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Botswana Energy Accounting report

2015/16

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Wealth Accounting and the Valuation of Ecosystem Services

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Abbreviations

APR	Alston Power Rentals
BCL	Botswana Concessions Limited
BOTASH	Botswana Ash
BPC	Botswana Power Cooperation
CH_4	Methane
CO_2	Carbon Dioxide
EDM	Electricidade de Mozambique
EI	Energy Intensity
Eskom	South African Power Utility
EU	European Union
F & B	Food and Beverages
GDP	Gross Domestic Product
ISIC	International Standard Industrial Classification
LPG	Liquid Petroleum Gas
MCM	Morupule Coal Mine
MWh	Megawatt hour (million-watt hour)
N_2O	Nitrous Oxide
PEFA	Physical Energy Flow Accounts

PV	Photovoltaic
RSA	Republic of South Africa
SB	Statistics Botswana
SDGs	Sustainable Development Goals
SEEA	System of Environmental and Economic Accounts
SF_6	Sulphur Hexafluoride
TJ	Tera Joule
ZESA	Zimbabwe Electricity Supply Authority
ZESCO	Zambia Electricity Supply Corporation Limited

EXECUTIVE SUMMARY

The 2015/16 is the second report on Botswana's energy accounts. Just like the first energy accounts for the period 2010/11-2014/15 which covered coal and electricity products, the current accounts also cover the same products and focus on Physical Energy Flow Accounts (PEFA).

Chapter 2 of the report highlights the methodology used to compile the accounts. Chapter 3 focuses on trend analysis of electricity and coal supplied and used and in particular, how the year 2015/16 fared especially in comparison to 2014/15. Technologies (electricity generation plants) are also discussed in this chapter, especially their contribution and efficiencies.

Chapter 4 discusses energy intensities and other linkages between the energy sector and the economy. Chapter 5 discusses the emissions generated within the electricity-coal subsector and their possible impact on the environment.

The report has also extracted the following broad conclusions and key messages from the data analysis.

The electricity sub-sector continued to experience challenges during the period 2015/16.

- With regard to plant efficiencies, there could be need to attend to the efficiency of Morupule B power plant with the intent to work it towards the reference standard, 9304.60 kJ/kWh.
- Local electricity generation decreased by 7.50% compared to the previous year 2014/15. The decline was due to the availability of Morupule B which went as low as 30% during some months of 2015/16.
- Given the current insignificant contribution of Renewables to the electricity supply and energy mix, Botswana's aspiration to increase the contribution of Renewables to the energy mix to 15% by 2030 in line with SDG 7.2. will call for radical strategies.
- The year 2015/16 experienced an increase in imports by 11.45% compared to the previous year. The increase in imports was due to operational problems experienced by Morupule B Power Plant which left the country with no option but to increase the imports. Although imports from the Republic of South Africa declined by 20.99%, the share of imports from Other Countries doubled compared to 2014/15 thus offsetting both the significant decline in RSA's share and the decline in local electricity production.
- Total electricity consumption gradually increased from 2010/11-2014/15 although a slight decrease of 1.27% was realised during 2015/16. The decrease was experienced

by the following economic sectors: Manufacturing; Water & Electricity; Trade, Hotels & Restaurants; General Government, Social & Personal Services sectors. The decline in consumption needs assessment to determine the course but could have been due to the 2015/16 slight recession.

- Mining and household sectors continued to be the dominant electricity users during 2015/16. Compared to 2014/15 consumption levels, the mining sector experienced an increase of 4.89% whilst households experienced a slight increase of 1.49%. Therefore, compared to other sectors, energy saving measures should be targeted to these two sectors.
- Looking at 2015/16 EI for all sectors, construction had the lowest EI of 2.61 MWh/BWP and Water & Electricity had the highest EI at 114.41MWh/BWP. This means that to produce the same amount of output, Water & Electricity sector required 43.8 times more energy than the construction sector. Within the mining subsector, the EI for coal mining was by far the highest at 386 MWh/BWP. For producing the same output, coal mining required 5 times more power than diamond mining.
- The mining sector's share of electricity use was higher than its share in value added whilst the share of electricity use by other sectors like manufacturing and services were lower than their respective shares in value added. Therefore, energy measures should be directed to the mining sector and there should be concerted efforts to diversify the manufacturing and services sectors.
- The level of CO_2 emissions declined by 14.78% during 2015/16 compared to 2014/15 due to decrease in local electricity production. To address CO_2 emissions, the country will have to consider the use of green energy especially in electricity generation.

1. INTRODUCTION

This report covers energy accounts from April 2015 to March 2016. It contains only coal and electricity accounts which provide a comprehensive overview of all relevant physical flows for Botswana using the System of Environmental-Economic Accounting (SEEA-Energy) methodology that was adopted as an international statistical standard by the United Nations Statistical Commission in February 2012. The report provides a conceptual framework for monitoring progress toward energy policy objectives related to the supply, use, as well as energy related aspects of the environment.

Though the main intent of the report is to provide an update on the 2015/16 accounts, a trend from 2010/11 to 2014/15 is also provided to see how 2015/16 accounts compare with the previous years. The report also covers the following: the relationship between the energy sector and the economy, (energy intensities of the mining sector); the relationship between the energy sector and particular sectors of the economy (share in electricity use and value added); the impact of energy on the

environment (energy related air emissions and contribution of renewable sources). The report also briefly touches on the link between energy accounts and Sustainable Development Goals (SDGs).

From the above data analysis, key messages are drawn to guide policy making decisions and investments.

2. METHODOLOGY AND DATA PROCESSING

2.1 Statistical Infrastructure

For clear and logical presentation of the energy accounts, a statistical infrastructure (Fig.1 below) has been developed containing four (4) types of worksheets. The first type of worksheets, made up of seven (7) files contain **source data** from Botswana Power Corporation (BPC) and Morupule Coal Mine (MCM). The second type of worksheets are divided into four (4) sub worksheets and this is where **calculations** are performed. The third type of worksheets contain **output** of energy accounts and energy indicators. Finally, there is a **check** sheet which looks at the consistency of the energy accounts and therefore shows errors and imbalances (if any).

The various worksheets are briefly discussed below.

2.2 Source Data

The source data contains data on coal production and sales. This basically shows production of thermal coal and sales to local customers. Details of sales data is also provided, and this is divided into both sales of thermal and washed coal sales. Washed coal sales is further broken down into local and international sales by customer. All this data is provided by MCM.

Still under source data are data provided by BPC. These include electricity generation and imports. BPC further provides data on the four (4) plants; namely: Morupule A; Morupule B (which are coal powered) and Matshelagabedi (APR) and Orapa plants which are diesel powered. Additional information on the plants cover data on inputs (coal and diesel) used to power the plants. BPC also provides an annual report that covers generation, imports, financial information etc.
There is also an Info worksheet under source data that gives details on the sources of various data: e.g. contact details; conversion factors for converting physical units into common units.

Lastly, there is a Customer Base workbook that shows consumption by all BPC customers as well as total Pula value of electricity consumed per customer. The Department has to code and sort this information according to ISIC classification and finally ensure that the results balance with the aggregated results provided in the BPC annual report.

Still under source data there is a workbook on national accounts data provided by Statistics Botswana (SB). The workbook also has data on gross output, intermediate consumption and value added at 2016 current and constant prices.

2.3 Calculations

There are four (4) files and this is where all the calculations/adjustments are done (note that the source data files are kept as is from source/data providers).

Summary Coal: The same data from the 2 coal source files are rearranged in our own format. Hence it contains production, sales of washed and thermal coal by customers and exports by destination.

Summary Electricity: The same data from the 2 electricity source files (gen & imports and power plants) are rearranged in our own format. It therefore contains data on generation, imports and consumption by sectors.

Summary Customer Base: It picks data from BPC Customer Base and BPC Annual Report source files and all calculations, adjustments, corrections and classifications (according to ISIC) are performed here and therefore it has our format.

Technical Stocks: The same data on diesel and coal which are transformation inputs for electricity generation are taken from Summary Coal and Summary Electricity files. It is therefore indirectly linked to the coal and electricity source files respectively.

2.4 Output

This worksheet has two (2) files, namely: Energy Accounts and Dashboard of Indicators.

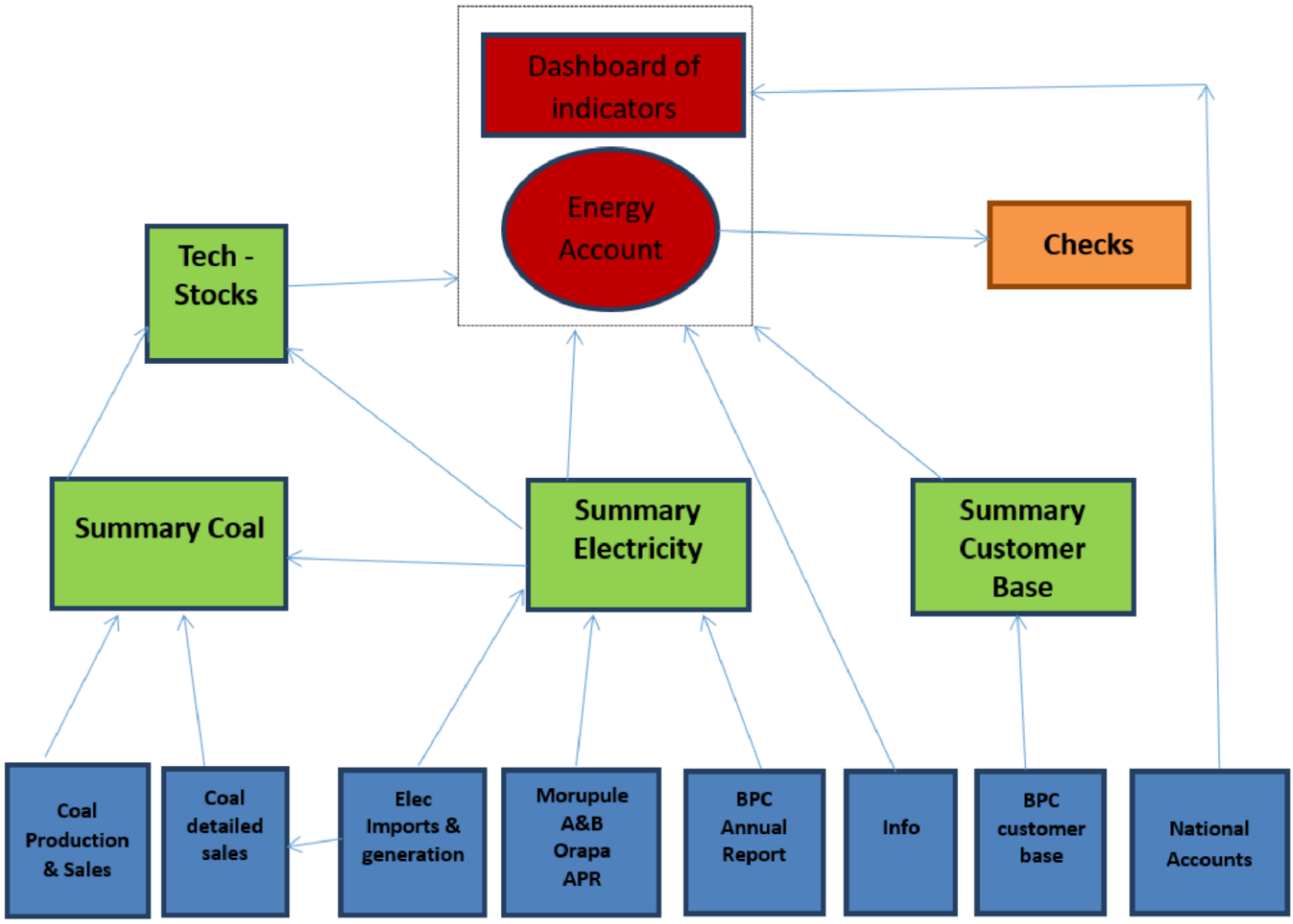
Energy Accounts: It uses summarized/calculated data from all four (4) calculation files and displays relevant outputs. Summary tables connected to it act as input tables which feed it.

Dashboard of Indicators: These include: electricity intensities; efficiency of power plants; coal and electricity supply; coal and electricity use by sector; carbon dioxide (co_2) emissions and most are calculated with data directly from the energy accounts file. However, some additional information is used for calculating emissions from the Information file.

2.5 Checks

There is one (1) checks worksheet linked to the energy accounts worksheet. All the balances in the energy accounts are checked to ensure consistency and that no mistakes have been made.

Figure 1: Energy Accounts Statistical Infrastructure.



3. TREND IN ENERGY SUPPLY AND USE

This chapter focuses on data analysis and discussions of the findings. Therefore, data will be presented in an orderly, easily accessible and understandable manner e.g. in picture or graphic form. Analysis of supply and use data gives the opportunity to better manage the energy resources, plan for the future, and determine the relationship between this sector, the economy and the environment. Conclusions from this are therefore relevant for policy making, research, as well as investment decisions.

3.1 Electricity Sub-Sector

Botswana Power Corporation (BPC) is the sole producer of electrical power. Most of the electricity is generated from coal and the rest from diesel. There are two (2) coal power plants, namely: Morupule A and B although Morupule A was decommissioned in August 2012 and is still being refurbished. Morupule B has four (4) units, each with a capacity of 150 MW. There are two (2) diesel peaking power plants, namely: Matshelagabedi (APR) with capacity of 105MW during the year under consideration (15/16) and Orapa with capacity of 90MW.

The country also imports electricity from neighbouring states of: Republic of South Africa (Eskom); Republic of Mozambique (EDM) and occasionally from Republic of Zambia (ZESCO); Republic of Zimbabwe (ZESA) and Republic of Namibia (NAMCO).

3.1.1 Contribution of each Plant to the Electricity Mix

Figure 2 below shows that during the first two years, Morupule A supplied more power than other plants but after decommissioning in August 2012, Morupule B took over. The last two (2) years show a decline in the contribution of both Matshelagabedi and Orapa, this was due to improvements in the operations of Morupule B. It is worth noting that generating power from diesel is very expensive and generally, it is cheaper to import.

During the year under consideration, the share of Morupule B's contribution to total electricity generated stood at 96.85% whilst the two diesel peaking plants' contribution stood at 3.15%. Compared to the previous year 2014/15, the plants share stood at 97.80% and 2.20% respectively. Whilst Morupule Bs' contribution decreased, the contribution of the two diesel plants increased. Morupule B plant was experiencing some operational problems and production had to be boosted through the diesel plants and imports

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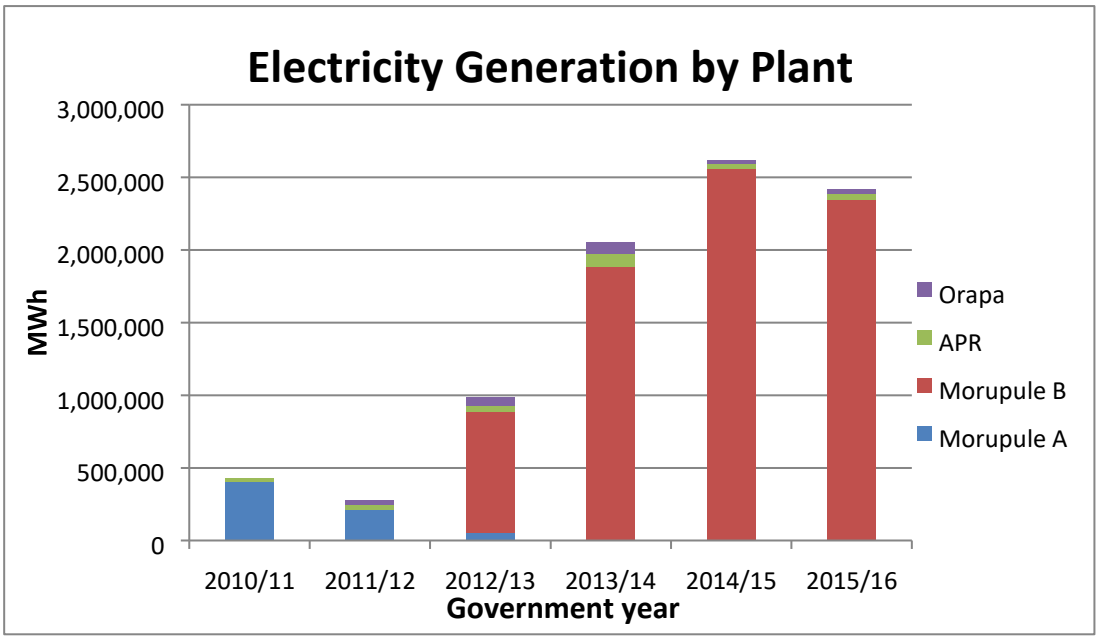

Figure 2: Share of Different Production Facilities in the Electricity Mix.

3.1.2 Plant Efficiency and Losses

Fuel conversion efficiency depends on technology type. The energy accounts have adopted the easy formula and simply divide output (gross generation) by input (coal or diesel) multiplied by 100%.

We consider efficiencies of three (3) power plants, namely: Morupule B, Orapa and Matshelagabedi (APR). Morupule A was closed in 2012 because it was operating at very low efficiency (See Energy Accounts for Botswana Technical Report, October 2016. pg. 30). During 2015/16, efficiencies of the three (3) plants stood at 34% for Morupule B; 37% for Orapa and 38% for Matshelagabedi (APR). Compared to 2014/15, the efficiency of Morupule B plant stood at 32% whist Orapa and Matshelagabedi plants stood at 35% and 34% respectively.

The bandwidth of efficiency from international experience for similar plants are: for coal power plants 32% - 42%; for ultra-super critical power plants at 300 bar and 600/600 0C can achieve efficiencies ranging from 45% - 48% and diesel engines and large capacity industrial engines can deliver efficiencies in the range of 35% - 42%.

Despite the slight increase in plants efficiencies during 2015/16, the efficiencies of all the three (3) plants still remained skewed to the lower side of the ranges. More attention should be given especially to Morupule B Plant, the main plant, to improve its efficiency.

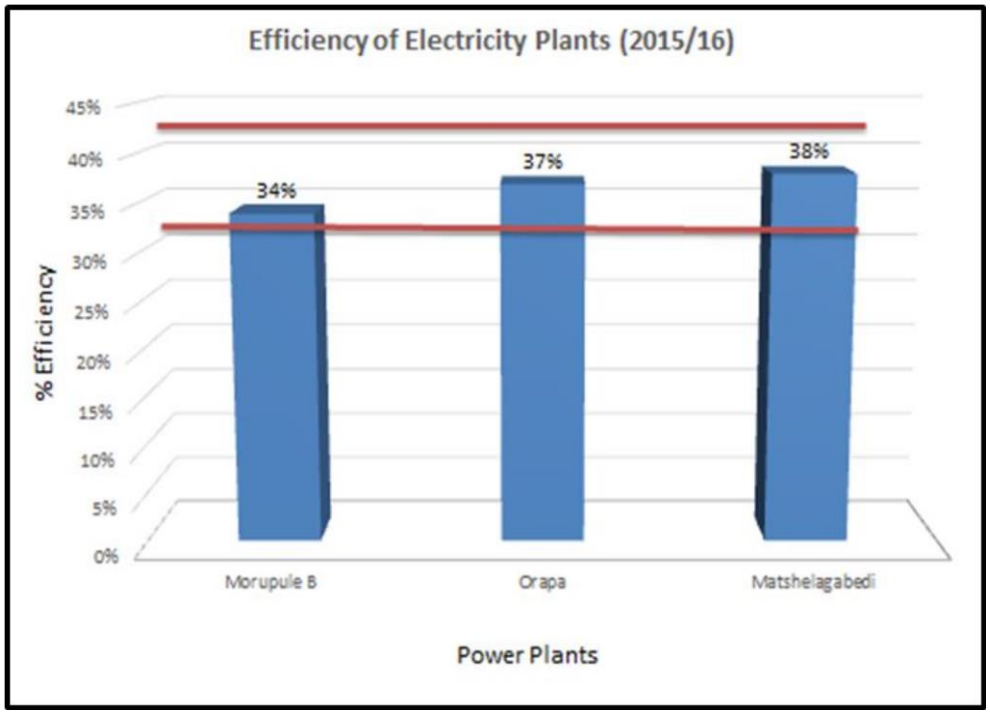

Figure 3: Efficiency of the Power Plants (2015/16)

On consulting Morupule B power plant, plant efficiency, which is regarded as turbine heat rate (kJ/kWh) is calculated as:

((Coal Consumption(t) 1,000* CVc(MJ/Kg)) + (LDO Consumption (t) *1,000 * CVd (MJ/Kg)))/Gross Generation (MWh)*

Where CVc and CVd are calorific values for coal and diesel respectively. LDO is light diesel Oil which is used in insignificant quantities for igniting coal and in the above formula; the value for (LDO Consumption(t) * 1,000* CVd(MJ/Kg) is always very insignificant, therefore, it is safe to consider the first part of the formula in deriving the heat rate.

For 2015/16, the turbine heat rate was calculated as 9,857kJ/kWh against the reference standard of 9304.60 kJ/kWh. There was an improvement over the 2014/15 figure which was 10,343kJ/kWh. For 2015/16, the variance (from the actual or reference standard) was negative 5.94%. Therefore, there could be a need to attend to the efficiency of the plant with the intent to work it towards the reference standard, 9304.60 kJ/kWh.

With regard to efficiencies of the two diesel power plants, the plants are operated according to manufacturer's specifications and rated at .027l/kwh. Since manufacturing specifications (including regularity of maintenance) have been observed, the plants were reported to be operating efficiently and that efficiencies have been constant.

3.1.3 Losses

There are three (3) types of losses experienced between the point of generation and before the power reaches the consumer. The losses are: transformation, internal (own use) and transmission & distribution. While the level of transformation losses is determined by the level of the plant efficiency (i.e. the higher the efficiency, the lower the losses and the lower the efficiency, the higher the losses); internal losses are what the plant consumes (own use) during operation/generation. On the other hand, distribution/transmission losses occur when power is being distributed to end users or consumers.

During 2015/16, transformation losses for Morupule B were 18430 TJ, translating to 66.48%. Internal losses for Morupule B were estimated to be around 1335TJ or 4.82%. Both transformation and internal losses were almost zero (0) for the diesel – powered plants. Transmission and Distribution losses amounted to 852 TJ (11.99%) during 2015/16.

3.1.4 Trend in Local Electricity Generation (2010/11-2015/16)

The trend in local electricity generation depicted in Figure 4 below shows a huge increase in local production (relative to total available electricity) from 7.5% during 2012/13 to as high as 64.20% during 2014/15. The sharp increase in local generation was due to the policy shift from least cost energy supply to self-sufficiency.

There is a slight change in the trend during 2015/16 where local production stands at 62.89% of available electricity representing a decrease of 7.50% compared to 2014/15. *The decline was due to availability of Morupule B Power Plant which went as low as 30% during some months of 2015/16.*

Currently, the contribution of renewables to the total energy mix is insignificant and currently not quantified. Sustainable Development Goal 7.2 requires that by 2030 the share of renewable energy in the global energy mix be increased substantially. In response, the country has determined that by 2030 the share of renewable energy to the energy mix will be increased to 15%.

In an effort to achieve this target, renewable energy projects in the pipeline include: 100MW Solar PV Plant; Off Grid Solar Solutions, Waste to Energy (at feasibility stage) and 20 mini grids. This could bring the total PV installed capacity to about 130 MW and the overall total installed capacity (grid and PV) to 1030MW. Therefore, the contribution of renewables to total energy mix in the next five years is estimated to be 12.62%. *Given the current insignificant contribution of Renewables to the electricity supply and energy mix, Botswana's aspiration to increase the contribution of Renewables to the energy mix to 15% by 2030 in line with SDG 7.2. will call for radical strategies.*

Monitoring of and reporting on SDG indicator 7.2.1: "Renewable energy share in the total final energy consumption" will be attempted after the implementation of the abovementioned projects and quantification of contribution of renewables through the planned survey.

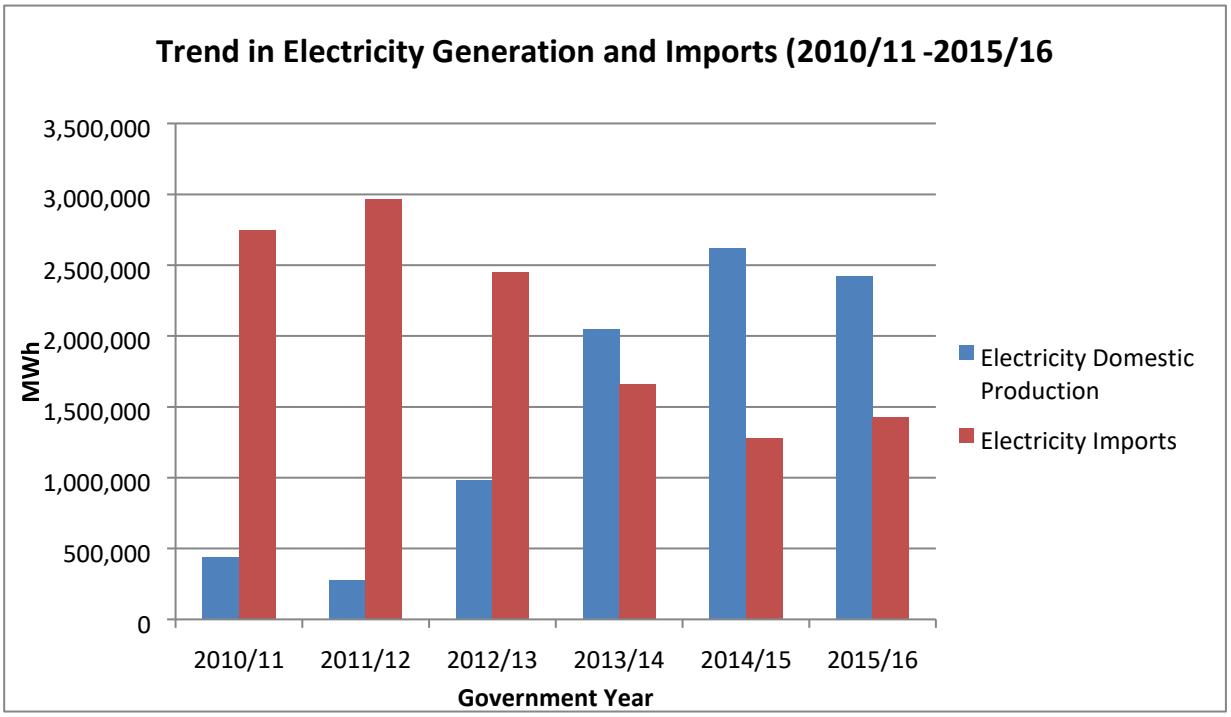

Figure 4: Trend in Electricity Generation and Imports.

3.1.5 Trend in Electricity Imports (2010/11-2015/16)

The trend as depicted in Figure 4 above shows a general decline in imports. During the first three (3) years, 2010/11 -2012/13, imports far exceeded local production. However, from 2013/14 till the year under discussion, imports fell below local generation. The year 2015/16 registered an increase in imports of 11.45% compared to the previous year, 2014/15. *The increase in imports was due to operational problems experienced by Morupule B Power Plant which left the country with no option but to increase the imports.*

During 2015/16, the percent share of electricity imports to total electricity supply was 37.1% representing an increase of 4.23% compared to 2014/15 share which stood at 32.87%.

3.1.6 South Africa and Other Countries' s Share in Total Electricity Imports (%)

To augment local production, Botswana imports power from neighboring countries as mentioned in Section 3.1 above. Figure 5 below shows that the Republic of South Africa's share of imports has been higher compared to the share of other countries from as far back as 2010/11. The share of RSA imports was as high as 92.51% during 2012/13 but gradually declined to 85% in 2014/15. A rather significant decline of 17.74% (from 1 233 706MWh

during 2014/15 to 1 068 391MWh during 2015/16) was further experienced as RSA continued experiencing local power shortages.

The share of imports from other countries was slightly high during the first two (2) years but went down during the next three (3) years, although the same three (3) years experienced a gradual increase. During 2015/16, the share of imports from other countries doubled compared to 2014/15 thus offsetting both the significant decline in RSA's share and the decline in local electricity generation.

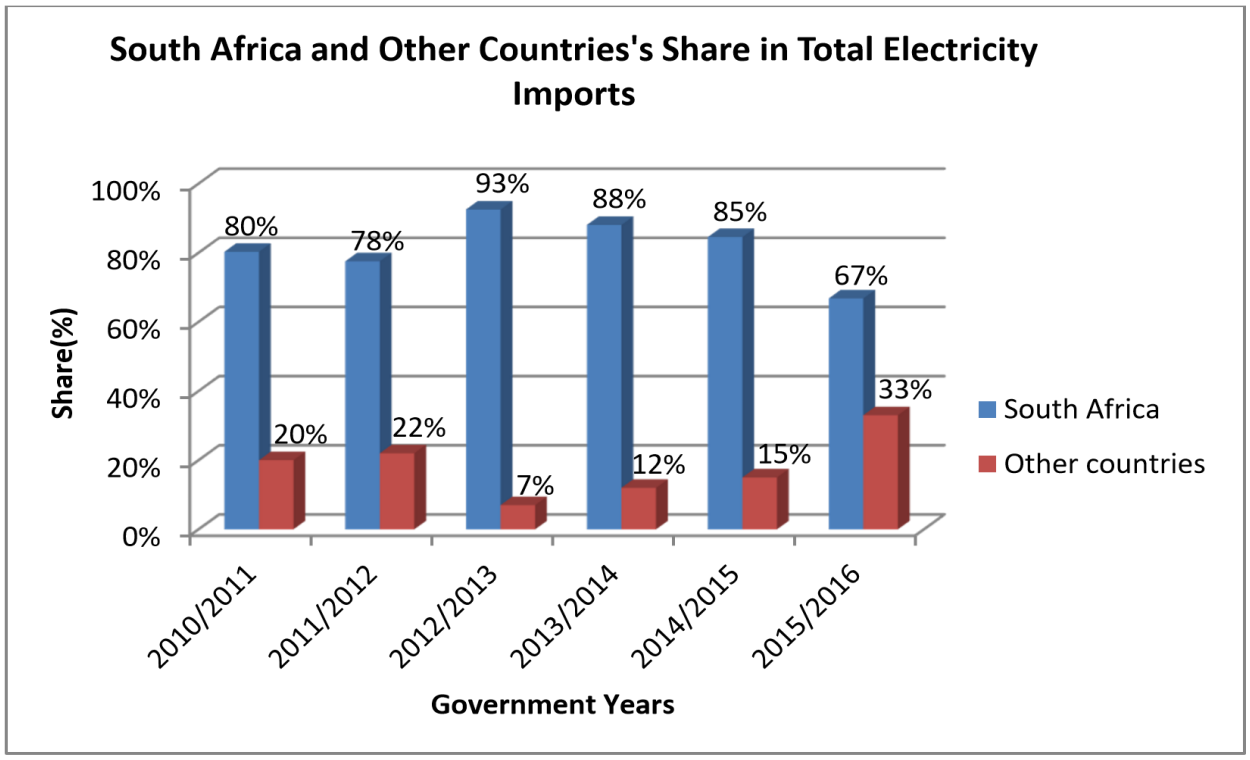

Figure 5: Republic of South Africa & Other Countries 's Share in Electricity Imports (%)

3.1.7 Trend in Total Electricity Consumption (2010/11-2015/16)

Despite the sharp increase in local electricity production and the decline in imports over the period under consideration, the trend in electricity consumption over the same period shows a gradual increase. Nevertheless, total electricity consumption slightly decreased during 2015/16 by 1.27% from 3899268 MWh during 2014/15 to 3849724 MWh. (See Figure 6 below.)

The decrease in consumption was experienced by the following sectors: manufacturing; water & electricity; trade, hotels & restaurants; general government; and social & personal services (See Figure 7 below). The decline in consumption needs assessment to determine the cause but could have been due to the slight recession in 2015/16.

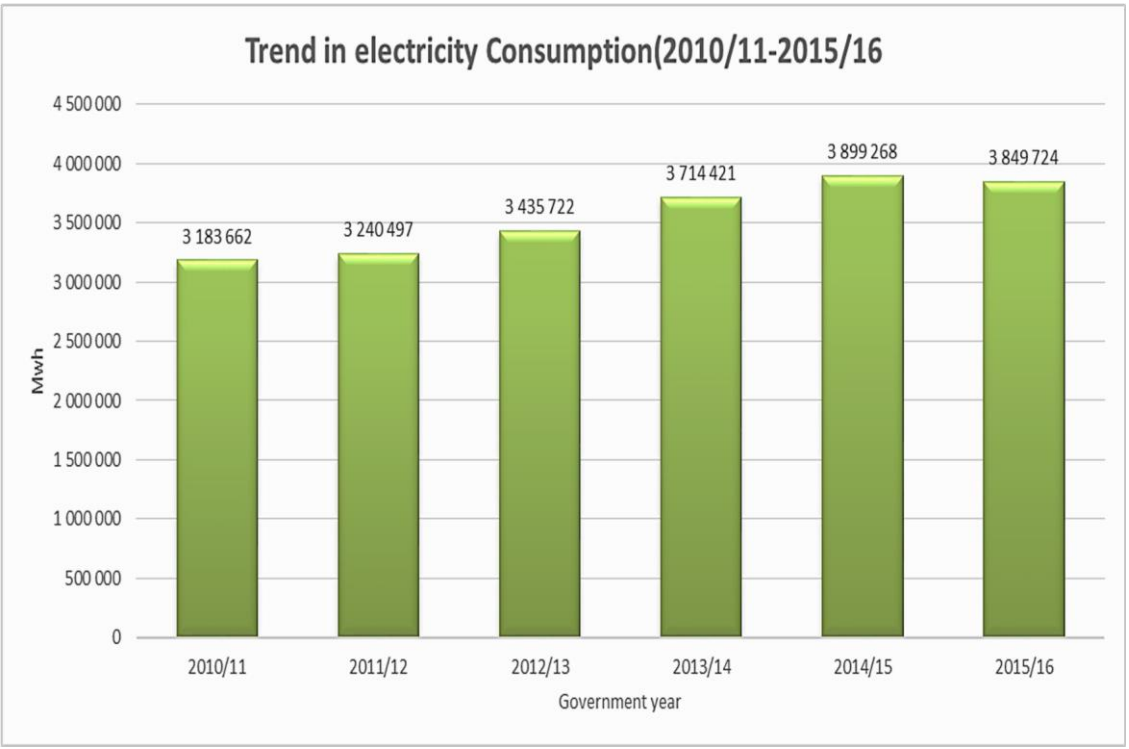

Fig.6: Trend in Electricity Consumption (2010/11-2015/16)

3.1.8 Trends in Electricity Consumption by Economic Sector (2010/11-2015/16)

Figure 7 below shows that sectorial distribution of electricity consumption has been stable since 2012/13. The share of mining and household sectors during 2015/16 continued to be dominant with an increase of 4.89% by mining and a slight increase of 1.49% by households compared to 2014/15. *Therefore, compared to other sectors, energy saving measures should be targeted to these two sectors.*

Looking at productive sectors (which excludes households), the mining sector leads. The two sectors of agriculture and construction use very minimal amounts. Other sectors like services, general government, and manufacturing use significant and comparable amounts although within this group the services industry uses more electricity than manufacturing.

This trend is evident from 2010/11 and it shows how the country is economically structured. (See *Energy Accounts for Botswana, Technical Report, October 2016, pg.27).*

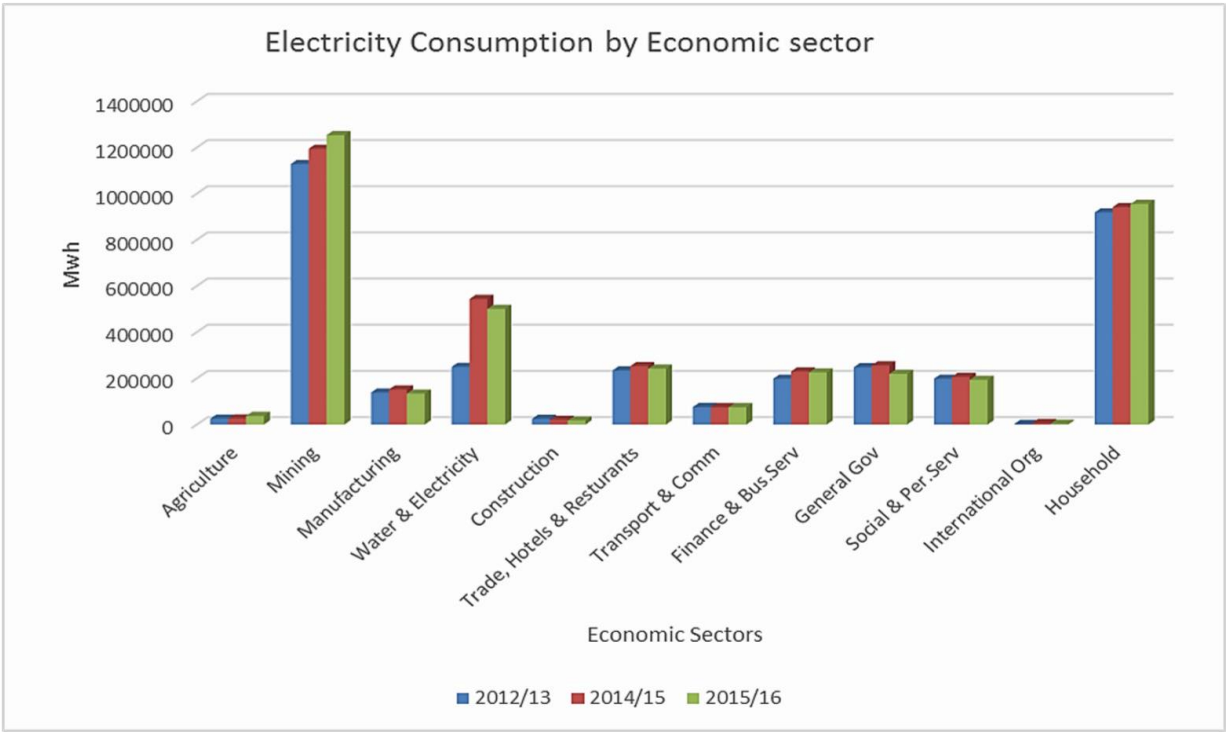

Figure 7: Electricity Consumption by Economic Sector (MWh).

3.2 Coal Sub Sector

There is only one (1) operating coal mine in Botswana called Morupule Coal Mine (MCM). Its mining capacity stands at 2.8 million tonnes but is currently producing 2.3 million tons per annum. Most of the raw coal is used for electricity generation while some is consumed locally by various industries. The balance of coal is washed and consumed both locally and internationally.

3.2.1 Trends in Total Coal Production (2010/11-2015/16)

Figure 8 below shows that total coal production follows an upward trend. Coal production increased from 1,849,872 tonnes during 2014/15 to 2,019,052 tonnes during 2015/16 representing a 9.15% increase. Thermal coal production follows a similar pattern and during the year under consideration, production increased by 11.09% compared to 2014/15. Trends in washed coal production shows a more stable pattern with a slight decrease of 0.65% during 2015/16 compared to the previous year.

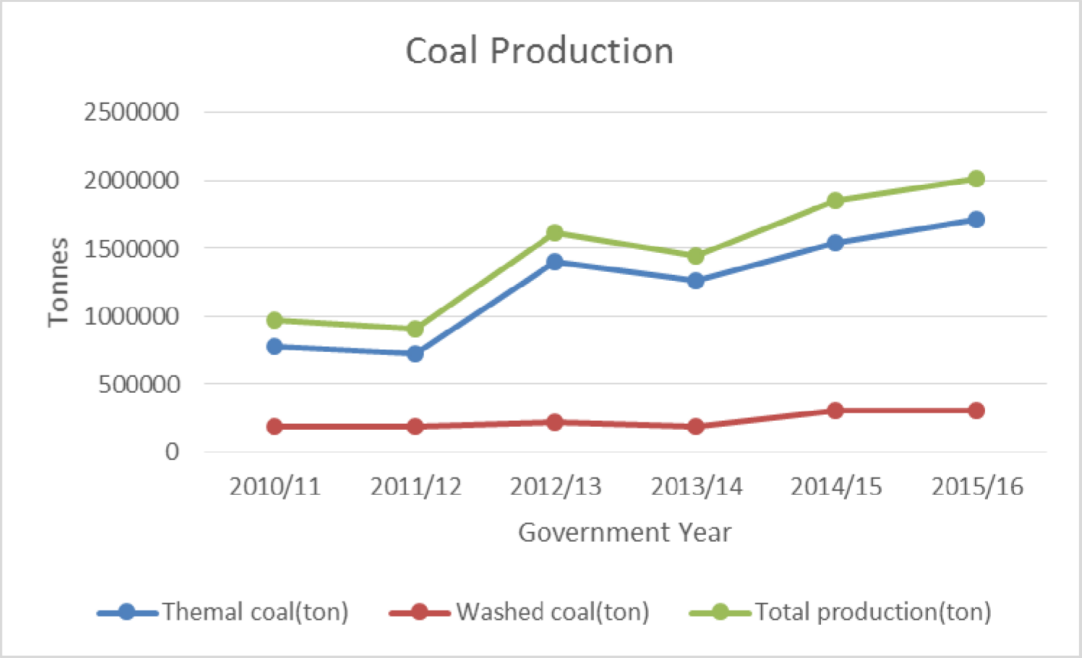

Figure 8: Trend in Total Coal Production (2010/11-2015/16)

3.2.2 Coal Production, Use and Stock Changes: 2014/15 and 2015/16 (1000tons)

Tables 1 and 2 below show that during 2015/16 most of the thermal coal (79.51%) went to BPC for electricity generation whilst most of the washed coal (77.45%) was exported. This pattern is also seen during the previous year 2014/15.

What is more interesting is the share of BPC during 2014/15 and 2015/16, there is a decline of 1,362 metric tonnes during 2015/16 from 1420 metric tons during 2014/15 representing a decrease of 4.08%. The decrease was because Morupule B was experiencing some operational problems resulting in consumption of less coal and increased stocks. We see a decrease in stocks during 2014/15 (-64.30). This was because total thermal coal was not enough to cover both BPC and other consumers' demand, hence the balance had to be drawn from existing stockpile.

Table 1: Coal Production, Use and Stock Change 2014/15 (1000 tons)

Total Production (2014/15) ***1850***					
Washed Coal 308 (16. 65%)			*Thermal Coal 1543(83.41%)*		
Exports 224(72.73%)	*Local Use 101(32.80%)*	*Stock Change 16(5.19%)*	*BPC 1420(92.03%)*	*Other 267(17.30%)*	*Stock Increase - 64.30(-4.17%)*

Table 2: Coal Production, Use and Stock Change 2015/16 (1000 tons)

Total Production (2015/16) ***2019***					
Washed Coal 306 (15.16%)			*Thermal Coal 1713(84.84%)*		
Exports 237(77.45%)	*Local Use 69(22.55%)*	*Stock Change - 1(-0.33%)*	*BPC 1362(79.51%)*	*Other 257(15.00%)*	*Stock Increase 315.36(18.41%)*

4. ENERGY AND THE ECONOMY

4.1 Energy Intensity (EI)

Energy Intensity (EI) is one of the crucial indicators which shows the relationship between Gross Domestic Product (GDP) growth and the growth in demand for electricity. It also informs how a particular sector or industry performs in terms of energy use in relation to its economic performance. It is calculated by dividing energy use in MWh by value added in Pula. Energy intensity helps in planning for future electricity demand, therefore as and when electricity constraints are encountered, sectorial electricity adjustments are done accordingly. More importantly, informed decisions in future investments can be made, be it in expanded generation capacity or in other energy sources.

Table 3 below shows the EI for all productive sectors for the years 14/15 and 15/16. For the year 2015/16, Construction has the lowest EI of 2.61 MWh/BWP and Water & Electricity has the highest EI at 114.41MWh/BWP. *This means that to produce the same amount of output, Water & Electricity sector requires 43.8 times more energy than the construction sector.*

During 2015/16, the following sectors: mining; trade, hotels & restaurants; finance & businesses; and general government had the highest value added compared to the rest. The EI for mining is rather on the very high side compared to the rest which could be associated with inefficiency in energy use thus calling for energy management measures. The other three sectors could still be looked into so that if there is no energy management in place, they are then advised to do so.

During 2015/16, all sectors experienced declining EI which is a good sign in terms of energy use. However, agriculture, mining and finance & business sectors experienced rising/higher EI compared to the year 2014/15. Although this could point to lower efficiencies, such occurrences need thorough analysis using a longer trend.

Table 3: Energy Intensity of Productive Sectors 2014/15-15/16(MWh/BWP, constant 2006 value added)

Yr./Sec	**Agric.**	**Mining.**	**Manf.**	**W&E**	**Const.**	**T,H&R**	**T&C**	**F&B**	**G.Govt.**	**S&PS**
14/15	17.56	85.82	29.07	2173.32	3.15	16.38	15.78	18.61	23.01	36.00
15/16	25.33	114.41	25.13	1116.40	2.61	14.64	14.43	21.25	19.11	32.07

4.2 Energy Intensity (EI) by Mining Sub-Sector

As stated above, EI indicates how a particular sector or industry performs in terms of energy (electricity) use in relation to its economic performance or contribution to GDP. Low EI means the sub-sector is more efficient in the use of electricity and high EI means less efficiency.

Looking at the various mining sub-sectors in Figure 8 below, for the three (3) years and the year under consideration (2015/16), diamond mining has the lowest EI (76 MW/BWP) and coal mining has the highest EI at 386 MWh/BWP. *This means that for these two sub-sectors to produce an equal amount of output, coal mining requires close to five (5) times more energy than diamond mining.*

The EI trend for all mining activities shows a general increase. The percentage increase during 2015/16 compared to 2014/15 were as follows: Diamonds (24.65%); Copper/Nickel (58.04%); Soda Ash (428.40%); Coal (16.68%) and Other Mining (36.48%).

This is worrisome as it shows that the efficiencies of the various mining sub-sectors have been declining. It also shows that for equal amount of output produced throughout the period by each sub-sector, more electricity was used. Therefore, there is need to look into EI's of these sub-sectors with the aim of improving or introducing energy efficiency measures.

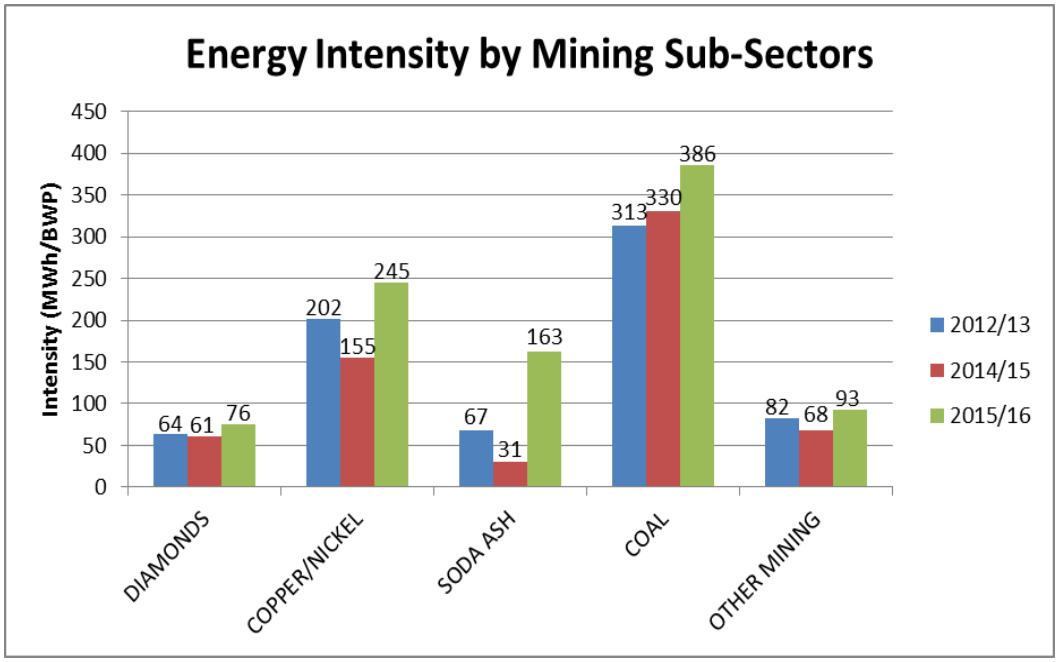

Fig.9: Trend in Energy Intensity by Mining Sub-Sectors (2012/13-2015/16).

4.3 Sectoral Shares (%) in Electricity Use and Value Added by Sector (2015/16)

Figure 10 below depicts the percentage shares in both electricity use and value added by different economic sectors during 2015/16. The mining sector used more than 30% of productive electricity and its share of value added was just below 20%. In contrast, the service sectors registered higher value added than their shares of electricity use. This trend or relationship was evident also for the 2010/11 -2014/15 energy accounts (*Energy Accounts for Botswana, Technical Report, October 2016; pg. 29-Fig.10*). *Therefore, energy measures should be directed to the mining sector and there should be concerted efforts to diversify the manufacturing and services sectors.*

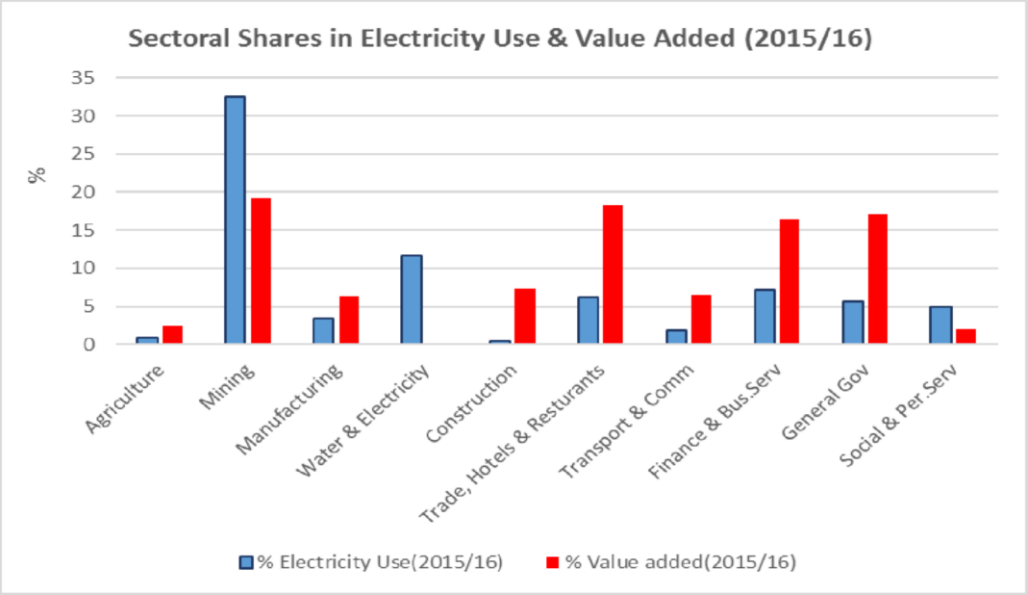

Figure 10: Sectoral Shares (%) in Electricity Use and Value Added per Sector (2015/16)

5. ENERGY AND THE ENVIRONMENT

The energy sector interacts with the environment at two distinct levels. On the one hand, energy operations such as production of electricity, heating of buildings, transportation, and some industrial processes generate air emissions that have direct impact on the environment. On the other hand, renewable energy sources (or use of same) relieves the environment or do not exert pressure on the environment.

5.1 Greenhouse Gas Emissions

As already indicated, much of Botswana's electricity is generated using coal and an insignificant amount is generated from diesel, therefore discussion on air emissions shall focus mainly on Co_2 emissions because: (i) coal combustion is more carbon intensive than natural gas or petroleum products (for example diesel) for electricity generation and (ii) within the electricity sub-sector, CO_2 is the major Greenhouse gas emission whilst only

smaller amounts of methane and (CH_4) and Nitrous Oxide (N_20) are produced. The amount of Sulphur Hexafluoride (SF_6) is very insignificant at less than 1 percent.

5.2 Trend in CO_2 Emissions

The trend in CO_2 emissions depicted in Figure 11 below shows a gradual increase between the first three (3) years (though with a dip during 2011/12) and a sharp increase from there till 2014/15. The rise was due to increase in local generation in pursuit of electricity selfsufficiency. During 2015/16, emissions stood at 2,756,773 tonnes of carbon dioxide equivalent (tCO2e) which was a decrease of 14.78% compared to 3,212,534 tCO2e during 2014/15. This was due to a decrease in local production.

Botswana is signatory to the Paris Agreement and has produced its intended nationally determined contribution. The country "*intends to achieve an overall emission reduction of 15% by 2030, taking 2010 as a base year. Base year emission estimation is 8307 Gg of CO_2 equivalent*". (*Botswana Intended Nationally Determined Contribution Paper).*

To address CO_2 emissions within the power sector, the country will have to consider using green energy especially in electricity generation. One of the mitigation actions is the planned two (2) 50 MW Solar Power Stations with the potential to avoid CO_2 emissions by approximately 761 Gg of CO_2 equivalent or 9% emission avoidance.

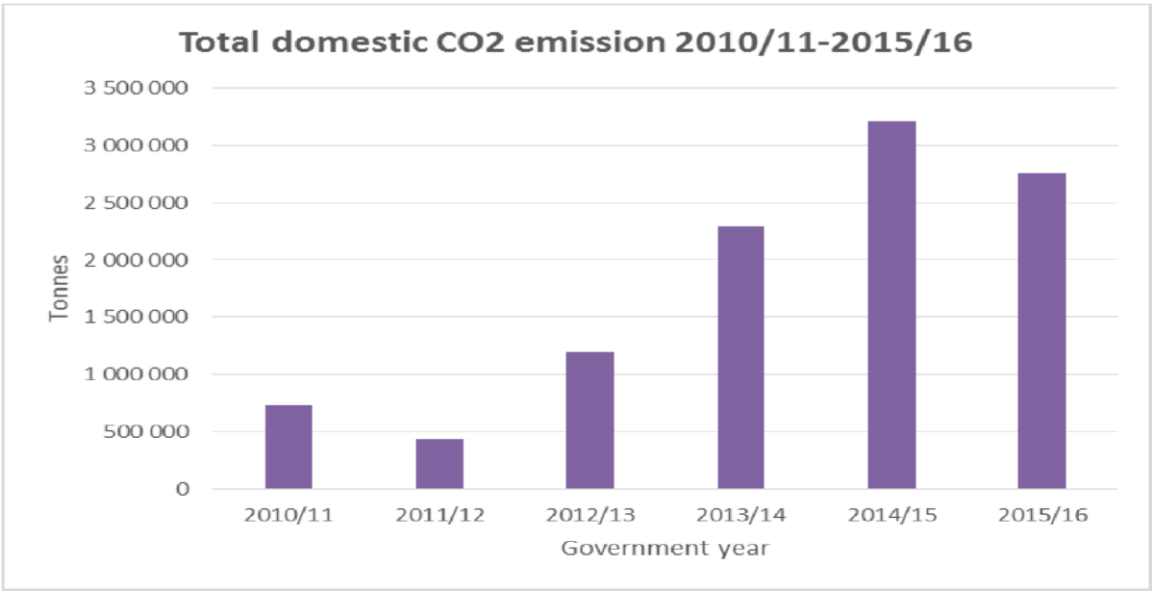

Figure 11: Trend in CO_2 Emissions (2010/11-2015/16)

Figure 12 below shows contribution of emissions by source during 2015/16. Whilst 96.64% (2,664,177 tCO2e) of the generated emissions were from Morupule B coal fired power plant, the balance of 2.22% (61,266 tCO2e) went to the other two (2) sources, namely: Orapa and

Matshelagabedi (APR) diesel powered plants and 1.14% (31 330tCO2e) to Other Coal Use. During 2014/15 emission shares stood a bit higher at 97.32%, 1.58% and 1.10% respectively.

The slight decrease in contribution of emissions by source during 2015/16 for Morupule B was due to the decline in local production. For the diesel plants, increase was probably due to the increased electricity production of the two plants as Morupule B was experiencing some operational problems. The slight increase in emissions by Other Coal Use resulted due to increase in amount of coal used.

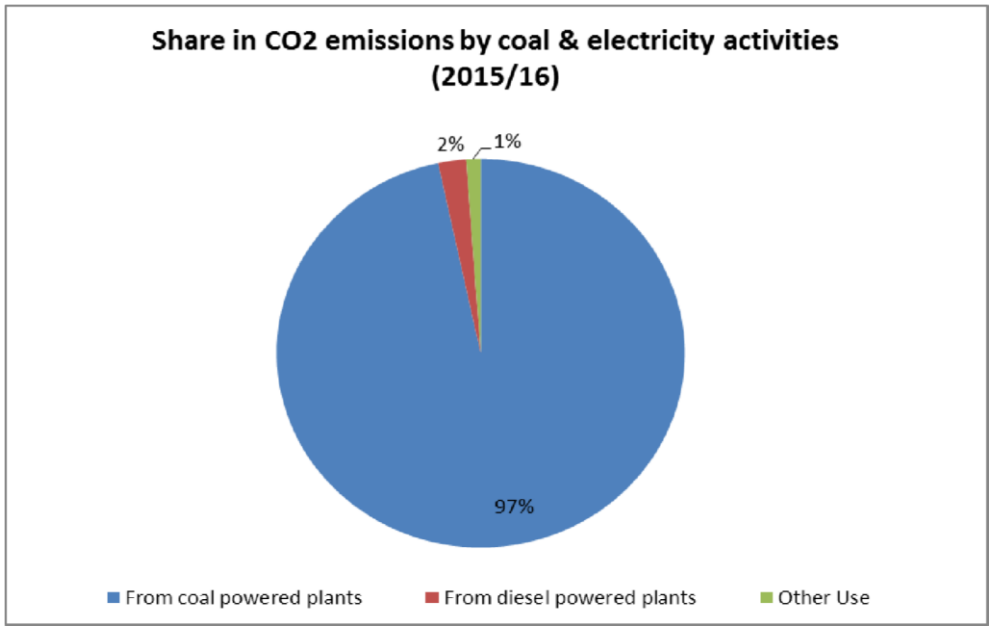

Figure 12: Share of CO_2 Emissions by Source (2015/16)

6. CONCLUSIONS

The focus of the report is on the year 2015/16, however, historical trend from 2010/11 2014/15 has been included to see how 2015/16 fared in comparison. The following general conclusions are drawn from the data analysis.

Generally speaking, as with the previous reporting period, 2010/11-2014/15, the electricity sub-sector continued facing some challenges, namely:

The availability of Morupule B to below 30% during some months of the period under review resulted in the country having no other option but to increase the level of imports in order to meet the local demand. Morupule B Power Plant continued experiencing rather low plant efficiency resulting in high transformation losses.

Future plans for the Energy Accounts should include and not be limited to: liquid fuels, all energy forms and monetary accounts. Capacity building in areas of generating and

interpreting energy indicators; policy analysis and impacting should be priority for both sustainability, continuity and improvement purposes. Emphasis should also be placed on dissemination of results for both buy-in by stakeholders and use in energy and development planning.

The accuracy and timeliness of the energy accounts are very crucial, and this is an area that will be continuously improved upon.

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ANNEX 1: INDICATORS

Table 4: Key Energy Indicators

KEY INDICATORS									
	Indicator	**Units**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**Change (%) (2014/15-2015/16**
Coal supply (1)	Domestic production (1)	1000 Tonnes	969	909	1623	1449	1850	2019	9.15%
Coal use (=2+3+4)	Consumption (2)	1000 Tonnes	712	501	943	1300	1707	1467	-14.05%
	Coal Use (non electricity)	1000 Tonnes	428	354	488	394	368	326	-11.38%
	Exports (3)	1000 Tonnes	16	15	14	14	224	237	6.03%
	Stock change (4)	1000 Tonnes	241	392	665	123	(81)	315	-489.67%
Electricity supply (1+2)	Domestic production (1)	MWh	430,922	275,608	985,783	2,051,186	2,617,595	2,421,237	-7.50%
	From coal-powered plants	*%*	*94.40%*	*76.97%*	*90.02%*	*92.04%*	*97.80%*	*96.85%*	-0.98%
	From diesel-powered plants	*%*	*5.60%*	*23.03%*	*9.98%*	*7.96%*	*2.20%*	*3.15%*	43.36%
	From renewables	*%*	*0*	*0*	*0*	*0*	*0*	*0*	0.00%
	Domestic share in total supply	*%*	*13.54%*	*8.50%*	*28.69%*	*55.22%*	*67.13%*	*62.89%*	-6.31%
	Imports (2)	MWh	2,752,740	2,964,989	2,449,938	1,663,235	1,281,672	1,428,487	11.45%
	Share of imports from S.A.	*%*	*80%*	*78%*	*93%*	*88%*	*85%*	*67%*	-17.74%
Electricity use (=3)	Consumption (3)	MWh	3,183,662	3,240,597	3,435,722	3,714,421	3,899,268	3,849,724	-1.27%
	Industries	*%*	*73%*	*73%*	*73%*	*75%*	*76%*	*75%*	-0.89%
	Households	*%*	*27%*	*27%*	*27%*	*25%*	*24%*	*25%*	2.79%
Efficiency/ intensity	Domestic Energy production (input/output)	%	18%	19%	25%	27%	24%	26%	7.79%
	Efficiency Morupule A	*%*	*23%*	*23%*	*20%*	*0%*	*0*	*0*	
	Efficiency Morupule B	*%*			*34%*	*33%*	*32%*	*34%*	5.95%
	Electrical intensity	MWh/output	37.5	36.2	36.8	37.5	38.6	37.7	-2.49%
CO2 emissions from coal and electricity production	Total domestic emissions	tonnes	733,970	431,858	1,197,792	2,289,664	3,212,534	2,756,773	-14.19%
	Emissions from electricity production	tonnes	692,884	397,822	1,150,898	2,251,808	3,177,181	2,725,443	-14.22%
	- From coal-powered plants	tonnes	663,698	343,974	1,063,539	2,117,049	3,126,284	2,664,177	-14.78%
	- From diesel-powered plants	tonnes	29,186	53,848	87,359	134,759	50,897	61,266	20.37%
	Other emissions from coal use	tonnes	41,086	34,036	46,894	37,856	35,353	31,330	-11.38%
	Embodied emissions in imports	tonnes	4,425,851	4,987,010	2,940,873	1,822,477	1,469,072	1,549,342	5.46%

Economic Sector/Year	2014/15		2015/16		Change (%) (2014/15-2015/16)
	MWh	%	MWh	%	
Agriculture	25289	0.85%	36382	1.26%	43.86%
Mining	1194000	40.36%	1252339	43.26%	4.89%
Manufacturing	151391	5.12%	133562	4.61%	-11.78%
Water & Electricity	543088	18.36%	448036	15.48%	-17.50%
Construction	19908	0.67%	17065	0.59%	-14.28%
Trade, Hotels &Restaurants	252749	8.54%	241413	8.34%	-4.49%
Transport & Communication	74232	2.51%	74348	2.57%	0.16%
Finance & Business Service	229399	7.75%	276441	9.55%	20.51%
General Government	255488	8.64%	219268	7.57%	-14.18%
Social & Personal Services	212723	7.19%	195870	6.77%	-7.92%
Total	2958268	100.00%	2894724	100.00%	-2.15%

Table 5: Electricity Use by Economic Sectors (2014/15 and 2015/16)

Table 6: Energy Intensity of Economic Sectors (electricity use/value added)

Energy Intensity			
Economic Sector/Year	2014/15	2015/16	Change (%) (2014/15-2015/16)
	MWh/BWP	MWh/BWP	
Agriculture	17.6	25.3	44.25%
Mining	85.8	114.4	33.31%
Manufacturing	29.1	25.1	-13.56%

Water & Electricity	2173.3	1116.4	-48.63%
Construction	3.2	2.6	-17.24%
Trade, Hotels &Restaurants	16.4	14.6	-10.61%
Transport & Communication	15.8	14.4	-8.58%
Finance & Business Service	18.6	21.3	14.22%
General Government	23	19.1	-16.94%
Social & Personal Services	36	32.1	-10.92%
Average	**38.6**	**37.7**	**-2.49%**

Table 7: Energy Intensity of Mining Sub-Sectors (electricity use/value added)

	Energy Intensity		
Name of Company	**2014/15**	**2015/16**	**Change (%) 2014/15-2015/16**
	(MWh/BWP 2006)	**(MWh/BWP 2006)**	
DIAMONDS	61	76	24.65%
COPPER/NICKEL	155	245	58.04%
SODA ASH	31	163	428.70%
COAL	330	386	16.68%
OTHER MINING	68	93	36.48%

2015/16 Supply (Common Unit) (TJ)			Agriculture	Mining	Meat and Meat products	Water Supply	Electricity	Construction and Trade	Hotels and Restaurants	Transport and Communications	Finance, Real Estate and Business Services	Government	International Organizations	Households	Import	Stock	Environment	**Total**
Natural Inputs	Resources	Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49063	**063**
	Renewables	Solar Power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Energy Products	Coal	Thermal Coal	0	41627	0	0	0	0	0	0	0	0	0	0	0	0	0	**627**
		Washed Coal	0	7436	0	0	0	0	0	0	0	0	0	0	0	0	0	**436**
		Other Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Electricity	Electricity	0	0	0	0	7382	0	0	0	0	0	0	0	5143	0	0	**525**
		-own use	0	0	0	0	1335	0	0	0	0	0	0	0	0	0	0	**335**
	Liquid Fuels	LPG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Aviation Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Paraffin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Petrol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Diesel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Other Liquid Fuels	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Biofuels	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Energy Residuals	Transformation Losses		0	0	0	0	18430	0	0	0	0	0	0	0	0	0	0	**430**
	Distribution Losses		0	0	0	0	885	0	0	0	0	0	0	0	0	0	0	**885**
	Other Energy Residuals		131	10747	1419	264	1868	700	391	1263	995	1831	10	3673	0	0	0	**293**

Total			**131**	**59810**	**1419**	**264**	**29899**	**700**	**391**	**1263**	**995**	**1831**	**10**	**3673**	**5143**	**0**	**49063**	**592**

ANNEX 2: DETAILED ENERGY SUPPLY AND USE TABLES

2015/16 Use (Common Unit) (TJ)			Agriculture	Mining	Manufacturing	Water Supply	Electricity	Construction and Trade	Hotels and Restaurants	Road Transport	Finance, Real Estate and Business Services	Central Government	International Organizations	Households	Exports	Stock	Environment	**Total**
Natural Inputs	*Resources*	*Coal*	0	49063	0	0	0	0	0	0	0	0	0	0	0	0	0	**49 063**
	Renewables	*Solar Power*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Energy Products	*Coal*	*Thermal Coal*	0	6241	0	0	27723	0	0	0	0	0	0			7663	0	**41 627**
		Washed Coal	0	0	938	0	0	0	161	0	0	347	0	235	5771	-16	0	**7 435**
		Other Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Electricity	*Electricity*	131	4508	481	264	14	700	230	268	995	1484	10	3438	0	0	0	**12 524**
		-own use	0	0	0	0	1335	0	0	0	0	0	0	0	0	0	0	**1 335**
	Liquid Fuels	*LPG*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Aviation Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Paraffin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Petrol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Diesel	0	0	0	0	827	0	0	0	0	0	0	0	0	0	0	**827**
		Other Liquid Fuels	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Biofuels	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Energy Residuals	*Transformation Losses*		0	0	0	0	0	0	0	0	0	0	0	0	0	0	18430	**18 430**
	Distribution Losses		0	0	0	0	0	0	0	0	0	0	0	0	0	0	885	**885**

	Other Energy Residual	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23293	**23 293**
Total		**131**	**59812**	**1419**	**264**	**29899**	**700**	**391**	**268**	**995**	**1831**	**10**	**3673**	**5771**	**7647**	**42607**	**155 419**

ANNEX 2: DETAILED ENERGY SUPPLY AND USE TABLES