Government of Republic of Malawi

DIGEST OF MALAWI ENERGY STATISTICS

JANUARY 2023

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AFREC	African Energy Commission
CO_2	Carbon dioxide
CPI	Consumers price index
CV	Calorific value
EGENCO	Electricity Generation Company
ESCOM	Electricity Supply Cooperation of Malawi
ERB	Energy Regulation Board (Zambia)
GOGLA	Global Association for the Off-grid Solar Energy Industry
GWh	Gigawatt hour
IHS	Integrated Household Survey
kToe	Kilo tonnes of oil equivalent
kWh	Kilowatt hour
IRES	International Recommendations for Energy Statistics
IPP	Independent Power Producers
LPG	Liquefied petroleum gas
MAP	Main activity producer electricity
MERA	Malawi Energy Regulatory Authority
MJ/kg	Megajoules per kilogram
MK	Malawi Kwacha
MoE	Ministry of Energy
MoM	Ministry of Mining
MW	Megawatt
n.a.	Not available
NDC	Nationally Determined Contribution
NSO	National Statistical Office
PIL	Petroleum Importers Limited
PML	Power Market Limited
PV	Photovoltaic
TJ	Terajoule

FOREWORD

This Digest of Energy Statistics denotes progress in Government efforts to put in place sound energy policies, strategies and plans that are well informed by quality energy data. The importance of energy to the socio-economic development of our country cannot be overemphasised, as energy is an enabler for developments in all sectors of the economy. Sound planning and decision making for developments in the energy sector depends on availability of quality energy data without which, energy demand and supply in the country would always be mismatched leading to haphazard investments. This has an overall impact on access to and utilisation of energy as evidenced in the recent trends where economic activities have been hampered due to limited availability of energy to run the economy.

Energy planning can be challenging, but it is harder still if we do not have reliable statistics to understand the current situation, to plan and develop models to understand what changes can be made and then to monitor the impact of the policies we decide upon. That is why this report, the first comprehensive set of energy statistics for Malawi, is so important. It is the first time we have produced a full energy balance to help us better understand the energy we use and how fuels are used together.

The work presented in this report marks the start of our work to really understand energy production and use in Malawi. We need to build on the data and use it to develop our energy modelling capabilities to be able to take the correct policy actions to ensure that Malawians have the energy they need and the country makes its fair international contribution to global action on climate change.

Improving our knowledge of energy will need co-operation across many ministries and with the energy businesses. The signs of working together are very positive with the Ministry of Mining (MoM), Department of Environmental Affairs (EAD), Malawi Energy Regulatory Authority (MERA) and National Statistics Office (NSO) all contributing to the development of these statistics. In addition, the energy industry with Electricity Generation Company Limited (EGENCO), Electricity Supply Corporation of Malawi (ESCOM), National Oil Company of Malawi (NOCMA) and Petroleum Importers Limited (PIL) have been active participants in stakeholder meetings and energy statistics trainings. Going forward, as we look to expand our knowledge, specifically on the users and uses of energy, all players in the energy industry will need to play a role.

Preparation of this report has been supported by the Nationally Determined Contribution Support Centre (NDC SC), a collaboration of Vito and African Energy Commission (AFREC) supported by the Government of Flanders. We are pleased that they chose to work with Malawi as one of the pilot countries for the project and are grateful for their financial and technical support through their experts. The work has left Malawi with a good framework to build on and I am confident that together, we will continuously strengthen our national energy statistics.

Eng. Alfonso Chikuni
SECRETARY FOR ENERGY

ACKNOWLEDGEMENTS

This publication and associated data is the first deliverable of a new degree of cross organisation and business collaboration on energy statistics. It is a result of an intensive and extensive consultative process involving Ministry of Energy, Ministry of Mining (MoM), Department of Environmental Affairs (EAD), Malawi Energy Regulatory Authority (MERA), National Statistics Office (NSO), Electricity Generation Company Limited (EGENCO), Electricity Supply Corporation of Malawi (ESCOM), Power Market Limited, National Oil Company of Malawi (NOCMA) and Petroleum Importers Limited (PIL). This publication would not have been possible without input and cooperation from these key stakeholders.

It is not possible to mention all who contributed to this work. However, special accolade should go to Joseph Kalowekamo, Acting Director of Energy and Thokozani Nelson Malunga for providing leadership support; Austin Patikani Theu, Chaona Sinalo and Ella Lisuntha for coordinating data collection and publication of this document; Olive Moya of Malawi Energy Regulatory Authority (MERA), Maxwell Kudzala of the Ministry of Mining (MoM), Kingsley Manda, Bright Mvula and Timothy Mmanga from National Statistics Office (NSO), Klema Hau of ESCOM and Gerald Kamthunzi of EGENCO for providing valuable input through their outputs and knowledge, which will be built on in the future.

The development and publication of this Digest of Energy Statistics would not have been possible without the financial and technical assistance of AFREC and Vito supported by the Government of Flanders through the NDC Support Centre (NDC SC). They are providing long-term support to countries across Africa to develop energy statistics and use them in energy and climate modelling to enhance countries NDCs and monitoring of their component parts. Government of Malawi is therefore greatly indebted to these cooperating partners for their invaluable assistance.

Finally, the Ministry of Energy would like to express thanks to Duncan Millard, an International Energy and Statistics Advisor and part of the NDC SC, for his support and guidance to Malawi through training, knowledge sharing, building collaboration and advice on all aspects of energy statistics and their use. Without his assistance, this work would not have been possible.

The NDC Support Center

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Specialized Energy agency of African Union. Its core mandate is to design, create and set up an energy continental data base and facilitate rapid dissemination of information among Member States, Regional Economic Communities around Africa, investors, academia and other stakeholders.

EXECUTIVE SUMMARY

Malawi's energy use is dominated by biomass (predominantly wood and charcoal). It accounted for 86% of all final use in 2020, compared to 10% for oil products, 3% for electricity and 1% for coal. For households the importance of biomass is even starker: it accounts for nearly all (99%) of energy used in homes, across the whole of the country.

Households in Malawi also consume far much energy than other sectors. Energy used in homes accounted for 80 % of all energy used by final consumers in 2020, followed by industry and transport, both accounting for 9% of all final consumption. Other sectors, commercial and agriculture accounted for around 2% of all final energy use.

These are some of the headline results from the first ever energy balance for Malawi, presented here. An energy balance shows where energy comes from and how it is used. This means the importance of fuels and the sectors that use the fuels can be properly understood. It is a single year snapshot of the energy situation and the results presented here cover 2020. It is built on data covering all forms of energy used in Malawi: coal, petroleum products, electricity and biofuels. Looking at these fuels over time also shed valuable insights.

Petrol has seen the largest increase in imports of all petroleum products since 2015, with imports in 2020 more than double the 2015 level. Petrol imports in 2020 accounted for nearly 45% of imports compared to just under 40% in 2015. On the other hand, there has been a sharp decline in imports of aviation fuels, linked to the impact of Covid restrictions of international travel globally.

Between 2017 and 2020 close to a fifth of the diesel imported has been used to generate electricity as thermal power has played a bigger role in electricity generation. From 2017 to 2020 diesel accounted for around 10% of all electricity generation compared to less than 1% in 2016. Hydro remains the largest source of electricity generation at close to 90%. Solar generation started in 2020 and as such contributed a small amount of 0.2 GWh in 2020, but as shown in the capacity data, going forward this is likely to rise with more solar power plants coming on-line.

Electricity is used by all economic sectors, but the main ones are the Food and Tobacco and Services (or commercial) sectors who are estimated to be consuming over two-thirds of the electricity supplied to business.

The prices of liquid fuels have risen sharply since 2010. However, over the past 10 years the value of the Malawian Kwacha has fallen sharply against the US dollar, the currency used in the oil market. Prices converted to US dollars, show that in dollar terms prices in 2021 were at or lower than seen in 2010.

These are some of the examples of information that can be drawn from an energy balance and associated energy statistics. They are the heart of understanding energy. The energy balance and enhanced statistics can form the basis for the developing energy and climate models, to help plan change and development including in NDCs and provide the means of measurement, reporting and verification.

INTRODUCTION

This report is the first comprehensive statistical assessment of energy in Malawi, aimed at helping all, government, business, investors, academia and the public, better understand energy supply and use.

The report is set out in the following sections. Section 1 covers headline data on energy supply and use in 2020, highlighting the significant role that biofuels (largely wood and charcoal) play in Malawi. The findings presented in Section 1 are drawn from the Energy Balance for Malawi, which is presented in full, alongside a headline description of a balance and a Sankey Flow chart (a pictorial presentation of the balance) in Section 2.

Section 3 then look in detail at the main fuel types used in Malawi, covering: coal, petroleum products, electricity and biofuels. The sub-sections on each fuel cover the supply, its intermediate use (i.e. where it is used to make other fuels, known as transformation), and to the extent possible who uses the fuel. For electricity, this section also covers the capacity of electricity power plants. Where available, data in this section is shown for 2021 and prior years.

Information on generation capacity is one example of how data beyond the energy balance is vital to understand energy. Another important data set is energy prices, which is the topic of Section 4. This covers prices of liquid fuels: petrol, diesel, paraffin (known internationally as kerosene), liquefied petroleum gas (LPG, known as gas in Malawi) and electricity. Statistics in this section show electricity prices for domestic (household) and business as well as liquid fuels prices in MK, US dollars and in real terms, i.e. adjusted for inflation.

Section 5 provides the information behind the report. It provides a table of key definitions used in the energy balance and throughout the report and tables of conversions used to convert the raw energy data into the energy units needed to compile an energy balance. This section also includes notes and methods on the calculations used to derive the data in the report, with a full write up of the approach used for biomass presented in Annex A.

The next part, Section 6, covers ideas on the next steps. Prior to this work, a full energy balance had not previously been produced for Malawi. It is therefore encouraging for the development of energy statistics in Malawi that a full balance has been produced primarily, using data that have already been collected. However, there remain gaps and some estimation has been used. This section sets out steps to fill those gaps.

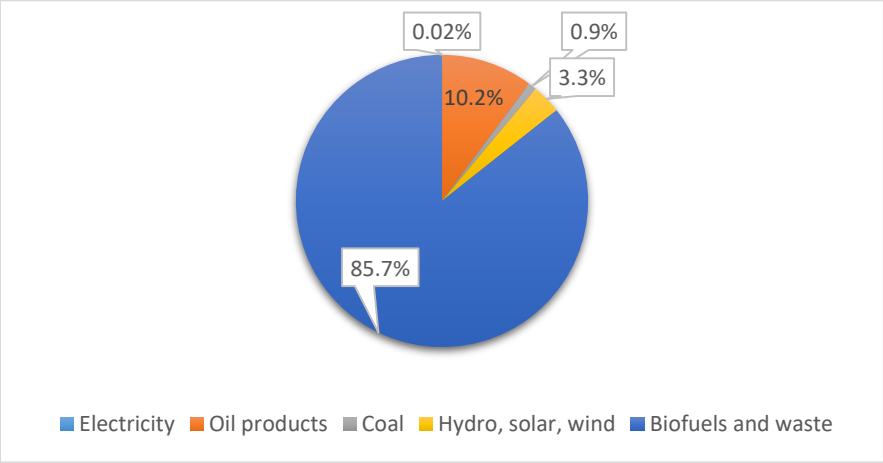
Finally, recognition of the support provided in producing the data used in this report is shown in Section 7 and references of reports used as inputs in Section 8.

SECTION 1: THE OVERALL ENERGY SITUATION IN MALAWI, 2020

1.1 Overall Energy Situation

The Total Energy Supply (TES) in Malawi in 2020 was 4902.2 thousand tonnes of oil equivalent (kToe). This is the total energy that was available for use in the country. Of this, 4206.8 kToe came from biofuels (largely wood and charcoal along with some bagasse and ethanol) representing 85.7%; 498.6 kToe came from oil products (petrol, diesel, aviation fuels and LPG) representing 10.2%, 160.4 kToe came from Hydro and solar representing 3.3% and 44.2 kToe came from coal representing 0.90%. Net imports of electricity, which are a part of total energy supply, were -0.9 kToe (ie a small export) but are not shown in the Figure 1.1.

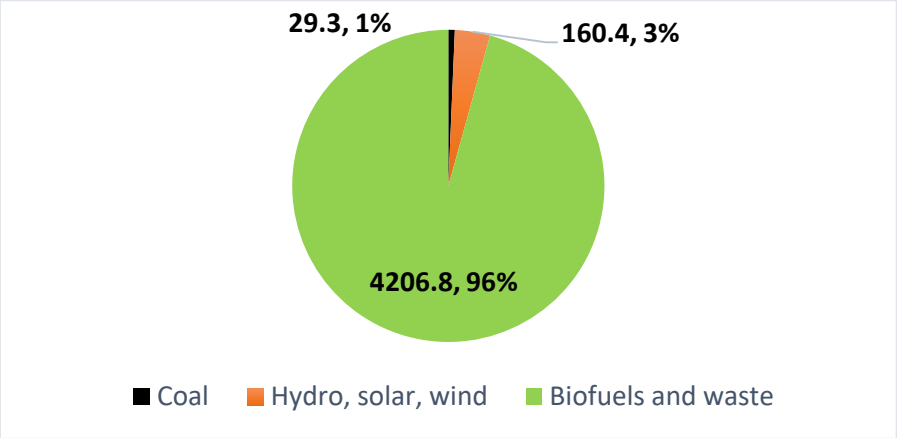
Figure 1.1: Share of Total Energy Supply (%)



1.2 Primary Energy Production

Primary energy production covers the fuels sourced from energy resources within Malawi. It covers the collection of wood, mining of coal and electricity generated from natural resources, such as hydro and solar. In 2020, 96% of the production came from biofuels and wastes with coal, hydro and solar contributing 1% and 3% respectively as shown in Figure 1.2.

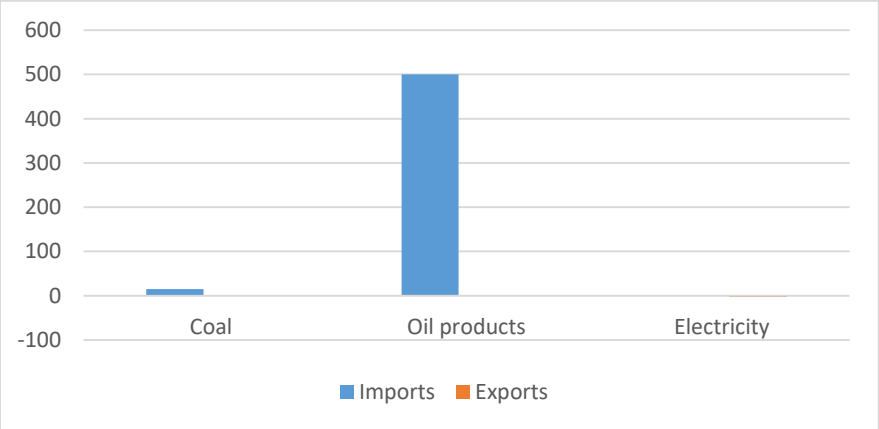
Figure 1.2: Share of Primary Energy Production (kToe and %)



1.3 Energy Imports and Exports

The other main component of the supply of energy is imports. Malawi imports in 2020 are shown in Figure 1.3, with oil products being the main imported fuel at 500.2 kToe, followed by coal at 14.9 kToe. Electricity was both imported and exported, but in small quantities, so not visible in the figure, with exports of 1.7 kToe and imports of 0.9 kToe.

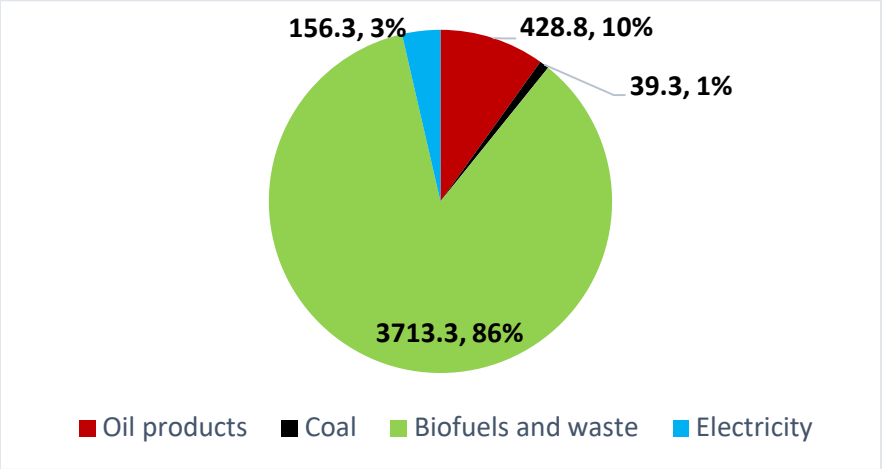
Figure 1.3: Malawi Energy Imports and Exports 2020 (kToe)



1.4 Total Final Energy Consumption (TFC)

Malawi's total final consumption of energy, as shown in Figure 1.4, is the energy that was used by households, in transport and businesses. In 2020, it amounted to 4337.7 kToe. Consumption was dominated by biomass (wood and charcoal) which accounted for 86% of the final use, compared to 10% for oil products, 3% for electricity and 1% for coal.

Figure 1.4: Total Final Energy Consumption in 2020 (kToe and Percentage Share)



As can be seen in Figure 1.5 below, the residential or household sector is the main consumer of energy in Malawi, accounting for 80% (3489.9 kToe), followed by industry and transport, both accounting for 9% of all final consumption. Other sectors, commercial and agriculture, accounted for 2% of all final energy use.

Figure 1.5 Final Energy Consumption by Sector 2020 (kToe and Percentage Share)

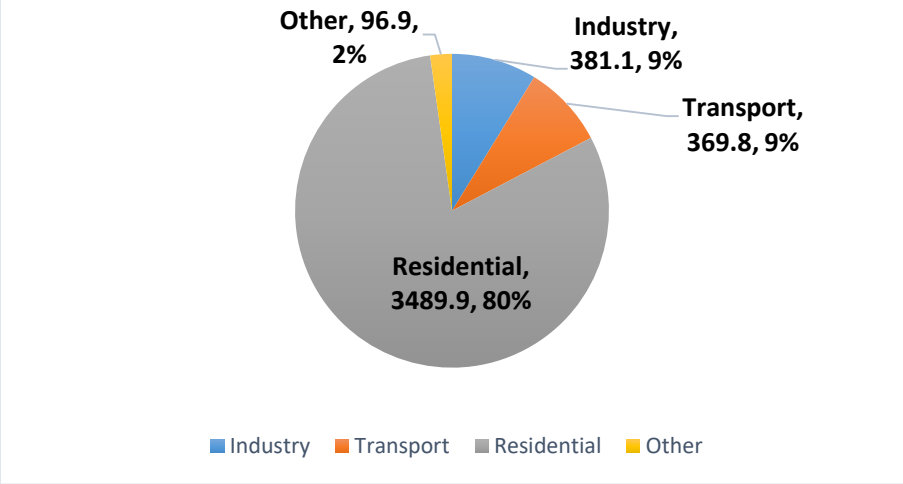


Table 1.1: Summary Energy Contribution by Fuel 2020 (kToe)

	Coal	Oil products	Biofuels	Hydro, Solar	Electricity	Total
Energy production	29.3		4206.8	160.4		4396.5
Net energy imports	14.9	500.2			-0.9	514.2
Total energy supply	44.2	498.6	4206.8	160.4	-0.9	4909.2
Total final energy consumption	39.3	428.8	3713.3		156.3	4337.7

Table 1.2: Total Final Energy Consumption by Sector 2020 (kToe)

	Industry	Transport	Residential	Other	Total
2020	381.1	369.8	3489.9	96.9	4337.7

SECTION 2: 2020 ENERGY BALANCE

The data presented in Section 1 are all taken from the Malawi Energy Balance, which is shown below in Table 2.1.

An energy balance can be best thought of as an accounting framework that shows for each type of energy where it comes from and how it is used. Energy balances form an essential element of understanding energy and are produced by many countries across the world. The majority of countries produce balances in line with the International Recommendations for Energy Statistics[1] (IRES), a United Nations publication that provides guidance on how balances are best created to help ensure international comparability. Malawi's first energy balance, as presented here, follows this guidance.

An energy balance is split into three (3) main parts. The first part is Supply. This shows where energy comes from for example from production or from imports. Energy not available for use in the country is removed in this section for example exports or where the fuel is used for international aviation and these cells are shown as a negative. The sum of the flows in this part is Total Energy Supply, which is the energy that is available for all uses in the country.

The second part is Transformation, which shows how different forms of energy are used to make other types. For example, in Malawi, diesel is used to generate electricity and wood is used to make charcoal. For transformation, the fuel that is used is shown as a negative, while the fuel produced is shown as a positive value. The difference between the inputs and the outputs is the fuel lost (often through heat) in the transformation process. It is because transformation is shown separately that in the supply section it is only the direct or primary production of electricity that is shown, i.e. from hydro and solar. The last two (2) rows in the transformation section covers the energy industry own use and losses in the transportation of fuel. These are shown in this section as they are uses of energy that have to happen before energy is available to final consumers. The energy industry needs to use some fuel to make fuel, and so, this energy is not available to other consumers, whilst as electricity is carried through transmission and distribution cables some is lost through natural processes as it travels through cables (called technical losses) and some through the unlawful use (i.e. illegal connections to the electricity network).

The third and final part of the balance is consumption, which shows who uses all the different types of energy. In this section, all transport use (even if it is undertaken by an industry) is shown in the transport sector. This section is often the most challenging to measure given the number of users and it is an area that needs further work and refinement for Malawi.

The final point to note about energy balances, is that they are produced in energy units (here thousand tonnes of oil equivalent, where 1 Toe = 41.868GJ), to allow all the interactions to be shown and to get a real understanding of the relative importance of energy types and users. Section 3 presents energy statistics in natural units for example litres, tonnes and MWh.

Section 5 sets out notes on the sources and methodologies used and a table of key definitions to assist in understanding energy balances, with additional information in IRES, as mentioned above.

[1] https://unstats.un.org/unsd/energystats/methodology/ires/

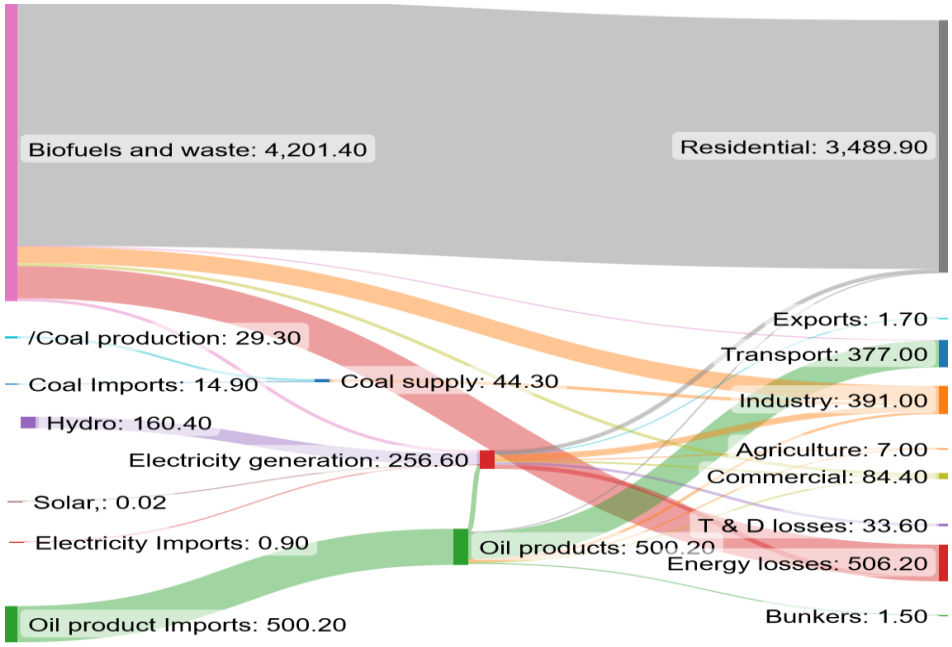
Table 2.1 shows the 2020 energy balance with Figure 2.1 presenting it in pictorial form as a Sankey diagram.

Table 2.1: Energy Balances, 2020 (kToe)

	Coal	Oil products	Hydro	Solar, wind, others	Biofuels and waste	Electricity	Total
Production	29.3		160.4	0.02	4206.8		4396.5
Imports	14.9	500.2				0.9	516.0
Exports	0.0					-1.7	-1.7
International marine bunkers							
International aviation bunkers		-1.5					-1.5
Stock changes							
Total Energy Supply (TES)	**44.2**	**498.6**	**160.4**	**0.0**	**4206.8**	**-0.9**	**4909.2**
Statistical differences	*0.0*	*22.0*			*0.1*	*-2.2*	*19.8*
Main activity electricity plants		-44.8	-160.1	-0.02		177.2	-27.8
Autoproducer electricity plants		-3.0	-0.3	-0.01	0.01	1.5	-1.8
Main activity producer CHP plants							
Autoproducer CHP plants					-40.2	9.4	-30.8
Charcoal production plants					-446.1		-446.1
Energy industry own use	5.0					0.3	5.3
Losses						32.8	32.8
Final Consumption	**39.3**	**428.8**			**3713.3**	**156.3**	**4337.7**
Industry	39.3	33.1			229.8	78.9	381.1
Iron and steel						0.6	0.6
Chemical and petrochemical						0.5	
Non-ferrous metals						0.0	
Non-metallic minerals					41.6	12.4	
Transport equipment						0.0	
Machinery						0.8	
Mining and quarrying						0.1	0.1
Food, beverages and tobacco					184.0	44.7	228.7
Paper, pulp and print						1.3	

Wood and wood products						2.9	
Construction						2.9	2.9
Textiles and leather						2.1	
Non-specified (Industry)	39.3	33.1			4.2	10.6	87.2
Transport		369.8			7.2	0.0	377.0
Road		356.3			7.2		363.5
Domestic aviation		0.2					0.2
Rail		4.4					
Domestic navigation		8.8					
Other	0.0	25.9			3483.5	77.4	3586.8
Residential		0.8			3437.5	51.6	3489.9
Commercial and public services		18.4		.	46.0	25.4	89.8
Agriculture/forestry/Fishing		6.6				0.4	7.0
Non-energy use							0.0

Figure 2.1: Malawi Sankey Flow Chart 2020 (kToe)



Note: 1) Industry includes energy sector own use for simplicity
2) Oil products include LPG, which is known as "gas" in Malawi, but is not methane, ie Natural gas.

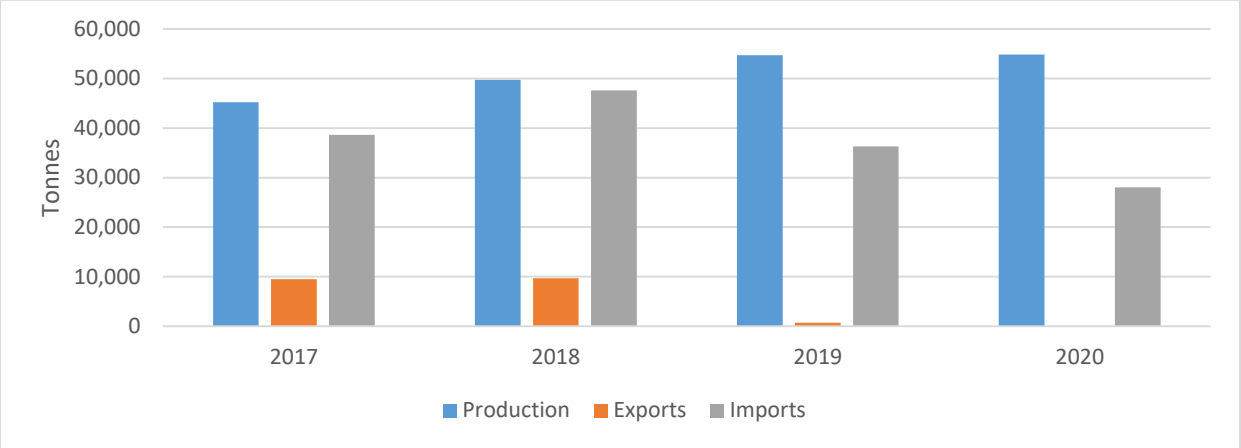
Sankey built using SankeyMATIC (BETA): Build a diagram

SECTION 3: SUPPLY AND USE OF ENERGY PRODUCTS

3.1 Coal

Coal plays a relatively small role in the current energy mix of Malawi. In 2020, 54,876 tonnes of coal were produced in Malawi, around the same as in 2019. Imports were down on 2019 with, 28,000 tonnes imported in 2020, compared to 36, 400 in 2019. No exports of coal occurred in 2020 (figure 3.1).

Figure 3.1: Coal, Imports and Exports (tonnes)



Source AER 2021 from the Ministry of Mining, NSO

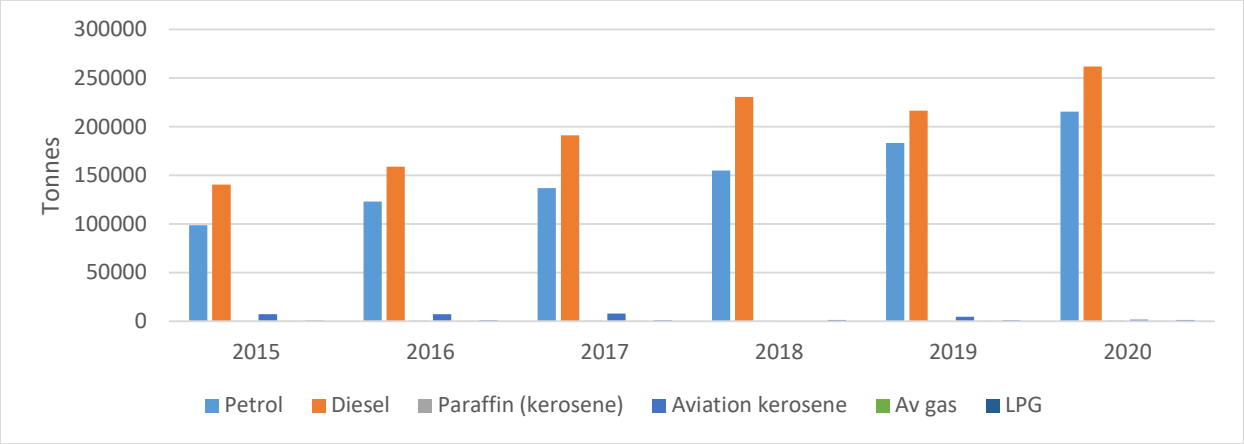
Coal is used by industry, but more work is needed to get a better understanding of its use by specific sectors, aside from its use in the production of ethanol, where it is used to create steam.

3.2 Petroleum Products

Malawi imports six (6) types of petroleum products namely; Petrol, Diesel, Paraffin (Kerosene), Jet Kerosene (Jet A1), Aviation Gasoline (Avgas) and Liquefied Petroleum Gas (LPG, known as gas in Malawi). The products are imported via three (3) main routes of Beira, Nacala and Der-es-Salam. Figure 3.2 and Table 3.1 shows the quantity of imports since 2015.

Petrol and Diesel make up the vast majority of imported fuels, together accounting for 98 to 99% of imports over the past 5 years. Petrol has seen the largest increase since 2015, with imports in 2020 more than double (up 118%) from 2015. Diesel imports have also increased by nearly 90% between 2015 and 2020, however, this lower rate of increase than seen for petrol means that petrol now accounts for nearly 45% of imports compared to just under 40% in 2015.

Figure 3.2: Imports of Petroleum Products (tonnes)



Source: MERA

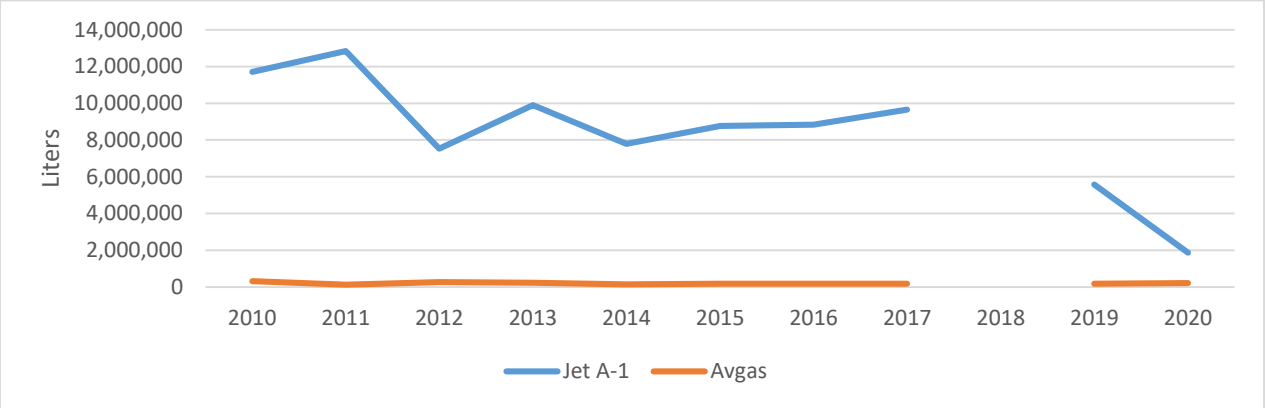
Table 3.1: Imports of Petroleum Products (tonnes)

	Petrol	Diesel	Paraffin (kerosene)	Aviation kerosene	Av gas	LPG	Total
2015	98599.6	140332.6	410.2	7035.6	124.5	658.9	247161.4
2016	123103.8	158935.5	633.5	7096.1	124.6	834.4	290728.0
2017	136912.2	191059.0	512.2	7747.5	125.0	883.9	337239.8
2018	154854.8	230428.9	382.4	n.a	n.a	1308.1	386974.1
2019	183136.4	216318.6	269.9	4470.6	124.2	1031.9	405351.7
2020	215263.0	261735.2	557.0	1497.5	151.6	1108.7	480313.0

Source: MERA

The only fuel to see a decline in imports in recent years has been Jet kerosene (Jet A1), with imports in 2020 around a third of the 2019 level, see figure 3.3. It is likely that the fall was due to the impact of COVID. Data for 2018 was not available hence the break in the trend.

Figure 3.3: Imports of Aviation Fuels (litres)

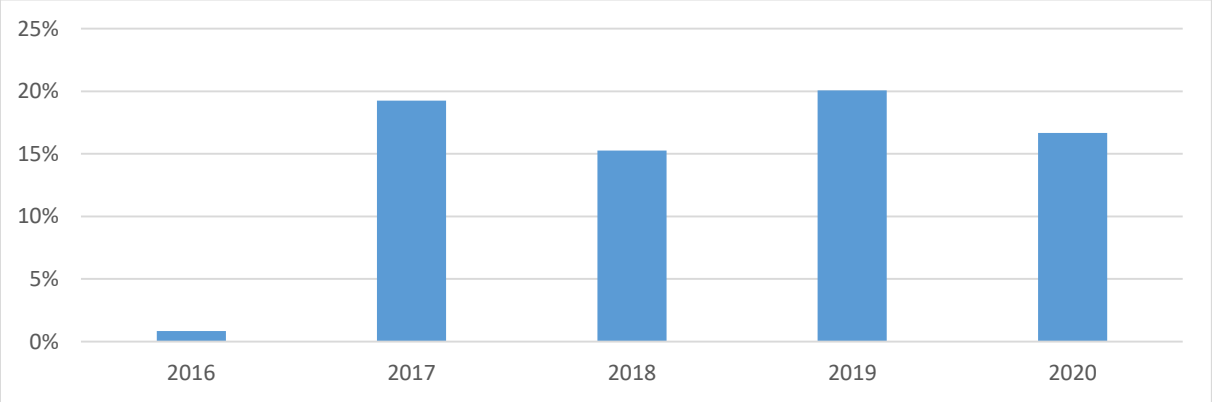


Source: MERA

MERA publish data on total sales of each product, but currently a full picture of the users and uses of all fuels needs to be developed and a survey of petroleum product distributors is a possibility to collect some additional information on users. However, using the framework of the energy balance some insights into the use of fuels can be made.

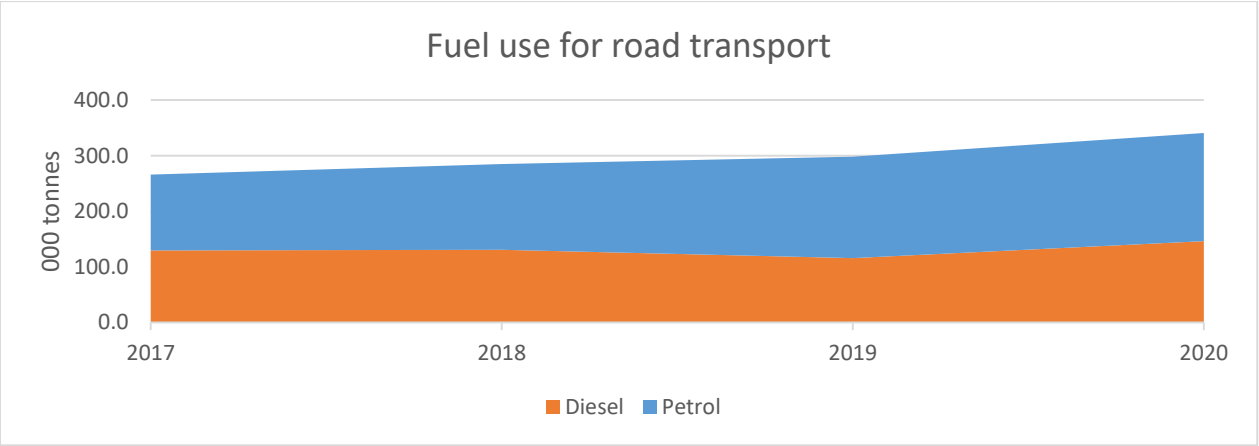
Diesel is a multi-purpose fuel, which can be used by many forms of transport, though road transport will be the largest, electricity generation, industry and agriculture, etc. As explained in the next section, since 2017, electricity produced from diesel has made a larger contribution of electricity generated in Malawi, mainly due to the Aggreko contact. This means that more of the available diesel has been used in power generation, the amount varies from 15 to 20% of imported diesel as shown in Figure 3.4. In addition, a small amount of diesel is also used by auto producer electricity generation plants (businesses and households producing their own electricity).

Figure 3.4: Estimated Percentage of Diesel Imports used by Main Electricity Generators



The use of diesel for power generation means the availability of the fuel for other purposes has reduced, despite imports increasing. This means that the share of diesel for road transport has been falling relative to petrol, as shown in Figure 3.5.

Figure 3.5: Estimated Fuel Use for Road Transport (thousand tonnes)



Section 2 explained the basis of the overall energy balance. A prior step in developing energy balances is to calculate commodity balances. These broadly take the same form as energy balances, but are calculated in natural units (i.e. tonnes or litres). A commodity balance for petroleum products for 2020 is shown in Table 3.2.

Table 3.2: Commodity Balance for Petroleum Products 2020 (thousand tonnes)

	Petrol	Diesel	Paraffin (kerosene)	Aviation kerosene	Aviation gasoline	LPG
Imports	215.3	261.7	0.6	1.5	0.2	1.1
Exports						
Bunkers				*-1.5*		
stock change						
TES	**215.3**	**261.7**	**0.6**	**0.045**	**0.2**	**1.1**
Stats difference	*-21.0*	*-5.8*	*-0.3*	*-0.045*	*0.0*	*0.0*
Losses						
Electricity generation		46.6				
MAP		43.7				
Autoproducer	0.5	2.9				
TFC	**194.8**	**215.1**	**0.3**	**0.0**	**0.2**	**1.1**
Industry		*32.3*				
Transport	194.8	*159.2*			0.2	
Rail		*4.3*				
Road	194.8	*146.3*				
Air				*0.0*	*0.2*	
Marine		*8.6*				
Households			*0.2*			*0.6*
Agriculture		*6.5*				
Services/commercial		*17.2*	*0.1*			*0.6*
Non-energy use						

Note: Figures in italics are estimated

3.3 Electricity

In the context of the energy statistics, electricity is generated from two types of producers. Firstly, Major Activity Producers (MAP), which are businesses whose main activity is to generate electricity, such as EGENCO, and auto producers, which are businesses who produce electricity largely for their own needs but their main economic activity is not the production of electricity. Examples for auto producers include sugar mills. Table 3.3 shows electricity generated by source from both types of generators.

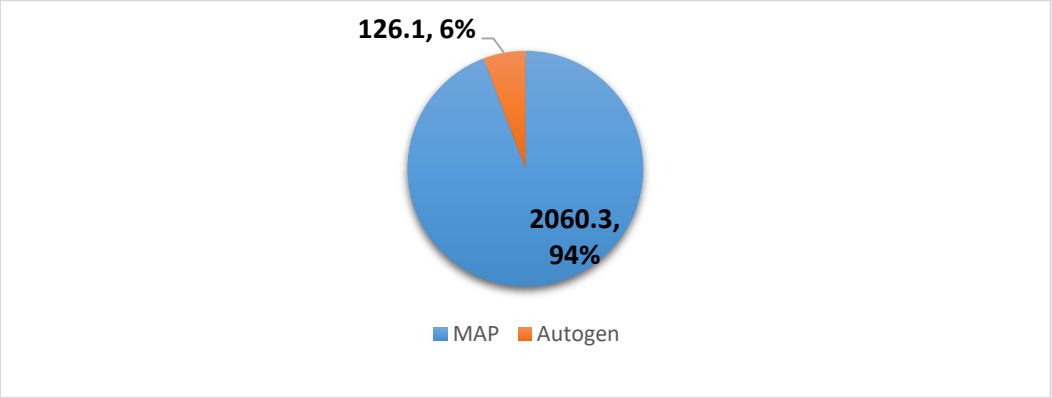
Table 3.3: Electricity Generation (GWh)

	2012	2013	2014	2015	2016	2017	2018	2019	2020
MAP									
Hydro	1877.1	1864.5	1969.5	1952.3	1850.6	1807.3	1666.6	1756.2	1862.0
Diesel					5.6	169.0	162.4	197.0	198.2
Solar									0.2
Total	**1877.1**	**1864.5**	**1969.5**	**1952.3**	**1856.2**	**1976.3**	**1829.0**	**1953.2**	**2060.3**
Autoproducers									
Hydro						3.4	3.4	3.4	3.4
Diesel						11.8	11.8	11.8	11.8
Solar						0.1	0.1	0.1	0.1
Biomass	148.2	106.0	106.3	140.1	133.4	130.8	98.1	71.9	109.0
Petrol						1.8	1.8	1.8	1.8
Total	**148.2**	**106.0**	**106.3**	**140.1**	**133.4**	**147.9**	**115.2**	**89.0**	**126.1**
Overall total	**2025.3**	**1970.5**	**2075.8**	**2092.4**	**1989.6**	**2124.2**	**1944.2**	**2042.2**	**2186.4**

Note: Estimates for autoproducers were made for 2020 and repeated for 3 prior years. No estimates have been made for years preceding 2017. Biomass is virtually all bagasse, which is used in sugar mills.

Electricity generated by MAP makes up the majority of electricity generated in Malawi, as shown in Figure 3.6, accounting for 94% of generation. It is the power produced by MAPs that is fed into the electricity grid and used by homes and businesses. However, it is also important to measure autoproducer electricity generation as it meets a need for electricity that would otherwise need to be provided from grid supplies.

Figure 3.6: Share of Electricity Generation by type of Electricity Producer 2020 (GWh)



Measuring the electricity that is produced by autoproducers needs to be collected from the businesses operating the plants, and whilst discussions are under way with MERA and others on the best way to obtain these data, currently autoproducer generation has been estimated (as described in the methodology section). Therefore, the rest of the focus on generation looks only at MAP generation.

As can be seen from Table 3.3 and Figure 3.7, the amount of electricity generated from hydro plants reached a peak (to date) in 2014 of 1969.5 GWh, before falling year on year to reach 1666.6 GWh in 2018, from where it increased again to 1862 GWh in 2020. However, overall MAP generation was the highest in 2020 at 2060.3, the first time it had surpassed 2 TWh. The main reason for this has been the growth in the use of diesel generation both from Aggreko plants and those run by EGENCO. Since 2017, diesel has accounted for around 10% of all electricity generation by MAP. Solar generation started in 2020 and as such contributed a small amount of 0.2 GWh.

Figure 3.7: Main Activity Producer Electricity Generation (GWh)

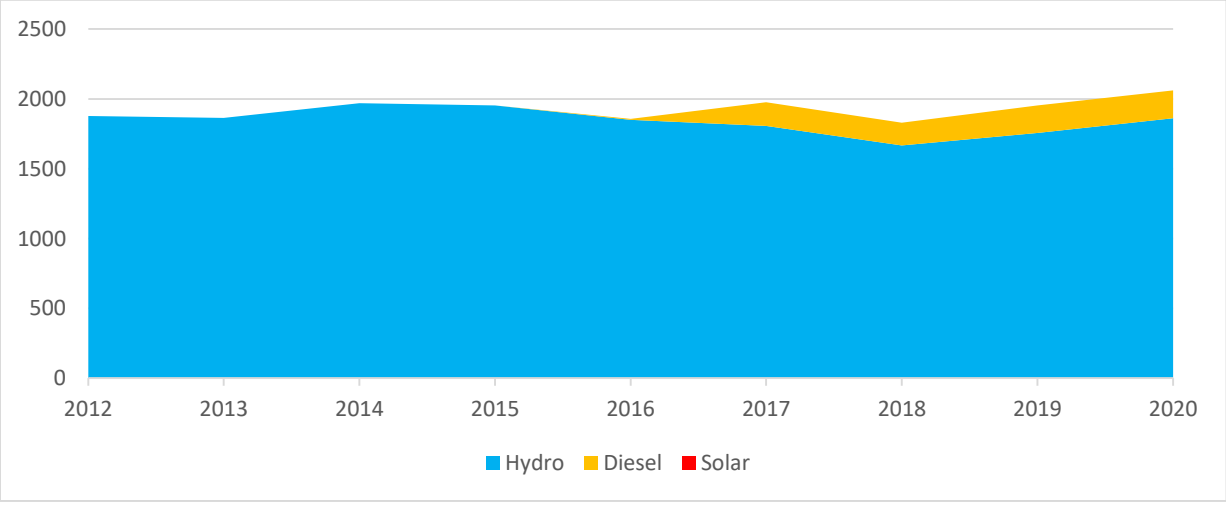


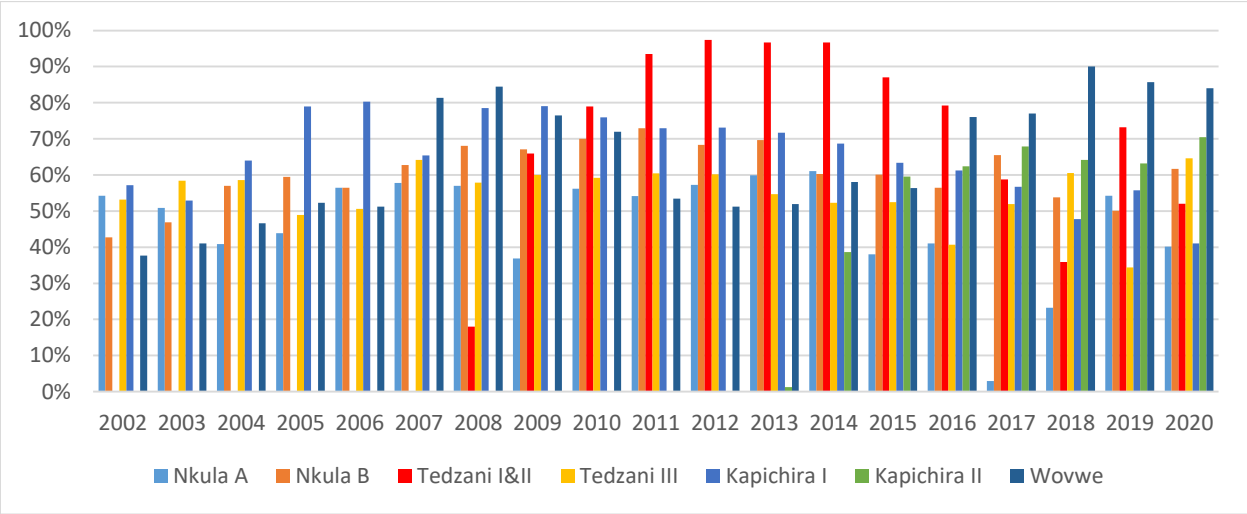
Table 3.4 shows the capacity of electricity generation plants in Malawi, split between EGENCO, IPPs and autoproducers of plants operating during 2022. The contract with Aggreko was completed in March 2022, so its capacity is not included in the total. Kapichira, although not operating for most of 2022 due to storm damage has been included, though it will have produced very little electricity in 2022.

Table 3.4: Electricity Generation Capacity (MW)

Operator	Plant name	Net capacity (MW)	Operation date	Energy type	Notes
EGENCO	Nkula A	35.1	1966	Hydro	
	Nkula B	100.0	1992	Hydro	
	Tedzani I	20.0	1972	Hydro	
	Tedzani II	20.0	1976	Hydro	
	Tedzani III	62.0	1995	Hydro	
	Kapichira Phase I	64.8	2000	Hydro	Kapichira offline in 2022 due to a storm
	Kapichira Phase II	64.8	2013	Hydro	Kapichira offline in 2022 due to a storm
	Wovwe	4.4	1996	Hydro	
	Tedzani IV	19.1	2021	Hydro	
	Mapanga	20.0	2018	Diesel	
	Luwinga	6.0	2017	Diesel	
	Kanengo Phase I	10.0	2016	Diesel	
	Kanengo Phase II	10.0	2019	Diesel	
	Lilongwe A	5.4	2016	Diesel	
	Likoma	1.2	2019	Diesel	
	Chizumulu	0.7	2019	Diesel	
	Likoma	1.0	2020	Solar	
	Chizumulu	0.3	2020	Solar	
	Total	**444.7**			
IPP	Mulanje Hydro	8.2	2018	Hydro	
	Cedar Hydro	3.0	2022	Hydro	
	Aggreko	78.0	2017	Diesel	Contract ended in March 2022, capacity not included in totals
	JCM Salima	60.0	2021	Solar	
	Golomoti	20.0	2022	Solar	
	Total	**91.2**			
Autoproducer	Dwangwa	18.0		Bagasse	
	Other autoproducers	17.0		Mixed	
	Total	**35.0**			
	Overall total	**570.9**			

With capacity and generation, it is possible to calculate the load or capacity factor of generation plants. That is the proportion of electricity generated against the theoretical maximum of the plant running 24 hours a day in 365 days a year. Figure 3.8 shows the load factor for EGENCO's hydro plants. This shows how some plants have operated over 80% for a number of years, but in general, there appears to be an increase up to a high level, but that level is only achieved for a number of years before a reduction occurs.

Figure 3.8: Load (Capacity) Factors of EGENCO Hydro Plants



Load factors for plants operating in 2020 are shown in Figure 3.9. This shows the higher rates of hydro compared to other plants. However, it should be noted that the solar plants started operation in 2020 and the figure will be lower because they were not operating for a part of the year.

Figure 3.9: Load (Capacity) Factors of Electricity Generation Plants 2020

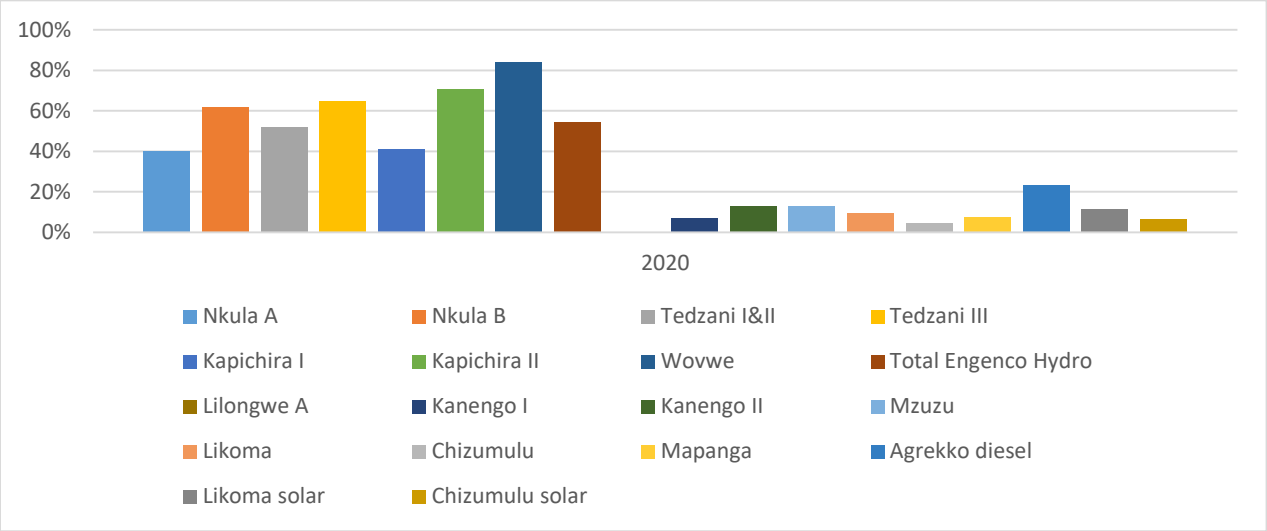
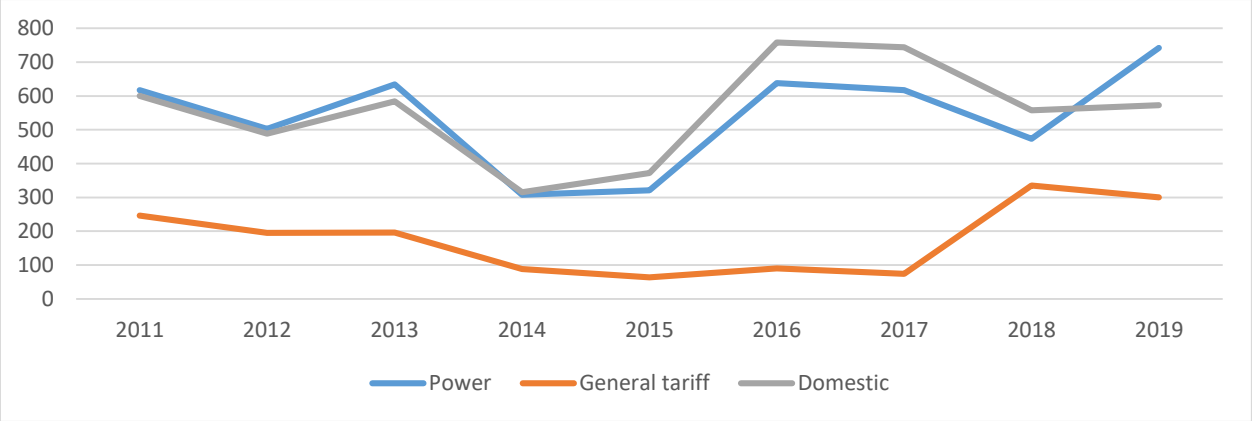


Figure 3.10 shows ESCOM electricity sales by the tariff types. Sales fell from 2013 before starting to increase again for Power and Domestic tariff categories in 2016 although sales on the General Tariff remained at a low level until 2018. Consumers on the Power tariff became the largest users in 2019 at 742.6 GWh, followed by Domestic at 572.3 GWh and General at 300 GWh.

Figure 3.10: Electricity sales by tariff (GWh)



Source: NSO from ESCOM

Currently no data exists to show consumption by detailed economic sector, although positive discussions are underway with ESCOM to produce such a series. As such, as an interim measure, sales have been allocated to sectors using the results of the NSO Census of Economic Activities (CEA) 2016-2017, which covered expenditure on electricity as can be seen in Methodology Section 5. Households/residential is sales on the Domestic tariff. Table 3.5 also includes consumption by autoproducers.

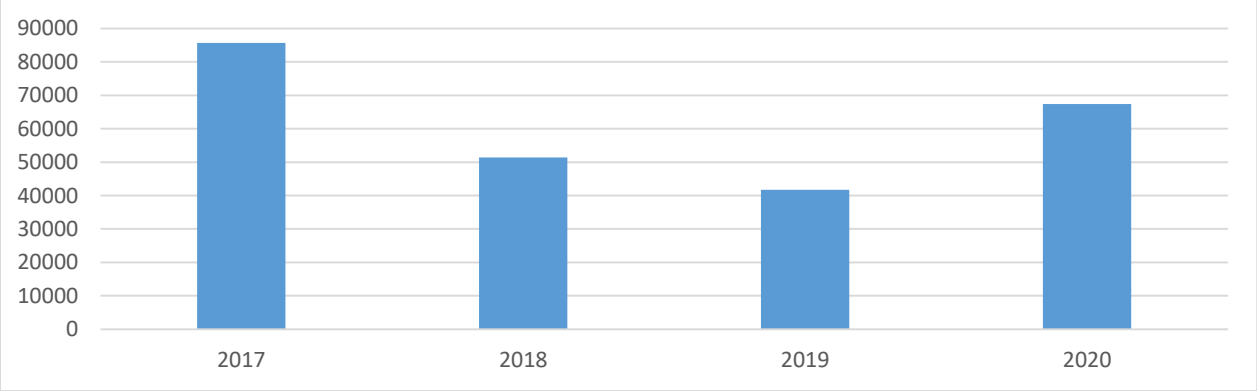
Table 3.5: Final Consumption of Electricity by Sector (GWh)

					GWh
	2016	2017	2018	2019	2020
Iron and steel	5.9	7.7	4.3	6.8	7.3
Food, beverages and tobacco	473.0	464.7	345.8	453.8	519.5
Textiles and leather	17.0	18.1	14.5	22.7	24.5
Paper, pulp and print	13.1	12.0	8.7	13.7	14.7
Wood products	33.0	30.2	20.2	31.6	34.1
Chemical and petrochemical	6.2	4.8	3.4	5.4	5.8
Non-metallic minerals	78.3	104.8	85.4	133.9	144.3
Machinery	9.3	7.5	5.3	8.2	8.8
Transport equipment	1.3	0.0	0.0	0.0	0.0
Mining and quarrying	1.1	1.2	0.7	1.1	1.2
Construction	33.0	30.3	20.2	31.7	34.1
Not specified	88.1	75.9	72.7	114.1	122.9
Services	86.2	72.9	329.8	295.5	295.5
Agriculture and fishing	3.8	1.1	5.2	4.7	4.7
Households/Residential	758.0	744.2	557.6	572.3	600.0
Total	**1607.3**	**1575.4**	**1473.7**	**1695.4**	**1817.4**

Note: consumption includes own consumption from autoproducers

The electricity above covers production and use via the main electricity grid and autoproducers. However, it is also important to consider local or home based systems, which are providing power to homes and communities. Across Malawi, there are a number of mini-grids ranging from 5 to 300 kW providing power to homes, hospitals and business. In addition there are increasing sales of home solar lighting, as Figure 3.11 using data from GOGLA shows, with nearly a quarter of million sold between 2017 and 2020. The 2018 Malawi census showed that across Malawi, 264,216 homes were using solar as a source of lighting, with 18,766 homes using solar as a source for cooking.

Figure 3.11: Sales of Portable Lanterns, Multi-light Systems and Solar Home Systems



Source: GOGLA, https://www.gogla.org/sites/default/files/resource_docs/malawi_country_brief.pdf

Grid system and sales do not necessarily mean additional use of electricity, so this is an area that data and understanding needs to be developed. However, based on homes using solar and sales it could be that between 1 and 3 GWh of additional electricity is being produced from home based solar systems. Continued cooperation with NSO and the use of the IHS is likely to provide an initial view of use of off grid electricity in homes in Malawi.

3.4 Biofuels

Biofuels covers biomass, bioliquids and biogases and as set out in Section 1, biofuels, specifically biomass is the most used fuel in Malawi.

Collecting data on biomass is considerably more challenging than for other fuels. Biomass (especially wood) has very few main suppliers and most of it is collected locally by women and children or, like charcoal, purchased at local markets. A lot of charcoal is made in homes and villages, with only a small amount being produced sustainably on a large scale.

Therefore, understanding the use of biomass has to be developed from understanding the use of the fuels in homes and business. In this first energy balance for Malawi, a methodology was developed to use all existing data to estimate biomass use, and the methodology is set in summary in the Methods Section 5 and in detail in Annex A. Going forward, substantial energy use surveys of households and business will be needed to understand more about the use and supply of all forms of biomass and indeed all biofuels.

Figure 3.12 and Table 3.6 show the estimates of the direct consumption of wood and charcoal in Malawi as well as the wood required to make the charcoal and the total amount of wood used each year. The direct consumption of wood is by far the largest element at 9.2 million tonnes in 2020, but as more homes switch to charcoal (as indicated by the IHS), an increasing amount of wood is required to make charcoal. The wood used for charcoal production was estimated at 669 thousand tonnes in 2010, but by 2020, it had grown to 1.7 million tonnes.

Figure 3.12: Total Wood and Charcoal Consumption and Production (tonnes)

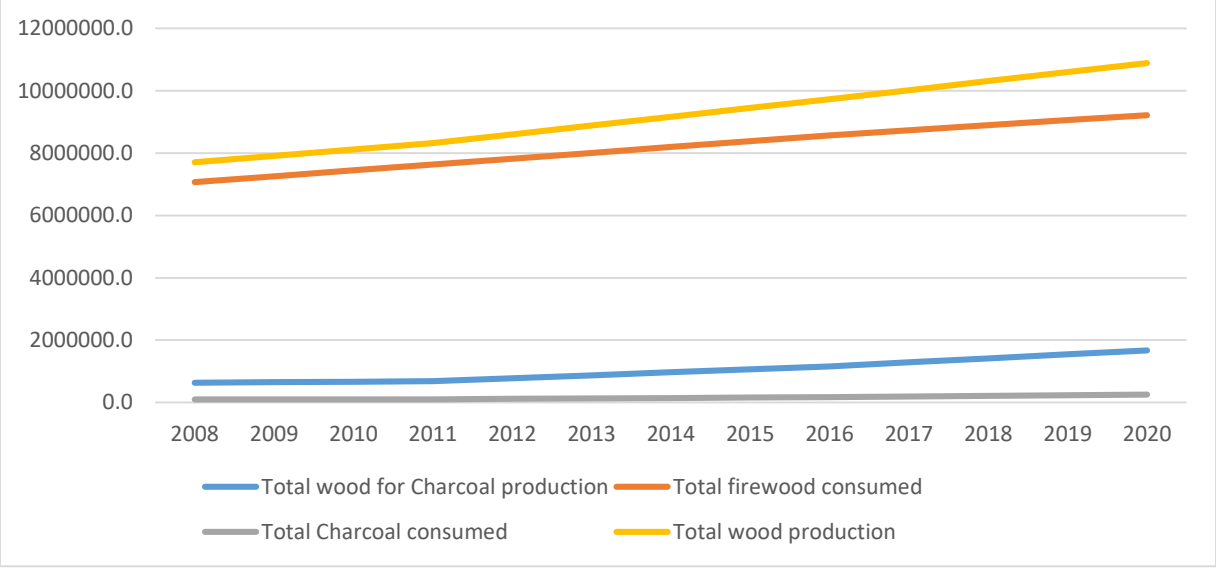
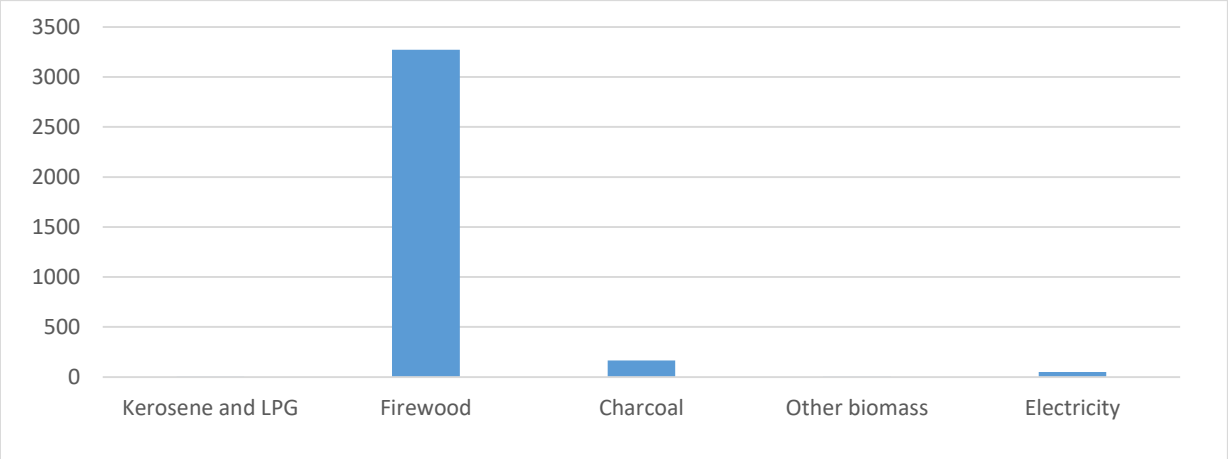


Table 3.6: Household (HH) and non-household (non-HH) Wood and Charcoal Consumption (tonnes)

Year	HH firewood consumed	Non-HH firewood consumed	HH charcoal consumed	Non-HH charcoal consumed	Wood for Charcoal production	Total wood required
2008	6729893.0	336000.0	89159.1	6574.0	638221.0	7704113.9
2009	6910885.2	345036.3	91290.4	6731.2	653477.3	7909398.8
2010	7091877.5	354072.6	93421.7	6888.3	668733.6	8114683.7
2011	7272869.8	363108.9	95553.0	7045.5	683989.8	8319968.6
2012	7450085.0	371956.7	108933.2	8032.1	779768.8	8601810.4
2013	7627300.2	380804.4	122313.5	9018.6	875547.7	8883652.3
2014	7804515.4	389652.1	135693.8	10005.2	971326.6	9165494.1
2015	7981730.6	398499.9	149074.0	10991.8	1067105.5	9447336.0
2016	8158945.8	407347.6	162454.3	11978.4	1162884.4	9729177.8
2017	8314405.4	415109.2	180213.0	13287.8	1290005.0	10019519.6
2018	8469865.1	422870.7	197971.6	14597.2	1417125.7	10309861.4
2019	8625324.7	430632.3	215730.3	15906.6	1544246.3	10600203.3
2020	8780784.4	438393.8	233489.0	17216.0	1671366.9	10890545.1

The use of biomass is especially significant in the residential sector. In 2020, it is estimated that 99% of fuels used by households in their homes across Malawi was biomass. Figure 3.13 and Table 3.7 show how home energy use is broken down.

Figure 3.13: Household/Residential Sector Final Energy Use 2020 (kToe)



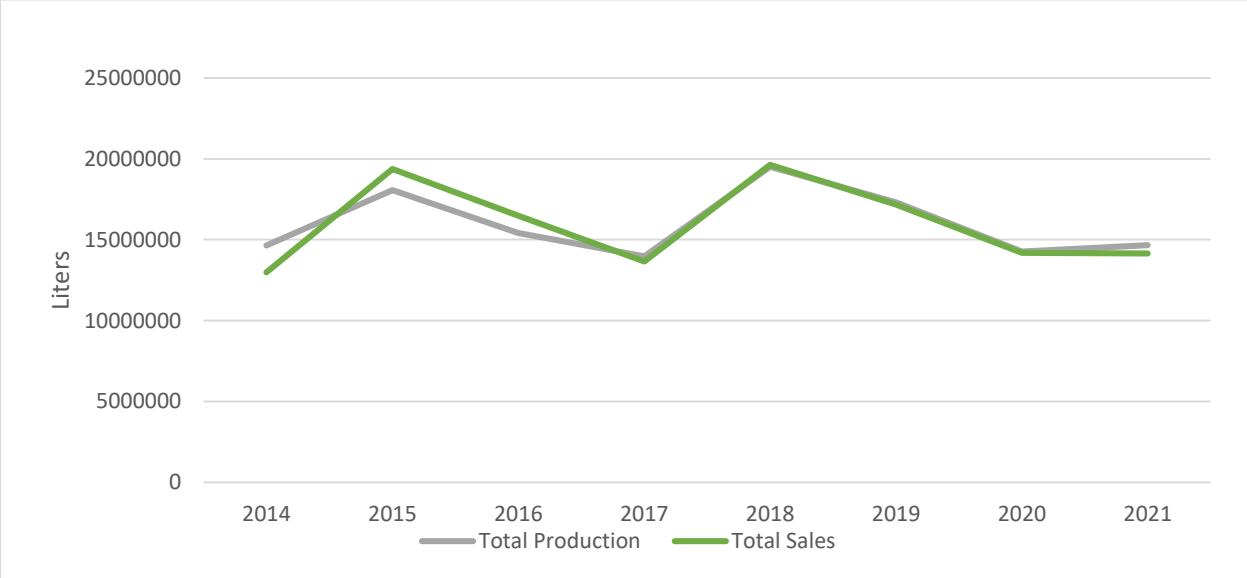
Note: these estimates exclude electricity provided by solar lamps etc., which as referenced in page 2, requires additional work to be able to estimate accurately.

Table 3.7: Household/Residential Sector Final Energy Use (kToe)

Kerosene and LPG	Firewood	Charcoal	Other biomass	Electricity
0.8	3271.7	164.5	1.3	51.6

In addition to biomass, there is also production and use of bioliquids, namely ethanol. This is produced from molasses and is used in transport, where it is blended with petrol. Figure 3.14 shows the production and sales of ethanol with around 15 million litres being produced in 2020, somewhat lower that the 20 million litres produced in 2015 and 2018.

Figure 3.14: Ethanol Production and Sales (litres)



Source: MERA

SECTION 4: ENERGY PRICES

4.1 Fuel Prices

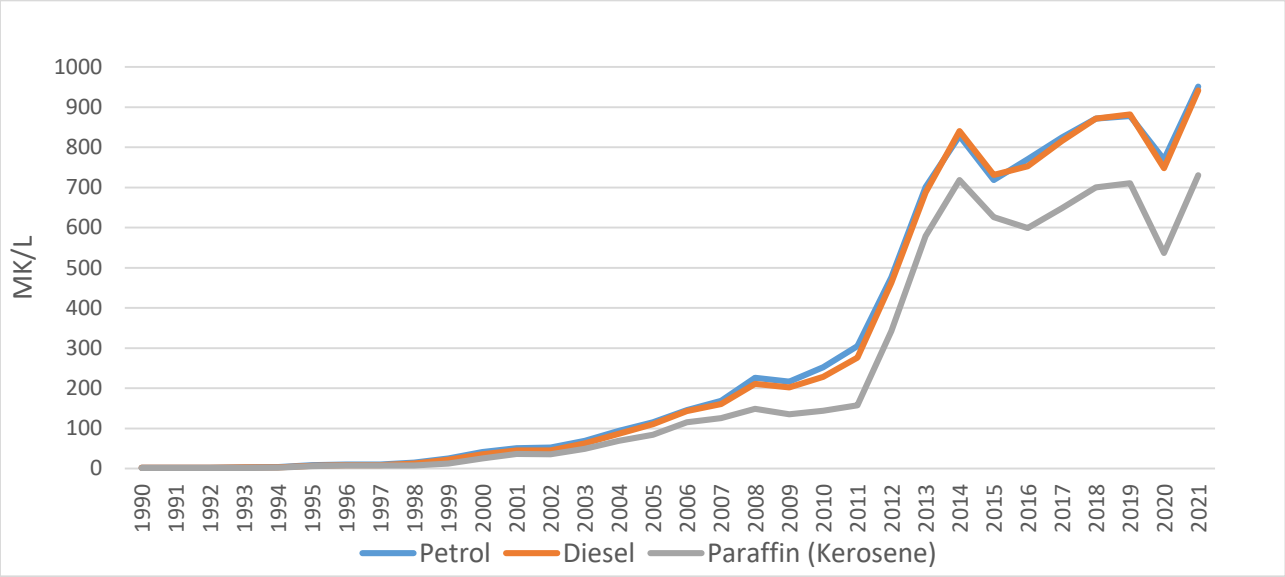
Prices for petrol, diesel and Kerosene (paraffin) are shown below in Table 4.1 and Figure 4.1, with data sourced from MERA.

Table 4.1: Prices of Petroleum Products (MK/litre)

Year	**Petrol**	**Diesel**	**Paraffin (Kerosene)**
1990	2.2	1.9	1.2
1991	2.2	1.9	1.2
1992	2.5	2.3	1.4
1993	3.0	2.8	1.7
1994	4.1	3.3	2.0
1995	8.8	7.3	6.1
1996	10.0	8.4	7.5
1997	10.0	8.4	7.5
1998	15.0	12.9	8.0
1999	24.9	21.8	12.3
2000	41.4	35.8	25.1
2001	51.1	45.3	36.8
2002	52.4	45.3	35.3
2003	69.1	62.5	49.1
2004	93.8	86.6	68.9
2005	115.4	110.2	84.0
2006	145.7	143.1	115.5
2007	168.5	160.6	125.9
2008	226.1	211.1	148.8
2009	216.6	202.2	135.0
2010	252.6	228.5	144.3
2011	305.0	276.7	157.7
2012	476.4	462.4	342.1
2013	701.2	687.2	578.9
2014	828.2	840.6	718.7
2015	718.9	731.4	626.0
2016	770.4	753.2	598.9
2017	824.7	815.8	648.7
2018	871.5	871.4	699.9
2019	878.3	882.3	710.5
2020	769.8	748.3	537.1
2021	951.1	941.6	730.2

Source: MERA

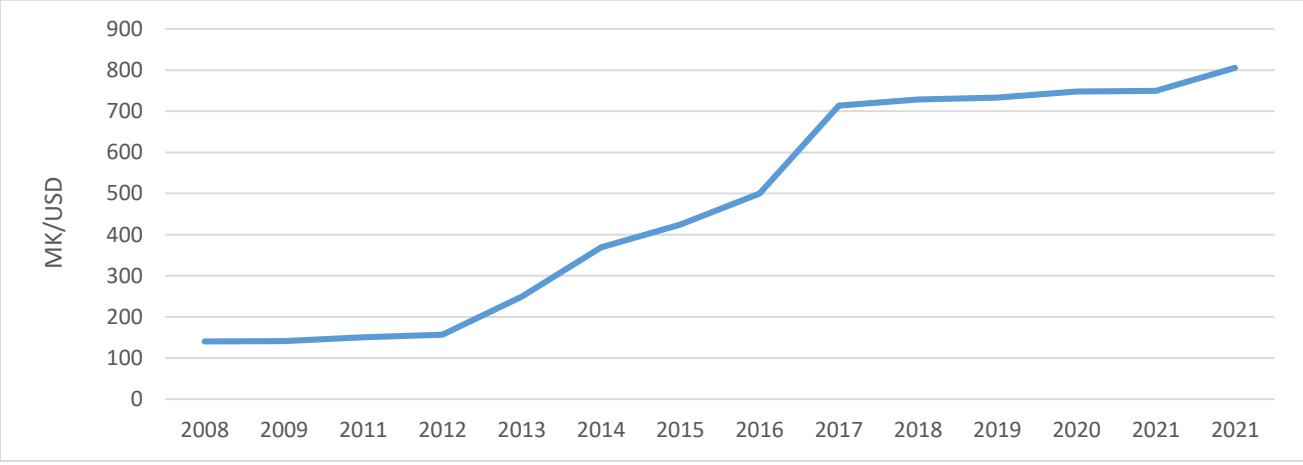
Figure 4.1: Prices of Petroleum Products (MK/litre)



Source: MERA

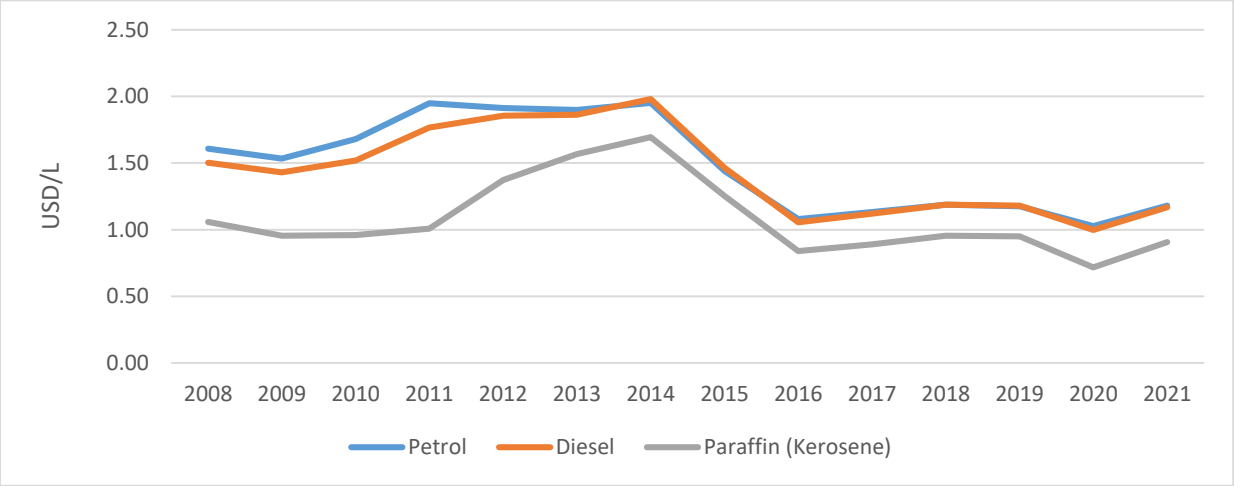
The overall time series show a steady increase in fuel prices from the late 1990's, before a rapid acceleration from around 2011. The price of fuels is driven by many factors and a significant one is the cost of crude oil, which is driven by global events along with refining and transport costs. However, there are other factors that drive the cost of fuel in Malawi. The first is the exchange rate with the dollar. Over the past 10 years, the value of the Malawi Kwacha fell sharply against the US dollar, the currency used in the oil market, as shown in Figure 4.2. This shows that in 2012, there were around 100 Malawi Kwachas to a US dollar, but by 2017 this had grown to over 700. Figure 4.3 shows the impact of this change. It shows fuel prices converted to US dollars, highlighting that in dollar terms prices in 2021 were at or lower than seen in 2010.

Figure 4.2: Malawian Kwacha to US dollar



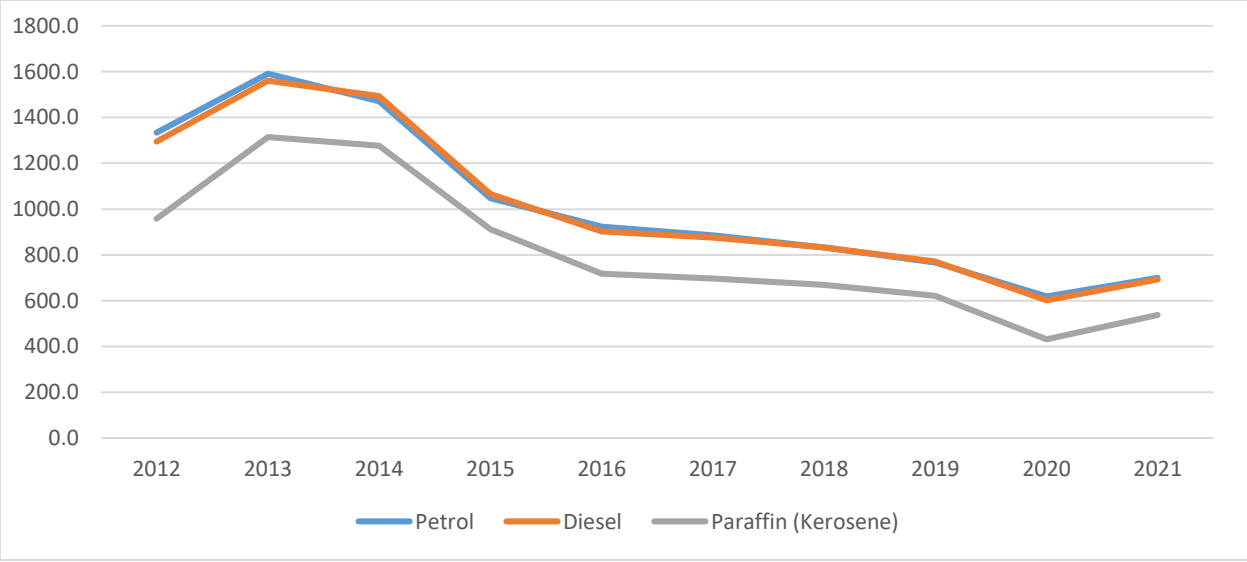
Source: Malawi NSO Quarterly Bulletin Table 6.3

Figure 4.3: Prices of Petroleum Product (USD/litre)



Another factor that influences the price of fuel is inflation. NSO data shows that inflation, as measured by the Consumer Price Index (CPI), in Malawi was running at over 20% between 2013 and 2016, but fell in more recent years to around 10%. Figure 4.4 shows the price of fuels adjusted for general inflation, which is known as real terms.

Figure 4.4: Prices of Petroleum Products in Real 2017 Prices (MK/litre)



LPG is priced in terms of MK/kg. Table 4.2 shows the price of LPG, again provided by MERA in actual prices, US dollars and in real terms, deflated by the CPI.

Table 4.2: LPG Prices

Year	MK/kg	USD/kg	In 2017 real terms (MK/kg)
2015	1,807.0	3.6	2,634.2
2016	1,967.6	2.8	2,356.5
2017	2,125.7	2.9	2,282.3
2018	2,153.4	2.9	2,056.7
2019	1,963.2	2.6	1,714.6
2020	1,681.6	2.2	1,351.8
2021	2,052.3	2.5	1,509.0

Source: MERA

4.2 Electricity Prices

Electricity prices can be more complicated to calculate as the amount paid consists of a unit charge, and a fixed charge and those rates can vary by the level of consumption or Phase. This is illustrated in Table 4.3 that shows the current tariffs for domestic (household consumers).

Table 4.3: Domestic Electricity Tariffs

Tariff Description	Type of Charge per month	Rate (Mk)
Domestic , Prepaid , Single Phase Supply	Fist 50 KWh Unit Charge	56.00
	Above 50 KWh Unit Charge	79.30
Domestic , Postpaid , Single Phase supply	Fist 50 KWh Unit Charge	49.30
	Above 50 KWh Unit Charge	75.30
	Fixed Charge	5,900.00
Domestic , Prepaid , Three Phase Supply	Unit charge per KWh	113.20
Domestic , Postpaid , Three Phase Supply	Fixed Charge	14,100.00
	Unit charge per KWh	109.65

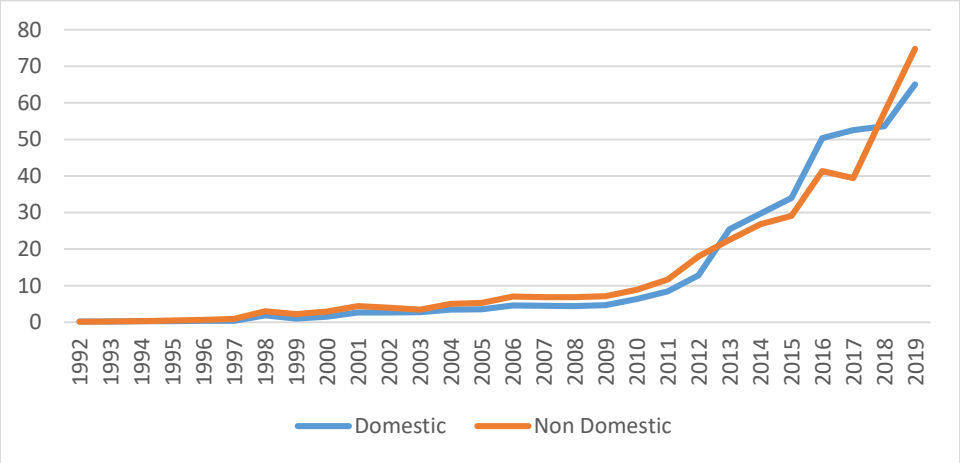
Source: MERA

One way of calculating an average price is to calculate an average value of sales per unit, which is the value of total sales divided by the volume of total sales. Data on electricity sales, both value and volume are published by the NSO in the Malawi Statistical Year book for each tariff type (i.e. Domestic, Power and General). Using this approach, Table 4.4 and Figure 4.5 show average electricity prices for domestic (households) and non-domestic consumers, where the non-domestic is the sum of the values and volumes for the Power and General tariffs.

Table 4.4: Average Electricity Prices (MK/kWh)

	Domestic	Non Domestic
1992	0.19	0.15
1993	0.20	0.20
1994	0.27	0.26
1995	0.33	0.49
1996	0.38	0.65
1997	0.43	0.91
1998	1.84	3.00
1999	0.98	2.21
2000	1.50	2.91
2001	2.70	4.39
2002	2.69	3.98
2003	2.76	3.44
2004	3.44	5.01
2005	3.50	5.27
2006	4.59	7.03
2007	4.46	6.89
2008	4.40	6.87
2009	4.65	7.11
2010	6.36	8.92
2011	8.44	11.70
2012	12.82	18.01
2013	25.44	22.54
2014	29.71	26.81
2015	33.97	29.11
2016	50.34	41.34
2017	52.56	39.44
2018	53.65	57.33
2019	65.10	74.78

Figure 4.5: Average Electricity Prices (MK/kWh)



SECTION 5: DEFINITIONS AND METHODS

5.1 Key Definitions

The table below provides definitions for some of the key flows of the energy balance. For a full definition see the International Recommendations for Energy Statistics,[2] the basis upon which the energy statistics for Malawi have been developed.

Table 5.1: Definitions of Main Flows in an Energy Balance

Term	Definition
Production	In energy balances, production refers to the quantities of fuels extracted or produced, calculated after any operation for removal of inert matter or impurities (e.g. sulphur from natural gas).
Imports, Exports	Comprise amounts having crossed the national territorial boundaries of the country whether or not customs clearance has taken place. Transit fuels (i.e. fuels destined for another country are excluded). In the energy balance exports are shown with a negative sign (i.e. it is removed from supply for the country).
International aviation bunkers	Includes deliveries of aviation fuels to aircraft of all flags for international aviation. In the energy balance bunkers are shown with a negative sign (i.e. it is removed from supply for the country).
Stock changes	Reflects the difference between opening stock levels on the first day of the year and closing levels on the last day of the year of stocks on national territory held by producers, importers, energy transformation industries and large consumers. A stock build is shown as a negative number, and a stock draw as a positive number (i.e. adds to the supply for the country).
Total energy supply (TES)	Is the energy available for use in the country in the specific year of the balance. It is made up of production + imports - exports -

[2] https://unstats.un.org/unsd/energystats/methodology/ires/

	international marine bunkers - international aviation bunkers ± stock changes. The term is also often referred to as Total primary energy supply (TPES).
Statistical difference	The difference between supply and demand. Statistical differences arise because the data for the individual components of supply are often derived from different data sources.
Transformation processes	Transformation processes comprises the conversion of primary forms of energy to secondary and further transformation (e.g. coking coal to coke, crude oil to oil products, and fuel oil to electricity). In the energy balance inputs to the transformation process are shown as a negative and outputs as a positive.
Main activity producer electricity	Main activity producers generate electricity for sale to third parties, as their primary activity. They may be privately (e.g. IPPs) or publicly owned (e.g. State company).
Autoproducer electricity	Autoproducer undertakings generate electricity wholly or partly for their own use as an activity, that supports their primary activity. They may be privately or publicly owned. Also known as auto-generators.
Charcoal production plants	The transformation of solid biofuels (normally wood) into charcoal.
Energy industry own use	Energy industry own use covers the amount of fuels used by the energy producing industries (e.g. for heating, lighting and operation of all equipment used in the extraction process, for traction and for distribution).
Losses	Losses in energy distribution, transmission and transportation.
Final consumption	The sum of the consumption in the end-use sectors. Energy used for transformation processes and for own use of the energy producing industries is excluded. It is broken down into the following categories:
Industry	The fuel, electricity or purchased heat consumption by the industrial undertaking in support of its primary activities. Quantities of fuels consumed for the production of electricity are reported under the appropriate Transformation sector. Industry is broken down into 13 sub-sectors defined in terms of ISIC classification.
Transport	Fuels / electricity used for all transport activity irrespective of the economic sector, in which the activity occurs. Transport is broken down into 6 categories defined by type of transport. Only domestic (internal to the country) aviation is shown in aviation.
Households	Fuels/electricity consumed by all households.
Commercial and public services	Consumption by businesses and offices in the following public and private sectors. [ISIC Rev. 4 Divisions and NACE Divisions 33, 36, 37, 38, 39, 45, 46, 47, 52, 53, 55, 56, 58, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 71, 72, 73, 74, 75, 77, 78, 79, 80, 81, 82, 84

	(exclude Class 8422), 85, 86, 87, 88, 90, 91, 92, 93, 94, 95, 96 and 99.]
Agriculture/ forestry/ fishing	Fuel and electricity consumption by users classified as agriculture, hunting and forestry by the ISIC, covering such users whether for traction (excluding agricultural highway use), power or heating (agricultural and domestic). Fishing includes all fuels used for inland, coastal and deep–sea fishing.
Non-specified	Energy consumed in activities not included elsewhere. This category includes the use of military fuel for all mobile and fixed consumption.
Non-energy use	Fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel. Non-energy use is part of final consumption under the heading non-energy use.

5.2 Data Sources and Methodology Notes

5.2.1 Coal

Data was sourced from the Annual Economic Report, Ministry of Economic Planning & Development and Public Sector Reforms with imports taken from the Quarterly Statistical Bulletin produced by the NSO. Additionally, a new data sharing template was developed between the Ministry of Mining and Ministry of Energy in March 2022. This led the way to a greater understanding of both data availability and data quality and will be used to provide data in the future. A template has also been successfully developed for the provision of trade data from NSO.

5.2.2 Petroleum Products

A new data sharing template was developed between MERA and MoE at the start of 2022. This paved the way for data held by MERA on petroleum products, electricity and energy prices to be provided in regular and consistent way to MoE. Additionally, data from the Annual Economic Report, Ministry of Economic Planning & Development and Public Sector Reforms was used.

Diesel fuel use was estimated by first subtracting the fuel used for electricity generation and then allocating the remainder using a mixture of data from other African countries and the results of the NSO Census of Economic Activities (CEA) 2016-2017. Petrol use was allocated to road transport, apart from a small amount used in autoproducer plants. LPG is mainly used as a cooking fuel, its use (taken as supply) was allocated 50% to residential and 50% to services. Kerosene (Paraffin) is largely a lighting fuel, but its use has fallen sharply in recent years as shown by the import data and the IHS survey. Its use was allocated as two-thirds households and one-third services.

Bunkers are the use of fuels for international transport, both aviation and marine. For the majority of countries (if not all), international aviation represent the largest share of the use of aviation fuels. Currently, a source of data for international aviation was not found. The possibility of obtaining these data through the Ministry of Transport and Department of Civil Aviation is being explored to fill this gap. As such, bunker fuel was estimated, using averages from other African countries to estimate domestic (internal aviation), with the remainder going to international flights and hence bunkers. It was also assumed that aviation gasoline was the main fuel used for internal flights. Therefore, the fuel used for internal (and shown in the transport section of the balance) is

the aviation gasoline plus an amount of jet kerosene required to reach the estimate of internal flights. The remainder of jet kerosene is then considered bunker fuel.

5.2.3 Electricity

Electricity supply data were drawn from generation data collected by MoE, along with data published by MERA and ESCOM. Imports were taken from the UN Comtrade database and published export data from Zambia's Energy Regulatory Board. In the future, the trade template developed with the NSO can be used to provide this data.

Demand data were calculated from NSO data on total sales (provided by ESCOM) allocated to business sub sectors using the NSO Census of Economic Activities (CEA) 2016-2017. Taking the power tariff as the electricity provided to industry, the general tariff as the electricity provided to the agricultural and service sectors and domestic as households. Total sales for 2020 were estimated, but given the size of the statistical difference, the overall estimation of total sales looks consistent. All electricity produced by autoproducers was assumed to be consumed on site, so consumption was allocated to the sector of the autoproducer business.

Expenditure is not a perfect way to allocate sales, as businesses will be on different prices. However, it is a start and overall the results look plausible. The best approach will be to get a breakdown of sub-sector use, for the largest consumers, from ESCOM. Discussions are underway and they are keen to help.

5.2.4 Autoproduction

Autoproduction (autogeneration) is the production of electricity by businesses whose main business activity is not electricity generation. Data on the electricity generated by auto-producers has initially been estimated by applying logical load factors derived from the findings of the 2012 Energy Survey to capacity data produced by MERA and the findings of the 2012 Energy Survey. In the future, it is anticipated that direct data collection from auto-producers will be possible through collaboration between MOE, MERA and businesses concerned.

Data on electricity generated from bagasse needs to be developed. The values for this initial work were estimated based on NSO data for sugar production and standard conversion factors developed by IRENA. The quantity of agricultural waste used for electricity generation was also estimated from the calculated generation.

5.2.5 Combined Heat and Power (CHP) also known as Co-generation

In its published reports, Ethanol Company (Ethco) states that it purchases steam from Dwangwa sugar mill. This means that least one, probably all, of the autogeneration plants are CHP plants, which are selling some of the steam (heat) produced.

The treatment of CHP in the energy balance is a little complex. All electricity generated is counted as electricity produced, but it is only heat that is sold that is recorded as heat. The fuel used to make the heat that is used on site is recorded as fuel consumption by the sector. The fact that electricity and heat have to be treated separately means data are needed on the energy used for both electricity and heat.

It is not really possible to make estimations on heat production. It is hoped that more information could be gathered from the mill operators (Illovo). However, for now a simplification has been taken. The autogeneration plants at the sugar mill are classified as CHP, but no heat is reported as sold. Therefore, all the bagasse used for heat is shown as final consumption of bagasse by the food and tobacco sector (see section below on bagasse).

5.2.6 Biofuels

Biomass

Biomass differs from electricity and most fossil fuels because there are no large suppliers. Some may be purchased at local markets, but a lot is collected or made at homes in local villages, in the case of charcoal. This means that it is not possible to collect data on the supplies of these fuels directly and supply can only be estimated from demand or use of the fuel.

The most complete way to understand household energy use is to run surveys of household energy use. Running household surveys require planning. Thought needs to be given to the period of the survey (wet and dry seasons or both), who is most trusted to be the enumerators, the design of survey form and the training of enumerators and some of the vital planning decisions. Thought is also needed on the questions. The goal of the survey is to understand fully the types of fuels used and the quantities (that is the mass of the fuel).

Establishing a full household energy survey is a goal for the future. However, for this initial energy balance, full use was made of all existing survey and census data. The methodology used is set out fully in Annex A.

Ethanol

In Malawi, ethanol is produced from molasses and is used as a road transport fuel, blended with gasoline and thus provides a source of locally produced transport fuel.

In the energy balance, ethanol is shown in the production row, without accounting for its manufacture from molasses, which is not an energy product. This is consistent with all forms of biofuels, with the exception of charcoal, which is shown as being produced via a transformation from wood, an energy product. However, in the energy balance, it is necessary to record the energy products that are used to make the ethanol, this fuel use is considered to be energy industry use.

Data on ethanol production and sales are provided in the AER. In addition, the Ethanol Company publishes an Annual Integrated report[3] that contains very useful data on energy used in making ethanol and data on production. The production data from the Ethanol Company shows all production of ethanol not just that used as a biofuel. Energy is used to make all the ethanol, so the total production figure is used in calculations of energy use.

In the integrated report, the Ethanol company published data on steam use and electricity per litre of ethanol as well as splits of electricity that are grid supplied and those generated from its own

[3] http://www.ethanolmw.com/files/Annual_Integrated_Report_2020.pdf

diesel electricity generation. Information released by Press Cane confirmed the steam used to make ethanol was produced from coal and the electricity it uses was supplied via the grid.

Applying the published input data to the Ethanol Company's production data and using average Ethanol Company factors for electricity use and ethanol per steam for Press Cane, provides the estimates of energy used as shown in Table 5.2.

Table 5.2: Energy Use in Ethanol Production

	2017	2018	2019	2020	Units
Coal	5538.6	8338.9	6907.1	9281.9	Tonnes
Steam purchased	22620.0	15300.0	30445.0	7925.3	Tonnes
Grid electricity	5094.1	6347.7	7069.1	6809.2	MWh
Auto-generation electricity from own diesel plants	413.3	527.2	131.5	166.4	MWh
Autoproducer diesel used for electricity generation	97.6	124.5	31.1	39.3	Tonnes

Ethanol is shown as being used directly as a transport fuel for road transport. Further work is needed with the petroleum industry and MERA to work out if it is included in fuel sales of petrol, given ethanol is blended for use.

5.3 Conversions and Calorific Values

In this report, the following conversion factors and calorific values (CV) were used.

	Petrol	Diesel	Kerosene	Jet kerosene	LPG	Aviation gasoline
litres per tonne	1350	1186	1235	1246	1856	1414
NCV (GJ/t)	44.3	43.0	43.8	44.1	47.3	44.3

Source: (1) IEA Oil information Page III.579 (2) AFREC Annual Energy Statistics Questionnaire (AESQ)

	Coal	Wood	Charcoal	Bagasse	Agricultural waste	Wood waste	Ethanol
NCV (GJ/t)	22.4	15.6	29.5	7.7	13.4	13.9	26.8

Source: AFREC AESQ

1 TJ	is	0.02388	kToe
1 GWH	is	3.6	TJ
1 GWh	is	0.08598	kToe
1 MWh	is	3600	MJ

The electricity load or capacity factor is calculated as:

$$\text{Capacity (or load) factor } = \frac{\text{Net Electricity Production}}{\text{Maximium output } (= \text{Capacity } \times \text{ Time})}$$

SECTION 6: NEXT STEPS

This report is a significant step forward for all in Malawi in understanding the energy we use and where it comes from. It has been established through collaboration between the MoE and other MDAs, supported by international experts. However, it is just the start. Going forward we have to continue to develop the data, fill the gaps and replace estimated data with real data. This can be achieved through the following five (5) steps:

6.1 Enhance collaboration across Ministries, Departments and Regulators

The work has marked an important step forward in collaboration with MoE working in tandem with MERA, MoM and NSO to maximise the use of existing data and establish a framework for data sharing through templates. This work needs to widen to other ministries and organisations including but not limited to: Ministry of Industry and Trade, Ministry of Agriculture, Ministry of Transport and the Department of Civil Aviation.

In addition, enhancing reach out also needs to encompass local communities. Their knowledge on the types of fuels used in their area, specifically the types of biomass will provide a valuable and vital insight.

6.2 Enhance collaboration with Energy Businesses

To date, the main energy businesses such as ESCOM and EGENCO have shown great interest in the work. They have actively engaged in meetings and training sessions. They have shown they value the benefit of enhanced energy data. Very good discussions have happened with them on sharing data. Going forward we need to finalize those procedures. The goal will be to achieve annual templates where the energy businesses can supply data they already hold, but are vital to the energy balance. Examples include, data on fuel used in producing electricity, electricity generated, stocks, losses through transmission and distribution and energy own use.

Equally, it will be important to reach out to trade associations to explore with them how cooperation can be mutually beneficial in energy.

6.3 Maximise the use of existing data collection

The work presented here has drawn heavily on the work of the NSO and their cooperation has been excellent. Going forward, we need to maximise the use of existing planned data collection such as the Integrated Household Survey and Economic surveys to ensure, that whilst we seek to keep the burden on respondents as low as possible, we look to be cost efficient by collecting the data we need on energy (for example on use of home solar kits or generators) through existing routes. The same is true for regulators, we need to explore how their existing data collection can be adapted to also meet the needs of enhanced energy statistics.

6.4 Explore with energy suppliers how to obtain better data on energy users

We need to know more about who uses energy and why and indeed where energy needs are not being met. To do this, we first need to explore how energy suppliers might be able to help. Initial discussions with ESCOM have been positive and working together more information on the sectors using electricity will be available. We also need to explore this in more detail with MERA for petroleum product distributors. Such businesses would not know who is buying fuel and for what use from retail outlets, for example petrol stations, but they are likely to know more about the sectors of their largest business users.

6.5 Plan for new surveys

The most significant gap in energy knowledge in Malawi is the lack of information on the energy used by businesses and for what purpose they use it. We therefore need to plan for a new survey to cover energy used by business specifically large businesses. Such a survey would need to include questions on the use of all energy purchased or sourced by the business. This would cover power, heating/cooling and other processes. The survey should also cover the use of any by-products of the business process used to meet energy needs. In addition, a new survey needs to cover the fuel used for own electricity generation, with this broken down into type of fuel, duration of use, electricity produced and details of any energy that is sold to other businesses. In addition, a new survey could be run by NSO, but supported by MoE, MERA and other Ministries. The survey could be run every three to five years. Initially, it might also prove useful to pilot the survey by looking at particular large businesses. Initially running a focused survey on such large energy consuming businesses or sectors may be a cost efficient way of gathering essential data and accumulating the knowledge necessary to conduct a wider all business/sector survey.

We also need to work together to plan and run a survey on household energy use. This would cover the fuels being used in cooking, lighting, appliances, why that fuel is being used and issues with its supply, including time taken to collect. A survey should also cover other aspects like the use of home solar-kits, small generators, how mobile phones are charged etc.

It is understood that new surveys cost money and that is a challenge. However, securing cross ministry/organization support to run the surveys will be a vital step in securing the finance to run the surveys.

6.6 Conduct Stakeholder Consultation, Validation and Information Dissemination Meetings

There is also need to continuously engage stakeholders to solicit more input on how best energy data could be strengthen in Malawi. Such engagements would also assist to get views on the compiled energy statistics and ensure that the information is validated. The compiled energy statistics need to be disseminated to the public on annual (and hopefully in the future, quarterly) basis through workshop presentation, websites and sharing publications with Ministries, Departments and Agencies as well as the civil society. This report and the associated data file marks an important first step in in dissemination of energy data to all. It needs to be continued on a regular basis and expanded as additional sources of data become available.

SECTION 7: REFERENCES

The following reports were used in the production of the data contained in this report

Title	Link
Annual Economic report (AER)	http://www.finance.gov.mw/index.php/our-documents/annual-economic-reports
2012 Energy Survey	https://mera.mw/reports-presentations/
Malawi Biomass Strategy 2009 report	http://conrema.org/wp-content/uploads/2019/01/Biomass-Strategy-2009.compressed.pdf
NSO Quarterly Statistical Bulletin	http://www.nsomalawi.mw/index.php?option=com_content&view=article&id=3&Itemid=3
NSO Malawi Statistical Yearbook	http://www.nsomalawi.mw/index.php?option=com_content&view=article&id=3&Itemid=3
NSO HIS (household survey) reports	http://www.nsomalawi.mw/index.php?option=com_content&view=article&id=43&Itemid=61 http://www.nsomalawi.mw/index.php?option=com_content&view=article&id=230&Itemid=111
NSO Census 2018	http://www.nsomalawi.mw/index.php?option=com_content&view=article&id=226:2018-malawi-population-and-housing-census&catid=8:reports&Itemid=6

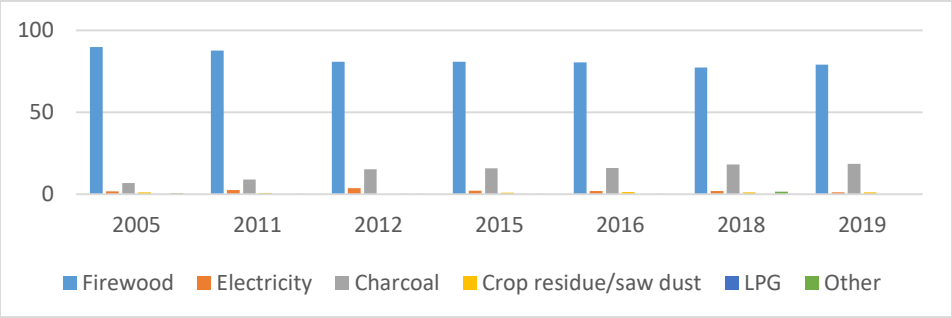
ANNEX A: THE METHODOLOGY USED TO DERIVE ESTIMATES FOR BIOMASS

Household use of biomass

Fuel use

The NSO undertakes a periodic household survey, the Integrated Household Survey (IHS), which has been run four times since 2005. This survey contains questions on the use of fuel for lighting and cooking. Figure A.1 and TA.1 show the breakdown of household fuel use for cooking alongside results from the Energy Survey, run in 2012 by MERA and NSO, the 2018 NSO Census and the 2015 Demographic Health Survey (DHS) an internationally funded survey supported by USAID[4]. These surveys highlight a change from the use of wood to charcoal, especially in the urban areas, with the share of wood use falling from 90% in 2005 to 80% in 2019, and charcoal rising from 7% in 2005 to 19% in 2019.

Figure 8.1: Percentage of households by fuel used for cooking



Source: NSO Integrated Household Surveys, DHS, NSO Census

[4] https://dhsprogram.com/Countries/Country-Main.cfm?ctry_id=24&c=Malawi&Country=Malawi&cn=&r=1

Table 8.1: Percentage of households by fuel used for cooking

	Year	% of households using					
		Firewood	Electricity	Charcoal	Crop residue	LPG	Other
NSO IHS	2005	89.9	1.7	6.8	1.1		0.5
NSO IHS	2011	87.7	2.5	8.9	0.8		0.2
Energy survey	2012	80.8	3.7	15.2		0.1	0.1
DHS	2015	80.9	2.1	15.7	1.0	0.1	0.2
NSO IHS	2016	80.5	1.9	16.0	1.4		0.1
Census	2018	77.4	1.9	18.2	1.1	0.0	1.5
NSO IHS	2019	79.1	1.2	18.5	1.2		0

Source: NSO Integrated Household Surveys, DHS, and NSO Census. Note: in 2018 Census other includes: solar 0.5%, kerosene 0.2%

Fuel consumption by households

A comprehensive survey on actual use of fuels was undertaken in 2008, as an input to the Malawi Biomass Energy Strategy[5] this provided data on household (and non-household) consumption for wood, charcoal, crop residues and wood residues. Key data from this report for households are shown in the table below. The survey data was multiplied by the average number of people per household (see Table A.3) to provide estimates for annual consumption per household, as is shown the 2rd data row of the table.

Table 8.2: Average household consumption of wood fuel and biomass

			Rural			Urban
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
	Firewood	Charcoal	Crop residue/saw dust	Firewood	Charcoal	Crop residue/saw dust
Household use per capita	601.1	7.21	21.1	292.92	94.02	0.38
Household use per household	2704.95	32.45	94.95	1318.14	423.09	1.71

Source Malawi Biomass Energy Strategy and calculations using IHS data

Actual consumption of fuel can vary for a number of reasons. However, it is the number of people in households which is a key driver on fuel use. Data from the IHS indicates that this has been relatively stable over the past 15 years, and thus the estimates of household energy use from 2008 are likely to still be applicable.

Table 8.3: Average household size, people per household

IHS2	IHS3	IHS4	IHS5
2005	2011	2016	2019
4.5	4.6	4.3	4.4

Source: NSO Integrated Household Surveys,

[5] http://conrema.org/wp-content/uploads/2019/01/Biomass-Strategy-2009.compressed.pdf

Number of households

Data on the number of households across Malawi were taken from NSO Census data. This was combined with separate data on the share of population living in urban areas to split households by rural and urban areas (Table A.4) to make use of the available split of consumption between urban and rural areas, which differs considerably. In the absence of data for non- census years, interpolation between census years was used to provide the number of households in each year from 1998.

Table 8.4: Number of households, thousands

	Total	Rural	Urban
1998	2310.2	1986.8	323.4
2008	2842.8	2407.9	435.0
2018	3984.9	3347.3	637.6

Source Calculations based on NSO Malawi Statistical year book, based on NSO census

Survey based estimate of biomass use

Taking the results of the tables above, a repeatable way to estimate biomass use by households in Malawi can be produced. The method takes the average household use (from Table A.2) multiplied by the number of households using the fuel (Table A.1) multiplied with the number of households (Table A.4). The calculation was done separately for urban and rural areas and then combined to produce figures for all of Malawi. Calculations were carried out for each year when an IHS was run and interpolated between IHS years. The rate of change between 2016 and 2019 was applied to 2019 to estimate 2020. The results are shown in Table A.5 below.

Table 8.5: Total household consumption per year, tonnes

	Firewood	Charcoal	Crop residue/saw dust	total
2005	6186916.1	82765.2	2603.0	6272284.3
2006	*6367908.4*	*84896.5*	*2553.0*	6455357.9
2007	*6548900.7*	*87027.8*	*2502.9*	6638431.4
2008	*6729893.0*	*89159.1*	*2452.9*	6821504.9
2009	*6910885.2*	*91290.4*	*2402.8*	7004578.5
2010	*7091877.5*	*93421.7*	*2352.8*	7187652.0
2011	7272869.8	95553.0	2302.7	7370725.6
2012	*7450085.0*	*108933.2*	*2862.8*	7561881.0
2013	*7627300.2*	*122313.5*	*3422.8*	7753036.5
2014	*7804515.4*	*135693.8*	*3982.8*	7944192.0
2015	*7981730.6*	*149074.0*	*4542.9*	8135347.5
2016	8158945.8	162454.3	5102.9	8326503.0
2017	*8314405.4*	*180213.0*	*4819.0*	8499437.4
2018	*8469865.1*	*197971.6*	*4535.0*	8672371.8
2019	8625324.7	215730.3	4251.1	8845306.2
2020	*8780784.4*	*233489.0*	*3967.2*	9018240.6

Charcoal production

It has been assumed that all charcoal consumed is produced in Malawi. A conservative conversion efficiency of 15% (reflecting the fact that a lot of charcoal is made on a small scale) has been applied to the charcoal consumed to derive an estimate of wood used in transformation to charcoal.

Calorific values

Understanding the energy content of biomass requires a calorific value (CV). However, currently no estimates of the CV's for biomass exist in Malawi. As such, default value from Food and Agriculture Organisation (FAO), which are the default AFREC values have been used. These are 13.8 MJ/Kg for wood and 29.5 MJ/Kg for charcoal. This approach is similar to many African countries.

Biomass supply

Estimating the actual supply of biomass is very difficult due to the great number of suppliers, including mainly the consumers (the households) themselves. As such, the approach used was to match the supply to the estimated demand with an assumption that there was no formal trade in any type of biomass.

Non-household use of biomass

The Malawi Biomass Energy Strategy mentioned above, also contained estimates of business use of wood, charcoal and residues. Data in the report for all fuels are in tonnes of wood equivalent, which have been converted into tonnes using factors in the report. Combining the data into sectors as used in energy balances, with an assumption that "Cottage industries" are a form of industrial activity provides the estimates shown in Table A.6.

Table 8.6: Business consumption of fuels by sector, tonnes per year and percentage share, 2008

	Charcoal	Firewood	Wood resides	Crop residues
Food and tobacco	1068.9	193000.0	0.0	12771.8
Non-metallic minerals	0.0	62500.0	10539.8	10539.8
Other Industry	1336.2	3500.0	0.0	0.0
Services	4168.9	77000.0	0.0	1736.0
Total	6574.0	336000.0	10539.8	25047.6
Share of each fuel				
	Charcoal	*Firewood*	*Wood resides*	*Crop residues*
Food and tobacco	*16%*	*57%*	*0%*	*51%*
Non-metallic minerals	*0%*	*19%*	*100%*	*42%*
other industry	*20%*	*1%*	*0%*	*0%*
Services	*63%*	*23%*	*0%*	*7%*
Total	*100%*	*100%*	*100%*	*100%*

Source: Calculations based on the Malawi Biomass Energy Strategy 2009

The figures for 2008 were then used as a base for estimating a time series of consumption. Growth rates were taken as follows: for charcoal and firewood, the annual growth rates for households per year; and for residues, the overall average growth for households over the whole period. The results are shown in Tables A.7, A.8 and A.9 below.

Table 8.7: Business consumption of charcoal, tonnes

	Food and tobacco	Other Industry	Services	Total
2008	1068.9	1336.2	4168.9	6574.0
2009	1094.5	1368.1	4268.6	6731.2
2010	1120.1	1400.1	4368.2	6888.3
2011	1145.6	1432.0	4467.9	7045.5
2012	1306.0	1632.5	5093.5	8032.1
2013	1466.4	1833.1	5719.1	9018.6
2014	1626.9	2033.6	6344.8	10005.2
2015	1787.3	2234.1	6970.4	10991.8
2016	1947.7	2434.6	7596.0	11978.4
2017	2160.6	2700.8	8426.4	13287.8
2018	2373.5	2966.9	9256.8	14597.2
2019	2586.4	3233.1	10087.1	15906.6
2020	2799.4	3499.2	10917.5	17216.0

Table 8.8: Business consumption of wood, tonnes

	Food and tobacco	Non-metallic minerals	Other Industry	Services	Total
2008	193000.0	62500.0	3500.0	77000.0	336000.0
2009	198190.5	64180.9	3594.1	79070.8	345036.3
2010	203381.0	65861.7	3688.3	81141.6	354072.6
2011	208571.5	67542.6	3782.4	83212.5	363108.9
2012	213653.7	69188.4	3874.5	85240.1	371956.7
2013	218735.9	70834.2	3966.7	87267.7	380804.4
2014	223818.0	72479.9	4058.9	89295.3	389652.1
2015	228900.2	74125.7	4151.0	91322.9	398499.9
2016	233982.4	75771.5	4243.2	93350.5	407347.6
2017	238440.7	77215.2	4324.1	95129.2	415109.2
2018	242899.0	78659.0	4404.9	96907.9	422870.7
2019	247357.2	80102.7	4485.8	98686.6	430632.3
2020	251815.5	81546.5	4566.6	100465.3	438393.8

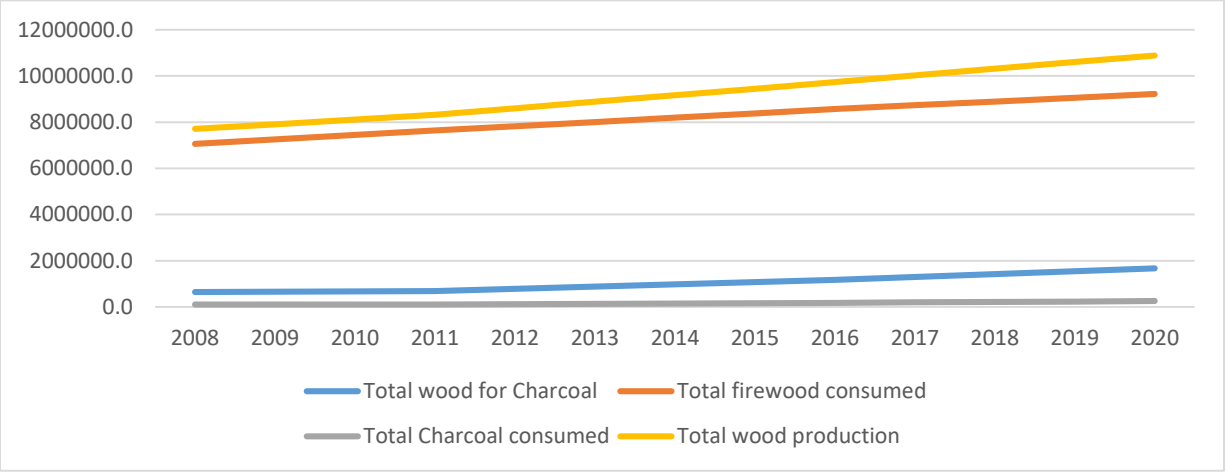
Table 8.9: Business consumption of residues, tonnes

Wood resides		Crop residues				
	Non-metallic minerals		Food and tobacco	Non-metallic minerals	Services	Total
2008	10539.8	2008	12771.8	10539.8	1736.0	25047.6
2009	10977.5	2009	13302.2	10977.5	1808.1	26087.8
2010	11433.4	2010	13854.6	11433.4	1883.2	27171.2
2011	11908.3	2011	14430.0	11908.3	1961.4	28299.6
2012	12402.8	2012	15029.3	12402.8	2042.8	29474.9
2013	12917.9	2013	15653.4	12917.9	2127.7	30699.0
2014	13454.3	2014	16303.5	13454.3	2216.0	31973.9
2015	14013.1	2015	16980.6	14013.1	2308.0	33301.7
2016	14595.1	2016	17685.8	14595.1	2403.9	34684.7
2017	15201.2	2017	18420.3	15201.2	2503.7	36125.2
2018	15832.5	2018	19185.2	15832.5	2607.7	37625.4
2019	16490.0	2019	19982.0	16490.0	2716.0	39188.0
2020	17174.8	2020	20811.8	17174.8	2828.8	40815.4

Overall results

Figure A.2 and Table A.10 show the overall consumption and use of wood and charcoal since 2012, derived from the approach set out here. The general trend is of increasing use of charcoal and with that wood for charcoal production.

Figure 8.2: Wood and charcoal, production and consumption all sectors, tonnes



Source: calculations based on Malawi Biomass Energy Strategy, NSO IHS, NSO census

Table 8.10: Household (HH) and other sector (non-HH) wood and charcoal consumption and production, tonnes

	Total Consumption of wood and charcoal					Wood use for charcoal production					
	HH firewood	Non-HH firewood	HH charcoal	non-HH charcoal		HH	non HH	Total wood for Charcoal production	Total firewood consumed	Total Charcoal consumed	Total wood production
2005	6186916.1		82765.2			551768.1					
2006	6367908.4		84896.5			565976.8					
2007	6548900.7		87027.8			580185.4					
2008	6729893.0	336000.0	89159.1	6574.0		594394.0	43826.94	638221.0	7065893.0	95733.1	7704113.9
2009	6910885.2	345036.3	91290.4	6731.2		608602.7	44874.59	653477.3	7255921.6	98021.6	7909398.8
2010	7091877.5	354072.6	93421.7	6888.3		622811.3	45922.25	668733.6	7445950.2	100310.0	8114683.7
2011	7272869.8	363108.9	95553.0	7045.5		637019.9	46969.91	683989.8	7635978.8	102598.5	8319968.6
2012	7450085.0	371956.7	108933.2	8032.1		726221.7	53547.09	779768.8	7822041.7	116965.3	8601810.4
2013	7627300.2	380804.4	122313.5	9018.6		815423.4	60124.27	875547.7	8008104.6	131332.2	8883652.3
2014	7804515.4	389652.1	135693.8	10005.2		904625.1	66701.46	971326.6	8194167.5	145699.0	9165494.1
2015	7981730.6	398499.9	149074.0	10991.8		993826.9	73278.64	1067105.5	8380230.5	160065.8	9447336.0
2016	8158945.8	407347.6	162454.3	11978.4		1083028.6	79855.82	1162884.4	8566293.4	174432.7	9729177.8
2017	8314405.4	415109.2	180213.0	13287.8		1201419.8	88585.26	1290005.0	8729514.6	193500.8	10019519.6
2018	8469865.1	422870.7	197971.6	14597.2		1319811.0	97314.69	1417125.7	8892735.8	212568.8	10309861.4
2019	8625324.7	430632.3	215730.3	15906.6		1438202.2	106044.1	1544246.3	9055957.0	231636.9	10600203.3
2020	8780784.4	438393.8	233489.0	17216.0		1556593.4	114773.6	1671366.9	9219178.2	250705.0	10890545.1

Source: Source: calculations based on Malawi Biomass Energy Strategy, NSO IHS, and NSO census

Data issues

The approach set out here provides an initial and repeatable means of calculating the use of wood, charcoal and residues on an annual basis. It is more robust for households as it draws on regular household surveys showing changes in fuels used. However, whilst it can be repeated, there is a need to update the actual consumption values for both households and business.

Overall, the understanding of the use of all biofuels needs to be developed, especially regarding the use of agriculture crops/waste. This will be taken forward by MoE and MERA to work with the Ministry of Agriculture, and others.