7	27.5
poultry farms	0.462	0.519	0.576	0.634	0.692	0.751	0.809	0.869	0.928	0.988	1.048
Land ploughing	33.4	35.3	37.3	39.5	41.7	44.1	46.6	49.3	52.1	55.1	58.3
Crop harvesting	12.5	13.5	14.6	15.7	16.7	17.8	18.9	19.9	21.0	22.1	23.2
Post harvest pro	0.008	0.009	0.009	0.010	0.010	0.011	0.012	0.012	0.013	0.013	0.014
Fishing	144.8	159.6	175.9	193.8	213.4	235.0	258.7	284.8	313.4	344.8	379.4
Total	200.3	220.0	241.2	264.2	289.0	316.0	345.2	376.9	411.4	448.8	489.4

Table A5.3: Final Energy Demand for Irrigation (ktoe)

Fuel	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	0.86	0.93	1.00	1.07	1.15	1.22	1.30	1.39	1.47	1.56	1.65
Diesel	1.45	1.56	1.67	1.78	1.90	2.02	2.14	2.27	2.40	2.53	2.67
Total	2.31	2.49	2.67	2.85	3.05	3.24	3.45	3.66	3.87	4.09	4.32
Fuel	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	3.92	4.89	5.93	7.03	8.19	9.41	10.69	12.03	13.42	14.88	16.40
Diesel	5.17	6.04	6.85	7.60	8.29	8.92	9.49	9.99	10.44	10.82	11.15
Total	9.08	10.94	12.79	14.63	16.48	18.33	20.18	22.02	23.86	25.70	27.54

Table A5.4: Final Energy Demand for Poultry Industry (ktoe)

Fuel	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	0.33	0.37	0.41	0.45	0.48	0.52	0.56	0.60	0.64	0.68	0.72
Diesel	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06
Total	0.36	0.40	0.44	0.48	0.52	0.57	0.61	0.65	0.69	0.74	0.78
Fuel	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	0.43	0.48	0.53	0.59	0.64	0.69	0.75	0.80	0.85	0.91	0.96
Diesel	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.09
Total	0.46	0.52	0.58	0.63	0.69	0.75	0.81	0.87	0.93	0.99	1.05

Table A5.5: Final Energy Demand for Fishing Industry (ktoe)

Sector	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Marine	119.38	131.87	145.61	160.72	177.34	195.61	215.70	237.77	262.02	288.66	317.91
Inland	24.34	26.34	28.51	30.86	33.40	36.14	39.11	42.32	45.79	49.55	53.61
Total	143.72	158.22	174.12	191.58	210.74	231.76	254.81	280.09	307.81	338.21	371.52
Sector	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Marine	123.23	136.54	151.23	167.43	185.30	205.01	226.74	250.69	277.08	306.16	338.18
Inland	21.62	23.09	24.66	26.32	28.09	29.97	31.96	34.07	36.31	38.67	41.18
Total	144.84	159.63	175.88	193.75	213.40	234.98	258.70	284.76	313.39	344.83	379.36

Annex 6 Transport Sector Energy Demand Projection

Table A6.1: Final Energy Demand for Transport Sector by sub-sectors (ktoe)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Passenger	3,058.8	3,253.2	3,460.5	3,681.7	3,917.6	4,169.3	4,437.7	4,724.1	5,029.5	5,355.3	5,702.8
Freight	642.7	717.4	799.2	888.9	987.2	1,094.7	1,212.4	1,341.0	1,481.5	1,635.0	1,802.5
Bunkering	248.1	261.5	275.6	290.5	306.3	322.9	340.4	358.9	378.4	398.9	420.6
Total	3,949.6	4,232.0	4,535.4	4,861.2	5,211.1	5,586.9	5,990.5	6,423.9	6,889.3	7,389.2	7,925.9
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Passenger	3,285.4	3,540.9	3,808.5	4,096.6	4,406.7	4,740.4	5,099.5	5,486.0	5,899.3	6,347.0	6,825.8
Freight	745.3	845.5	957.1	1,081.1	1,218.8	1,371.7	1,541.4	1,729.4	1,937.6	2,168.2	2,423.3
Bunkering	270.7	287.9	306.2	325.6	346.3	368.3	391.8	416.8	443.3	471.6	501.8
Total	4,301.4	4,674.3	5,071.8	5,503.3	5,971.8	6,480.4	7,032.7	7,632.1	8,280.3	8,986.9	9,750.9

Table A6.2: Final Energy Demand for Modes of Transport (ktoe)

Mode	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Road	2,931.0	3,079.6	3,237.3	3,404.4	3,581.6	3,769.4	3,968.5	4,179.6	4,403.3	4,640.5	4,891.9
Rail	739.0	856.7	985.5	1,126.1	1,279.8	1,447.6	1,630.7	1,830.4	2,048.2	2,285.5	2,544.1
Lake	1.5	1.5	1.6	1.6	1.7	1.8	1.8	1.9	2.0	2.0	2.1
Domestic Air	28.9	31.3	34.0	36.8	39.9	43.1	46.7	50.4	54.5	58.9	63.5
Pipelines	1.1	1.3	1.5	1.7	1.9	2.1	2.4	2.6	3.0	3.3	3.7
Bunkering_Air	186.4	197.2	208.6	220.8	233.6	247.1	261.4	276.6	292.6	309.6	327.6
Bunkering_Marin	61.7	64.3	67.0	69.8	72.7	75.8	79.0	82.3	85.7	89.3	93.1
Total	3,949.6	4,232.0	4,535.4	4,861.2	5,211.1	5,586.9	5,990.5	6,423.9	6,889.3	7,389.2	7,925.9

Mode	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Road	2,949.0	3,120.2	3,294.6	3,479.6	3,675.6	3,883.5	4,103.8	4,337.2	4,581.9	4,844.1	5,118.7
Rail	1,016.1	1,192.0	1,387.3	1,604.0	1,844.3	2,110.5	2,405.2	2,731.2	3,091.5	3,489.6	3,929.1
Lake	1.8	1.9	2.0	2.1	2.2	2.4	2.5	2.7	2.8	3.0	3.2
Domestic Air	60.7	68.8	77.6	87.2	97.8	109.4	122.1	136.0	151.1	167.8	185.9
Pipelines	3.0	3.5	4.1	4.8	5.5	6.4	7.3	8.3	9.5	10.8	12.2
Bunkering_Air	204.8	218.7	233.6	249.5	266.4	284.6	303.9	324.6	346.6	370.2	395.4
Bunkering_Marin	66.0	69.2	72.6	76.1	79.9	83.8	87.9	92.2	96.7	101.4	106.4
Total	4,301.4	4,674.3	5,071.8	5,503.3	5,971.8	6,480.4	7,032.7	7,632.1	8,280.3	8,986.9	9,750.9

Table A6.3: Final Energy Demand for Transport Sector by fuel type (ktoe)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	1.1	1.3	1.5	1.7	1.9	2.1	2.4	2.6	3.0	3.3	3.7
Diesel	2,270.1	2,460.2	2,665.5	2,887.0	3,126.1	3,384.1	3,662.6	3,963.0	4,287.2	4,636.9	5,014.1
Gasoline	1,399.0	1,476.1	1,558.1	1,645.4	1,738.3	1,837.1	1,942.2	2,054.0	2,173.1	2,299.7	2,434.4
Gasoline premix	0.0021	0.0023	0.0025	0.0027	0.0029	0.0031	0.0033	0.0035	0.0037	0.0040	0.0042
Jet Kerosene	215.3	228.5	242.6	257.6	273.4	290.2	308.1	327.0	347.1	368.5	391.1
LPG	64.0	65.8	67.7	69.6	71.4	73.3	75.2	77.1	79.0	80.8	82.6
Total	3,949.6	4,232.0	4,535.4	4,861.2	5,211.1	5,586.9	5,990.5	6,423.9	6,889.3	7,389.2	7,925.9

Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	6.1	7.1	11.8	17.0	23.0	29.7	37.2	45.6	56.4	67.0	80.2
Diesel	2,566.6	2,828.9	3,116.1	3,430.3	3,774.2	4,150.3	4,561.7	5,011.6	5,503.5	6,041.2	6,628.8
Gasoline	1,398.8	1,483.9	1,563.5	1,647.5	1,736.1	1,829.7	1,928.5	2,032.5	2,138.2	2,253.8	2,371.0
Gasoline premix	0.0025	0.0028	0.0031	0.0035	0.0039	0.0043	0.0047	0.0052	0.0057	0.0063	0.0069
Jet Kerosene	265.5	287.5	311.2	336.7	364.2	393.9	426.0	460.5	497.8	538.0	581.3
LPG	64.4	66.8	69.2	71.7	74.2	76.7	79.3	81.8	84.4	87.0	89.6
Total	4,301.4	4,674.3	5,071.8	5,503.3	5,971.8	6,480.4	7,032.7	7,632.1	8,280.3	8,986.9	9,750.9

Table A6.4: Final Energy Demand for Passenger Transport by modes (kTOE)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Road	2,569.4	2,692.7	2,823.2	2,961.4	3,107.7	3,262.5	3,426.3	3,599.8	3,783.3	3,977.5	4,183.1
Rail	459.8	528.4	602.6	682.8	769.4	862.9	964.0	1,073.1	1,191.0	1,318.1	1,455.4
Lake	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Domestic Air	28.9	31.3	34.0	36.8	39.9	43.1	46.7	50.4	54.5	58.9	63.5
Total	3,058.8	3,253.2	3,460.5	3,681.7	3,917.6	4,169.3	4,437.7	4,724.1	5,029.5	5,355.3	5,702.8
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Road	2,580.2	2,722.2	2,865.1	3,016.2	3,175.7	3,344.3	3,522.4	3,710.4	3,906.3	4,115.9	4,334.0
Rail	643.5	749.0	864.9	992.2	1,132.1	1,285.5	1,453.9	1,638.4	1,840.6	2,062.1	2,304.6
Lake	0.9	0.9	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.3	1.4
Domestic Air	60.7	68.8	77.6	87.2	97.8	109.4	122.1	136.0	151.1	167.8	185.9
Total	3,285.4	3,540.9	3,808.5	4,096.6	4,406.7	4,740.4	5,099.5	5,486.0	5,899.3	6,347.0	6,825.8

Table A6.5: Final Energy Demand for Passenger Transport by fuel type (ktoe)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	-	-	-	-	-	-	-	-	-	-	-
Diesel	1,566.9	1,679.9	1,800.7	1,929.9	2,068.1	2,215.8	2,373.6	2,542.5	2,722.9	2,915.9	3,122.2
Gasoline	1,399.0	1,476.1	1,558.1	1,645.4	1,738.3	1,837.1	1,942.2	2,054.0	2,173.1	2,299.7	2,434.4
Gasoline premix	0.0013	0.0014	0.0015	0.0016	0.0017	0.0018	0.0019	0.0020	0.0021	0.0022	0.0023
Jet Kerosene	28.9	31.3	34.0	36.8	39.9	43.1	46.7	50.4	54.5	58.9	63.5
LPG	64.0	65.8	67.7	69.6	71.4	73.3	75.2	77.1	79.0	80.8	82.6
Total	3,058.8	3,253.2	3,460.5	3,681.7	3,917.6	4,169.3	4,437.7	4,724.1	5,029.5	5,355.3	5,702.8
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	3.0	3.6	7.7	12.3	17.5	23.3	29.9	37.3	46.9	56.2	68.0
Diesel	1,758.4	1,917.8	2,090.6	2,277.9	2,481.0	2,701.2	2,939.8	3,198.4	3,478.6	3,782.3	4,111.3
Gasoline	1,398.8	1,483.9	1,563.5	1,647.5	1,736.1	1,829.7	1,928.5	2,032.5	2,138.2	2,253.8	2,371.0
Gasoline premix	0.0016	0.0018	0.0020	0.0022	0.0025	0.0028	0.0030	0.0033	0.0037	0.0040	0.0044
Jet Kerosene	60.7	68.8	77.6	87.2	97.8	109.4	122.1	136.0	151.1	167.8	185.9
LPG	64.4	66.8	69.2	71.7	74.2	76.7	79.3	81.8	84.4	87.0	89.6
Total	3,285.4	3,540.9	3,808.5	4,096.6	4,406.7	4,740.4	5,099.5	5,486.0	5,899.3	6,347.0	6,825.8

Table A6.6: Final Energy Demand for Road Passenger Transport by sub-sectors (ktoe)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Intracity	1,309.5	1,391.5	1,478.9	1,572.0	1,671.2	1,776.8	1,889.4	2,009.2	2,136.9	2,272.9	2,417.8
Intercity	1,260.0	1,301.2	1,344.3	1,389.4	1,436.5	1,485.6	1,537.0	1,590.5	1,646.4	1,704.6	1,765.4
Total	2,569.4	2,692.7	2,823.2	2,961.4	3,107.7	3,262.5	3,426.3	3,599.8	3,783.3	3,977.5	4,183.1
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Intracity	1,311.7	1,401.7	1,490.1	1,584.1	1,684.0	1,790.1	1,902.7	2,022.3	2,146.5	2,281.2	2,421.0
Intercity	1,268.6	1,320.5	1,375.0	1,432.0	1,491.8	1,554.3	1,619.7	1,688.2	1,759.8	1,834.7	1,913.0
Total	2,580.2	2,722.2	2,865.1	3,016.2	3,175.7	3,344.3	3,522.4	3,710.4	3,906.3	4,115.9	4,334.0

Table A6.7: Final Energy Demand for Road Passenger Transport by fuel type (ktoe)

Fuel	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	-	-	-	-	-	-	-	-	-	-	-
Diesel	1,106.4	1,150.8	1,197.4	1,246.5	1,298.0	1,352.1	1,408.9	1,468.6	1,531.3	1,597.0	1,666.1
Gasoline	1,399.0	1,476.1	1,558.1	1,645.4	1,738.3	1,837.1	1,942.2	2,054.0	2,173.1	2,299.7	2,434.4
LPG	64.0	65.8	67.7	69.6	71.4	73.3	75.2	77.1	79.0	80.8	82.6
Total	2,569.4	2,692.7	2,823.2	2,961.4	3,107.7	3,262.5	3,426.3	3,599.8	3,783.3	3,977.5	4,183.1

Fuel	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	3.0	3.6	7.7	12.3	17.5	23.3	29.9	37.3	46.9	56.2	68.0
Diesel	1,114.0	1,167.9	1,224.7	1,284.7	1,347.9	1,414.5	1,484.8	1,558.8	1,636.8	1,718.9	1,805.4
Gasoline	1,398.8	1,483.9	1,563.5	1,647.5	1,736.1	1,829.7	1,928.5	2,032.5	2,138.2	2,253.8	2,371.0
LPG	64.4	66.8	69.2	71.7	74.2	76.7	79.3	81.8	84.4	87.0	89.6
Total	2,580.2	2,722.2	2,865.1	3,016.2	3,175.7	3,344.3	3,522.4	3,710.4	3,906.3	4,115.9	4,334.0

Table A6.8: Final Energy Demand for Urban Road Passenger Transport (ktoe)

Vehicle Type	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Motor cycles	72.5	75.8	79.2	82.8	86.6	90.5	94.7	99.0	103.4	108.1	113.0
Private cars	813.8	869.6	929.3	993.1	1,061.5	1,134.5	1,212.7	1,296.2	1,385.6	1,481.2	1,583.3
Taxis	173.5	182.9	192.9	203.5	214.7	226.6	239.1	252.5	266.5	281.5	297.3
Mini & Midi Buse	103.3	106.2	109.1	112.0	114.9	117.7	120.5	123.2	125.9	128.4	130.8
Big Buses	136.8	144.8	153.2	162.2	171.7	181.7	192.4	203.7	215.7	228.4	241.8
High Occupancy I	9.7	12.3	15.2	18.3	21.9	25.7	30.0	34.7	39.8	45.4	51.6
Total	1,309.5	1,391.5	1,478.9	1,572.0	1,671.2	1,776.8	1,889.4	2,009.2	2,136.9	2,272.9	2,417.8
Vehicle Type	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Motor cycles	72.9	76.9	81.0	85.4	89.9	94.7	99.8	105.0	110.6	116.4	122.5
Private cars	822.2	873.1	930.2	990.8	1,055.1	1,123.2	1,195.4	1,271.7	1,354.3	1,440.8	1,534.3
Taxis	165.0	184.5	195.1	206.5	218.7	231.9	246.2	261.8	274.0	291.1	304.6
Mini & Midi Buse	104.0	107.8	111.6	115.4	119.3	123.2	127.0	130.8	134.6	138.2	141.7
Big Buses	137.8	146.9	156.7	167.2	178.3	190.1	202.8	216.2	230.5	245.8	262.0
High Occupancy I	9.7	12.4	15.5	18.9	22.7	26.9	31.6	36.8	42.5	48.9	55.9
Total	1,311.7	1,401.7	1,490.1	1,584.1	1,684.0	1,790.1	1,902.7	2,022.3	2,146.5	2,281.2	2,421.0

Table A6.9: Final Energy Demand fo Urban Road Passenger Transport by fuel type (ktoe)

Fuel	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	-	-	-	-	-	-	-	-	-	-	-
Diesel	266.2	281.5	297.7	314.8	333.0	352.3	372.8	394.4	417.4	441.7	467.5
Gasoline	979.3	1,044.2	1,113.5	1,187.6	1,266.7	1,351.2	1,441.4	1,537.7	1,640.6	1,750.4	1,867.7
LPG	64.0	65.8	67.7	69.6	71.4	73.3	75.2	77.1	79.0	80.8	82.6
Total	1,309.5	1,391.5	1,478.9	1,572.0	1,671.2	1,776.8	1,889.4	2,009.2	2,136.9	2,272.9	2,417.8
Fuel	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	3.0	3.6	7.7	12.3	17.5	23.3	29.9	37.3	46.9	56.2	68.0
Diesel	268.0	285.7	304.5	324.5	345.9	368.6	392.8	418.7	446.1	475.4	506.5
Gasoline	976.2	1,045.6	1,108.8	1,175.7	1,246.4	1,321.4	1,400.7	1,484.5	1,569.0	1,662.6	1,756.9
LPG	64.4	66.8	69.2	71.7	74.2	76.7	79.3	81.8	84.4	87.0	89.6
Total	1,311.7	1,401.7	1,490.1	1,584.1	1,684.0	1,790.1	1,902.7	2,022.3	2,146.5	2,281.2	2,421.0

Table A6.10: Final Energy Demand for Inter-city Road Passenger Transportation (ktoe)

Vehicle Type	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Motor cycles	33.5	31.6	29.5	27.3	24.9	22.4	19.6	16.7	13.5	10.1	6.4
Private cars	162.7	172.1	181.9	192.3	203.3	214.8	227.0	239.8	253.3	267.4	282.4
Taxis	241.6	248.7	256.1	263.7	271.8	280.1	288.8	297.8	307.2	317.0	327.2
Mini & Midi Buse	436.3	446.8	457.7	469.0	480.7	492.9	505.5	518.5	532.0	546.0	560.4
Big Buses	385.9	402.1	419.1	437.0	455.8	475.4	496.0	517.7	540.3	564.1	589.0
Total	1,260.0	1,301.2	1,344.3	1,389.4	1,436.5	1,485.6	1,537.0	1,590.5	1,646.4	1,704.6	1,765.4
Vehicle Type	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Motor cycles	33.7	32.0	30.2	28.2	25.9	23.4	20.7	17.7	14.4	10.9	7.0
Private cars	163.8	174.6	186.1	198.2	211.1	224.8	239.2	254.5	270.7	287.9	306.0
Taxis	243.3	252.4	261.9	271.8	282.2	293.0	304.3	316.1	328.4	341.2	354.6
Mini & Midi Buse	439.2	453.4	468.1	483.4	499.2	515.7	532.7	550.4	568.7	587.6	607.2
Big Buses	388.5	408.1	428.7	450.4	473.3	497.4	522.7	549.4	577.5	607.1	638.2
Total	1,268.6	1,320.5	1,375.0	1,432.0	1,491.8	1,554.3	1,619.7	1,688.2	1,759.8	1,834.7	1,913.0

Table A6.11: Final Energy Demand for Inter-city Road Passenger Transportation by fuel type (ktoe)

Fuel	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Diesel	840.2	869.3	899.8	931.6	964.9	999.7	1,036.1	1,074.2	1,113.9	1,155.4	1,198.6
Gasoline	419.8	431.9	444.6	457.8	471.6	485.9	500.8	516.3	532.5	549.3	566.7
Total	1,260.0	1,301.2	1,344.3	1,389.4	1,436.5	1,485.6	1,537.0	1,590.5	1,646.4	1,704.6	1,765.4
Fuel	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Diesel	846.0	882.2	920.3	960.2	1,002.0	1,045.9	1,091.9	1,140.1	1,190.6	1,243.5	1,298.9
Gasoline	422.6	438.3	454.7	471.8	489.7	508.3	527.8	548.0	569.2	591.2	614.1
Total	1,268.6	1,320.5	1,375.0	1,432.0	1,491.8	1,554.3	1,619.7	1,688.2	1,759.8	1,834.7	1,913.0

Table A6.12: Final Energy Demand for Inter-city Rail Passenger Transport (ktoe)

Vehicle Type	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Diesel Train	459.8	528.4	602.6	682.8	769.4	862.9	964.0	1,073.1	1,191.0	1,318.1	1,455.4
Electric train	-	-	-	-	-	-	-	-	-	-	-
Total	459.8	528.4	602.6	682.8	769.4	862.9	964.0	1,073.1	1,191.0	1,318.1	1,455.4
Vehicle Type	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Diesel Train	643.5	749.0	864.9	992.2	1,132.1	1,285.5	1,453.9	1,638.4	1,840.6	2,062.1	2,304.6
Electric train	-	-	-	-	-	-	-	-	-	-	-
Total	643.5	749.0	864.9	992.2	1,132.1	1,285.5	1,453.9	1,638.4	1,840.6	2,062.1	2,304.6

Table A6.13: Final Energy Demand for Inland Lake Passenger Transport (toe)

Vehicle Type	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Ferries	709.4	713.8	717.5	720.3	722.1	722.9	722.3	720.4	716.8	711.4	704.0
Motor boat	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3
Total	710.7	715.2	719.0	721.9	723.9	724.7	724.3	722.4	718.9	713.6	706.3
Vehicle Type	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Ferries	887.0	924.5	963.7	1,004.7	1,047.6	1,092.5	1,139.3	1,188.2	1,239.3	1,292.6	1,348.1
Motor boat	1.6	1.8	2.0	2.2	2.5	2.8	3.0	3.3	3.7	4.0	4.4
Total	888.6	926.3	965.7	1,007.0	1,050.1	1,095.2	1,142.4	1,191.6	1,243.0	1,296.6	1,352.5

Table A6.14: Final Energy Demand for Domestic Air Passenger Transport (ktonne)

Vehicle Type	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Small Plane	28.9	31.3	34.0	36.8	39.9	43.1	46.7	50.4	54.5	58.9	63.5
Vehicle Type	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Small Plane	60.7	68.8	77.6	87.2	97.8	109.4	122.1	136.0	151.1	167.8	185.9

Table A6.15: Final Energy Demand for Freight Transport (ktoe)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Road	361.5	386.9	414.0	443.0	473.9	506.9	542.2	579.9	620.1	663.0	708.7
Rail	279.2	328.3	382.9	443.4	510.4	584.6	666.7	757.3	857.2	967.4	1,088.7
Lake	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4
Pipelines	1.1	1.3	1.5	1.7	1.9	2.1	2.4	2.6	3.0	3.3	3.7
Total	642.7	717.4	799.2	888.9	987.2	1,094.7	1,212.4	1,341.0	1,481.5	1,635.0	1,802.5
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Road	368.8	398.0	429.5	463.4	499.9	539.1	581.4	626.8	675.7	728.2	784.7
Rail	372.6	443.0	522.4	611.8	712.3	825.0	951.3	1,092.8	1,250.9	1,427.5	1,624.5
Lake	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.9
Pipelines	3.0	3.5	4.1	4.8	5.5	6.4	7.3	8.3	9.5	10.8	12.2
Total	745.3	845.5	957.1	1,081.1	1,218.8	1,371.7	1,541.4	1,729.4	1,937.6	2,168.2	2,423.3

Table A6.16: Final Energy Demand for Freight Transport by fuel type (ktoe)

Vehicle Type	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	1.1	1.3	1.5	1.7	1.9	2.1	2.4	2.6	3.0	3.3	3.7
Diesel	641.6	716.1	797.8	887.3	985.3	1,092.6	1,210.0	1,338.3	1,478.5	1,631.7	1,798.8
Gasoline premix	0.0008	0.0009	0.0010	0.0011	0.0012	0.0013	0.0014	0.0015	0.0016	0.0018	0.0019
Total	642.7	717.4	799.2	888.9	987.2	1,094.7	1,212.4	1,341.0	1,481.5	1,635.0	1,802.5
Vehicle Type	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	3.0	3.5	4.1	4.8	5.5	6.4	7.3	8.3	9.5	10.8	12.2
Diesel	742.3	842.0	952.9	1,076.3	1,213.3	1,365.4	1,534.1	1,721.0	1,928.2	2,157.4	2,411.1
Gasoline premix	0.0009	0.0010	0.0011	0.0012	0.0014	0.0015	0.0017	0.0019	0.0021	0.0023	0.0025
Total	745.3	845.5	957.1	1,081.1	1,218.8	1,371.7	1,541.4	1,729.4	1,937.6	2,168.2	2,423.3

Table A6.17: Final Energy Demand for Road Freight Transport (ktoe)

Vehicle Type	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Local	130.4	142.7	155.9	170.2	185.7	202.5	220.5	240.1	261.2	283.9	308.4
Long distance	231.1	244.3	258.1	272.8	288.2	304.5	321.7	339.8	358.9	379.1	400.3
Total	361.5	386.9	414.0	443.0	473.9	506.9	542.2	579.9	620.1	663.0	708.7
Vehicle Type	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Local	133.1	146.8	161.7	178.1	195.9	215.3	236.5	259.5	284.6	311.8	341.5
Long distance	235.8	251.3	267.8	285.3	304.0	323.8	344.9	367.3	391.1	416.4	443.2
Total	368.8	398.0	429.5	463.4	499.9	539.1	581.4	626.8	675.7	728.2	784.7

Table A6.18: Final Energy Demand for Inter-city Rail Freight Transport (ktoe)

Vehicle Type	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Diesel Train	279.2	328.3	382.9	443.4	510.4	584.6	666.7	757.3	857.2	967.4	1,088.7
Vehicle Type	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Diesel Train	372.6	443.0	522.4	611.8	712.3	825.0	951.3	1,092.8	1,250.9	1,427.5	1,624.5

Table A6.19: Final Energy Demand for Inland Freight Lake Transportation (toe)

Boat Type	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Barge	725.1	768.7	815.0	864.0	915.9	970.8	1,029.0	1,090.6	1,155.8	1,224.9	1,298.1
Ferries	49.8	53.4	57.3	61.4	65.8	70.5	75.6	81.0	86.7	92.9	99.5
Motor boat	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.8	1.9
Total	775.7	823.1	873.2	926.4	982.8	1,042.6	1,105.9	1,173.1	1,244.2	1,319.6	1,399.4
Boat Type	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Barge	805.8	869.4	938.0	1,012.0	1,091.8	1,177.9	1,270.8	1,371.0	1,479.1	1,595.7	1,721.5
Ferries	55.4	60.4	65.9	71.9	78.4	85.6	93.3	101.8	111.0	121.0	131.9
Motor boat	0.9	1.0	1.1	1.2	1.4	1.5	1.7	1.9	2.1	2.3	2.5
Total	862.1	930.8	1,005.0	1,085.1	1,171.6	1,265.0	1,365.8	1,474.7	1,592.2	1,719.0	1,856.0

Table A6.20: Final Energy Demand for Pipeline Transport (GWh)

Vehicle Type	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Crude oil Pipeline	1.7	1.9	2.1	2.4	2.7	3.0	3.3	3.6	4.0	4.4	4.9
Petroleum produc	11.6	13.2	15.0	17.0	19.1	21.5	24.2	27.1	30.3	33.8	37.7
Total	11.5	12.7	14.0	15.4	16.9	18.5	20.1	21.9	23.8	25.8	28.0
Vehicle Type	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Crude oil Pipeline	4.5	5.2	6.0	6.9	7.9	9.0	10.1	11.5	12.9	14.5	16.2
Petroleum produc	30.5	35.9	42.0	48.8	56.4	65.0	74.6	85.3	97.4	110.8	125.8
Total	31.0	35.2	39.8	44.7	50.0	55.7	61.9	68.5	75.5	83.1	91.3

Table A6.21: Final Energy Demand for Bunkering (ktoe)

Vehicle Type	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Air	186.4	197.2	208.6	220.8	233.6	247.1	261.4	276.6	292.6	309.6	327.6
Marine	61.7	64.3	67.0	69.8	72.7	75.8	79.0	82.3	85.7	89.3	93.1
Total	248.1	261.5	275.6	290.5	306.3	322.9	340.4	358.9	378.4	398.9	420.6
Vehicle Type	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Air	204.8	218.7	233.6	249.5	266.4	284.6	303.9	324.6	346.6	370.2	395.4
Marine	66.0	69.2	72.6	76.1	79.9	83.8	87.9	92.2	96.7	101.4	106.4
Total	270.7	287.9	306.2	325.6	346.3	368.3	391.8	416.8	443.3	471.6	501.8

Annex 7 Electricity Demand Projection

Table A7.1: Final Electricity Demand (GWh)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Households	7,597.2	8,018.3	8,453.3	8,902.3	9,365.3	9,842.5	10,302.6	10,725.0	11,127.9	11,547.9	11,977.2
Services	3,948.2	4,255.1	4,577.0	4,914.7	5,269.1	5,641.0	6,031.3	6,441.0	6,870.9	7,322.1	7,795.8
Industry	5,038.6	5,347.8	5,668.2	6,000.9	6,346.1	6,704.7	7,094.2	7,498.6	7,919.0	8,356.4	8,811.7
Valco	1,930.8	1,929.3	1,927.7	1,926.2	1,924.6	1,923.0	1,921.5	1,919.9	1,918.4	1,916.8	1,915.3
Agriculture	13.9	15.1	16.4	17.7	19.0	20.4	21.8	23.2	24.7	26.2	27.7
Transport	13.3	15.1	17.1	19.3	21.8	24.5	27.5	30.7	34.3	38.2	42.6
Total	18,542.0	19,580.7	20,659.8	21,781.2	22,946.1	24,156.2	25,398.8	26,638.5	27,895.2	29,207.6	30,570.1
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Households	8,953.7	9,376.5	9,812.7	10,262.7	10,726.3	11,203.9	11,705.5	12,221.1	12,750.5	13,290.1	13,843.3
Services	5,193.0	5,720.5	6,287.9	6,898.5	7,555.3	8,262.0	9,022.2	9,840.0	10,719.6	11,665.6	12,683.0
Industry	5,772.4	6,186.4	6,617.6	7,560.7	8,177.9	10,937.8	11,933.5	12,952.9	14,298.6	15,671.2	17,072.6
Valco	1,930.8	2,572.4	3,212.9	3,210.3	3,207.7	3,205.1	3,202.5	3,199.9	3,197.3	3,194.7	3,192.1
Agriculture	50.6	62.6	75.3	88.7	102.8	117.6	133.1	149.3	166.2	183.8	202.1
Transport	70.5	82.8	137.0	198.3	267.6	345.4	432.8	530.8	655.5	778.7	933.3
Total	21,971.0	24,001.1	26,143.3	28,219.1	30,037.6	34,071.6	36,429.6	38,893.9	41,787.6	44,784.0	47,926.3

Table A7.2: Final Electricity Demand for Household Sector (GWh)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Metro Urban	2,949.0	3,082.7	3,219.9	3,360.6	3,504.9	3,652.6	3,789.6	3,929.6	4,072.5	4,248.6	4,429.3
Other Urban	2,883.9	3,032.3	3,185.7	3,344.2	3,507.9	3,676.9	3,828.4	3,984.1	4,143.9	4,308.0	4,476.4
Coastal	374.7	404.6	435.7	468.1	501.7	536.6	574.1	613.1	653.5	673.3	693.2
Forest	862.2	930.4	1,001.0	1,074.1	1,149.7	1,227.7	1,311.1	1,346.3	1,381.6	1,417.1	1,452.6
Savanna	527.4	568.4	611.0	655.3	701.1	748.6	799.4	852.0	876.4	900.9	925.6
Total	7,597.2	8,018.3	8,453.3	8,902.3	9,365.3	9,842.5	10,302.6	10,725.0	11,127.9	11,547.9	11,977.2
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Metro Urban	3,277.2	3,444.5	3,617.8	3,797.3	3,983.1	4,175.4	4,393.0	4,617.7	4,849.7	5,085.4	5,328.3
Other Urban	3,328.3	3,514.7	3,708.6	3,910.0	4,119.1	4,335.8	4,540.9	4,752.3	4,970.2	5,194.6	5,425.4
Coastal	526.5	544.9	563.5	582.2	601.1	620.0	641.5	663.3	685.4	707.6	730.0
Forest	1,112.3	1,140.5	1,168.4	1,196.1	1,223.4	1,250.2	1,281.6	1,312.9	1,344.0	1,374.7	1,405.1
Savanna	709.5	731.9	754.4	777.1	799.8	822.5	848.5	874.8	901.2	927.8	954.5
Total	8,953.7	9,376.5	9,812.7	10,262.7	10,726.3	11,203.9	11,705.5	12,221.1	12,750.5	13,290.1	13,843.3

Table A7.3: Final Electricity Demand for Service Sector (GWh)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Offices	370.2	386.4	403.3	420.8	439.1	458.0	477.7	498.2	519.5	541.7	564.6
Lodging	325.4	345.5	366.7	389.1	412.7	437.7	464.0	491.8	521.2	552.1	584.8
Health Facilities	371.9	396.2	421.9	449.2	478.2	508.9	541.5	576.1	612.7	651.5	692.7
Educational facili	837.4	908.3	983.2	1,062.4	1,146.1	1,234.4	1,327.7	1,426.0	1,529.7	1,639.0	1,754.2
Retail Facilities	947.7	1,048.5	1,155.5	1,269.1	1,389.4	1,517.0	1,652.2	1,795.3	1,946.8	2,107.1	2,276.6
Restaurants and	311.7	335.5	360.9	387.9	416.6	447.1	479.6	514.1	550.8	589.7	631.2
Others	133.9	131.7	129.5	127.3	125.1	122.8	120.6	118.4	116.2	114.0	111.7
Street lighting	650.0	703.0	756.0	809.0	862.0	915.0	968.0	1,021.0	1,074.0	1,127.0	1,180.0
Total	3,948.2	4,255.1	4,577.0	4,914.7	5,269.1	5,641.0	6,031.3	6,441.0	6,870.9	7,322.1	7,795.8

Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Offices	438.3	465.2	493.7	523.8	555.6	589.3	624.9	662.5	702.3	744.3	788.7
Lodging	532.9	588.3	649.1	715.8	788.8	868.8	956.4	1,052.3	1,157.2	1,271.9	1,397.3
Health Facilities	477.8	518.1	561.0	606.9	655.8	707.9	763.5	822.7	885.8	953.0	1,024.5
Educational facili	1,231.8	1,376.3	1,533.5	1,704.4	1,890.2	2,091.9	2,310.7	2,548.1	2,805.3	3,083.9	3,385.4
Retail Facilities	1,340.4	1,516.3	1,707.6	1,915.4	2,141.0	2,385.6	2,650.8	2,938.0	3,248.8	3,585.0	3,948.5
Restaurants and	352.5	383.3	416.4	451.8	489.9	530.6	574.3	621.1	671.2	724.9	782.3
Others	136.7	134.8	132.9	130.9	129.0	127.1	125.1	123.2	121.2	119.3	117.4
Street lighting	682.5	738.1	793.8	849.4	905.1	960.7	1,016.4	1,072.0	1,127.7	1,183.3	1,239.0
Total	5,193.0	5,720.5	6,287.9	6,898.5	7,555.3	8,262.0	9,022.2	9,840.0	10,719.6	11,665.6	12,683.0

Table A7.4: Final Electricity Demand for Industrial Sector excluding VALCo (GWh)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Water productio	458.7	487.1	515.4	543.6	571.6	599.5	627.3	655.0	682.6	710.0	737.4
Mining and Quar	2,548.5	2,674.7	2,807.0	2,946.1	3,091.9	3,244.6	3,404.6	3,572.2	3,747.9	3,931.8	4,124.6
Construction	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Manufacturing	2,030.4	2,185.0	2,344.8	2,510.2	2,681.7	2,859.6	3,061.2	3,270.4	3,487.6	3,713.5	3,948.7
Total	5,038.6	5,347.8	5,668.2	6,000.9	6,346.1	6,704.7	7,094.2	7,498.6	7,919.0	8,356.4	8,811.7
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Water productio	520.1	554.6	589.0	623.3	657.5	691.6	725.5	759.4	793.1	826.8	860.3
Mining and Quar	2,909.5	3,092.3	3,285.8	3,491.6	3,717.1	3,992.1	4,245.2	4,512.6	4,801.0	5,105.5	5,426.8
Construction	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2
Manufacturing	2,341.6	2,538.5	2,741.6	3,444.7	3,802.1	6,252.9	6,961.6	7,679.7	8,703.2	9,737.7	10,784.2
Total	5,772.4	6,186.4	6,617.6	7,560.7	8,177.9	10,937.8	11,933.5	12,952.9	14,298.6	15,671.2	17,072.6

Table A7.5: Final Electricity Demand for VALCo (GWh)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
VALCo	1,930.8	1,929.3	1,927.7	1,926.2	1,924.6	1,923.0	1,921.5	1,919.9	1,918.4	1,916.8	1,915.3
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
VALCo	1,930.8	2,572.4	3,212.9	3,210.3	3,207.7	3,205.1	3,202.5	3,199.9	3,197.3	3,194.7	3,192.1

Table A7.6: Final Electricity Demand for Agricultural Sector by subsector (GWh)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Irrigation	9.97	10.77	11.59	12.44	13.32	14.23	15.17	16.13	17.12	18.14	19.19
poultry farms	3.85	4.29	4.73	5.18	5.62	6.07	6.52	6.98	7.43	7.89	8.35
post harvest proc	0.08	0.09	0.09	0.10	0.10	0.11	0.12	0.12	0.13	0.13	0.14
Total	13.90	15.14	16.42	17.72	19.05	20.41	21.80	23.23	24.68	26.16	27.67
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Irrigation	45.54	56.92	68.99	81.77	95.25	109.42	124.29	139.85	156.11	173.06	190.70
poultry farms	4.97	5.58	6.19	6.81	7.42	8.05	8.67	9.30	9.93	10.56	11.20
post harvest proc	0.09	0.10	0.11	0.11	0.12	0.13	0.13	0.14	0.15	0.15	0.16
Total	50.60	62.60	75.29	88.69	102.79	117.59	133.09	149.29	166.18	183.77	202.05

Table A7.7: Final Electricity Demand for Transport Sector by freight (GWh)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Passenger	-	-	-	-	-	-	-	-	-	-	-
Freight	13.3	15.1	17.1	19.3	21.8	24.5	27.5	30.7	34.3	38.2	42.6
Total	13.3	15.1	17.1	19.3	21.8	24.5	27.5	30.7	34.3	38.2	42.6
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Passenger	35.5	41.7	89.0	142.6	203.3	271.5	348.1	434.0	545.3	653.4	791.3
Freight	35.0	41.1	48.0	55.7	64.3	73.9	84.7	96.8	110.3	125.3	142.0
Total	70.5	82.8	137.0	198.3	267.6	345.4	432.8	530.8	655.5	778.7	933.3

Annex 8 Petroleum Products Demand Projection

Table A8.1: Petroleum Products Demand (kTonnes)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gasoline	1,332.4	1,405.8	1,483.9	1,567.0	1,655.5	1,749.6	1,849.7	1,956.2	2,069.6	2,190.2	2,318.5
Jet Kerosene	209.0	221.9	235.6	250.1	265.5	281.8	299.1	317.5	337.0	357.7	379.7
Kerosene	2.9	2.2	1.7	1.2	0.8	0.5	0.2	0.1	0.1	0.1	0.1
Diesel	2,790.2	3,006.1	3,238.3	3,489.6	3,759.9	4,050.7	4,364.4	4,702.1	5,065.4	5,456.3	5,877.1
Residual Fuel Oil	104.1	110.8	117.6	124.4	131.1	137.8	146.7	155.5	164.3	173.1	181.9
LPG	313.0	330.8	349.2	368.2	387.8	408.1	429.2	450.3	471.9	493.8	516.2
Gasoline premix	79.3	86.3	93.9	102.2	111.3	121.1	131.7	143.3	155.8	169.4	184.2
Total	4,830.8	5,163.9	5,520.2	5,902.7	6,311.8	6,749.5	7,221.1	7,725.0	8,264.0	8,840.6	9,457.6
Natural Gas (MMS	2,497.7	2,682.5	2,881.0	3,094.2	3,323.2	3,569.1	3,833.2	4,116.9	4,421.6	4,748.7	5,100.2
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gasoline	1,332.2	1,413.3	1,489.0	1,569.1	1,653.5	1,742.6	1,836.6	1,935.7	2,036.4	2,146.5	2,258.1
Jet Kerosene	257.8	279.1	302.1	326.9	353.6	382.5	413.6	447.1	483.3	522.3	564.4
Kerosene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Diesel	3,126.0	3,420.1	3,740.4	4,090.8	4,479.3	5,085.3	5,581.7	6,120.2	6,731.5	7,393.7	8,111.5
Residual Fuel Oil	118.7	132.5	146.2	154.1	162.1	199.8	216.7	233.9	255.4	277.2	299.5
LPG	358.3	383.5	409.9	437.1	465.7	495.5	526.2	558.2	591.6	626.3	662.4
Gasoline premix	78.5	85.4	92.8	101.0	109.8	119.4	129.7	141.0	153.2	166.5	180.8
Total	5,271.6	5,713.9	6,180.5	6,679.1	7,224.0	8,025.1	8,704.6	9,436.2	10,251.4	11,132.5	12,076.6
Natural Gas (MMS	2,640.8	2,852.1	3,080.2	7,318.3	11,500.5	49,582.6	57,526.9	65,496.0	78,518.8	91,570.5	104,653.5

Table A8.2: LPG Demand by sectors (kTonnes)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Household	207.1	219.0	231.2	244.0	257.1	270.6	284.0	297.2	310.6	324.1	337.8
Urban	*184.4*	*193.8*	*203.6*	*213.7*	*224.0*	*234.8*	*245.1*	*255.8*	*266.7*	*278.0*	*289.5*
Rural	*22.7*	*25.1*	*27.7*	*30.3*	*33.0*	*35.9*	*38.9*	*41.4*	*43.9*	*46.1*	*48.3*
Industry	25.5	27.8	30.1	32.4	34.8	37.2	40.4	43.7	46.9	50.2	53.6
Manufacturing	*25.5*	*27.8*	*30.1*	*32.4*	*34.8*	*37.2*	*40.4*	*43.7*	*46.9*	*50.2*	*53.6*
VALCO	*0.9*	*0.9*	*0.9*	*0.9*	*0.9*	*0.9*	*0.9*	*0.9*	*0.9*	*0.9*	*0.9*
Services\Formal	20.3	22.2	24.3	26.5	28.9	31.5	34.2	37.2	40.3	43.7	47.4
Transport\Passenger	59.3	61.0	62.7	64.4	66.1	67.9	69.6	71.4	73.1	74.8	76.5
Total	312.1	329.9	348.3	367.3	386.9	407.2	428.3	449.5	471.0	492.9	515.3

Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Household	243.0	260.1	278.0	296.8	316.4	336.8	356.8	377.6	399.3	421.7	445.0
Urban	*213.0*	*227.7*	*243.2*	*259.5*	*276.6*	*294.6*	*312.0*	*330.1*	*348.9*	*368.6*	*389.1*
Rural	*30.0*	*32.4*	*34.8*	*37.3*	*39.7*	*42.2*	*44.9*	*47.6*	*50.3*	*53.1*	*55.9*
Industry	29.0	31.6	34.3	36.9	39.6	42.4	46.1	49.8	53.5	57.3	61.1
Manufacturing	*29.0*	*31.6*	*34.3*	*36.9*	*39.6*	*42.4*	*46.1*	*49.8*	*53.5*	*57.3*	*61.1*
VALCO	*0.9*	*1.2*	*1.5*	*1.5*	*1.5*	*1.5*	*1.5*	*1.5*	*1.5*	*1.5*	*1.5*
Services\Formal	25.8	28.8	32.0	35.6	39.5	43.8	48.5	53.6	59.2	65.2	71.8
Transport\Passenger	59.7	61.9	64.1	66.4	68.7	71.0	73.4	75.8	78.2	80.5	82.9
Total	357.5	382.4	408.4	435.7	464.2	494.0	524.8	556.8	590.1	624.8	660.9

Table A8.3: Diesel Demand by Sectors (kTonnes)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	98.3	107.2	117.0	127.7	139.3	152.1	166.0	181.3	197.9	216.2	236.2
Irrigation	*1.4*	*1.5*	*1.6*	*1.7*	*1.9*	*2.0*	*2.1*	*2.2*	*2.4*	*2.5*	*2.6*
poultry	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.1*	*0.1*	*0.1*
Land ploughing	*28.0*	*29.1*	*30.3*	*31.6*	*32.9*	*34.2*	*35.6*	*37.1*	*38.6*	*40.1*	*41.8*
Crop harvesting	*9.5*	*10.2*	*11.0*	*11.7*	*12.5*	*13.3*	*14.0*	*14.8*	*15.6*	*16.3*	*17.1*
Fishing	*59.3*	*66.3*	*74.0*	*82.6*	*92.1*	*102.6*	*114.2*	*127.1*	*141.4*	*157.2*	*174.6*
Industry	464.0	484.5	505.7	529.2	553.4	578.5	605.3	633.1	662.0	691.8	722.8
Mining and Quarrying	*351.7*	*367.6*	*384.1*	*402.6*	*421.7*	*441.4*	*461.7*	*482.8*	*504.5*	*527.0*	*550.3*
Construction	*74.9*	*75.4*	*76.0*	*76.5*	*77.0*	*77.6*	*78.1*	*78.6*	*79.2*	*79.7*	*80.2*
Manufacturing	*37.4*	*41.4*	*45.7*	*50.1*	*54.7*	*59.5*	*65.5*	*71.7*	*78.3*	*85.1*	*92.2*
VALCo	*2.3*	*2.3*	*2.3*	*2.3*	*2.3*	*2.3*	*2.3*	*2.3*	*2.3*	*2.3*	*2.3*
Transport	2,225.6	2,412.0	2,613.2	2,830.4	3,064.8	3,317.8	3,590.8	3,885.3	4,203.1	4,546.0	4,915.8
Passenger	*1,536.2*	*1,647.0*	*1,765.4*	*1,892.1*	*2,027.5*	*2,172.3*	*2,327.1*	*2,492.6*	*2,669.6*	*2,858.7*	*3,061.0*
Freight	*629.0*	*702.0*	*782.1*	*869.9*	*966.0*	*1,071.2*	*1,186.3*	*1,312.1*	*1,449.5*	*1,599.7*	*1,763.6*
Bunkering	*60.5*	*63.0*	*65.7*	*68.4*	*71.3*	*74.3*	*77.4*	*80.7*	*84.0*	*87.6*	*91.3*
Total	2,787.9	3,003.7	3,236.0	3,487.2	3,757.5	4,048.3	4,362.1	4,699.7	5,063.1	5,454.0	5,874.8

Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	111.3	122.5	134.5	147.6	161.7	177.0	193.7	211.8	231.6	253.1	276.7
Irrigation	*5.1*	*5.9*	*6.7*	*7.5*	*8.1*	*8.7*	*9.3*	*9.8*	*10.2*	*10.6*	*10.9*
poultry	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Land ploughing	*32.7*	*34.6*	*36.6*	*38.7*	*40.9*	*43.3*	*45.7*	*48.3*	*51.1*	*54.0*	*57.1*
Crop harvesting	*12.2*	*13.3*	*14.3*	*15.4*	*16.4*	*17.4*	*18.5*	*19.6*	*20.6*	*21.7*	*22.7*
Fishing	*61.2*	*68.6*	*76.9*	*86.0*	*96.2*	*107.5*	*120.1*	*134.0*	*149.5*	*166.7*	*185.8*
Industry	496.1	521.0	547.0	576.3	613.5	835.5	911.8	991.1	1,100.5	1,214.0	1,332.1
Mining and Quarrying	*374.2*	*393.4*	*413.4*	*436.5*	*467.2*	*525.8*	*558.4*	*592.0*	*631.1*	*671.3*	*712.6*
Construction	*79.3*	*80.3*	*81.3*	*82.2*	*83.2*	*84.2*	*85.2*	*86.1*	*87.1*	*88.1*	*89.1*
Manufacturing	*42.6*	*47.4*	*52.4*	*57.6*	*63.1*	*225.4*	*268.2*	*313.0*	*382.3*	*454.7*	*530.4*
VALCo	*2.3*	*3.1*	*3.9*	*3.9*	*3.9*	*3.9*	*3.9*	*3.9*	*3.9*	*3.9*	*3.9*
Transport	2,516.3	2,773.5	3,055.0	3,363.1	3,700.2	4,068.9	4,472.3	4,913.3	5,395.6	5,922.7	6,498.9
Passenger	*1,723.9*	*1,880.2*	*2,049.6*	*2,233.3*	*2,432.4*	*2,648.2*	*2,882.1*	*3,135.7*	*3,410.4*	*3,708.1*	*4,030.7*
Freight	*727.7*	*825.5*	*934.2*	*1,055.2*	*1,189.5*	*1,338.6*	*1,504.0*	*1,687.3*	*1,890.3*	*2,115.1*	*2,363.8*
Bunkering	*64.7*	*67.8*	*71.2*	*74.6*	*78.3*	*82.1*	*86.2*	*90.4*	*94.8*	*99.5*	*104.3*
Total	3,123.7	3,417.0	3,736.5	4,087.0	4,475.4	5,081.4	5,577.8	6,116.3	6,727.6	7,389.9	8,107.6

Table A8.4: Gasoline Demand (kTonnes)

Sector	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Transport/Passenger	1,332.4	1,405.8	1,483.9	1,567.0	1,655.5	1,749.6	1,849.7	1,956.2	2,069.6	2,190.2	2,318.5
Sector	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Transport/Passenger	1,332.2	1,413.3	1,489.0	1,569.1	1,653.5	1,742.6	1,836.6	1,935.7	2,036.4	2,146.5	2,258.1

Table A8.5: Premix Demand (kTonnes)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	79.2	86.3	93.9	102.2	111.3	121.1	131.7	143.3	155.8	169.4	184.2
Transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	79.3	86.3	93.9	102.2	111.3	121.1	131.7	143.3	155.8	169.4	184.2
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	78.5	85.4	92.8	101.0	109.8	119.3	129.7	141.0	153.2	166.5	180.8
Transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	78.5	85.4	92.8	101.0	109.8	119.4	129.7	141.0	153.2	166.5	180.8

Table A8.6: ATK Demand (kTonnes)

Sectors (Transport)	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Domestic Air	28.0	30.4	33.0	35.7	38.7	41.9	45.3	49.0	52.9	57.1	61.7
Bunkering Air	181.0	191.5	202.6	214.3	226.8	239.9	253.8	268.5	284.1	300.6	318.0
Total	209.0	221.9	235.6	250.1	265.5	281.8	299.1	317.5	337.0	357.7	379.7
Sectors (Transport)	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Domestic Air	59.0	66.8	75.3	84.7	95.0	106.2	118.5	132.0	146.7	162.9	180.5
Bunkering Air	198.8	212.3	226.8	242.2	258.7	276.3	295.0	315.1	336.5	359.4	383.9
Total	257.8	279.1	302.1	326.9	353.6	382.5	413.6	447.1	483.3	522.3	564.4

Table A8.7: Kerosene Demand (Tonnes)

Sectors (Household)	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Urban	61.6	61.7	61.6	61.5	61.3	61.0	60.4	59.7	58.8	57.9	56.8
Rural	2,793.7	2,182.6	1,635.6	1,156.0	746.8	411.0	151.5	46.0	13.6	13.3	13.0
Industry/Construction	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	2,855.4	2,244.4	1,697.4	1,217.6	808.2	472.1	212.0	105.8	72.5	71.3	69.9
Sectors (Household)	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Urban	61.9	62.0	62.1	62.0	61.8	61.5	60.8	60.0	59.0	57.9	56.7
Rural	14.6	14.3	14.0	13.7	13.3	12.9	12.6	12.2	11.8	11.4	11.0
Industry/Construction	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Total	79.1	79.0	78.7	78.3	77.7	77.0	76.0	74.8	73.4	71.9	70.3

Table A8.8: RFO Demand (kTonnes)

Sectors (Industry)	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Manufacturing	86.8	93.6	100.3	107.1	113.9	120.6	129.4	138.3	147.1	155.9	164.7
VALCO	17.3	17.3	17.3	17.3	17.2	17.2	17.2	17.2	17.2	17.2	17.2
Total	104.1	110.8	117.6	124.4	131.1	137.8	146.7	155.5	164.3	173.1	181.9
Sectors (Industry)	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Manufacturing	101.4	109.4	117.4	125.4	133.4	171.1	188.1	205.2	226.7	248.6	270.9
VALCO	17.3	23.0	28.8	28.8	28.7	28.7	28.7	28.7	28.6	28.6	28.6
Total	118.7	132.5	146.2	154.1	162.1	199.8	216.7	233.9	255.4	277.2	299.5

Table A8.9: Natural Gas Demand (MMSCF)

Sector	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Manufacturing	2,497.7	2,682.5	2,881.0	3,094.2	3,323.2	3,569.1	3,833.2	4,116.9	4,421.6	4,748.7	5,100.2
Sector	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Manufacturing	2,640.8	2,852.1	3,080.2	7,318.3	11,500.5	49,582.6	57,526.9	65,496.0	78,518.8	91,570.5	104,653.5

Annex 9 Woodfuel Demand Projection

Table A9.1: Woodfuel Demand (kTonnes)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Households	6,449.9	6,371.4	6,283.9	6,187.4	6,082.1	5,968.0	5,852.0	5,772.1	5,703.1	5,644.6	5,580.7
Services	209.2	210.2	210.9	211.3	211.3	211.0	210.4	209.5	208.2	206.5	204.4
Industry	1,292.5	1,336.9	1,381.7	1,426.9	1,472.4	1,518.3	1,560.9	1,603.6	1,646.4	1,689.2	1,732.0
Total	7,951.7	7,918.6	7,876.5	7,825.6	7,765.8	7,697.3	7,623.4	7,585.1	7,557.6	7,540.2	7,517.1
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Households	5,790.7	5,712.3	5,627.5	5,536.6	5,439.7	5,337.0	5,237.6	5,132.2	5,021.1	4,904.4	4,782.2
Services	269.9	277.5	284.8	291.8	298.4	304.5	310.2	315.5	320.1	324.2	327.6
Industry	1,296.0	1,341.5	1,387.5	1,434.1	1,481.2	1,528.7	1,570.2	1,611.7	1,653.3	1,694.9	1,736.5
Total	7,356.6	7,331.3	7,299.9	7,262.5	7,219.2	7,170.2	7,118.0	7,059.4	6,994.6	6,923.5	6,846.3

Table A9.2: Firewood Demand (kTonnes)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Household	5,458.4	5,358.1	5,249.7	5,133.2	5,008.8	4,876.6	4,746.1	4,652.5	4,570.3	4,497.9	4,420.7
Urban	*425.2*	*429.3*	*433.1*	*436.4*	*439.3*	*441.7*	*442.4*	*442.6*	*442.3*	*441.6*	*440.3*
Rural	*5,033.3*	*4,928.8*	*4,816.6*	*4,696.8*	*4,569.5*	*4,434.9*	*4,303.7*	*4,209.9*	*4,127.9*	*4,056.4*	*3,980.5*
Services	137.3	136.5	135.6	134.5	133.2	131.8	130.3	128.6	126.7	124.7	122.5
Industry	1,289.7	1,334.0	1,378.7	1,423.9	1,469.4	1,515.3	1,557.9	1,600.6	1,643.4	1,686.2	1,729.0
Total	6,885.4	6,828.6	6,764.0	6,691.5	6,611.4	6,523.7	6,434.3	6,381.7	6,340.4	6,308.9	6,272.3
Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Household	4,789.0	4,692.2	4,589.5	4,481.0	4,367.2	4,248.0	4,137.1	4,021.0	3,899.9	3,773.9	3,643.2
Urban	*423.3*	*427.5*	*431.2*	*434.4*	*437.2*	*439.5*	*439.9*	*439.8*	*439.2*	*438.2*	*436.7*
Rural	*4,365.7*	*4,264.7*	*4,158.3*	*4,046.6*	*3,930.0*	*3,808.5*	*3,697.2*	*3,581.2*	*3,460.7*	*3,335.7*	*3,206.5*
Services	184.9	189.0	192.9	196.6	200.1	203.4	206.4	209.1	211.6	213.7	215.4
Industry	1,293.1	1,338.6	1,384.6	1,431.1	1,478.2	1,525.6	1,567.1	1,608.7	1,650.3	1,691.9	1,733.5
Total	6,267.0	6,219.7	6,167.0	6,108.8	6,045.4	5,977.0	5,910.6	5,838.8	5,761.7	5,679.5	5,592.1

Table A9.3: Charcoal Demand by Sectors (kTonnes)

Sectors	Business as Usual										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Household	991.5	1,013.3	1,034.2	1,054.3	1,073.3	1,091.4	1,105.9	1,119.6	1,132.8	1,146.7	1,160.0
Urban	*851.4*	*869.9*	*888.2*	*906.3*	*924.2*	*941.9*	*956.5*	*970.7*	*984.6*	*998.2*	*1,011.3*
Rural	*140.1*	*143.4*	*146.1*	*148.0*	*149.1*	*149.5*	*149.5*	*148.8*	*148.2*	*148.5*	*148.7*
Services	72.0	73.7	75.4	76.8	78.1	79.2	80.1	80.9	81.4	81.7	81.8
Industry	2.9	2.9	2.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Total	1,066.3	1,090.0	1,112.6	1,134.1	1,154.4	1,173.6	1,189.1	1,203.4	1,217.2	1,231.4	1,244.8

Sectors	Accelerated Economic Growth										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Household	1,001.7	1,020.1	1,038.1	1,055.6	1,072.6	1,089.0	1,100.5	1,111.2	1,121.2	1,130.5	1,139.0
Urban	*859.2*	*877.2*	*894.9*	*912.2*	*929.1*	*945.6*	*956.6*	*967.0*	*976.7*	*985.8*	*994.2*
Rural	*142.5*	*142.9*	*143.2*	*143.4*	*143.5*	*143.4*	*143.9*	*144.2*	*144.5*	*144.7*	*144.8*
Services	85.0	88.5	91.9	95.2	98.2	101.1	103.8	106.3	108.6	110.5	112.2
Industry	2.9	2.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Total	1,089.6	1,111.6	1,133.0	1,153.7	1,173.8	1,193.2	1,207.3	1,220.6	1,232.8	1,244.1	1,254.2

Annex 10 Key Issues Raised by Stakeholders

Table A10.1: Residential Sector

ISSUES/CONCERNS RAISED BY PARTICIPANTS	SUGGESTED RECOMMENDATION BY PARTICIPANTS
Electricity billing of compound houses has still not been resolved fully by the electricity tariff structure as of 2016 since it first cropped up in the 1990s, even though raised in SNEP1. The issue of sharing metering facilities invariably cause the units consumed by compound house class of customers who largely happen to be in the poorer and low-income group to move up into the high tariff brackets of the existing progressive tariff structure; i.e. most of them are transferred above the 50 unit price margins into relatively expensive tariff blocks. Thus communal use of meters increases electricity bills of users, particularly for the poor mainly due to the prevailing electricity tariff structure. 1. The challenge is how to make the internal systems in compound houses more equitable to electricity consumers. Universal electrification by 2020 is not practically achievable without distributed or decentralised systems like mini-grids for hard-to-reach off-grid communities. 2. The challenge, however, has been providing such communities with high or grid-quality electricity in order to ensure equity in electricity distribution. 3. There has also been inadequate coordination among utility and physical planning agencies culminating in uneven distribution of power networks in general.	1. The utilities make available and accessible more meters to all consumers in compound houses. 2. Since compound house dwellers are generally familiar with the 'point' system, the utilities and PURC could share with the consumers, information on the advantages of own meter. 3. Utilities could experiment with voltage or current limiters in compound houses since they are less expensive than meters. 4. Continue the extension of the national grid to all communities where appropriate but provide grid-quality decentralised or mini-grid systems in off-grid large populated communities using decentralised systems such as solar, wind or biomass-to-power plants, whichever is applicable. 5. Consider providing off-grid communal facilities like schools, health centres with mini-grid systems.

Table A10.2: Services Sector

SUB-SECTOR	ISSUES/CONCERNS RAISED BY PARTICIPANTS	SUGGESTED RECOMMENDATION BY PARTICIPANTS
Educational Services	1. Erratic supply of power. 2. High cost of power. 3. Inadequate educational and institutional capacity for skills development among the youth specifically students in the energy sector. 4. Weak enforcement of regulation by regulatory institutions.	1. Ensure efficient and cheap sources of energy supply to second and third cycle public institutions. For example the use of biogas 2. Intensive public education and awareness creation campaigns especially at the grass-root level 3. Training in fields of energy development and allocation of resources in research and development. 4. Ensure independence of regulatory institutions and build their capacities to perform. 5. Establishment of energy court to fast track prosecution.
Tailors & Dressmakers	Lack of effective engagement between the Energy Commission and the public.	1. More engagement between the Commission and the general public. 2. Commission should link up with National Commission for Civic Education (NCCE) for greater and effective dissemination of their mandate to the grassroots.
Health Services	1. Unreliable and poor quality of electricity supply. 2. High cost of power.	1. Invest in energy efficient medical devices, technology and equipment. 2. Explore alternate sources of energy for health facilities. 3. Replace obsolete medical devices/equipment which consume more energy. 4. Ensure that all medical equipment donated to medical facilities meet standards.

Hotels & Guest Houses	1. Lack of effective and efficient communication system between the Energy Commission and the public. 2. High cost of power.	1. Energy Commission should enhance its communication and information dissemination. 2. Hotels should be encouraged to install solar panels on their roofs to feed into the grid in order to benefit from net metering. 3. Encourage the use of solar panels in households thereby saving energy for the productive sectors of the economy 4. Licensing programmes of all electricians should include educating their clients on the benefit of using efficient energy appliances.
Others	1. Need to decentralize Energy Commission's operations. 2. Lack of cooperation and collaboration among relevant institutions and agencies. 3. Unreliable power supply. 4. High cost of power. 5. Use of old and inefficient electrical appliances and motors due to very high cost of replacement. 6. Weak enforcement of laws banning the importation of secondhand refrigerators.	1. Decentralize operations of the Commission 2. Increase cooperation and collaboration between relevant institutions and agencies. 3. Energy efficiency appliance compliance should be mandatory for government institutions and offices. 4. Introduce standards in the energy industry are commendable. 5. Enhance promotion of energy conservation programmes. 6. Use alternate energy sources e.g. biogas, wind and solar. 7. Improve on effective communication and education to all stakeholders especially the Services sector to be abreast with current trends in energy-related issues. 8. Educate consumers on ways to reduce reactive power from their system through the use of power factor corrective equipment. 9. Involve the private sector on the need to ensure efficient use of energy. 10. Set up regular monitoring and evaluation measures. 11. Strictly enforce laws banning the importation of secondhand refrigerators.

Table A10.3: Transport Sector

SUB-SECTOR	ISSUES/CONCERNS RAISED BY PARTICIPANTS	SUGGESTED RECOMMENDATION BY PARTICIPANTS
Railway	1. Diminishing share in both passenger and freight traffic. 2. Narrow gauge of 1,067 mm limits the speed to 56 km/hr, increases travel time and therefore passenger and freight traffic per unit of fuel consumed per km travelled. 3. Limited axle load of 16 tonnes also limits passenger and freight traffic per unit of fuel consumed per km travelled. 4. Limited or lack of sub-urban railway services from Accra to Tema. Takoradi to Sekondi and Kumasi to Ejisu thus putting pressure on road for urban passenger transport. 5. Eastern rail line of the network out of service e.g. Jema to Kumasi via Boankra thus putting pressure on road for freight traffic. 6. Poor state of the Western rail line from Takoradi to Kumasi and from Dunkwa to Awaso, thus putting pressure on road for freight traffic e.g. freight of bauxite and manganese to the port. 7. Current locomotives are old with poor fuel economy, hence there is higher fuel consumption in rail travel. 8. Obsolete signal and telecommunication system hence, frequent stops and thus long travel time and less patronage.	1. Revamp the railway system to increase the railway share in both passenger and freight traffic thereby reduce the pressure on the road. 2. Convert the current gauge of 1067 mm to 1435 mm thereby increase the speed from 56 km/h to 120 – 160 km/h, which will decrease travel time, increase passenger and freight traffic per unit of fuel consumed per km travelled. 3. Increase the axle load from 16 tonnes to 21 – 25 tonnes thereby increase the passenger and freight traffic per unit of fuel consumed per km travelled. 4. Revamp sub-urban railway services from Accra to Tema. Takoradi to Sekondi and Kumasi to Ejisu thus relieving the pressure of urban passenger transport by road. 5. Re-develop Eastern line railway service e.g. Jema to Kumasi via Boankra to relief the pressure on road due to freight traffic. 6. Re-develop Western line railway service from Takoradi to Kumasi and from Dunkwa to Awaso, to relieve the pressure on road due to freight traffic e.g. freight of bauxite and manganese to the port. 7. Government to acquire new locomotives with improved fuel economy, hence reduce fuel consumption in rail travel. 8. Install modern signal and telecommunication system hence, minimize stops and thus reduce travel time and increase patronage of rail services. 9. Ensure sustainable supply of electricity for operation of energy-efficient electric trains in the future.
Domestic Air	Limited domestic aviation infrastructure to match the expanding domestic aviation industry.	Upgrade and modernize domestic aviation infrastructure to match the expanding domestic aviation industry.

Road	1. Absence of an efficient and effective intra-city transport system. 2. High proportion of low fuel economy mini-buses in the intra-city transport system. 3. Poor road infrastructure, hence poor vehicle fuel economy. 4. Increasing traffic congestion on country roads especially on roads in Central Business District (CBD) in large urban centres. 5. Limited transport fuel options (only petrol, diesel and LPG). 6. Over-aged vehicles with poor fuel economy on our roads. 7. Increasing vehicular emissions on the country's major roads. 8. No vehicle fuel labelling in the country to check emissions into the atmosphere. 9. Lack of data on conversion of vehicle fuel systems to use LPG. 10. No data on vehicles according to fuel systems e.g. how many cars use petrol, diesel or LPG in the country. 11. Limited access roads are a constraint to traffic flow. 12. Poor traffic management adversely affecting fuel consumption. 13. High import tax on new cars compared to old and over-aged vehicles.	1. Operate an efficient and effective intra-city transport system. (light rail/tram, rail, BRT) 2. Promote high capacity buses and Bus Rapid Transit (BRT) system with high fuel economy in the intra-city transport system. 3. Upgrade road infrastructure thereby improve vehicle fuel economy. 4. Limit the traffic congestion on country roads by revamping the railway system, promoting high capacity buses and limiting the number of vehicles especially on roads in Central Business District in large urban centres. 5. Promote the alternative transport fuel options to include biofuels, LNG and CNG. 6. Promote the gradual removal of over-aged vehicles with poor fuel economy from the country's stock of vehicles. 7. DVLA should standardise and monitor vehicular emissions to improve air quality. 8. Improve access roads to allow easy flow of traffic. 9. Ensure effective and efficient ticketing to enhance the patronage of Metro Mass Transport. 10. Vehicles should be taxed according to their energy efficiency. 11. Allow only buses to operate in the city centres. 12. Need to label vehicles during registration to know their emissions levels.
Inland Lake	Lake transport hampered by tree stumps in the lake, which serves as a breeding ground for fingerlings and fish traps.	More stakeholder consultation with the fishing communities and the transport operators.
Marine	Marine transport from Tema to Takoradi in the past declined due to seasickness	Revamp marine transport from Tema to Accra, to Cape Coast, and to Takoradi.

Table A10.4: Industrial Sector

ACTIVITY/SUBSECTOR	ISSUES/CONCERNS RAISED BY PARTICIPANTS	SUGGESTED RECOMMENDATION BY PARTICIPANTS
Production/ Generation	1. Lack of guaranteed sources of fuel supply for power generation at competitive prices. 2. Poor quality of electricity supply. 3. Over-dependence on hydropower generation supply.	1. Government ensures that environmentally friendly and efficient models are considered in the generation mix. 2. Government must guarantee sources of supply of fuel at competitive prices for electricity generation. 3. Coal generation must be seriously considered in the power generation mix due to its low power generation cost. 4. Serious consideration must be given to solar, wind and nuclear generation to augment electricity production. 5. The Commission should coordinate the LNG project to guarantee adequate quantities of gas to sustain the power generation. 6. Encourage private sector or IPPs to enter the power investment market to help augment the existing power supply. 7. Assist SMEs also to invest in Renewables to partly meet their energy requirements.
Transmission & Distribution	High losses in electricity distribution.	1. Distribution companies must work hard to reduce their distribution losses. 2. Introduce DC grid system to the existing AC grid network to reduce conversion losses. 3. ECG and NEDco must ensure that electric pole metering policy should also include the industrial sector. 4. The utilities must include surveillance cameras as part of their security system to reduce theft and sabotage. 5. Distribution companies must ensure that industries caught by-passing the metering system are severely sanctioned to serve as a deterrent to others.

		6. Government must ensure that before new communities are connected to the grid, the backbone of the supply (sub transmission and primary substation) can support the demand or the extension.
Energy Efficiency	1. Use of energy inefficient technologies in industries. 2. Lack of research into more energy-efficient technologies.	1. Government should use part of the energy fund to support industries to adopt energy-efficient technologies. 2. Need to sensitize domestic consumers on the need to conserve energy and undertake energy efficiency measures. 3. The Energy Commission should conduct research into technologies that are more efficient especially to SMEs to make them efficient and competitive. The Commission in collaboration with relevant institutions such as the National Board for Small-Scale Industries should intensify the campaign on the productive uses of electricity.
Energy Use and Pricing	1. Unfair electricity pricing policy. 2. Subsidization of residential electricity use by industry. 3. Lack of technological knowhow hindering the transition from the use of solid fuels to the use of modern and safer energy services	1. Government must eliminate cross-subsidization of tariffs by industry to residential customers. 2. Government must ensure that electricity is sold at the same price to all bulk customers whether embedded in ECG network or not. 3. Electricity supply should be priced at the prevailing market rate taking into consideration the contribution of industry to the economy. 4. PURC must insist on the application of the automatic price adjustment formula in order to avoid crisis. 5. Government should provide subsidies used to support lifeline domestic consumers. 6. Conduct research to determine all factors affecting the transition from the use of solid fuels to the use of more modern fuels.

Regulation, Monitoring & Evaluation, Stakeholder Consultation & Collaboration	1. Lack of coordination and enforcement of standards in the energy sector. 2. Lack of monitoring and evaluation of programmes and policies recommended in SNEP1. 3. Lack of collaboration and consultation among stakeholder institutions.	1. The relevant authorities meet with stakeholders to enforce standards. 2. Monitoring role of Energy Commission and other concerned regulators must be enhanced. 3. Energy Commission must evaluate policies and programmes recommended in SNEP1. 4. Involve IPPs in resolution of conflicts. 5. The Commission should organize regular consultations with the Association of Ghana Industries (AGI). 6. Energy Commission must work in close coordination with NDPC to ensure that SNEP fits into the National Development framework.

Table A10.5: Agriculture and Fisheries Sector

ACTIVITY/SUBSECTOR	ISSUES/CONCERNS RAISED BY PARTICIPANTS	SUGGESTED RECOMMENDATION BY PARTICIPANTS
Irrigation	1. High tariffs faced by farmers who use electricity pumps. 2. Low patronage of irrigation schemes due to high cost of operation. 3. Non-use of public electricity based irrigation schemes because of high electricity cost.	1. Replace diesel-driven pumps with solar pumps. 2. Give concessionary tariffs to electric pump irrigation scheme farmers to reduce cost of production and increase income. 3. Build mini – hydro dams with priority concession of generated power given to irrigation. 4. Irrigation on river banks with wind pumps and solar energy driven equipment.
Livestock	1. High electricity tariffs for meat processing, milk processing and prodding for poultry. 2. Lack of collaboration between Energy Commission and Ministry of Food and Agriculture. 3. No or Low investment in other alternative sources of energy like electricity production from feed waste or animal dropping.	1. Subsidize electricity for the livestock subsector especially for poultry. 2. Energy Commission should collaborate with the Ministry of food and Agriculture in conducting research on the use of waste for energy production. 3. Production of manual heating system from traditional sources. 4. Mapping of where to find waste in large quantities in the country in order to be able to attract investors to the potential of that industry.
Crops	1. High cost of fuel for agriculture mechanization. 2. High cost of electricity tariffs for post-harvest processing of crops. 3. Environmental issues in planting jatropha.	1. Develop special tariff for the Agricultural Sector. 2. Agriculture customers should not pay for the residential sector. 3. Environmental impact assessment (EIA) should be conducted before planting jatropha.
Energy Efficiency	Energy inefficient mechanization of the sector.	1. Replacement of energy inefficient equipment with energy-efficient ones. 2. Propose in-house energy efficiency management system, i.e. procurement, replacement, maintenance, load management, demand reduction and power factor improvement.

Fishing	1. Diverting of premix fuel by fishermen to other economic activities at higher prices. 2. High electricity tariff for aquaculture hatcheries. 3. Inefficient fish smoking methods.	1. Remove subsidies on premix to reduce the abuse by greedy fishermen. 2. Subsidize electricity for aquaculture production especially hatching fingerlings. 3. Promote solar drying of fish. 4. Promote more efficient fish smoking methods. 5. Promote the use of LPG for fish smoking.
Forestry	1. Apparent little collaboration between the Forestry Commission and Energy Commission. 2. Depletion of forest cover for woodfuel 3. Land tenure system preventing forest plantation	1. There is a need for more collaboration between the Energy Commission and the Forestry Commission. 2. Rejuvenation of depleted woodfuel plantations. 3. Promote the establishment of woodfuel plantations. 4. Planting of fast-growing woodfuel species should be encouraged. 5. Favourable land tenure system to attract investors
General comments	High electricity prices.	1. Restructure the electricity tariffs for non-residential sector which discourages electricity use for productive activities 2. The tariff reduction or subsidization should be looked at holistically. Economic sectors should not pay for subsidies in the residential sector. 3. Cheaper sources of fuel, such as coal, should be considered in electricity production. 4. Development of more mini-hydro to serve the agriculture sector. 5. Pilot schemes should be initiated to assess the viability of waste to energy in the agriculture sector.

Annex 11 Key Drivers and Assumptions for the Energy Demand Projections

Key Drivers of Future Demand for Energy

The key factors that would drive the country's future demand for energy are:

(i) demographic;
(ii) macro-economic; and
(iii) government policies and interventions.

A summary of these factors are presented in Tables 3.1, 3.2 and 3.3.

Table A11.1: Demographic Factors driving Final Energy Demand

Demographic Factors	Unit	Base Year_2010	BaU Scenario_2030	AEG Scenario_2030
Total Population	million	24.7	38	37.4
Population Growth rate (2010-2030)	%	n.a	2.17	2.09
Urbanization Rate	%	50.9	65	65.98
Household Sizes	1	4.4	3.94	3.8
Total Number of Households	million	5.58	9.73	9.65

Table A11.2: Macro-economic Factors driving Final Energy Demand

Macro-economic Factors	Unit	Base Year_2010	BaU Scenario_2030	AEG Scenario_2030
Total GDP	million US$	32.19	126.9	158.6
GDP Growth rate (2010-2030)	%	n.a	7.1	8.3
GDP per capita	US$	1,305	3,341	4,243
GDP per capita growth rate	%	n.a	3.8	4.8

Note: GDP/cap in 2020 for BaU and AEG scenarios are US$ 1,439 and US$ 3,009

Table A11.3: Government Policy driving Final Energy Demand

Government Policy	Unit	Base Year_2010	BaU Scenario_2030	AEG Scenario_2030
Efficient Lightening Programme				
Urban CFL Penetration	%	100	62.6	43.1
Urban LED Penetration	%	0	36.4	55.5
Rural CFL Penetration	%	100	87	80.3
Rural LED Penetration	%	0	13	19.7
Refrigerator Rebate Scheme				
Standard Refrigerators	%	99.95	0	0
Efficient Refrigerators	%	0.05	100	100
Fuel Substitution				
Household Electrification Rate	%	64.3	100	100
LPG Penetration	%	18.2	38.9	100
Transport Fuel Reduction				
BRT	%	0	10	20

Note: 1 – 100% household electrification rate is achieved from 2025 under the BaU scenario;
Note: 2 – 100% household electrification rate is achieved in 2020 under the AEG scenario;

Drivers and Assumptions for the Energy Demand by Sectors

The drivers of the final energy demand by sectors are:

- activity levels and energy use intensity of the sector;
- demographic factors such as population, shares of urban and rural population, urban and rural household sizes;
- economic factors such as structure of the economy (i.e. shares of industry, services and agriculture in total GDP) and personal disposable income; and
- Government policies such as the National Electrification Scheme and the promotion of productive use of electricity and energy efficiency programmes as well as specific industrial and agricultural interventions.

Household Sector Energy Demand

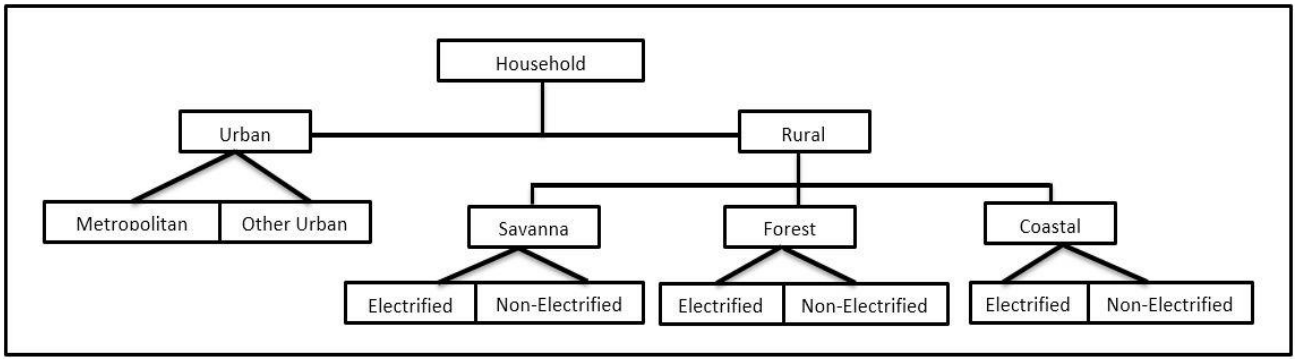


Figure A11.1: Classification of Household Sector

The household sector is classified into urban and rural households. The urban households are further classified into Metro-urban and Other-urban households whilst the rural households are classified according to the following ecological zones: Savannah, Forest and Coastal. The rural households in each ecological zone are further classified into households connected to electricity grid and those not connected to the electricity grid. These classifications are done to obtain homogenous patterns for household energy use, which would contribute to the realistic evaluation of the final energy demand for the various households.

The drivers of the final energy demand of the households are mainly the number of households and the intensity of the household's energy usage. The number of households is influenced by demographic factors such as population, urban and rural share of the population as well as urban and rural household sizes. Economic factors such as personal disposable income levels also influence the acquisition of energy consuming appliances as well as the intensity of their usage. Government policies and programmes on energy efficiency also influence the intensity of the household energy use. These policies and programmes include:

- promotion, acquisition and use of energy-efficient appliances such as LED lamps and energy-efficient refrigerators and efficient/improved woodfuel cookstoves;
- increase use of electricity through the National Electrification Scheme;
- increase use of LPG to achieve the 50% penetration of LPG use in households by 2030; and
- Promotion and adoption of 2 million improved[72] woodfuel stoves by 2030.

[72] Woodfield stove with thermal efficiency of at least 20% is considered to be improved/efficient stove with corresponding saving of not using traditional woodfuel stoves to be estimated to be at least 10%.

The drivers and assumptions for the final energy demand for households for the BaU and AEG scenarios are presented in Table 3.4.

Table A11.4: Demographic Factors driving Energy Demand for Households

Demographic Factors	Unit	Base Year_2010	BaU Scenario_2030	AEG Scenario_2030
Total Number of Households	million	5.68	9.73	9.65
Share of urban Households	%	50.9	67.59	68.9
Household size	1	4.4	3.94	3.8
Household Electrification rate	%	64.2	100	100
Penetration of LED lamps in Households	%	0	28.9	44.4
Penetration of Efficient Households Refrigerators	%	0.1	100	100
Penetration of Household LPG use	%	18.2	38.9	46.8

Tables 3.5 and Table 3.6 present the drivers and assumptions for final energy demand for urban and rural households respectively.

Table A11.5: Main Driving Factors and Assumptions for Energy Demand by Urban Household

Demographic Factors	Unit	Base Year_2010	BaU Scenario_2030	AEG Scenario_2030
Total Number of Households	million	3.1	6.5	6.6
Share of Metro urban Households	%	41.97	44	44.8
Household size	1	4.04	3.42	3.38
Urban household Electrification rate	%	83.8	100	100
Penetration of LED lamps in Urban households	%	0	36.4	55.5
Penetration of Efficient Refrigerators in Urban Households	%	0.5	100	100
Penetration of Household LPG use in Urban Households	%	59.9	53.2	60.5

Table A11.6: Main Driving Factors of the Energy Demand by Rural Household Subsector

Demographic Factors	Unit	Base Year_2010	BaU Scenario_2030	AEG Scenario_2030
Total Number of Rural Households	million	2.4	3.2	3
Rural Household size	1	4.93	4.17	4.09
Share of Rural Households	%	43.88	32.4	31.1
Share of Coastal Rural Households	%	21.5	22.8	24.3
Share of Forest Rural Households	%	48.3	46.4	44.4
Share of Savannah Rural Households	%	30.2	30.7	31.3
Rural Household Electrification rate	%	35.8	97.6	100
Penetration of LED lamps in Rural Households	%	0	13	19.7
Penetration of Efficient Refrigerators in Rural Households	%	0	100	100
Penetration of LPG use in Rural Households	%	4.2	9.1	16.4

Services Sector Energy Demand

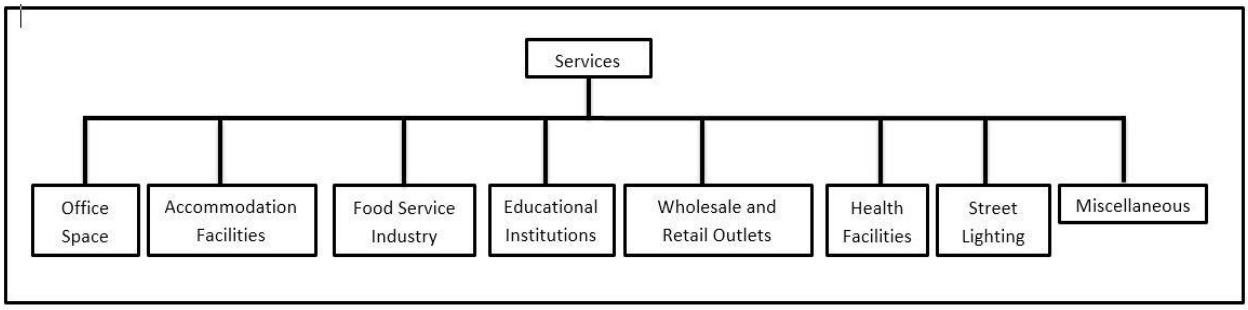


Figure A11.2: Classification of Service Sector

The Services Sector final energy demand was projected by classifying the formal service sector into the following sub-sectors: office space/buildings; accommodation facilities; health facilities; educational institutions; retail facilities; restaurants & eateries; street lighting and miscellaneous (see Figure 3.2).

The main drivers for the final energy demand for the service sector are:

(i) number of buildings;
(ii) service sector GDP;
(iii) Government policies and programmes; and
(iv) energy use intensity.

The total number of buildings is influenced by demographic factors such as population and employment in the service sector. Economic factors such as GDP for the service sector, which is projected to increase at an average annual rate of 7.1% for the BaU scenario and 8.3% for the AEG

scenario would drive energy demand in the sector. Personal disposable income would influence the demand for consumer goods and the penetration of energy use appliances as well as the energy use intensity in the service sector. The intensity of energy use in the service sector is also influenced by Government policies or programmes on energy efficiency.

Final Energy Demand in Office Buildings

Assumptions that guided the assessment of the final energy demand for office buildings include the following:

(i) public offices are projected to account for 19% of the total number of office buildings in 2030;
(ii) penetration of energy-efficient end-use technologies such as LED lamps for office lighting; air conditioning appliances and other office equipment (on electrical appliances efficiency standard and labelling programme and energy-efficient office building codes) would decrease the intensity of energy use in office buildings by 10% in 2030; and
(iii) implementation of public awareness campaigns.

Final Energy Demand for Accommodation Facilities

Assumptions that guided the evaluation of final energy demand of accommodation facilities include the following:

(i) Hotel subsector is projected to account for 19% of the total number of accommodation facilities in 2030 for the BaU scenario and 31% for the AEG scenario;
(ii) modern multi-storey concrete and glass hotel buildings with central elevators;
(iii) increased penetration of energy-efficient end-use technologies such as LED lamps for lighting, and the implementation of energy-efficient hotel building codes; and
(iv) public awareness campaign and electrical appliances efficiency standard and labelling programme would decrease the accommodation facilities' energy use intensity by 10% in 2030.

Final Energy Demand for Health Facilities

The assumptions that guided the assessment of the final energy demand of health facilities include:

(i) an annual growth rate of the total number of health facilities of about 4.0% is projected for both scenarios. The seemingly low rate for the AEG scenario is on account of a lower population growth rate;

(ii) hospitals would account for 16% of the total number of health facilities in 2030 for the BaU scenario and 30% for the AEG scenario; and
(iii) energy efficient end-use technologies such as LED lamps and implementation of energy-efficient building codes would reduce energy use intensity by 10% in 2030.

Final Energy Demand for Educational Institutions

The total number of educational institutions is influenced by the total population of school-going age (5–24 years), which creates the demand for educational institutions. Assumptions that guided the evaluation of final energy demand of educational institutions are as follows:

(i) an annual growth rate of educational institutions of 2.7% is projected to persist over the planning period for the BaU scenario and would be 4.9% for the AEG scenario on account of a lower population growth rate;
(ii) share of tertiary educational institutions is projected to increase from 0.2% of the total number of educational institutions in 2010 to about 1.1% in 2030;
(iii) share of high school educational institutions is projected to increase from 1.5% of the total number of educational institutions in 2010 to 1.8% in 2030;
(iv) share of basic school institutions is projected to decrease from 97.6% of the total number of educational institutions in 2010 to 96.0% in 2030;
(v) increased penetration of electrical appliances and other electrical educational equipment e.g. computers in educational institutions; and
(vi) increased penetration of energy-efficient end-use technologies such as LED lamps for lighting, implementation of energy-efficient educational building code, public awareness campaign and electrical appliances efficiency standard and labelling programme would decrease the intensity of energy use in educational buildings by 10% in 2030.

Final Energy Demand for the Wholesale and Retail Industry

The main assumptions that guided the evaluation of the final energy demand for the wholesale and retail industry include:

(i) number of wholesale and retail establishments is projected to be driven by the annual average GDP growth rate of 6.7% for the BaU scenario and 8.7% for the AEG scenario;
(ii) penetration of electrical appliances and other electrical equipment such as central air-conditioning and energy-efficient end-use technologies such as efficient refrigerator, LED lamps for lighting is projected to increase in wholesale and retail shops, shopping malls and supermarkets; and

(iii) implementation of energy-efficient wholesale and retail facilities building code, public awareness campaigns and electrical appliance efficiency standard and labelling programme would decrease the energy use intensity of wholesale and retail facilities by 10% in 2030.

Final Energy Demand for the Food Service Industry

Assumptions that guided the evaluation of final energy demand for the food service industry include:

(i) number of foodservice industry establishments is projected to be driven by the increase in the per capita income from US$ 1,305 in 2010 to US$ 3,341 in 2030 for the BaU scenario and US$ 4,243 in 2030 for the AEG scenario;
(ii) air conditioning appliances and other electrical equipment; and
(iii) increased penetration of energy-efficient end-use technologies such as efficient refrigerating appliances and LED lamps for lighting, implementation of energy-efficient food service building codes, public awareness campaigns and electrical appliance efficiency standard and labelling programme would decrease the energy intensity of the foodservice industry by 10% in 2030.

Final Energy Demand for Street Lighting

The main assumptions that guided the evaluation of the final energy demand for street-lights include the following:

(i) total number of street-lighting fixtures is driven by the projected increase in the urban population from 12.6 million in 2010 to 30 million in 2030 for the BaU scenario and to 37.4 million in 2030 for the AEG scenario and the rate of extension of the grid;
(ii) number of street-lighting facilities has been projected to increase from 200,780 in 2010 at an annual rate of 7.8% to about 694,000 in 2030 for the BaU scenario and at an average annual rate of 8.04% to 1,008,000 for AEG scenario; and
(iii) penetration of energy-efficient street-lighting devices such as LED lamps is projected to decrease the energy intensity of prevailing street-lighting by 15%.

Final Energy Demand for Miscellaneous Services

Miscellaneous services include all others not captured such as religious establishments and public advertisements. The final energy demand for the miscellaneous sub-sector is driven by factors such as population, urbanization and labour force in the informal sector, lighting technology as well as their corresponding energy use intensity. Economic factors such as disposable personal income levels also influence miscellaneous activities and energy use intensity. The energy use intensity of miscellaneous

activities is also influenced by Government policies and programmes on energy efficiency to promote the use of energy-efficient end-use technologies and energy prices.

Industrial Sector Energy Demand

The country's industrial sector is classified mainly into manufacturing, construction, mining & quarrying and water production. The mining and quarrying sub-sector was further classified into gold mining, manganese mining, bauxite mining, diamond mining, quarrying and salt mining (*see Figure 3.3*).

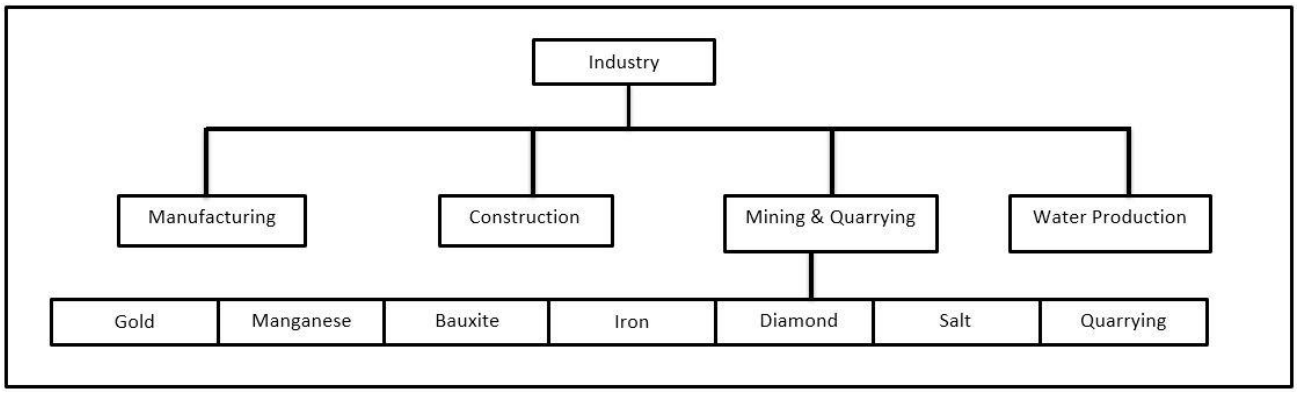


Figure A11.3: Classification of Industrial Sector

The main drivers of the final energy demand for industries are the industrial output and the industrial energy use intensity. The industrial output is influenced by population, which creates the market for industrial consumer goods. Economic factors such as the increasing personal disposable income levels also drive the demand for industrial consumer goods and influences the industrial energy use intensity. The industrial energy use is also influenced by Government policies and programmes and energy efficiency which promotes the acquisition of energy-efficient industrial equipment.

The main assumptions that guided the evaluation of the final energy demand of the industrial sector include:

(i) industrial sector GDP or output is projected to increase at an average annual rate of 8.9% over the planning period for the BaU scenario and 10.4% for the AEG scenario to achieve GDP per capita of US$ 3,000 by 2020;
(ii) manufacturing sub-sectors such as food and beverages, rubber and plastics, iron and steel, cement, electrical appliances and machinery, wood-processing would drive industrial growth rate;
(iii) construction industry would grow at a high rate to meet the shortfall in demand for housing units and expand infrastructure to ensure sustainable economic growth;

(iv) water production and supply would grow at a very high rate to meet the demand gap in future industrial and urban water demand; and
(v) increased penetration of energy-efficient end-use technologies such as energy efficient electric motors and drives, LED lamps for industrial lighting, public awareness campaigns and electrical appliance efficiency standard and labelling; would decrease the industrial energy use intensity by 10% in 2030.

Final Energy Demand for Water Production and Pumping

Assumptions that guided the evaluation of the final energy demand for water production and pumping (supply) are as follows;

(i) projected increase in urban households from 3.1 million in 2010 to 6.6 million in 2030 for the BaU scenario and 6.62 million in 2030 for the AEG scenario;
(ii) projected increase in urban water coverage from 62.7% in 2010 to 87% for the BaU scenario and 90% for the AEG scenario in 2030;
(iii) projected increase in the per capita water production from 10 m^3 in 2010 to 30 m^3 for the BaU scenario and 45 m^3 for the AEG scenario; and
(iv) improved pumping technologies and adoption of energy efficient practices for water production and supply is projected to decrease the energy intensity for water production and supply by 10% in 2030.

Final Energy Demand for the Mining and Quarrying Sector

Assumptions that guided the evaluation of the final energy demand for the mining and quarrying sub-sector include:

(i) Completion and operation of the Precious Minerals Marketing Company's Osagyefo Gold Refinery, and any other is projected to increase gold production and value addition;
(ii) Integrated Bauxite and Aluminium industries, and Integrated Iron Industry; and
(iii) Government policy to meet the country's housing deficit would foster strong growth in the quarry industry.

A. Final Energy Demand for Gold Mining

Gold is a rare but precious metal and is globally recognized as a symbol of wealth and prosperity. It has only one grade and thus single pricing, meaning it is very liquid[73]. It is quite dense, inert and doesn't corrode, implying it doesn't lose value and can be carried away in small containers for storage

[73] If one was to trade in diamonds or oil, one has to deal with myriad range of grades & quality.

and in times of crisis or migration. Thus, gold can be handed over from generation to generation. Unlike other precious metals like silver or platinum, gold has very little industrial use; about 78% of gold consumed annually is used in the manufacture of jewellery. Global output has ranged from 3,000–3,300 tonnes every year since the beginning of the millennium.

Gold mining has been the most prominent mining activity in the country and accounts for about 90% of the country's total mineral exports[74]. Ghana has ranked as the eighth to ninth world's producer since 2010 from the 10^{th}–12^{th} position in the 1990s to the last decade, delivering between 90-136 tonnes per annum, up from 60–80 tonnes per annum in the 1990s.

Assumptions that guided the evaluation of the final energy demand for gold mining include:

(i) gold production is projected to increase at an annual average rate of 4.21% up to 2030;
(ii) intensity of diesel consumption is projected to increase by 10% by 2030 due to the decline of ore grades (gold yield/quantity of ore processed).

B. Final Energy Demand for Manganese Mining

Demand for manganese is projected to be driven by the global demand for steel. The main assumptions that influence the evaluation of the final energy demand for manganese mining include:

(i) annual production of manganese would increase from 1.6 million tonnes in 2010 to about 2.6 million tonnes in 2030; and
(ii) penetration of energy-efficient technologies in manganese mining is projected to lead a marginal increase in energy intensity by 5% in 2030, primarily due to the decline in ore grades.

C. Final Energy Demand for Bauxite Mining and Alumina Production

Assumptions for the evaluation of the final energy demand for bauxite mining are as follows:

(i) annual bauxite production is projected to increase from 0.6 million tonnes in 2010 to about 1.78 million tonnes in 2030 mainly due to government's policy of integrated Aluminum industry;
(ii) alumina production is assumed to commence from 2025 under AEG scenario; and
(iii) penetration of energy-efficient technologies is projected to lead to a marginal decrease in energy intensity by 5% in 2030 as a result of the decline in ore grades.

[74] Institute of Statistical, Social and Economic Research, State of the Ghanaian Economy in 2015, September 2016

D. Final Energy Demand for Diamond Mining

Assumptions for the evaluation of the final energy demand for industrial-scale diamond mining are as follows:

(i) annual diamond production by the Ghana Consolidated Diamond Mines Ltd is projected to increase to account for about 40% of the total diamond production in 2030;
(ii) total annual diamond production would increase from 310 thousand carats in 2010 to about 845 thousand carats in 2030; and
(iii) refurbishment of the production technology and equipment of the Ghana Consolidated Diamond Mines Ltd. is projected to decrease the energy use intensity by 5% in 2030.

E. Final Energy Demand for Stone Quarrying

Assumptions that guide the evaluation of the final energy demand for the stone quarrying industry are as follows:

(i) historical annual growth rate of the construction industry is projected to persist into the future and drive the annual growth of the quarrying industry at a rate of 6.8% for the BaU scenario and 7.8% for the AEG scenario; and
(ii) penetration of energy-efficient technologies is projected to decrease the intensity of energy use by 10% in 2030.

F. Final Energy Demand for Salt Mining

The assumptions that guide the evaluation of the final energy demand for the salt mining industry include;

(i) annual salt production which is projected to increase to about 1.3 million tonnes in 2030;
(ii) large-scale commercial salt producers are projected to account for 65.7% of the total salt production in 2030; and
(iii) state-of-the-art salt harvesting technologies would be introduced to decrease energy intensity by 10% in 2030.

Final Energy Demand for the Construction Industry

The assumptions that guide the evaluation of the final energy demand for the construction industry is the output of the construction industry, which is projected to increase at an average annual growth rate of 1.5% for the BaU scenario and 9.9% for the AEG scenario.

Final Energy Demand for the Manufacturing Sub-sector

The intensity of energy use in the manufacturing sub-sector is influenced by Government policies such as the Industrial Competitive Bill, the promotion of agro-processing industries to link industry to agriculture and the exploitation of solid mineral resources. Futhermore, processing of these raw materials into higher value-added products as well as energy efficiency programmes, which promotes modern energy-efficient technologies and state-of-the-art plants and machinery[75] would influence energy intensity.

The main assumptions that guide the evaluation of the final energy demand for the manufacturing sub-sector are as follows:

(i) manufacturing sub-sector would drive the country's socio-economic transformation; and
(ii) industrial activities of the manufacturing sub-sector would experience higher growth rates than in the past decade as a result of industrialisation policies such as one-district-one-factory policy.

A. Final Energy Demand for Cement Production

The assumptions that guide the evaluation of the final energy demand of the cement industry include:

(i) per capita cement production would increase from 133 kg in 2010 to about 442 kg for the BaU scenario and about 530 kg for the AEG scenario in 2030;
(ii) penetration of new energy-efficient cement plants would reduce the energy intensity of cement production by 10% in 2030; and

B. Final Energy Demand for Iron and Steel Production

Assumptions that influence the evaluation of the final energy demand for the steel industry are as follows:

(i) strong growth in the construction industry would persist over the planning period driving the demand for steel;
(ii) per capita steel production would increase from 3.20 kg in 2010 to 10.3 kg for the BaU scenario and 12.3 kg for the AEG scenario in 2030;
(iii) pig iron production is assumed to commence from 2025 under AEG scenario; and
(iv) penetration of new energy-efficient steel plants would decrease the energy intensity of steel production by 10% in 2030.

[75] National Development Planning Commission: "Medium-Term National Development Policy Framework: Ghana Shared Growth and Development Agenda, 2010 - 2013". Volume 1, December 2010

C. Final Energy Demand for Plastic Production

Assumptions that influence the evaluation of the final energy demand for the plastic industry are as follows:

(i) per capita plastic production would increase from 10.5 kg in 2010 to about 41.0 kg for the BaU scenario and 48.8 kg for the AEG scenario in 2030; and
(ii) penetration of energy-efficient plastic production technologies is projected to decrease the energy use intensity in plastic production by 10% by the year 2030.

D. Final Energy Demand for the Food Processing Industry

Assumptions that influence the evaluation of the final energy demand for the food processing industry are as follows:

(i) urban population is projected to grow at an average annual growth rate of 3.1% for the BaU scenario and 3.09% for the AEG scenario;
(ii) historical growth rate of 8.1% of the food processing industry is projected to persist throughout the planning period for the BaU scenario and 9.0% for the AEG scenario which included one district one factory; and
(iii) penetration of energy-efficient technologies is projected to decrease the energy use intensity of the food processing industry by 10% in 2030.

E. Final Energy Demand for the Beverage Industry

Assumptions that influence the evaluation of the final energy demand for the beverage industry are as follows:

(i) urbanisation is projected to grow at an average annual growth rate of 2.7% for the BaU scenario and 2.5% for the AEG scenario;
(ii) growth rate of 6.4% of the beverage industry is projected to persist throughout the planning period for the BaU scenario and 7.3% for the AEG scenario; and
(iii) penetration of energy-efficient technologies is projected to decrease the energy use intensity of the beverage industry by 10% by the year 2030.

F. Final Demand for the Textile Industry

Assumptions that guide the evaluation of the final energy demand for the textile industry are as follows:

(i) Government policy to resuscitate the textile industry;

(ii) domestic production of textiles is projected to increase at an average annual growth rate of 6.1% for the BaU scenario and 8.1% for the AEG scenario; and
(iii) penetration of energy-efficient technologies in textile production is projected to decrease the energy use intensity by 10% in 2030.

G. Final Energy Demand for the Chemical Industry

Assumptions that guide the evaluation of the final energy demand for the chemical industry (such as manufacturing of paints, detergents, pesticides and medical chemicals) are as follows:

(i) growth in the construction industry is projected to continue to drive the demand for chemical products;
(ii) annual output of the chemical industry is projected to increase at an average annual rate of 8.5% for both the BaU scenario and AEG scenario; and
(iii) penetration of energy-efficient technologies is projected to decrease the energy use intensity by 10% in 2030.

H. Final Energy Demand for the Metal Fabrication Industry

Assumptions that guide the evaluation of the final energy demand for the metal fabrication industry are as follows:

(i) growth of the construction industry is projected to persist in influencing the output of the fabrication industry;
(ii) domestic production of fabricated products is projected to increase at the historical average of 5.6% for the BaU scenario and 6.2% for the AEG scenario; and
(iii) penetration of energy-efficient technologies is projected to decrease the energy use intensity by 10% in 2030.

I. Final Energy Demand for the Paper and Printing Industry

Assumptions that guide the evaluation of the final energy demand for paper products and the printing industry are as follows:

(i) Government policy of free compulsory universal basic education would drive the demand for stationery and books;
(ii) growth in the packaging industry is projected to drive the demand for paper products and printing;
(iii) average annual growth rate of 8.5% in the paper products and printing industry is projected to persist for the BaU scenario and 8.8% for the AEG scenario; and

(iv) penetration of energy-efficient technologies is projected to decrease the average energy use intensity of paper products and the printing industry by 10% in 2030.

J. Final Energy Demand for the Wood Processing Industry

Assumptions that guide the evaluation of the final energy demand for the wood processing industry are as follows:

(i) growth in the construction industry is projected to drive the wood processing industry output to 3.0 million m^3 in 2020;
(ii) Government policies are projected to reverse the weak forest resource base to support the wood processing industry;
(iii) wood processing industry is projected to increase at an average annual rate of 4.0% for the BaU scenario and 4.2% for the AEG scenario; and
(iv) penetration of energy efficient technologies is projected to decrease the average energy use intensity by 10% in 2030.

K. Final Energy Demand for the Informal Manufacturing Sector

Assumptions that guide the evaluation of the final energy demand for the informal manufacturing sub-sector include:

(i) informal manufacturing sector which is projected to increase at at a rate equivalent to the rate of urbanisation of 2.7% for the BaU scenario and 2.1% for the AEG scenario; and
(ii) penetration of improved energy efficient technologies is projected to enhance productivity and decrease energy use intensity by 10% in 2030.

L. Final Energy Demand for the Aluminium Smelter

Aluminium ranks high as one of the most valuable and versatile in the global class of metals and elements in diverse application. Global production and use range from 60 million to 80 million tonnes annually. Its relatively light-weight, non-corrosive, non-magnetic and malleability make it ideal for packaging (cans, foil, frame etc.) food and beverage, transportation (automobiles, aircraft, trucks, railway cars, marine vessels, bicycles, spacecraft, etc.) as sheet, tube, and castings. It forms alloys with other metals including copper, magnesium and silicon by combining the strength of the alloy metals with its non-reactive nature to produce valuable cables for electrical transmission.

Although among the most versatile elements, aluminium does not occur naturally anywhere on the planet but exists as bauxite from which alumina (its oxide) is extracted and consequently smelt.

The Volta Aluminium Company, VALCo is still the only smelter and the single largest non-utility electricity customer when in operation, processing alumina (currently imported) into aluminium (hot or cast metal) ingots. The smelter's installed capacity of 200,000 tonnes of primary aluminium production via five potlines remains the same as during SNEP1. Maximum power demand is still 320 Megawatt per annum if operating at full capacity. Operations since the beginning of the millennium on the average of one potline has been the worst of the plant's history compared to an average of three potlines up to the 1990s.

Although the aluminium smelter is not an economic sector but part of the manufacturing sub-sector of industry, it was considered as a demand sector, due to its unique energy requirement features.

Main assumptions that guide the evaluation of the final energy demand for the aluminium smelter are as follows:

(i) the smelter would operate at one pot-line till 2016, two pot-lines from 2016 to 2020 and after that three pot-lines till 2030 but for the AEG scenario, smelter would operate at three pot-lines and four pot-lines in 2020 and 2021 respectively then five pot-lines till 2030;
(ii) there would be no significant change in the smelter technology except for improvement in smelter efficiency.

Agricultural Sector Energy Demand

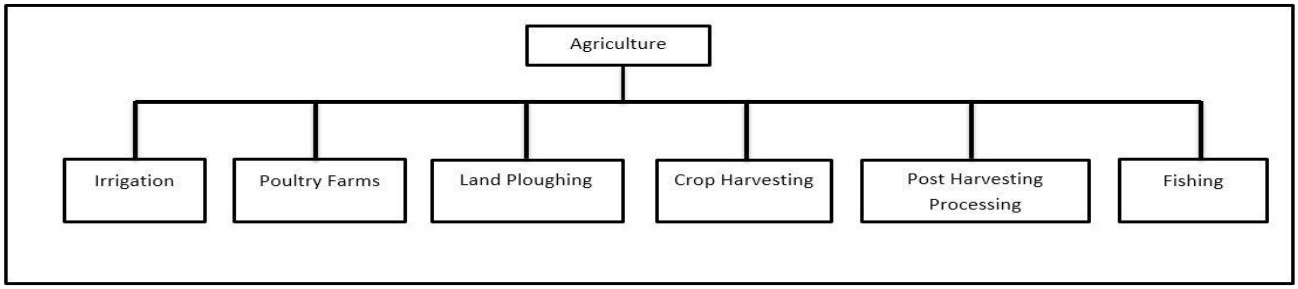


Figure A11.4: Classification of Agricultural Sector

Assumptions that guide the evaluation of the final energy demand for the Agricultural Sector are as follows:

(i) share of agriculture in the total GDP is expected to decrease from 29.8% in 2010 to 18.9% for the BaU scenario and 17.2% for the AEG scenario in 2030;
(ii) agricultural sector is projected to grow at an average annual rate of 9.0% for the BaU scenario and 9.3% for the AEG scenario; and
(iii) implementation of the Accelerated Agricultural Growth and Development Strategy to promote increased mechanisation in the agricultural sector is projected to increase the energy use intensity by 10% in 2030.

Final Energy Demand for Irrigation

The final energy use for irrigation purposes is driven by the land area irrigated and the energy use intensity. The energy use intensity for irrigation is influenced by Government projects and policies such as the National Irrigation Policy, the Accelerated Agricultural Growth and Development Strategy, the Ghana Commercial Agriculture Project, the rehabilitation of the Kpong Irrigation Project, the implementation of the National Irrigation Development Master Plan (NIDMAP) and the promotion of energy-efficient technologies, one village one dam and planting for food and jobs.

Assumptions that influence the evaluation of the final energy demand for irrigation are as follows:

(i) total land area irrigated would increase from 4,746 ha in 2010 to about 29,000 ha in 2030;
(ii) concessionary electricity tariff would be given to boost the use of electric pumps. As a result, it is projected that diesel pumps would be eliminated by 2020;
(iii) use of solar-powered direct current and alternating current pumps for irrigation; and
(iv) intensity of energy used for irrigation is expected to increase by 10% in 2030.

Final Energy Demand for Land Ploughing

Assumptions that influence the evaluation of the final and total energy used for land ploughing are as follows:

(i) total land area ploughed would increase from 1.36 million hectares in 2010 at an average annual growth rate of 4.0% for the BaU scenario and 5.64% for the AEG scenario;
(ii) use of tractors is projected to account for 98% of the total land area ploughed in 2030; and
(iii) energy use intensity for ploughing is projected to increase by 10% by 2030.

Final Energy Demand for Crop Harvesting

Assumptions that influence the evaluation of the final energy used for crop harvesting are as follows:

(i) total amount of cereal harvested would increase from about 196 thousand tonnes in 2010 at an average annual growth rate of 10.3% for the BaU scenario and 6.2% for the AEG scenario; and
(ii) energy use intensity for crop harvesting would decrease by 10% in 2030 as a result of the penetration of more efficient Combine Harvesters.

Final Energy Demand for the Post-Harvest Processing

Assumptions that influence the evaluation of the final energy demand for post-harvest processing are as follows:

(i) total amount of post-harvest grains processed is projected to increase annually at an average rate of 5.3% for the BaU scenario and 5.5% for the AEG scenario; and
(ii) energy use intensity of post-harvest processing is projected to increase by 5% by 2030 as a result of the increase in intense post-harvest processing.

Final Energy Demand of the Poultry Industry

Assumptions that influence the evaluation of the final energy demand for the poultry industry are as follows:

(i) annual per capita demand for poultry products would increase from 4.5 kg in 2010 to 12.0 kg in 2030 for the BaU scenario and 15.0 kg for the AEG scenario;
(ii) poultry production from mechanized poultry farms would increase from 7,640 tonnes in 2010 to about 63,500 tonnes in 2030 for the BaU scenario and 85,200 tonnes for the AEG scenario; and
(iii) energy use intensity for poultry production from mechanized poultry farms is projected to increase by 5% in 2030 as a result of increased processing.

Final Energy Demand for Fishing

The final energy demand for fishing is driven by the annual fish catch and the energy use intensity. The energy use intensity for fishing is influenced by Government policies to develop more fish landing sites along the coast. The prices of various forms of energy used for fishing and energy efficiency programmes to promote energy efficient technologies for fishing also influence the energy use intensity.

Assumptions that influence the evaluation of the final energy demand for fishing are as follows:

(i) annual fish catch is projected to increase at an annual rate of 8.0% for both the BaU scenario and AEG scenario; and
(ii) energy use intensity for fishing is projected to increase by 5% by 2030 as a result of longer trips by fishers due to the depletion of the fish resource in the waters.

Transport Sector Energy Demand

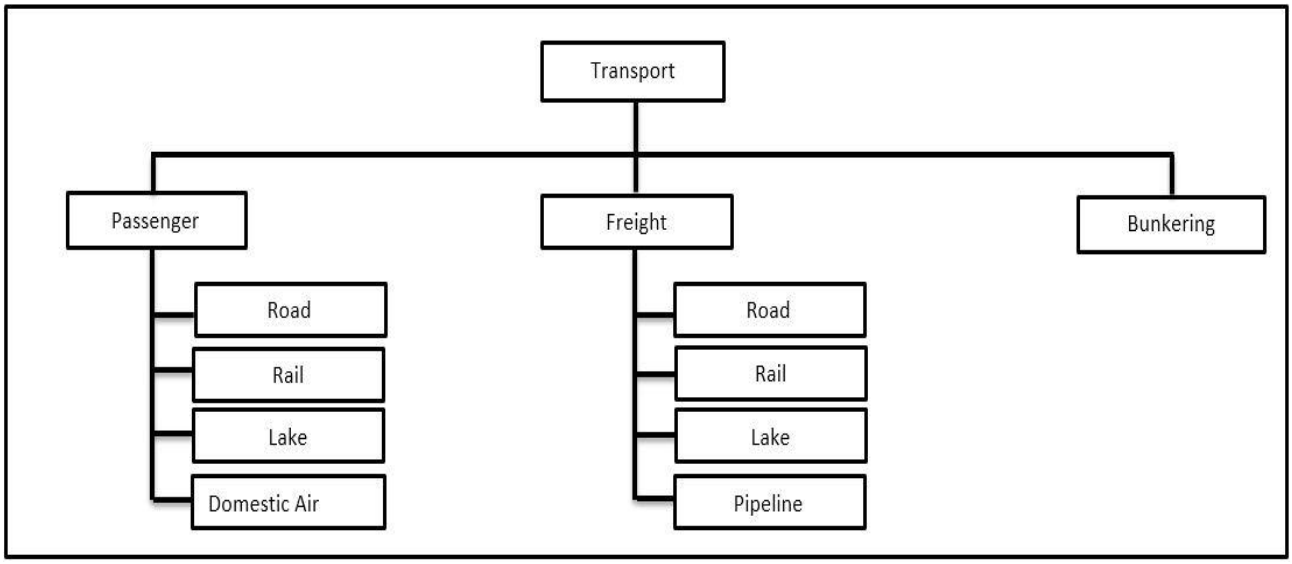


Figure A11.5: Classification of Transport Sector

The final energy demand of the Transport Sector is driven by passenger and freight traffic and the corresponding intensity of energy used for transportation. The intensity of energy use in transportation is also influenced by Government policies on transportation such as the Urban Transport Programme, prices of energy forms used for transportation and energy efficiency programmes to promote efficient energy use in the transportation sector.

Assumptions that influence the evaluation of the final energy demand for the transport sector are as follows:

(i) passenger traffic is projected to increase at an average annual rate of 4.9% for the BaU scenario and 6.2% for the AEG scenario;
(ii) freight traffic is projected to increase at an average annual rate of 7.1% for the BaU scenario and 8.3% for the AEG scenario;
(iii) passenger transport by road is projected to account for about 87% of the total passenger traffic for the BaU scenario in 2030 and 79% for the AEG scenario;
(iv) energy use intensity of passenger and freight transport for all the modes of transport is projected to decrease by about 5% and 2% respectively by 2030; and
(v) electric vehicles would enter the Ghanaian market by 2020 for passenger transport and light urban freight.

Final Energy Demand for Passenger Transportation

Assumptions that influenced the evaluation of the final energy demand for passenger transportation were as follows:

(i) passenger traffic is projected to increase at an average annual rate of 4.9% for the BaU scenario and 6.2% for the AEG scenario; and
(ii) road passenger traffic is projected to account for 86.6% of the total passenger in 2030 for the BaU scenario and 79% for AEG scenario; and
(iii) energy use intensity of passenger transport for all the modes of passenger transport is projected to decrease by about 2% by 2030.

A. Final Energy Demand for Road Passenger Transportation

The final energy demand for road passenger transport is driven by the annual road passenger traffic and the corresponding energy use intensity. The energy use intensity in passenger transportation is also influenced by Government policies on transportation such as the Urban Transport Programme - promotion of mass-transport e.g. Bus Rapid Transit (BRT); promotion of other modes of transport e.g. inter-city and urban rail system; the prices of fuel for passenger transportation including the use of solar energy for transport, the promotion of energy efficiency and fuel substitution in passenger transportation.

Main assumptions that influenced the evaluation of the final energy demand for road passenger transportation were as follows:

(i) share of road passenger traffic would decrease from 97.1% in 2010 to 86.6% in 2030; and
(ii) energy use intensity of road passenger transport vehicles would decrease by about 2% in 2030.
(iii) Electric vehicles will enter the Ghanaian market by 2020 and would be charged by grid electricity or solar power.

B. Final Energy Demand for Urban Road Passenger Transportation

Assumptions that influenced the evaluation of the final energy demand for urban passenger transportation by road were as follows:

(i) urban road passenger traffic would account for 37.2% of the total road passenger traffic for the BaU scenario and 37.2% for the AEG scenario by 2030;
(ii) high occupancy Bus Rapid Transit (BRT) system would be introduced in Accra by the end of 2016 and would account for 11% of the total urban passenger traffic for the BaU scenario and 8% for the AEG scenario by 2030;

(iii) electric vehicles would influence the rate of growth of petroleum fuel demand for passenger transport and light freight and increase electricity use; and
(iv) penetration of energy efficient urban transport vehicles would decrease the energy use intensity of urban road passenger transport vehicles by about 2% in 2030.

C. Final Energy Demand for Inter-City Road Passenger Transportation

Assumptions that influence the evaluation of the final energy demand for inter-city road passenger transportation are as follows:

(i) inter-city road passenger traffic was projected to account for 63% of the total road passenger traffic for the BaU scenario and 62% for the AEG scenario by 2030; and
(ii) penetration of energy efficient inter-city road passenger vehicles was projected to decrease the energy intensity of inter-city road passenger transport vehicles by about 2% in 2030.

D. Final Energy Demand for Inter-City Rail Passenger Transportation

Assumptions that influenced the evaluation of the final energy demand for rail passenger transportation were as follows:

(i) western rail corridor would be rehabilitated and as such inter-city passenger traffic by rail and is projected to account for 10% of the total passenger traffic for the BaU scenario and 13% for the AEG scenario by 2030; and
(ii) penetration of energy efficient rail transport rolling-stocks is projected to decrease the energy use intensity of rail passenger transportation by 5% in 2030.

E. Final Energy Demand of Passenger Transport by Inland Lake

Assumptions that influenced the evaluation of the final energy demand for inland lake passenger transportation were as follows:

(i) inland lake passenger traffic was projected to account for 0. 8% of the total passenger traffic by 2030 for the BaU scenario and 1.2% for the AEG scenario; and
(ii) penetration of energy efficient ferries is expected to decrease the energy intensity of inland lake passenger transportation by about 2% in 2030.

F. Final Energy Demand for Passenger Transport by Domestic Air

Assumptions that influenced the evaluation of the final energy demand for domestic air passenger transportation were as follows:

(i) domestic air passenger traffic was projected to account for 2.6% of the total passenger traffic for the BaU scenario and 6.4% for the AEG scenario in 2030; and
(ii) penetration of energy efficient planes is projected to decrease the energy intensity of domestic air passenger transportation by 2% in 2030.

Final Energy Demand for Freight Transport

Assumptions that influenced the evaluation of the final energy demand for freight transportation were as follows:

(i) freight traffic was projected to increase annually at the historical average rate of 7.1% for the BaU scenario and 8.3% for the AEG scenario;
(ii) share of freight transport by road was expected to decrease to 83% of the total freight traffic for the BaU scenario and 79% for the AEG scenario in 2030;
(iii) penetration of electric vehicles for urban short haul light freight; and
(iv) penetration of energy efficient freight vehicles is expected to decrease the energy intensity of freight transportation by 2% in 2030.

A. Final Energy Consumption for Freight Traffic by Road

Assumptions that influenced the evaluation of the final energy demand for freight transportation are were as follows:

(i) urban freight traffic by road was projected to account for 83.4% of the total freight traffic by road for the BaU scenario and 79% for the AEG scenario in 2030;
(ii) long distance freight traffic would account for 82.1% of the total freight traffic by road for the BaU scenario and 82.1% for the AEG scenario in 2030; and
(iii) penetration of energy efficient freight transportation vehicles and fuel substitution is likely to decrease the energy use intensity of local and long distance freight transportation by 2% in 2030.

B. Final Energy Demand for Freight Traffic by Rail

Assumptions that influenced the evaluation of the final energy demand for rail freight transportation were as follows:

(i) rehabilitation of the western railway corridor was projected to drive rail freight traffic to account for about 14% of the total freight traffic for the BaU scenario and 18% for the AEG scenario in 2030; and

(ii) penetration of energy efficient rolling-stock would decrease the energy intensity of rail freight transportation by 5% in 2030.

C. Final Energy Demand for Freight Traffic by Inland Lake

Assumptions that influenced the evaluation of the final energy demand for inland lake freight transportation were as follows:

(i) inland lake freight traffic was projected to account for 2.5% of the total freight traffic for the BaU scenario and 2.8% for the AEG scenario in 2030; and
(ii) penetration of energy efficient barges, ferries and boats is projected to decrease the energy intensity of inland lake transportation by 2% in 2030.

D. Final Energy Demand of Freight Transportation by Pipeline

Assumptions that influenced the evaluation of the final energy demand for freight transportation by pipelines were as follows:

(i) share of crude oil and petroleum products freight traffic by pipeline is projected to account for 0.1% of the total freight traffic for the BaU scenario and 0.3% for the AEG scenario in 2030; and
(ii) energy use intensity of pipeline transportation is projected to decrease by 5% in 2030.