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ENERGY ACCOUNTS FOR BOTSWANA

Technical Report

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This report has been prepared by a team from the Department of Energy with support from Dr. Rutger Hoekstra (Statistics Netherlands) and the Centre for Applied Research (Dr. Jaap Arntzen and Ms Tshepo Setlhogile).

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Abbreviations

BCL	Botswana Concessions Limited
BEMP	Botswana Energy Master Plan
BOL	Botswana Oil Limited
BOTASH	Botswana Ash
BPC	Botswana Power Cooperation
CAR	Centre for Applied Research
CBM	Coal Bed Methane
CH_4	Methane
CO_2	Carbon Dioxide
CTG	Coal to Gas
CTL	Coal to Liquid
DAM	Day Ahead Market
DoE	Department of Energy
EDM	Electricidade de Mozambique
EI	Energy Intensity
EnA	Energy Accounts
Eskom	South African Power Utility
GDP	Gross Domestic Product
GDSA	Gaborone Declaration on Sustainability in Africa
GJ	Giga Joule
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producers
ISIC	International Standard Industrial Classification
KV	Kilovolts
KWh	Kilowatt (thousand watt hour)
LPG	Liquid Petroleum Gas
MCM	Morupule Colliery Mine
MFDP	Ministry of Finance & Development Planning
MJ	Mega Joule
MMEWR	Ministry of Minerals, Energy and Water Resources
Mt	Metric tons
MTC	Ministry of Transport and Communications
Mtpa	Metric tons per annum
MWh	Megawatt hour (million watt hour)
NDP	National Development Plan
NEF	National Electricity Fund
NESC	National Electricity Standard Connection Cost
PSC	Project Steering Committee
PV	Photovoltaic
RoM	Run of Mine
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SB	Statistics Botswana
SEEA	System of Environmental and Economic Accounts

SEEA-CF	System of Environmental and Economic Accounts – Central Framework
SNA	System of National Accounts
SNEL	Société Nationale d' Électricité
SUT	Supply and Use Tables
TJ	Tera Joule
TWG	Technical Working Group
UB	University of Botswana
UNDP	United Nations Development Programme
VA	Value Added
WAVES	Wealth Accounting and Valuation of Ecosystem Services
WB	World Bank
WUC	Water Utilities Corporation
ZESA	Zimbabwe Electricity Supply Authority
ZESCO	Zambia Electricity Supply Corporation Limited

Executive Summary

This is the first comprehensive report on Botswana's energy accounts project. The report presents the methodology, data compilation process, results and policy messages of energy accounts for Botswana. The prime focus of the report is on the Physical Energy Flow Accounts (PEFA). The accounts cover two (2) energy products, namely coal and electricity in physical energy units during the reference period 2010/11 to 2014/15.

The report is structured into three (3) parts, which can be read separately. This has been done because the report is designed to cater to different types of audiences:

Part A is meant for readers who would benefit from a basic introduction to energy accounting (Chapter 2) and would like to know what methodology and data were used to compile the coal and electricity accounts (Chapter 3). A simplified example of the resulting energy accounts is shown in Chapter 3 for the financial year 2012/13. The full energy accounts for the years 2010/11 and 2014/15 (supply and use tables, or SUT) are shown in Appendix 3.

Part B, which is likely to interest planners and policy makers, can be easily read and understood without reference to Part A. Chapter 4 provides an overview of the coal and electricity sector in Botswana. Chapter 5 discusses the policy messages derived from the energy accounts.

Part C is meant for readers interested in the institutional setting of the energy accounts (Chapter 6), as well as future plans for energy accounting in Botswana (Chapter 7).

The following are key messages arising from the data analysis:

- *Significant shift from an electricity importer to an electricity producer*

The electricity situation in Botswana has undergone significant changes during the period 2010/11 to 2014/15. During the said period, Botswana shifted from being highly dependent on South African electricity to producing most of its own electricity. As a result, the share of domestic electricity generation in the total electricity supply increased from 14% during 2010/11 to 69% during 2014/15.

- *Decrease in imports and increase in energy use*

Electricity imports decreased by more than half, from 2.7 million MWh during 2010/11 to 1.2 million MWh during 2014/15, while energy use increased by 22% over the same period. While domestic production was expected to grow faster, the achieved increase has, together with imports, sustained a modest growth in electricity use. However, electricity (and water) constraints have become a primary concern to businesses.

- *The volatile transition to electricity security*

The transition to increased domestic production has not been smooth. Monthly data indicate that there has been substantial volatility due to the fact that the Morupule B Power Plant has been out of operation on various occasions. During the months in which Morupule B was not operating properly, Botswana reverted back to its position as an energy importer and, where imports fell short of demand, load shedding became inevitable. Nevertheless, during the months in which Morupule B was running satisfactorily, Botswana was almost entirely self-sufficient. Corrective measures at Morupule B, as well as the refurbishment of Morupule A and other plans for power plants, should alleviate power constraints in the future and show potential for Botswana to become a net exporter of electricity.

- *Coal stock management problems*

The volatile domestic electricity generation has also affected coal production and sales as BPC is the largest consumer of thermal coal. The operational problems at Morupule B initially caused an increase of 1.2 million Mt in thermal coal stocks during the period 2010/11 to 2012/13, but better plant performance during 2014/15 led to a decrease of 62,000 Mt in the stock pile. This volatility in the domestic production of some power plants negatively affects economic performance measured by Value Added (VA), resulting in high-energy (electricity) intensities.

- *Significant increase in domestic carbon emissions*

The increase in coal-fired electricity production has led to an almost five-fold increase in domestic carbon dioxide (CO_2) emissions, from 0.7 million tons during 2010/11 to 3.2 million tons during 2014/15. The latter is around 1.5 t/person and represents a significant environmental cost.[1] On the positive side, as imports decreased, direct emissions stemming from imported electricity also decreased, from 2.5 million tons to 1.2 million tons. Nevertheless, the shift towards domestic electricity generation has created a far more CO_2 intensive economy which, if not properly managed, may have future implications for international negotiations concerning climate change.

- *Mining and household sectors*

Mining and household sectors are the biggest users of electricity. The mining sector's share of electricity use is much higher than its share in value added. This signifies a very high electricity use intensity. While the copper and nickel subsector is the largest electricity user in the mining sector, the soda ash subsector represents the highest intensity user. National electricity intensity has remained stable, indicating that electricity efficiency has not changed during the five-year period under consideration. This is normally referred to as 'own use' in the electricity sector but actually relates to losses that can be allocated to all users, thereby implying a lower electricity intensity use for the electricity sector. This is an artificial figure.

- *Energy efficiency of power plants*

[1] As a rough estimate, assuming a carbon sink value of US$ 50/ of CO_2T, the costs of this CO_2 increase are US$125 million.

The efficiency performance of Morupule B and diesel plants are mostly within the broad range of international norms and standards of 32% - 42% for coal fired power plants and 35% - 42% for diesel powered power plants. However, Morupule A performed far below the standard, at 19% during 2012/13, and therefore its closure and subsequent plans for major refurbishment are understandable. Matshelagabedi (APR) performed slightly below the minimum range at 33%, whilst Orapa and Morupule B performed at the low side of the range at 35% and 34% respectively. This calls for concerted efforts to increase the efficiency of the plants toward the upper side of the range of standards.

1. Background

1.1 Introduction

This is the first report on Botswana's energy accounts project. The project is co-funded by the World Bank and the Botswana Government under the Wealth Accounting and Valuation of Ecosystem Services (WAVES) partnership, and is hosted by the Department of Energy. The current phase of the WAVES partnership runs until June 2016. This report presents the methodology, data construction process, results and policy messages regarding energy flow accounts. The results, which are in physical energy units, are mainly restricted to two energy products, namely coal and electricity, and partially to diesel. Further work is being done on liquid fuels, which are also partially used for electricity generation but mainly for transportation activities and the use of (mobile) machines and for the compilation of monetary accounts.

1.2 Energy Accounts

Energy accounts provide systematic resource information about the use and supply of energy. These accounts are part of the System of Environmental and Economic Accounts (SEEA,) which is an internationally agreed standard for environmental-economic accounting adopted by the United Nations Statistical Commission, the SEEA Central Framework (SEEA-CF; (UN et al, 2014)). This statistical framework provides the so-called "satellite accounts" to the System of National Accounts, which governs the way in which economies around the world are measured world. This means that indicators from the SEEA/Energy Accounts can be compared to economic data because they are produced using the same concepts, definitions and industry breakdowns. Moreover, results from Botswana can be compared to results from other countries, e.g. the Southern African Development Community (SADC).

1.3 Botswana's WAVES Program

The overall objective of the WAVES partnership is to promote sustainable development worldwide through the implementation of environmental accounting that focuses on integrating the value of natural capital into development strategies, policies and investment decisions (World Bank, 2011). Natural capital accounting is also a key component of the 2012 Gaborone Declaration on Sustainability in Africa (GDSA), which was signed by 10 African countries including Botswana.

The work plan for the WAVES Botswana program, which spanned from June 2012 to June 2016, was adopted by the Steering Committee in March 2012 and has four components: (i) water accounts; (ii) mineral and energy asset accounts; (iii) land and ecosystem accounts with a focus on tourism; and (iv) fiscal policy and macroeconomic indicators of sustainability. The scope of the energy accounts in the original WAVES work plan was limited to the stocks and asset value of coal and did not include detailed flow accounts for the supply and use of energy. Energy accounts have since been given higher priority, and consequently a scoping mission was carried out from February to May 2014 and a stakeholder workshop was held to discuss the report and map the way forward. The Project Steering Committee (PSC) was briefed on the progress of the energy accounts and the committee requested a detailed work plan for review and approval. The work plan was prepared by the Department of Energy in consultation with key stakeholders.

In November 2014, an Action Plan on Energy Accounting in Botswana was adopted by the WAVES PSC. Activities to be undertaken during the period January 2015 to June 2016 were outlined therein, together with cost estimates. As part of strengthening capacity to compile and update the energy accounts, the Modelling and Statistics Unit within the Department of Energy has since been designated as the Energy Accounts Unit. Technical support from the World Bank/WAVES will continue to be solicited to build the necessary technical capacity within the Unit and to advocate for inclusion of the energy accounting work in the draft NDP 11 to ensure sustainable energy accounting development and use in Botswana.

In September 2015, the action plan was updated. The short-term goal was to produce physical energy flow accounts in physical units for coal and electricity for the period 2010/11 to 2014/15.

1.4 Reading Guide

This report is divided into three (3) parts, which can be read separately as they cater to different audiences.

Part A is meant for readers who are likely to benefit from a basic introduction to energy accounting (Chapter 2) and would be interested in knowing the methodology and data used to create the coal and electricity flow accounts (Chapter 3). A simplified example of the resulting energy accounts is depicted in Chapter 3 for the year 2012/13. The full energy accounts for 2010/11 through 2014/15 (supply and use tables) are shown in Annex 3.

It is possible to read and follow **Part B** without having to read the methodology discussion in Part A. Chapter 4 provides an overview of the coal and electricity sector in Botswana. Chapter 5 discusses policy messages derived from the energy accounts. This part is likely to interest planners and policy makers.

Part C is meant for readers who are particularly interested in the institutional setting of the energy accounts (Chapter 6) as well as the future plans of the project (Chapter 7).

PART A: METHODOLOGY

2. System of Environmental and Economic Accounts (SEEA)/Energy Accounts (EnA)

2.1 SEEA

A consistent statistical description of the interactions between the economy and the environment is important to determine socio-economic and environmental sustainability. The System of Environmental and Economic Accounting (SEEA) was developed for this purpose. The SEEA is an international statistical system that brings together economic and environmental information in a common framework to measure the contribution of the environment to the economy via natural resources and ecosystem services, and the impact of the economy on the environment (UN *et al*., 2014; referred to as SEEA – CF 2012).

Environmental accounts are conceptually consistent with the System of National Accounts (SNA) (UN *et al*, 2009; referred to as 2008 SNA). Data from both the SNA and SEEA can be combined for environmental economic analysis. Environmental accounts use the same concepts (such as the residence principle) and classifications (e.g. for economic activities) and products as those employed in the SNA, but at the same time enlarge the asset boundary to include non-SNA assets such as ecosystems, in recognition of the services they provide that often lie outside the market. They also introduce additional classifications (e.g. for residuals) and definitions (e.g. environmental subsidies).

By using common concepts, definitions and classifications, the SEEA provides a transparent information system for strategic planning and policy analysis, which can be used to identify more sustainable paths of development. Since environmental accounts are integrated with concepts from the national accounts, environmental and macro-economic developments can be directly compared. Key indicators can be derived from the environmental accounts. Composite indicators can be derived from a combination of the national accounts and the environmental accounts, such as resource productivity and intensity indicators. These provide insight into sustainability with respect to environmental, natural resources and economic developments. The integrated nature of the system makes it possible to quantify and analyze the underlying causes of changes in environmental indicators. The SEEA supports sustainable development, wider wealth development and green economy policies, and can be used to inform research and economic-environmental policies such as climate change mitigation, resource efficiency, natural resource management, evaluation of policy instruments, and the development of the environmental goods and services sector.

The SEEA Central Framework (SEEA-CF) was adopted as an international statistical standard by the United Nations Statistical Commission in February 2012. It therefore has the same status as the System of National Accounts (SNA) from which such key economic indicators like GDP are derived. SEEA provides an internationally agreed set of recommendations expressed in terms of concepts, definitions, classifications, accounting rules and standard tables, which will help in obtaining international comparability of environmental-economic accounts and related statistics.

2.2 Energy Accounts: The Basics

Energy is essential to many economic activities as an input for production processes and for consumers (households/dwellings). As global demand for energy increases and non-renewable energy resources like crude oil and natural gas become scarce, energy prices may increase to a point where they may hamper future economic development.[2] The impact of economic development on the environment is related to the use of energy. Energy is often supplied from exhaustive non-renewable resources, so at the cost of the natural asset base, energy use often directly determines the emission of greenhouse gasses like CO_2 and CH_4 and many other environmental pollutants. Therefore, improving energy efficiency and decoupling energy use from economic growth are important goals for green growth.

The energy accounts are part of the SEEA and represent a consistent framework in which energy data, both in monetary and physical terms and in terms of flows and assets, have been integrated into the national accounting framework. The physical energy flow accounts show all energy flows that occur within the economy, with the environment, and with the rest of the world. The energy accounts can be used to determine how energy use by economic activities changes over time, which industries are most energy intensive, how energy use is related to the creation of value added, and how dependent the economy is on energy imports. The energy asset accounts monitor the physical energy asset base and the value of those assets over time.

2.3 Energy Accounts: Structure and Example

To understand the energy flow accounts, a simple representation is used based on the 2012/13 data and results collected for Botswana. For didactic purposes, the energy flow account has been aggregated and simplified. Detailed energy accounts are provided in Annex 2 and the results are discussed in Chapter 5.

Table 1 shows the structure of the simplified energy flow accounts. The top section shows the supply of energy products (supply table) while the lower section shows who actually uses these energy products (use table). Notice that the rows distinguish natural inputs of energy, energy products and energy residuals. These are defined by the SEEA-Energy as follows: “In broad terms, energy from natural inputs flow from the environment into the economy, energy products circulate within the economy and energy residuals i.e. energy losses and other energy

[2]The current drop in oil price is due to a slow-down of global economic growth and increased supplies (e.g. shale oil) and global increase in supply from renewable energy sources.

residuals flow from the economy into the environment" (SEEA-Energy, 2014). In these supply-use tables we have singled only one (1) natural input (coal); three (3) energy products (coal, electricity, and diesel) and three (3) residuals (transformation losses, distribution losses and heat losses).

Below is an explanation of the figures in Table 1:

The total amount of coal mined represents a calorific value of 39,432 TJ. In the supply table, this is a natural input provided by the environment which is then "used" by the mining sector. The mining sector then supplies the coal (as an energy product) to the rest of the economy. A sizeable amount of coal ends up in the electricity production sector (11,067 TJ) but most coal is actually added to the coal stocks or coal inventory (15,433 TJ). This large stock increase was a curious aspect of the 2012/13 energy situation of Botswana (See Chapter 5).

The table further shows that there were three (3) sources of electricity produced during 2012/2013 (coal-powered – 2,744 TJ; diesel-powered – 345 TJ and imports – 8,828 TJ). The use table further indicates that electricity is basically used in all sectors of the economy.

Finally, a look at the columns on electricity production show that the total amount of electricity supplied to customers (11,917 TJ) is not equal to the electricity produced. To deliver 2,744 TJ of electricity to customers, the coal fired plants require 11,067 TJ of coal. In addition, the coal fired plants buy around 11 TJ of electricity and use 446 TJ of electricity that they produce for their own use. In total, 11,959 TJ of inputs leads to 2,744 TJ. The differences are determined as the category 'energy residuals' and come from transformation losses (burning the coal to produce electricity), distribution losses (getting the electricity to the users (customers) and the other energy residuals (final energy used). In the use table, these are recorded as losses to the environment.

Table 1 provides a simplified version of the energy accounts in order to explain the basics. However, the actual energy flow accounts of Botswana have far greater industry detail and a greater number of energy product categories.

Note that energy flow accounts are compiled in two units. First, in units that are typical for the energy carrier (MWh for electricity) and second, in a common unit that shows the uniform energy content (terajoules, TJ). In the simplified version mentioned above, data is presented in common units (TJ) only.

Table 1: Energy Flow Accounts Supply and Use Tables (condensed), Botswana, 2012/2013

Supply Table (TJ)				Industries							Households	Imports	Environment	Total
				Mining		Electricity production								
			Agriculture	Coal	Other	From Coal	From Diesel	Other industries						
Natural inputs	Resources	Coal											39,432	39,432
Energy products	Coal	Coal			39,432									39,432
	Electricity	Electricity					2,744	345				8,828		11917
		- own use				446								446
	Liquid fuels	Diesel										1,147		1,147
Energy residuals	Transformation losses						7,507							7,507
	Distribution losses						370	46				1,189		1,605
	Other energy residuals			81	81	12,733	457	756	5,595		3,481			23,538
Total				81	39,513	12,733	11,959	1,147	5,595		3,481	9,975	39,432	123,835

Use Table (TJ)		Agriculture	Industries									
			Mining		Electricity production		Other industries	Households	Exports		Stock changes	Environment
			Coal	Other	From Coal	From Diesel						
Natural inputs	Resources	Coal		39,432								
Energy products	Coal	Coal			8,565	11,067		1,679	175	2,513	15,433	
	Electricity	Electricity	81	81	4,168	11		3,916	3,306			
		-own use			446							
	Liquid fuels	Diesel					1,147					
Energy residuals	Transformation losses											7,507
	Distribution losses											1,605
	Other energy residuals											23,538
Total			81	39,513	12,733	11,959	1,147	5,595	3,481	2,513	15,433	31,461

3. Methodology and Data Processing

3.1 Statistical Infrastructure

It is important to produce energy accounts in a coherent and structured statistical manner. Equally, consistency with the monetary figures that relate to energy in the national accounts is important and can provide mutual benefit during the compilation process of the accounts. This is to ensure that there is little chance of making mistakes, and to work efficiently. Figure 1 provides a schematic representation of the Excel worksheets that underlie the energy accounts.

There are four types of worksheets:

- Source data (Blue): These worksheets contain the source data which is used in the calculations.
- Calculations (Orange): There are four worksheets which deal with calculations of the data.
- Output (Red): The energy accounts and a worksheet with some key indicators are the output worksheets of the excel file.
- Checks (Green): Finally, there is a worksheet that checks all the balances in the energy accounts to ensure that no mistakes have been made.

Below is a discussion of the worksheets in the order which they are named above:

3.2 Source Data

The Botswana coal-electricity system is dominated by two large companies: Morupule Colliery Mine (MCM) and Botswana Power Cooperation (BPC). The files as captured in Figure 1 below are discussed from left to right.

1. *Coal – production and sales*: This data is provided by MCM and includes raw data on local and international sales of washed and thermal coal. It also includes the amount of coal produced in tons.
2. *Coal – sales details*: This data is also provided by MCM. It covers data on sales of thermal coal and sales of washed coal (local as well as exports).
3. *Electricity – generation and imports*: This data is provided by BPC. The table gives information on electricity generation and imports by the electricity sector.
4. *Morupule A and B, Orapa and Matshelagabedi (APR)*: These show the MWh of technological information about the functioning of the four (4) major electricity plants. It includes inputs of coal and diesel required to produce electricity.
5. *Electricity - Annual Report*: The report captures the financial information from the Annual Financial Statements of BPC.
6. *Info* - This shows information regarding the data files called metadata. It provides the sources of data for each worksheet and the relevant contact person's details (name, email, etc.). This sheet also provides the conversion factors used for calculations, that is the calorific values used for coal and Terajoules to MWh conversion factor.

7. *BPC customer base* - This is the only workbook with calculations that take place outside of the Excel file. BPC provided their billed client list for the period 2010/11 through 2014/15. The data indicated the amount of electricity used (KWh), VAT, and total Pula value of electricity used per customer. The electricity rate category (Pula/KWh), which varies according to households, government, mining and commercial sectors, is also provided. Table 2 shows the total number of records per rate category in each year. The number reduces significantly because households (E_DOM) and small businesses (E_S_BUSB1) started using prepaid services and hence were not included in this data.

Figure 1: The Statistical Infrastructure of Botswana's Energy Flow Accounts on Coal and Electricity

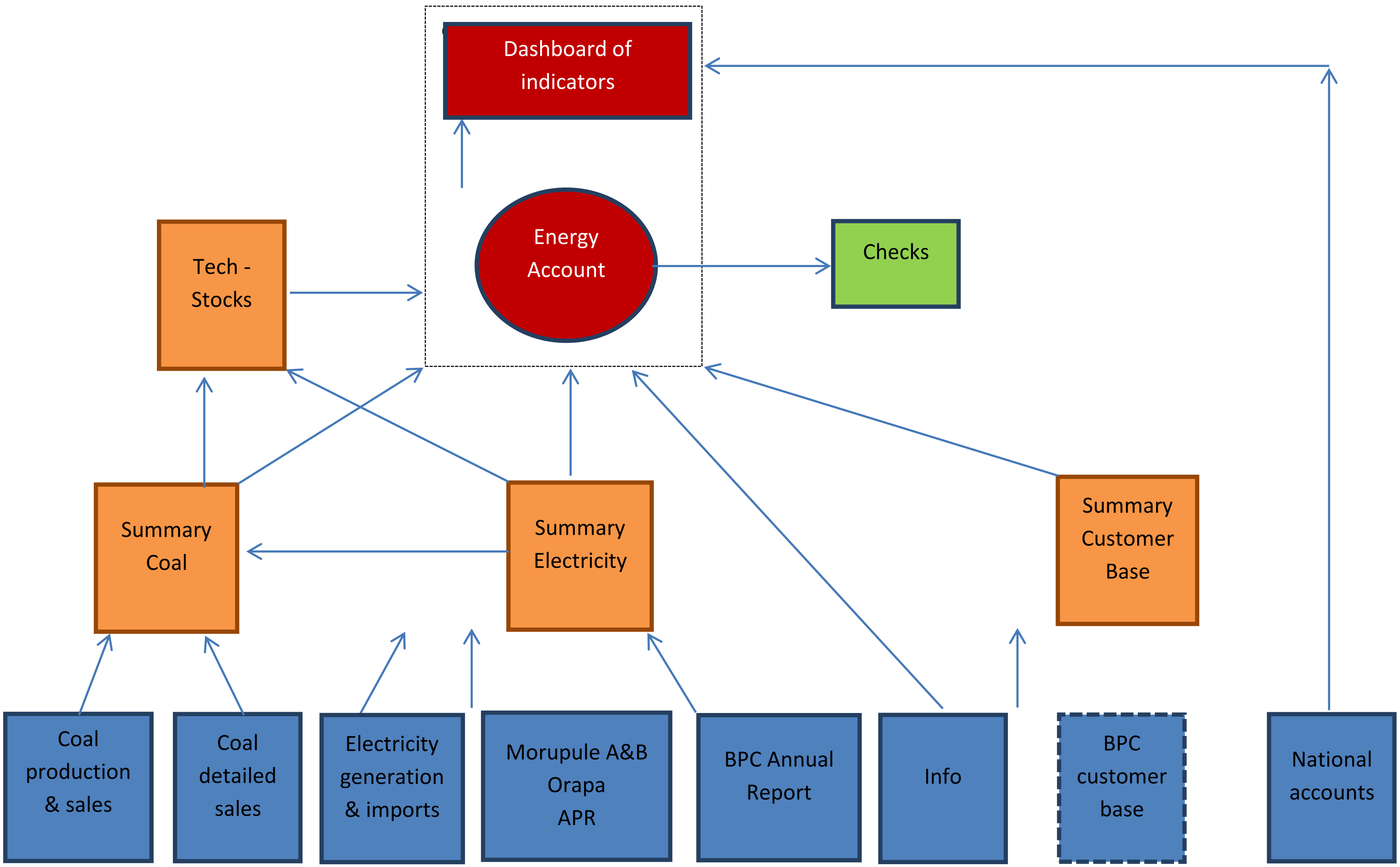


Table 2: Number of Records per Rate Category (BPC Rate Category Code in Brackets)

Year	Domestic (E_DOM)	Government (E_GOVT)	Business 1 (E_S_BUSB1)	Business 2 (E_M_BUSB2)	Business 3 (E_L_BUSB3)	Business 4 (E_L_BUSB4)	Water pumps (E_WTRPMP)	Total
2010/11	76,207	4,955	10,104	1,938	152	12	245	93,613
2011/12	80,451	5,233	10,492	2,172	248	11	237	98,844
2012/13	82,247	5,292	10,753	2,338	281	10	186	101,107
2013/14	37,955	5,217	9,958	2,614	281	16	159	56,200
2014/15	2,727	5,119	5,013	2,582	255	5	148	15,849

The sales were not originally disaggregated by industry, based on the International Standard Industrial Classification (ISIC), therefore the data had to be sorted and coded. The EnA team agreed on a set of economic sector codes for the energy electricity accounts based on the ISIC categories for all economic activities, Revision 4, national accounts industry classification, and the classifications used for the water accounts. This process was done manually over a period of five (5) weeks for coding of 2012/13 data and about three (3) weeks for 2014/15 data. A similar exercise was done for the water accounts, and therefore a list of coded Water Utilities Corporation (WUC) clients was cross-referenced to check for matches and the remaining entries that did not match were coded manually. Team knowledge, internet searches, and telephone directories and follow-ups by phone assisted in the economic sector allocation process. The clients that could not be allocated to a particular economic sector were given the code for unknown ("32"). This accounted for only 1% of the total electricity used.

A similar approach was used for coding the data for 2014/15, and therefore the process took some time. The coded 2012/13 data was used for cross-referencing. This produced an overlap of 8,244 contracts which were linked automatically and this left 36% of the contracts to be coded manually and adjusted in the same way as discussed above for the year 2012/13.

The system was automated by using the coding for the years 2012/13 and 2014/15 to produce the time series for 2010/11 to 2014/15. A Microsoft Access system was also developed. The results obtained were entered into the calculation file for the customer base where some other adjustments were made to the totals (see section 3.2).

8. *National Accounts* - Statistics Botswana (SB) provided time series of quarterly and annual national accounts data. Data was also provided on gross output, intermediate consumption and value added at current prices levels and in prices for 2006. Data was provided according to a 10 and a 40 industry classification. Since SB does not provide annual data according to the government year (which runs from 1st April to March 31st) we summated the four (4) quarters (in constant prices) for the calculations of the indicators.

3.3 Calculations

There are four (4) worksheets in the Excel file that contain calculations for the energy accounts, namely: Summary Coal; Summary Electricity; Summary Customer Base; and Technology-Stocks. The first two worksheets illustrate the production and use statistics for coal and electricity, respectively. Various adjustments and calculations are done in these worksheets. Data on the summary sheets for coal and electricity is aggregated into monthly, quarterly, government year and calendar year data sets.

The Customer Base Summary is derived from the total sales of electricity by industry as per BPC sales reports over the years mentioned. The worksheets also contain some assumptions to adjust the totals to the totals from the annual report.

The worksheet on Technology-Stocks contains calculations related to the technological losses of electricity production. The changes in stocks of thermal and washed coal are also calculated in this worksheet.

The calculations are discussed in greater detail in the following four (4) sections.

3.2.1 Summary Coal

Various sets of data were obtained from Morupule Colliery Mine (MCM). The monthly variables that were provided for the years 2012/13 and 2014/15 included:

MCM1	Run of Mine (RoM) production
MCM2	Thermal coals sales
MCM3	Washed coal production
MCM4	Washed coal sales
MCM5	Thermal coal sales breakdown (BPC, BOTASH, BCL and other)
MCM6	Washed coal domestic sales breakdown (Government, Food and Beverages, Parastatals and Others)
MCM7	Washed coal exports breakdown (South Africa, Zimbabwe, Zambia and others)

One data set covered MCM 1-4. The second data set covered MCM 5-7. However, data sets MCM 5-7 were sent twice (the last version in December 2015) and there were inconsistencies between the two versions. There were also differences in the deliveries of coal to BPC as reported by MCM and BPC, and such inconsistencies were discussed with MCM. Some were resolved during discussions but unfortunately not all issues could be resolved within the time frame of this report, therefore, assumptions had to be made. Another issue was that MCM provided data on stock changes but these differed from the calculated stock changes. In future, the hope is to resolve all of these issues with MCM.

The data set with variables MCM 1-4 covered the period 2010/11 to 2014/15 and appeared consistent. Sometimes a data point would be zero when a value was expected. In this case, a value was estimated. The initial data set for the variables MCM 5-7 also provided sales totals for thermal and washed coal, however these differed from the figures for MCM2 and MCM4. The differences were larger for the earlier year. The new data differed from the earlier data with the sales break-down and exports. In principle, we took the newest delivery of data unless there was a zero-value which we deemed unrealistic. The total sales were adjusted to the totals in MCM2 and MCM4 to make sure that a consistent time series emerged.

The difference between the stock data and the calculated stock changes could not be resolved, and therefore it was decided to use the calculated stock changes in the supply and use tables. The following types of stocks exists: thermal coal stocks and a (small) stock of washed coal.

Estimates of stock changes were made using the following formulas (the BPC code refers to data described in section 3.2.2).

1. Stock of Thermal Coal = MCM1 – MCM2 - MCM3 – BPC4
2. Stock of Washed Coal = MCM4 - MCM3

In terms of linking the domestic sales of thermal coal to an economic classification, we assumed the following:

- BPC = Electricity (code 15)
- BOTASH = Soda Ash (code 7)
- BCL = Copper (code 5)

In terms of relating the domestic sales to an economic classification, we assumed the following for washed coal:

- Government = Social and Personal Services (Code 28)
- Food and Beverages = Hotels and Restaurants (Code 18)
- Parastatals = Finance , Real Estate and Business Services (Code 25)
- Others = This was divided (80%-20%) between Meat and Meat products (code 10) and Households. (This was based on insights from MCM representatives at a workshop in September 2015).

The MCM data are provided monthly, allowing quarterly and annual supply and use to be calculated. Moreover, accounts can easily be calculated for both calendar and government years. In order to link with economic development planning, the accounts are currently provided in government years.

3.2.2 Summary Electricity

BPC is the only electricity service provider in the energy sector. As discussed in section 3.1 above, BPC provided the following data:

BPC1	Domestic generation in MWH (Morupule A (Total sent out); Morupule B (Total sent out); APR (Billed) and Orapa (Billed)
BPC2	Imports: ESKOM (RSA); EDM (Mozambique); SNEL (DRC); ZESA (ZIMBABWE); ZESCO (ZAMBIA) and DAY AHEAD MARKET (DAM).
BPC3	Morupule A&B - Coal received (tons)
BPC4	Morupule A&B - Coal burned (tons)
BPC5	Orapa – Diesel fuel consumption (litres)
BPC6	Matshelagabedi – Diesel fuel consumption (liters)

BPC 1-2 data is provided by the sales department while BPC 3-6 data is more technological information and is provided by the various power plants. The two data deliveries have a couple of small inconsistencies which do not significantly impact the final results, therefore no adjustments were made.

3.2.3 Summary Customer Base

The calculations done in the Microsoft Access database have been discussed under section 3.2 above. In this summary file, the time series data are used as a basis for the electricity consumption but three adjustments are made:

- The total sales in the BPC Annual Report include households and so the total in the customer base is adjusted to this total.
- The mining sector is reported in the Annual Report and the six (6) mining sectors identified in the energy accounts are increased proportionally so that the total adds up to the annual report total.
- The remaining sectors are adjusted proportionally so that the final total adds up to the total electricity reported in the Annual Report.

3.2.4 Technology and Stocks

This worksheet calculates the technological aspects of producing and distributing electricity in Botswana. All of the energy losses that occur during production, distribution and import of electricity are recorded. The worksheets start by looking at the coal and diesel that are required for the coal plants (Morupule A and B) and diesel power plants (Orapa and Matshelagabedi (APR). Each input of fuel is converted into a common unit (TJ). The conversion factor Net Calorific Value for coal is 24.3 TJ/ton (based on the coal analysis, the variation of the CV is very narrow hence the average value was taken to be representative.)

1. 0.0383 TJ/1000 liters of fuel
2. MWh to TJ = 0.0036

Other data in the tables (extracted from elsewhere) are Inputs, Output from turbines, and Output to grid. Other cells still need to be calculated. Other calculations in the table are given as:

- Transformation Losses = Output from turbines – Input
- Own use/ internal losses = Output to grid – output from turbines
- Transmission/Distribution losses = Output to grid * distribution loss % Supplied to customers
- Customers = Output to grid - Transmission/Distribution losses

The worksheets also calculate the stock changes in thermal and washed coal in the Botswana energy system. The calculations are discussed under section 3.2.1 above.

3.3 Output

3.3.1 Physical Accounts – Government Year 10/11 - 2014/15

The energy accounts are sourced from the four (4) "calculation-worksheets" discussed above. In some instances the "info" file is also used for conversion factors.

The tables are labeled "P-GY14-15" with the P standing for Physical and GY for the government year. Thirty-one (31) economic sectors have been identified for the accounts. Supply and use tables (SUT) in mixed units are provided where each energy carrier is measured accordingly (tons, liters, MWh, etc.). The SUTs are also compiled in a common unit (TJ) so that energy flows can be compared, losses shown and figures compared.

3.3.2 Dashboard

The dashboard highlights a set of key indicators derived from the energy accounts. These are especially meant for resource and development planners as well as decision makers who prefer the broader picture and not the detailed accounts. While detail may be lost, the indicators are more appealing to policy and decision makers as they focus on the issues that are most pertinent to them and leave out less relevant information. These indicators are expanded and presented in more detail in Chapter 5. Examples of the indicators derived are as follows:

- Production, use and export/import of electricity and coal. The year-on-year supply and use percentage growths are also captured in the data, as well as the stock changes of coal for the given period
- Carbon dioxide emissions – these show the total domestic emissions from the production of coal and electricity, using available data
- Coal and electricity use by industry
- Electricity intensity (use/value added) by industry and
- Electricity generation efficiency of power plant.

Most of the data in the dashboard is taken directly from the energy accounts. However, the calculations of carbon emissions require some additional information. Emissions from fuel consumption are calculated by multiplying an "emission factor" with the quantity of fuel used. Emission factors are country specific, however, in the case of Botswana where country-specific emission factors have not yet been developed, default IPCC figures are used. To calculate direct emissions that relate to imported electricity, all the imports were assumed to be from South Africa. The assumption was based on the fact that at least 86% of the electricity imports were from South Africa and the remaining 14% were mostly from Namibia, which also largely relies on South Africa for power imports. Based on South Africa's electricity characteristics (90% Coal, 5% Renewables, 5% Nuclear), the imports were assumed to be 10% from low-emission sources ("clean") and 90% from coal. The portion from coal was then treated to get the original coal used using the formula below:

$$Original\ coal\ (TJ) = \frac{0.9 \times Electricity\ Imports\ (TJ)}{efficiency\ of\ the\ transformation}$$

The efficiency of the transformation was assumed to be equal to that of the Morupule B power plant. Direct Emissions of Interegional Imports (EEII) were then computed as follows:

$$EEII = Original\ Coal\ (TJ) \times emission\ factor\ (\frac{tCo2}{TJ})$$

3.4 Checks

This worksheet provides arithmetic checks of the balance restrictions of the supply and use totals (both rows and columns). This checks if the supply and use of energy are balanced or if any mistakes have been made.

3.5 Data Quality Assessment

Botswana's coal and electricity sector is fairly straightforward because it only has two major players, namely MCM (responsible for coal production) and BPC (responsible for electricity generation). The initial data was therefore fairly easy to collect. These companies have monthly data with the most important variables needed for energy accounts.

The data provided by BPC was excellent. There were some minor inconsistencies in the data sets provided by the same company, however the time series appeared to be accurate.

The BPC customer base also provided a good source of data for the use of electricity. A point that should be investigated further is the consistency in the coding of industries (following ISIC-Rev4 industry classification) and sectors in the national accounts and the energy accounts. In February 2016, a link was made between the latest version of the Standard Business Register (SBR), which was under development by SBB, and the BPC client base. The overall conclusion was that there did seem to be some differences in the coding, but because SBR was converting to ISIC Rev4 and the National Accounts are still in ISIC Rev3, the comparisons should be done at a later date when the two systems are both in ISIC Rev4.

By comparison, the MCM data series contained more inconsistencies. For example, MCM provided data on total sales and a breakdown of the sales. However, the total sales from these two sources were not consistent. Two separate deliveries of the detailed sales series were received and for some months they contained different numbers. There was also a difference between the amount of coal sold and received by MCM to BPC, respectively. A closer observation showed that MCM recorded these as sales whilst BPC recorded the same as coal received. While the data situation has shown slight improvement over recent years, compilers of future works need to spend more time analyzing the MCM data to get a more robust time series.

PART B: BACKGROUND, TRENDS AND DISCUSSION

4. Botswana's Coal and Electricity Sector

4.1 Introduction

Coal and electricity sources have been prioritized for the compilation of the physical energy supply and use accounts, based on the following reasons and challenges. Most electricity generated within the country is from coal, and most coal produced in Botswana is used for power generation. Electricity supply currently poses the largest challenge to the energy sector. Challenges include the need to meet the ever-growing electricity demand, to substantially increase domestic electricity generation and reduce dependency on imports, and to increase access to electricity, especially in rural areas. Given that Botswana is a sparsely populated country, connection to the national grid has been costly and a challenge for accessibility. With respect to the coal resource, the challenge has been to get it to play a wider role in the drive for economic diversification.

In the past, the energy sector was guided by the Botswana Energy Master Plan (BEMP). The master plan is now giving way to the National Energy Policy, which will inform and direct the sector as well as address the above challenges and many more.

4.2 Electricity Sector

The Botswana Power Corporation (BPC), a parastatal formed through an act of Parliament, has been mandated to be the sole supplier of electricity in the country. BPC produces the country's electricity and the rest comes mainly from Eskom in South Africa, supplemented by EDM in Mozambique and occasionally the rest of the Southern African Power Pool (SAPP).

Due to population and economic growth and stagnant domestic electricity production, reliance on electricity imports from South Africa has steadily increased since the 1980s. To reduce this reliance dependency on imports, a 600 MW coal-fired power plant (Morupule B) was built and commissioned in 2013; at that time, the smaller power plant Morupule A stopped operating. Had the total installed domestic capacity of 927 MW been operational, the country would have been self-sufficient in electricity use. However, the road to self-sufficiency has been hampered by plant breakdown and system failures leading to load shedding. This was further exacerbated by the decline of imports from South Africa due to increased domestic demand in South Africa.

The current maximum peak demand capacity for Botswana is estimated at 681 MW and is expected to grow by 336 MW to 1017 MW in 2025. Of the country's installed generating capacity, 132 MW of production capacity is currently being refurbished and is expected to be back in operation by the end of 2017. The currently available production capacity is estimated at 495 MW (300 MW from Morupule B, 90 MW from Orapa Power Plant and 105 MW from

Matshelagabedi plant). This calls for capacity expansion as well as for increasing energy efficiency and demand management, such as through peak shaving.

In an effort to ensure security of supply and exports, additional generation capacity is planned through independent power producers (IPP), comprising two (2) 300 MW coal-fired plants, one to be located at Morupule B and the other at a site to be determined.

In 2010, the government introduced the National Electricity Standard Connection Cost (NESC) and the National Electrification Fund (NEF) with a view to ease upfront electricity connection costs and improve accessibility. As of September 2014, the national access rate to grid electricity was 69%; it is expected to increase to 80% in 2016.

Challenges experienced by the subsector include, but are not limited to:

- Inadequate domestic electricity generation and supply, leading to load shedding and power outages
- Limited transmission and distribution infrastructure, especially in the north-western region
- High connection costs due to limited infrastructure and high electricity tariffs that are not cost-reflective.
- High supply costs due to the almost permanent use of diesel power plants with high operational costs. As a result, BPC has experienced losses since 2010-11 (a total of BWP 4.4 billion between 2010/11 and 2013/14) and the government has supplied revenue grants of BWP 2.9 billion during the period 2010/11 to 2013/14 (BPC Annual Reports).

4.3 Coal Sector

Botswana's coal resources are estimated to be over 200 billion tons (Department of Geological Surveys, 2012). These coal resources are currently exploited on a very small scale and future development opportunities of coal resources need to be identified and exploited. This can assist the country in its economic diversification drive. Coal is one of the minerals that is included in the mineral asset accounts (physical and monetary stocks/assets and annual use), and coal and electricity are economic sub-sectors in the water accounts (Econsult, 2015 and DWA and CAR, 2014 and 2015).

As of June 2014 there were only two (2) measured (proven) coal reserves, namely Morupule and Mmamabula coal basins, with a capacity of 7.2 billion tons. The coal use (raw coal) of Botswana is around 1.6 million tons per annum (Mtpa) to date. However, in an optimal setting when the top three coal users (BPC, BCL, Soda Ash Botswana) are taking all of their allocations, total local raw coal requirements would rise to 2.55 Mtpa (0.5 Mtpa for Morupule A; 1.8 Mtpa for Morupule B; and 0.25 Mtpa for local consumption). Even with increased domestic consumption, proven coal reserves in Botswana will last for centuries.

There is currently only one operating coal mine, Morupule Coal Mine (MCM) with a total production capacity of 3.2 million tons, although average production for the period 2010/11 to

2014/15 was only 1.4 million tons. When Morupule B is fully operational, production is expected to increase to 2.7 Mtpa. A small portion of the coal produced (around 15%) is washed and sold locally and abroad. About 75% of the mined coal is used for power generation and the rest is used in various industries and exported. Very little coal is used for household purposes.

MCM has a wash plant with a capacity of 0.5 Mtpa, and produced on average 0.2 Mtpa over the period 2010/11 to 2014/15. Around a quarter of output is sold locally while three-quarters are exported to countries in Southern Africa. Exporting coal to international markets is hampered by inadequate transportation infrastructure, high transportation costs, as well as the ever decreasing price of coal. Future export opportunities may be limited by global shifts in demand for renewable energy resources and away from coal, along with efforts to reduce CO_2 emissions.

A coal roadmap study was conducted in 2011 to find ways to better monetize the country's coal resource. The study proposed a three-tiered strategy for coal valuation in monetary terms. In the first tier, coal exports, domestic power generation and coal by wire were seen as favourable. In the second tier, cement and Coal Bed Methane (CBM) are to be considered. Lastly, in the third tier conversion of Coal to Liquid (CTL), Coal to Gas (CTG) and fertilizer manufacturing are to be explored.

5. Major Recent Trends in Energy Supply and Use

5.1 Introduction

This chapter gives an in-depth analysis of the data and the first results of the physical energy flow accounts, allowing for the construction of a foundation for assessing the policy implications of the work thus far. The chapter explores production and supply of both coal and electricity, extraction of coal volumes from the environment and use and supply within the economy, electricity self-sufficiency and imports, electricity production technology, energy efficiency and $C0_2$ emissions. The physical Supply and Use Tables (SUT) are shown in Annex 3.

5.2 Electricity Production, Use and Imports

The supply tables for energy flow show a rapid rise in domestic electricity production. This has been the result of the policy shift from least-cost energy supply to extended self-sufficiency, which led to significant investment in domestic power generation infrastructure. Figure 2 shows that domestic production and use have grown during the period 2010/11 to 2014/15, although the increase in use was much smaller than the increase in domestic production. This was mainly due to declining electricity imports.

Figure 2: Trends in Electricity Production, Imports and Use (MWh)

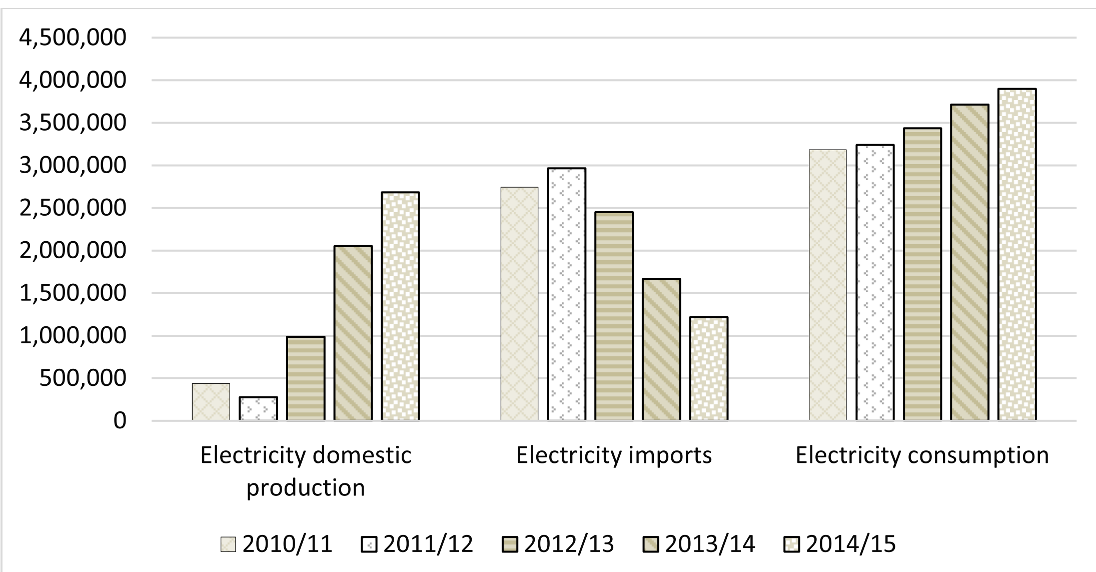
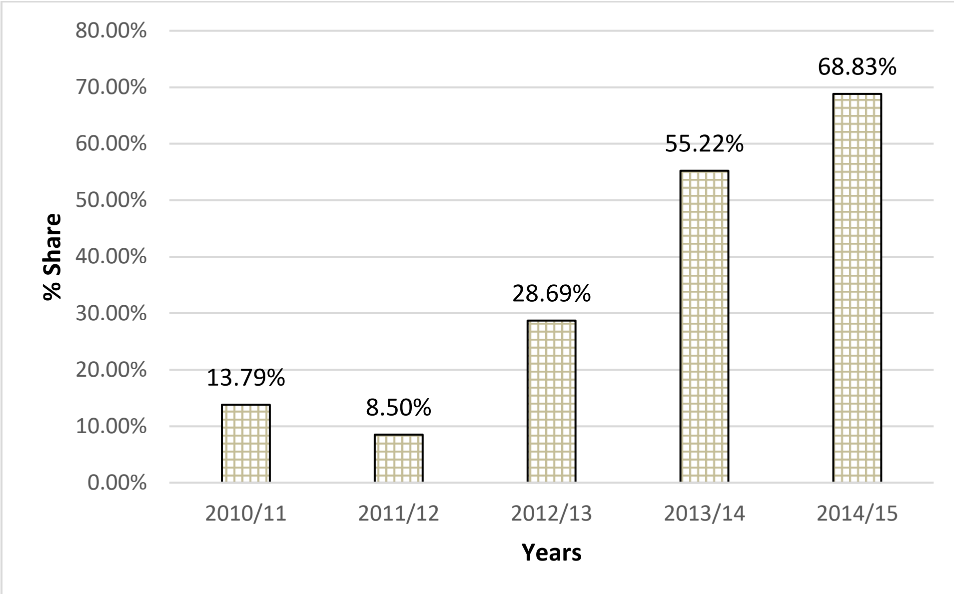


Figure 2 shows that, from 2010/11 to 2014/15, the share of domestic electricity generation increased from 12% to 70% of total available electricity.

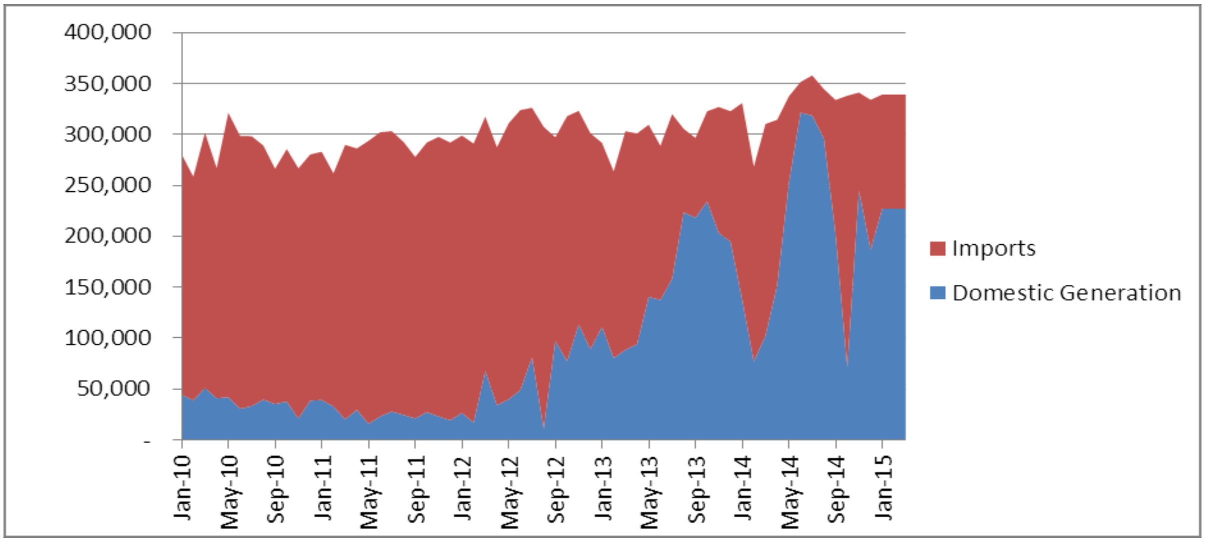
Figure 3: Share of Domestic Electricity Production as % of Total Electricity Supply



5.2.1 Electricity Imports

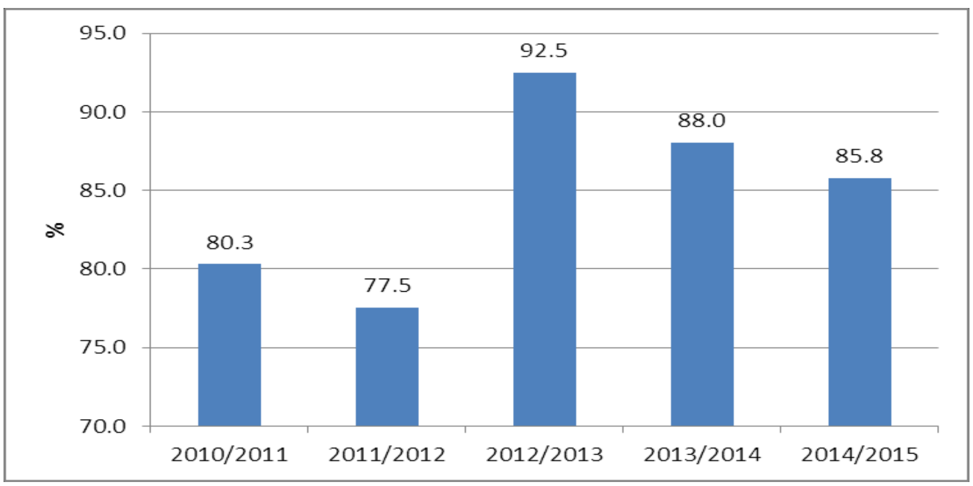
The supply table shows that the overall contribution of imports has decreased from 88% in 2010/11 to 30% in 2014/15. While most imported electricity came from South Africa, not more than 25% is imported from other neighbouring countries such as Namibia, Zambia and Zimbabwe. From 2010/11 to 2012/13, Botswana's reliance on South African imports increased, reaching a high of 92.5%. Since then, imports from South Africa have decreased relative to other countries, to about 86% during 2014/15. This is largely due to South Africa's inability to supply enough power. As stated in Chapter 4, Botswana's power situation is facing challenges due to the woes of the Morupule B power plant (see figure 3). It is, however, anticipated that the plant will resume normal operations by 2017.

Figure 4: Power Imports versus Domestic Generation



The volatility of the power supply situation can clearly be seen in Figure 4 above. Domestic supply has increased since 2010 but the transition has not been that smooth.

Figure 5: Electricity Imports from South Africa, Share of Total Electricity Supply



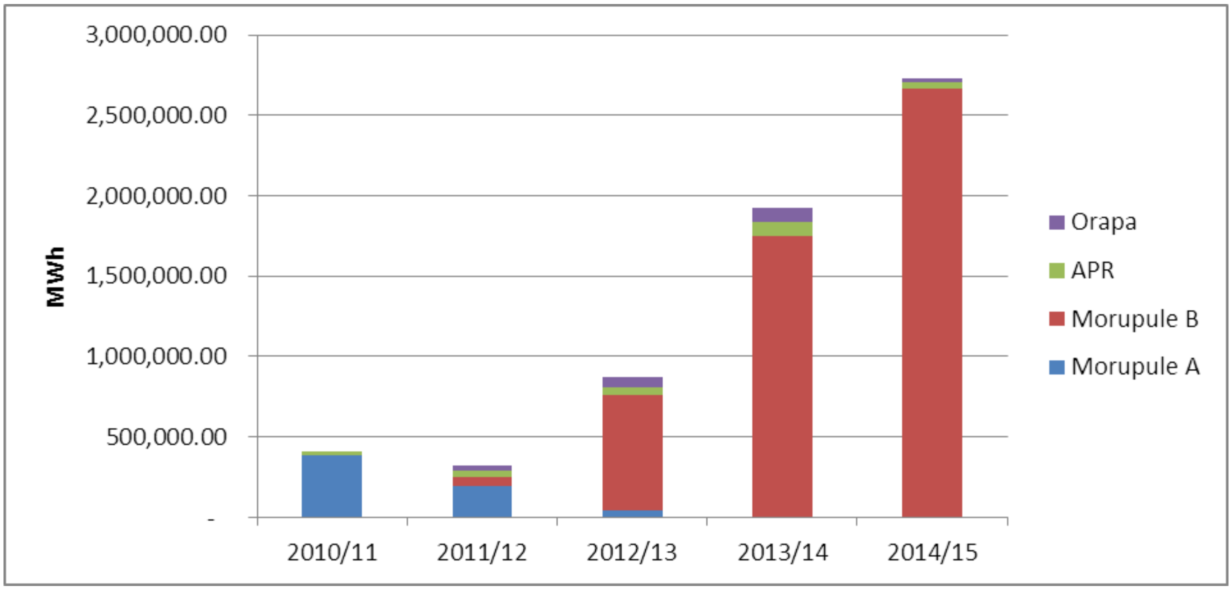
5.3 Contributions of each Technology to the Electricity Mix

This section focuses on Morupule A&B (coal-fired) and the two diesel peaking power plants of Orapa, with a capacity of 90 MW, and Matshelagabedi (APR) with a capacity of 105 MW.[3] Figure 6 shows that, from 2010 to 2012, most power supply came from Morupule A; in 2012, the

[3] In addition, the country has a small solar power plant with a capacity of 1.3 MW.

power station started experiencing maintenance problems, as earlier explained. Morupule B took over from 2012 to date. With improvements in Moruple B, there has been a reduction on the dependency of diesel-powered power stations.

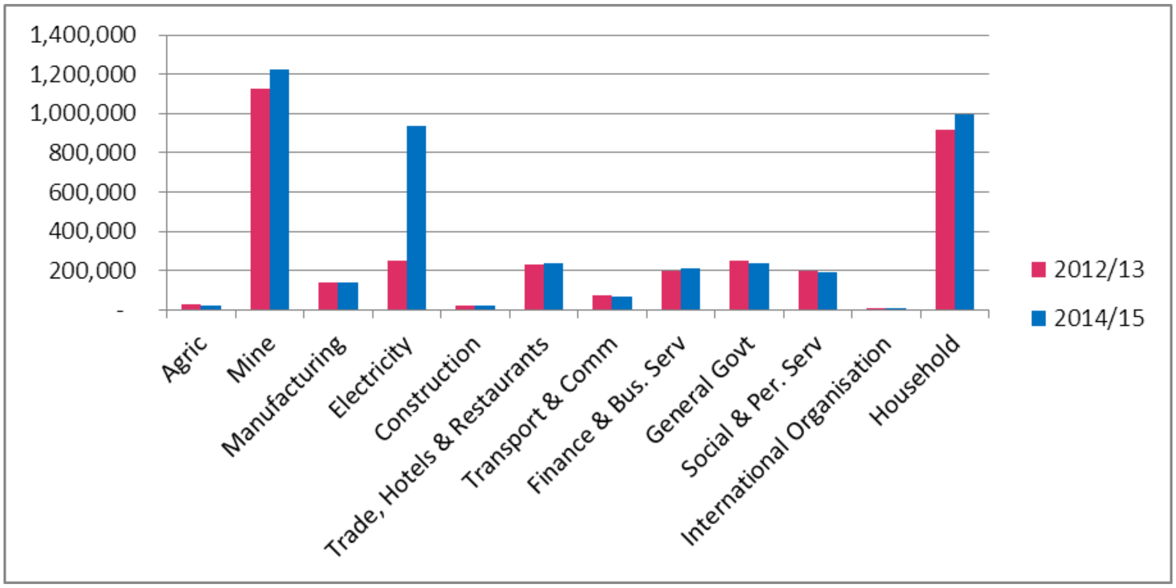
Figure 6: Share of Different Production Facilities in the Supply Mix



5.4 Electricity Use by Economic Sector

The use tables show that electricity use by the productive sectors increased from 2.4 GWh during 2012/13 to 2.6 GWh during 2014/15. The mining sector is by far the largest productive user of electricity, accounting for around half of the productive electricity use (Figure 7). Copper and nickel, as well as diamond mining, use the most electricity. Copper and nickel mining accounts for 48.9% of the mining sector's electricity used, closely followed by the diamond sub-sector at 45.2%. In contrast, agriculture and construction use only small amounts of electricity, while other sectors, like manufacturing, service industries and government, use comparable amounts. The service industry uses more than manufacturing, which reflects the country's economic structure.

Figure 7: Electricity Use by Sector (MWh)



5.5 Electricity Intensity

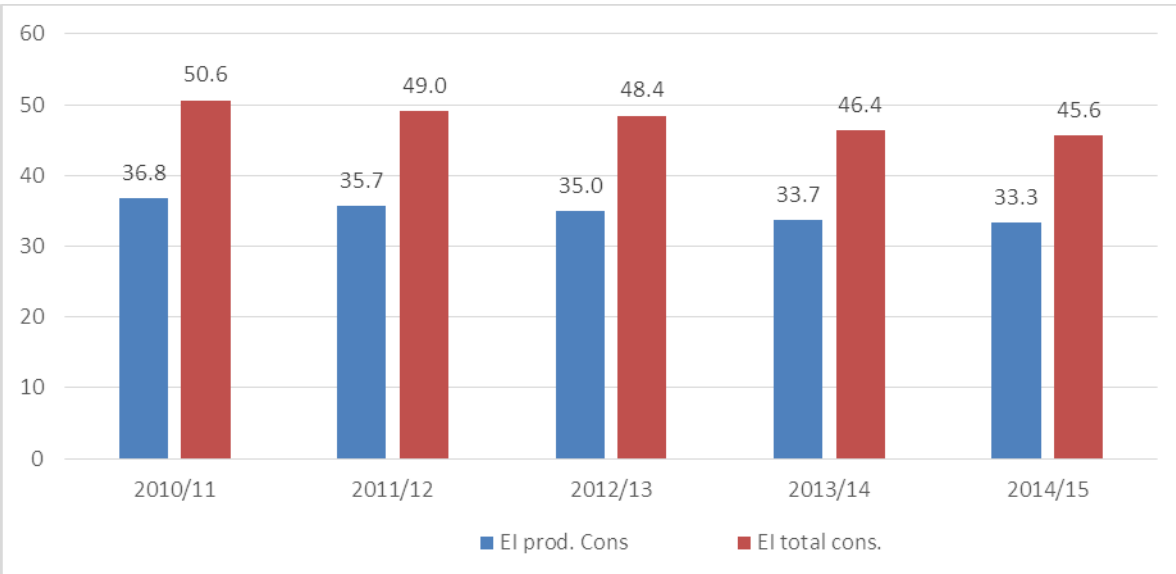
Electricity intensity (EI) is a key parameter in determining future electricity demand. Using electricity intensity, the power requirements of different economic growth scenarios can be estimated and electricity constraints and sectoral trade-offs can be identified well in advance. This informs both energy planning in terms of required expanded power generation capacity, as well as macro-economic planning in terms of taking decisions on sectorial electricity allocations during periods of power scarcity (e.g. during load shedding) and investments in other energy sources, as well as economic diversification.

EI is measured as energy use in MWh/Pula divided by value added. The purpose of determining the national and sectorial energy intensities is to inform the relationship between Gross Domestic Product (GDP) growth and the growth in demand for electricity. This also serves to inform how each particular industry or sector performs with regard to energy use in relation to the economic performance of each sector/industry, or to discover if energy saving efforts have had any effect on energy use.

The national EI (Figure 8) shows both the energy intensity and efficiency of the national economy. If the national EI decreases, the national economy reduces the intensity of use and increases efficiency. This may be due to energy savings or to a shift in economic structure toward less energy-intensive sectors. The sectorial EI figures identify the energy-intensive sectors as well as the energy-extensive industries. Rapid growth in the energy-extensive industries will reduce the national EI figure in due course. If economic diversification focuses on energy- and electricity-extensive industries, energy supply has to expand less than if diversification focuses on electricity-intensive industries.

National EI figures have been calculated for the period 2010/11 to 2014/15 for productive electricity consumption and for total electricity consumption, which includes household consumption. Both indicators are slowly decreasing, demonstrating a decline in energy intensity across the economy. During 2014/15, 36.8 MWh was needed for the productive sectors to create 1 Pula of value added (in constant 2006 values). If household consumption is included,[4] the required amount is 45.6 MWh. Energy intensity decreased by just under 10% over this five-year period. In other words, energy use grew at a slower pace than economic growth.

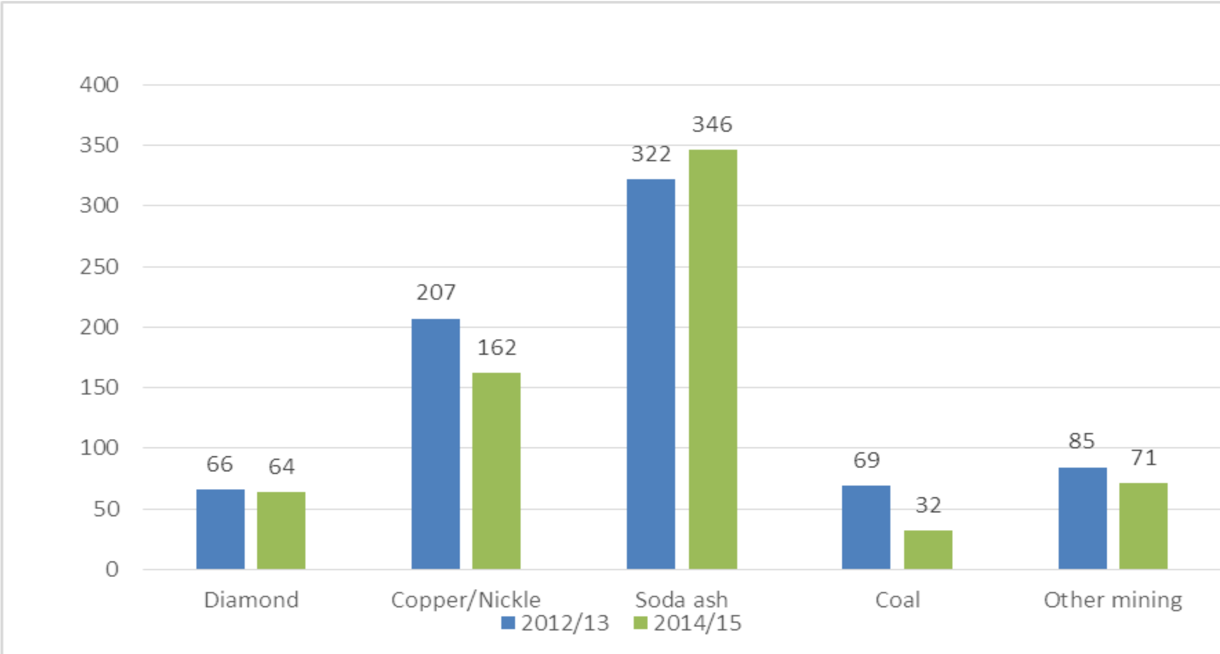
Figure 8: Electricity Intensity of Productive Sectors (MWh/BWP, constant 2006 value added)



As the mining sector is the main user of electricity, it is worthwhile to investigate this sector in greater detail. Figure 9 shows the EI of the main mining sub-sectors. While copper/nickel and diamonds are the largest users of electricity in the mining sector, the EI for soda ash is by far the highest. This reflects the electricity intensive nature of soda ash mining. Expansion of soda ash mining will thus require more electricity than any other mining expansion.

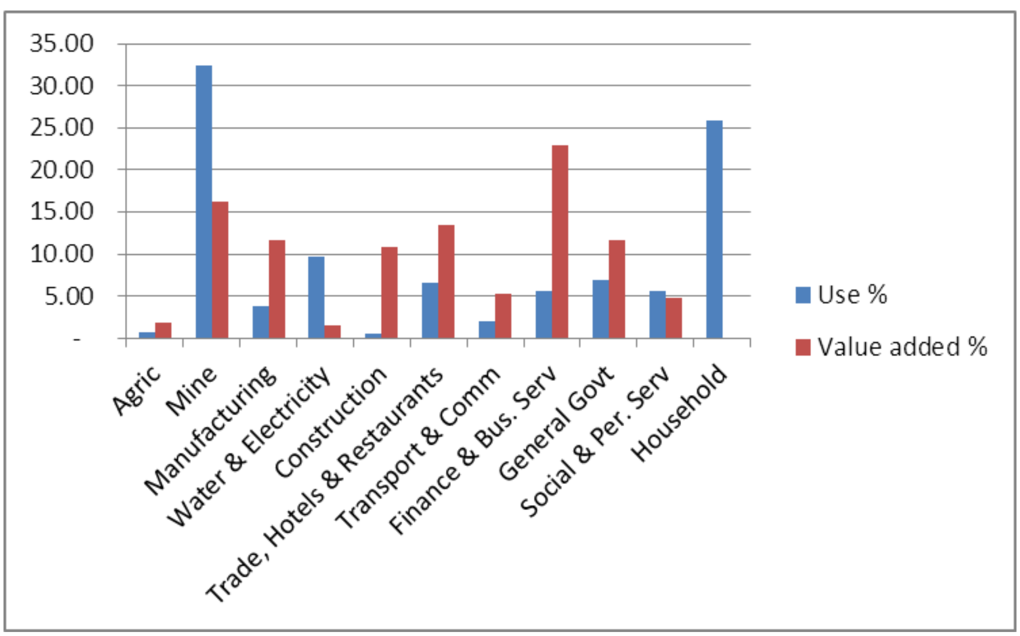
[4] The breakdown in productive and household electricity consumption is currently only available for 2012/13 and 2014/15. For the other years, only total electricity consumption is available (BPC annual reports). It has been assumed that the share of household and productive consumption is the same as the average for the years 2012/13 and 2014/15.

Figure 9: Energy Intensity by Mining Sub-Sectors (MWh/BWP, constant 2006 value added)



Another way of linking sectorial electricity use with economic planning is through the comparison of the shares in electricity use and contribution to GDP. Figure 10 shows that the mining sector uses almost half of the productive electricity and contributes just under 20% to GDP. In contrast, the other sectors contribute more to GDP than their share in electricity use.

Figure 10: Share in Electricity Use and Contribution to GDP by Sector, Averaged over the Period 2010-2015



5.6 Energy Efficiency and Losses

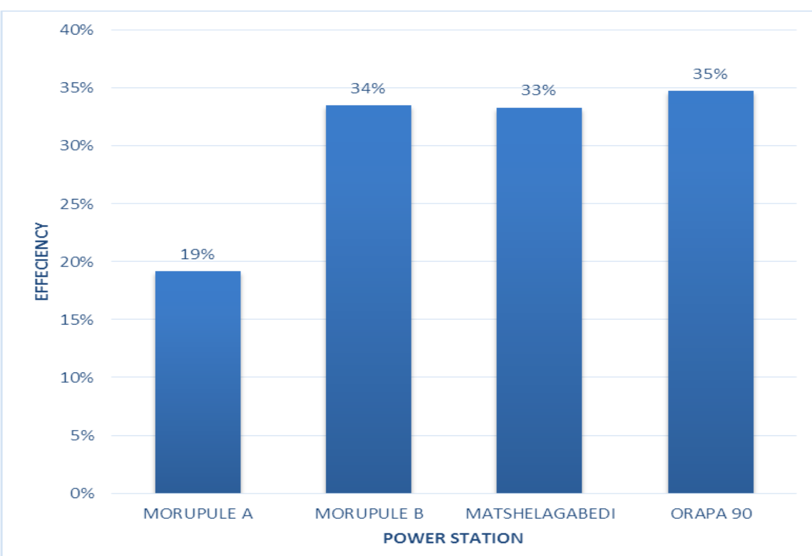
5.6.1 Energy Efficiency

Fuel conversion efficiency is dictated by the technology type. For coal power plants, the overall efficiency ranges from 32% to 42%. However, ultra-super critical pressure power plants at 300 bar and 600/600 °C can achieve efficiencies in the range of 45% to 48%. Diesel engines and large capacity industrial engines deliver efficiencies in the range of 35 – 42%.

Figure 11 below shows the efficiencies of power plants in Botswana for the years 2012/2013 and 2014/2015. Morupule A performed far below the standard, at just 19%, during 2012/13 and therefore its closure and subsequent plans for major refurbishment are understandable.[5] Matshelagabedi performed slightly below the minimum range, at 33%, and Orapa and Morupule B performed at the lower side of the range, at 35% and 34% respectively. It is important to make efforts to increase the efficiency of the plants to the upper side of this range.

High-efficiency plants are normally scheduled to deliver the base load for the grid, and consequently they are operated at a very high load factor (the load factor is a measure of plant utilization which indicates how effectively the plant capacity is matched to consumer (peak) demand).

Figure 11: Efficiency of Four Electricity Plants



[5] At such a low efficiency, Morupule A was seriously underperforming and may have reached the end of its useful life. The plant was commissioned around 1985 and had been in operation for about 30 years.

5.6.2 Losses

Three (3) types of losses are considered in the energy supply tables, namely: transformation losses, internal use, and distribution losses. Transformation losses are closely related to the efficiency of the power plant. For example, Morupule A - with an efficiency of 19% - loses 81% of the input energy during the transformation process from coal to electricity. The internal losses arise as a result of own use. These have been estimated to be around 4% for the coal-powered plants and almost zero for the diesel-powered plants. The distribution losses are estimated to be around 14% and they occur during the distribution of power.

5.7 Coal Production, Use and Stock Changes

Coal has long been the dominant source of energy for electricity generation in Botswana (from Morupule A in the perioid 1985–2013, and from Morupule B since 2012). Figures 12 and 13 below give an overall picture of coal production and use during 2012/13 and 2014/15. MCM produced about 1.623 million tons of coal during 2012/13 and there was a 14% (1.850 million tons) increase in production during the year 2014/15. This is, however, far below the maximum operational capacity of the mine, which is about 3.2 million tones. Thermal coal accounted for more than 83% of total coal produced during the two years. The latter is more important for generation of electricity, particularly at BPC. Production of washed and thermal coal increased by 39% and 10.5% in 2012/13 and 2014/15, respectively. It appears that stock piles grew rapidly during 2012/13 due to the operating problems at Morupule B, which resulted in low sales to BPC (33% of production in 2012/13 and 87% during 2014/15).

Figure 12: Coal Production and Use 2012/13 (1,000 tons)

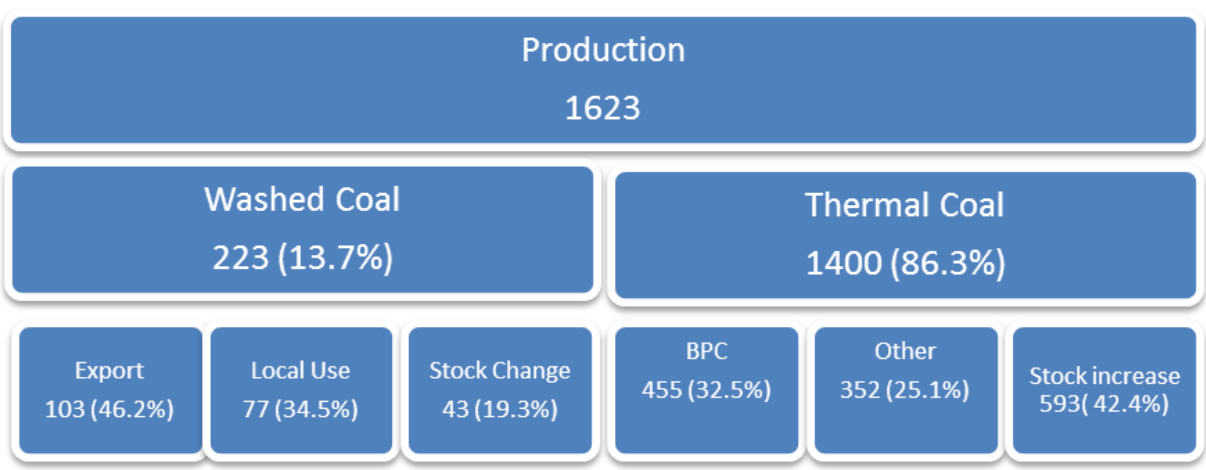
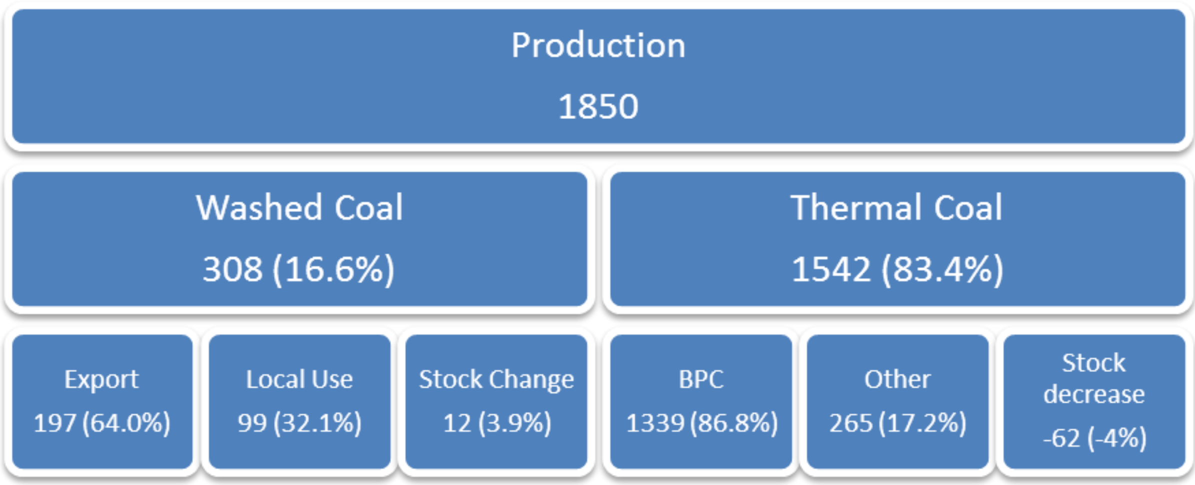


Figure 13: Coal Production and Use 2014/15 (000 Tons)



The quarterly figures for coal production and sales are given in Figures 14 and 15. There was a slight fluctuation in the production and sale of washed coal throughout 2012/13 while levels were stagnant during 2014/15. There was variation in the thermal growth production pattern during 2012/13. There was more production during the 4th quarter of 2012, which is an increase of 35% from the first quarter. However, thermal coal production went down during the first quarter of 2013, possibly due to the high stocks at MCM and BPC. It must be noted that overall, thermal coal production between the beginning and end of 2012/13 increased by almost 100%. Sales increased less, leading to increased stocks at MCM. However, sales picked up in early 2013. During 2014/15, coal production and sales of thermal coal were better aligned and more stable, although we see a fluctuation in thermal coal production throughout the year. There was a moderate increase in production between the quarters with the highest production, recorded during the 1st quarter of 2015.

Production and sales of washed coal are much closer aligned and stock piles are low. The quarterly variance is relatively small as compared to thermal coal. Washed coal sales have remained stagnant during the two years, while there was growth in thermal sales during 2012/13 and fluctuations during 2014/15. These sales are discussed in more detail below.

Figure 14: Quarterly Coal Production and Sales by Ty[e (2012/13, tons)

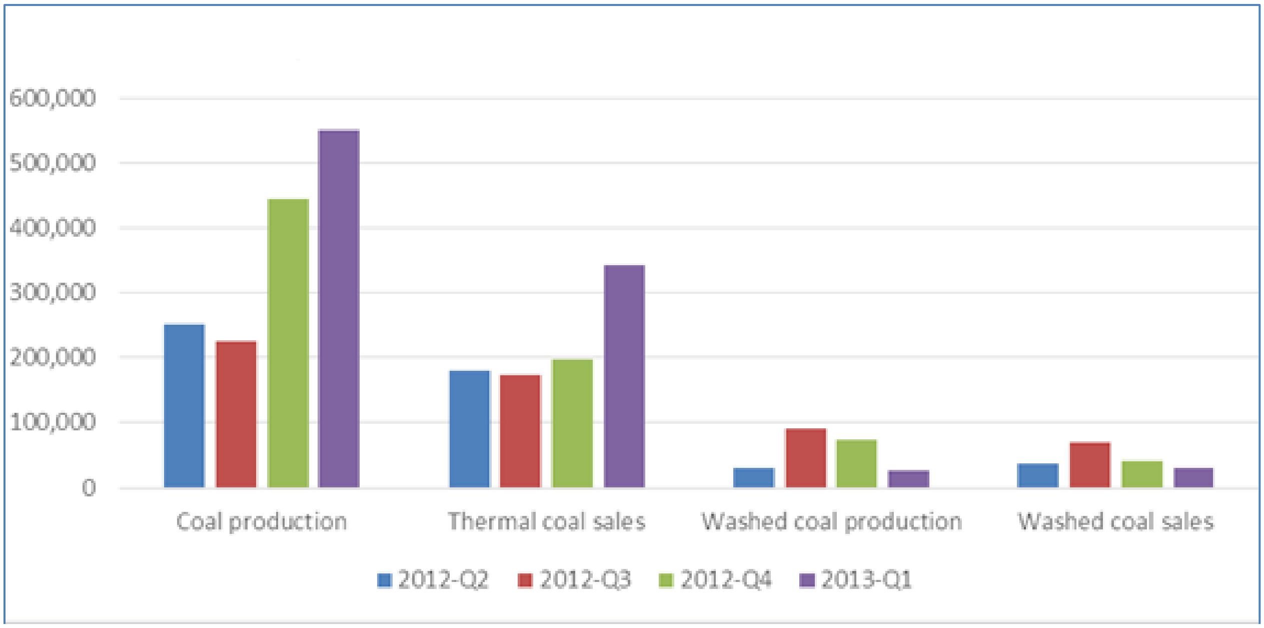


Figure 15: Quarterly Coal Production and Sales by Type (2014/15, tons)

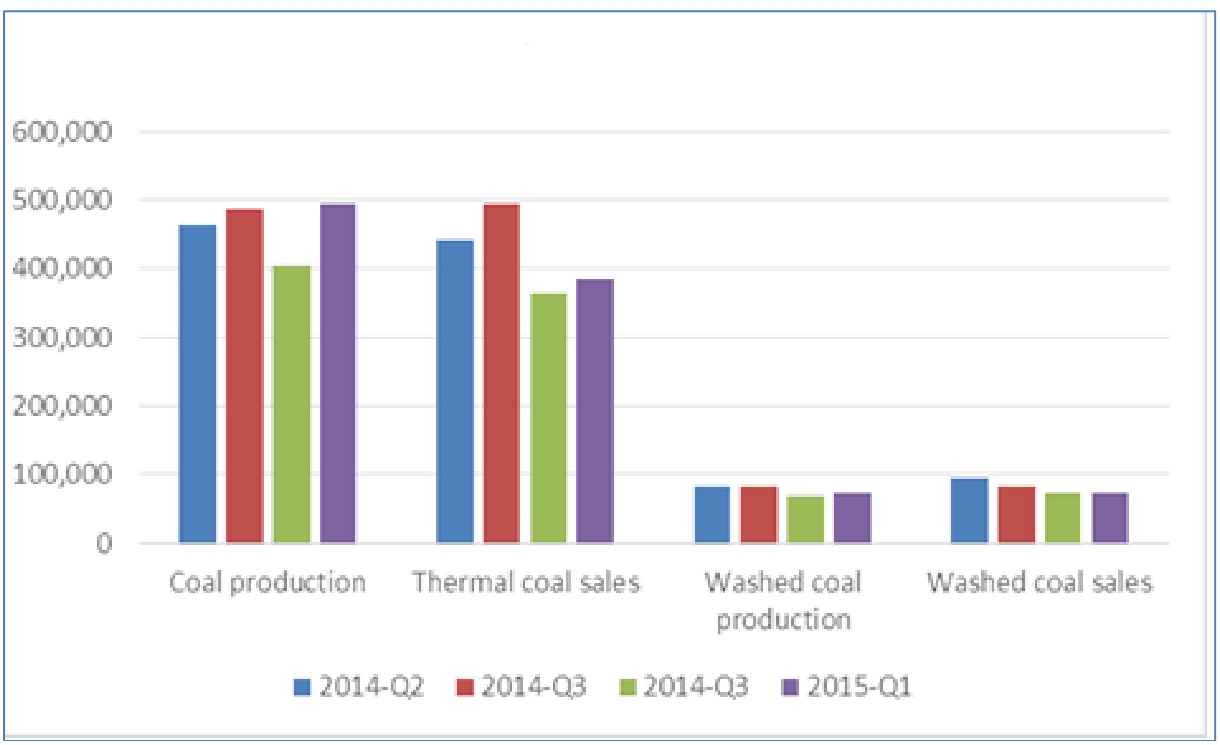
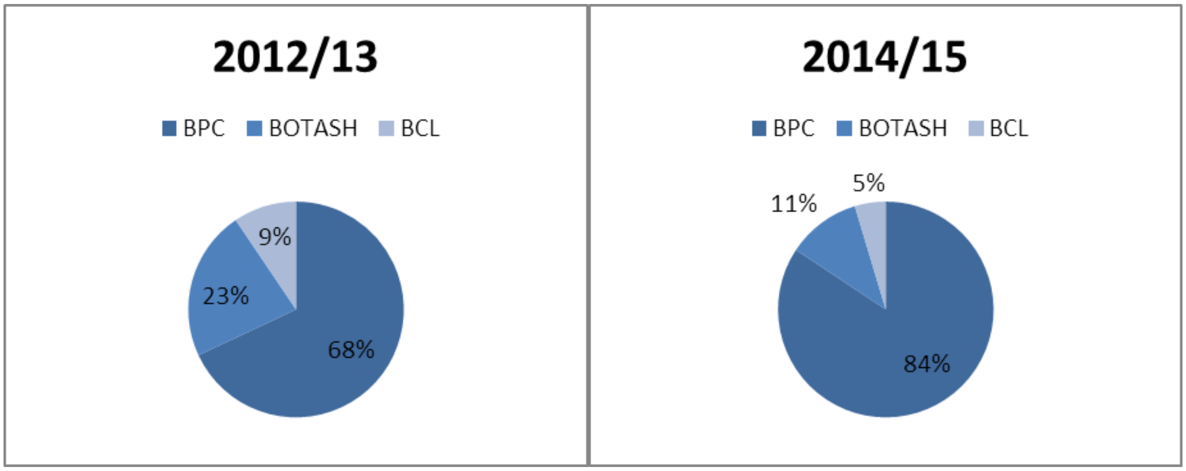


Figure 16: Thermal Coal Sales (Sales Percentages)



During the 2012/13 Government year, sales of thermal coal to BPC constituted 749,945 metric tons, which was 68% of total sales. Meanwhile, 248,115 metric tons were sold to BOTASH, constituting 23% of total sales, and 104,357 metric tons were sold to BCL, constituting 9% of sales. The total amount of thermal coal sold during 2012/13 was 1,102,417 metric tons. The dominance of BPC in the thermal coal market is to be expected, as the utility is the only electricity producer operating coal-fired powered stations.

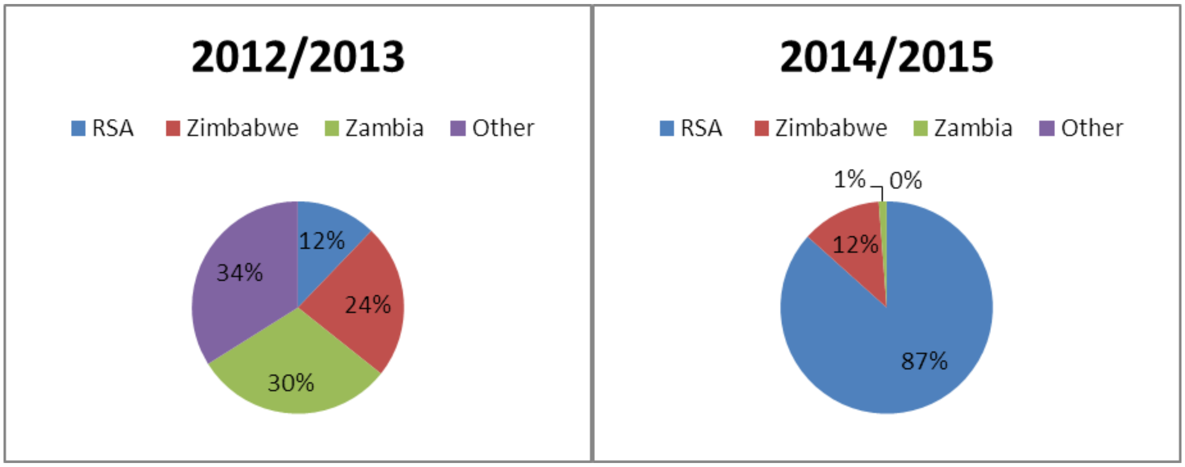
The 2014/15 Government year saw an increase of almost 53% in sales of thermal coal as compared to 2012/13. BPC dominated the sales again accounting for 86.9% or 1,422,153 metric tons. This was an increase of about 90% or 672,208 metric tons over 2012/13. This increase in use of thermal coal is attributed to Morupule B's prominence in electricity generation. The volume bought and share of total sales of thermal coal to BOTASH fell from 23% during 2012/13 to 11% during 2014/15 constituting a decrease of 61,854 MT. Sales share of BCL also fell from 9% during 2012/13 to 5% during 2014/15 representing a decrease of 26,016 MT. Therefore total amount of thermal coal sold during 2014/15 was 1,686,756 metric tons.

5.7.1 Washed Coal Exports

During 2012/13, "other countries " accounted for 34 % of washed coal exports, or 31,440 Mt. Zambia followed closely with a 30% share of exports of washed coal, or 31,440 Mt. Zimbabwe and South Africa contributed to 24% and 12% of exports, or 24,322 and 12,589 Mt respectively. Exports of washed coal totalled 103,429 Mt during 2012/13.

Exports of washed coal increased by 91%, or 93,911 Mt, between 2012/13 and 2014/15. Exports to South Africa increased from 12 %, or 12,589 Mt, to 87%, or 170,956 Mt. Zimbabwe's share of washed coal exports fell from 24% to 12%, but the volumes stayed virtually unchanged at 24,322 Mt during 2012/13 and 23,999 Mt during 2014/15. Zambia's share and volume decreased significantly from 30%, or 31,440 Mt, to 1%, or 2,385 Mt. Total exports of washed coal totalled 197,339 Mt during the year 2014/15.

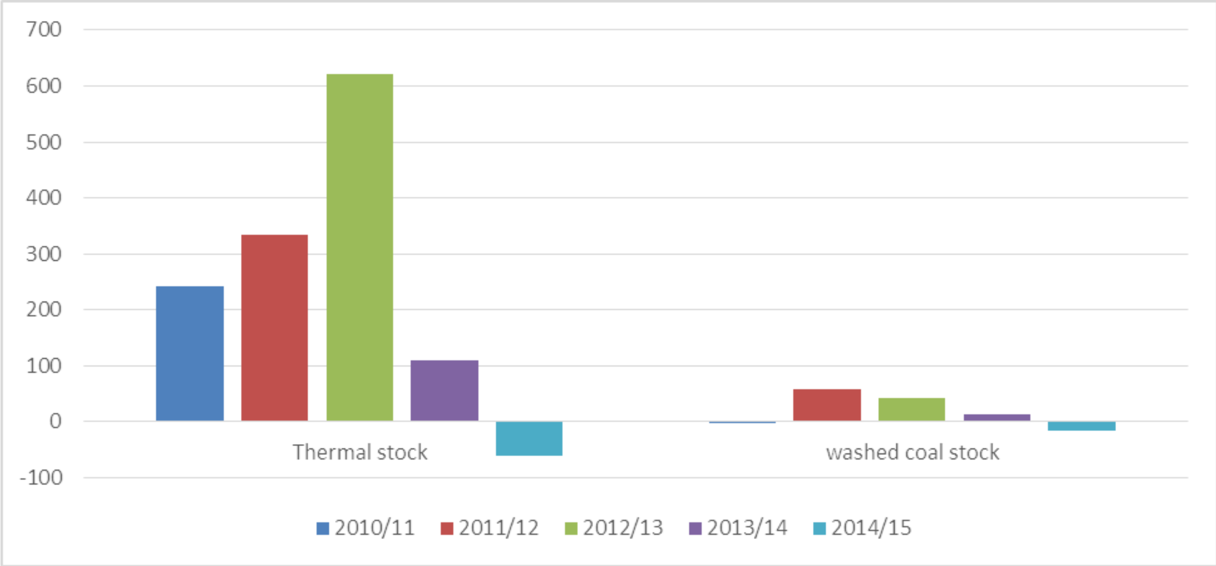
Figure 17: Washed Coal Exports



5.7.2 Stock Changes

The energy accounts have also captured the stocks of both washed and thermal coal. Coal that is produced is not always directly utilized or sold to customers. If more is extracted than required, it is stockpiled and stored for future use. Calculated changes in stockpiles of washed and thermal coal are shown in Figure 18. For details regarding the calculations, see Chapter 3. Clearly, thermal coal stocks increased very rapidly until 2013/14 but the increase slowed down rapidly during 2013/14 and was followed by a decrease during 2014/15. The functioning (or otherwise) of Morupule B has a direct impact on the MCM sales and stock piles. The stocks of washed coal are very low and have not been changing much. Washed coal appears to be produced on real demand, while production may be determined by expected demand for thermal coal.

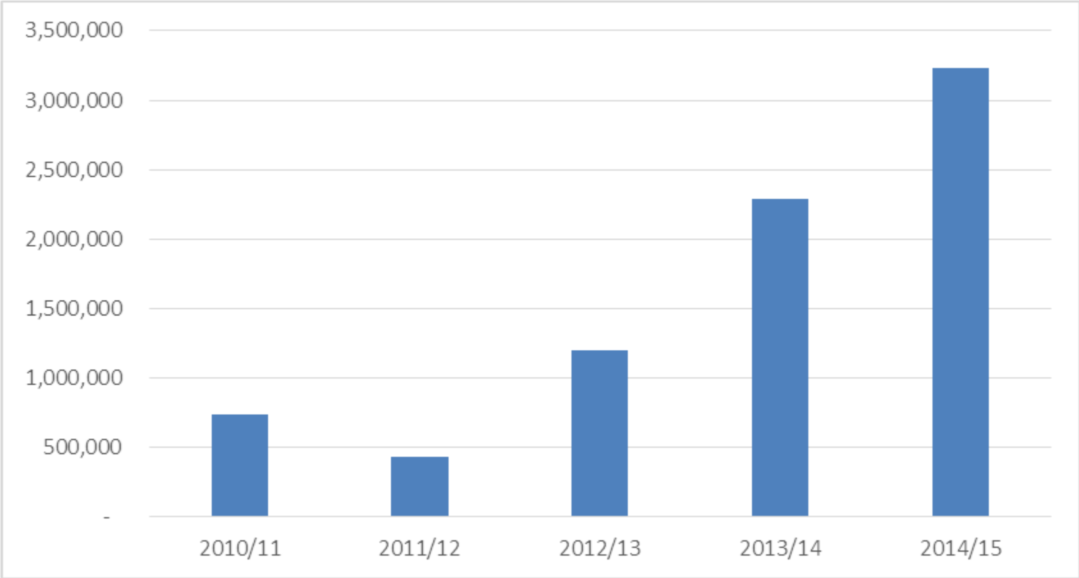
Figure 18 Annual Coal Stock Changes (2010/11 and 2014/15; 1,000 tons)



5.8 Emissions

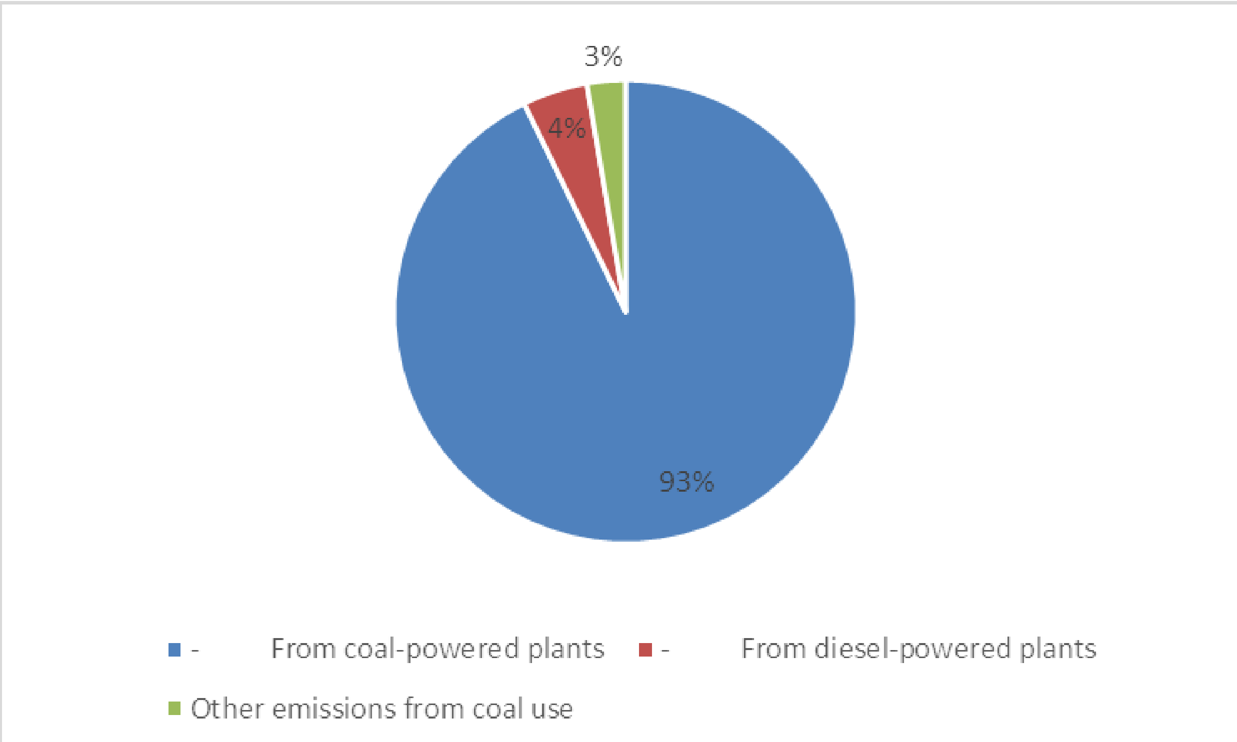
The domestic CO_2 emissions related to coal and electricity have increased rapidly to over 3 million tons (Figure 19).

Figure 19: CO_2 Emissions Related to Coal-Fired Electricity Generation (tons)



As an average for the period 2010/11 – 2014/15, coal-fired power plants accounted for more than 90% of these emissions. The remainder came from other coal use.

Figure 20: Emission Shares for Electricity Generation and Coal



There has been a decrease of 45% in emissions from diesel-powered plants. Emissions from other coal use decreased by 15%. As the country has moved closer to electricity independence from neighboring countries, direct emissions that relate to imports have declined by 52%. Direct emissions caused by electricity imports accounted for 55% of total emissions during 2012/13, while during 2014/15 they only accounted for 24%. Imports of electricity are mainly from South Africa, a country whose electricity supply is 90% from coal, 5% nuclear and 5% renewable. The huge contribution of coal in the South African energy mix has a bearing on direct emissions connected to the electricity imports. Where possible, if Botswana has to import electricity, it should be clean energy with low-carbon-intensive energy products to compensate for its own dependence on coal power, which causes high carbon-intensities.

PART C: INSTITUTIONAL SETTING AND FUTURE PLANS

6. Institutional Setting

6.1 Introduction

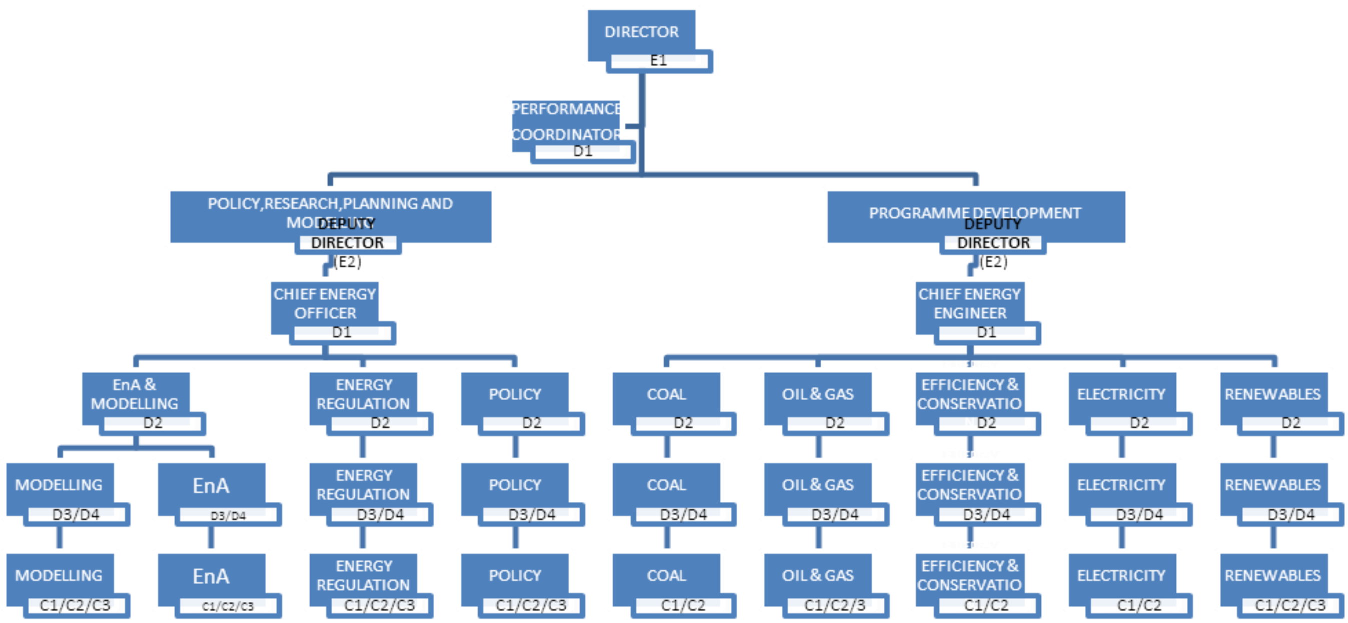
The Department of Energy Affairs (DoE), as a government organization in the Ministry of Minerals, Energy and Water Resources (MMEWR), is the lead agency for the energy accounts. It has therefore formed an Energy Accounting Unit (EnAU) headed by Mr. Kuvare Venjonoka and four (4) staff members: Ms. Mukani Thapelo, Ms. Keshia Senwelo Keipeile, Ms. Jacqueline Wantwa and Mr. Mahwi George. Furthermore, the World Bank has contracted the Centre for Applied Research (CAR), represented by Dr. Jaap Arntzen and Tshepo Setlhogile (September 2015-June 2016), as well as Dr. Rutger Hoekstra from Statistics Netherlands, as consultants (September 2015-June 2016) to assist and support the development of the energy accounts and the implementation of the action plan (See Chapter 8).

6.2 Energy Accounting Unit

The EnAU was formed by the Department of Energy in realization of the importance of energy statistics. As part of its core mandate, Energy Statistics provides the necessary information to guide policy decision-making on sustainable utilization of energy resources in the country. Statistics and inferences gained from the EnA will be able to inform policy and decision makers into making much more informed decisions with regards to energy system planning and policies. EnA relates the physical aspects of energy supply and use with economics, and connects energy provision with the natural environment. With available resources, it also allows for the calculation of the relevant emissions. The DoE structure has been provided below (Figure 21). The larger structure is given for illustration purposes, but the focus will be with those primarily involved in the energy accounting work. The leadership of the Department of Energy is the Director followed by two Deputy Directors, one for Policy, Research, and Planning and the other for Programme Development. The division primarily focused on the energy accounts is the Policy, Research and Planning Division.

Two units were involved in the compilation of the energy accounts, namely the Energy Accounts Unit and the Modeling Unit, with two members from each. The team was led by Mr. Kuvare Venjonoka.

Figure 21: Department of Energy Organizational Structure



The development of energy accounts also requires collaborative support from key players in Botswana's energy sector. Consequently, this prompted the formation of a technical working group (TWG). This technical working group is made up of members from The Department of Energy (DoE), Botswana Power Cooperation (BPC), Ministry of Minerals, Energy and Water Resources (MMEWR), Morupule Coal Mine (MCM), Statistics Botswana (SB), University of Botswana (UB), Ministry of Finance and Development Planning (MFDP), Ministry of Transport & Communications (MTC), and Botswana Oil Limited (BOL). Each of the TWG member has roles and responsibilities to play. Some were key data providers from their respective sectors, as shown below.

Table 3: Key Stakeholders and their Roles

Organization	Data to be/or provided by the Organization
Morupule Colliery Mine	Coal data
Botswana Power Cooperation	Electricity generation and coal sales & burned data
Statistics Botswana	Economic data
Botswana Oil Limited	Petroleum data
Ministry of Transportation	Transport data
MFDP and University of Botswana	Guidance and analysis

7. Future Plans

7.1 Introduction

To catalyse the work going forward, an action plan has been updated to cover the period from October 2015 to June 2016 (which is the end of the WAVES program in Botswana). The action plan covers four components with the following objectives:

Table 4: Energy Accounts Components and Objectives

	Component	Strategic Objectives
I	Compilation of the energy flow accounts and energy asset accounts	Provide systematic information on the supply and use of energy products in the economy and natural energy resources extracted from the environment over a period of time, using internationally agreed SEEA methodology
II	Capacity building and training	Increase knowledge about energy accounting among those aiding the compilation of the EnA and those using the EnA results (engineering/research/policy/decision makers)
III	Policy analysis and impacting	Analyze trends in energy supply and use, and technical and economic performance of the energy supply-use system with the aid of physical energy indicators (e.g. energy efficiency) and composite indicators combining energy with economics, to support energy and development planning and management
IV	Dissemination of results	Ensure that the findings and policy implications regarding the energy resource and supply system are widely distributed among stakeholders and used in energy planning, development planning and other sectorial/resource planning (e.g. water)

Furthermore, the action plan provides a detailed breakdown of deliverables for each of these objectives. The responsibilities of the various institutions are also defined.

7.2 Construction of Energy Accounts

As part of objective 1, a number of energy accounts were compiled. Table 5 shows the goals and dimensions related to the energy accounts:

- Energy type: The data availability for coal and electricity is far better than for liquid fuels.
- Units: The energy accounts can be measured in energy units (physical) or in monetary units (million Pula).
- Time period: Normally energy accounts are made on an annual basis. However, given the quality of the monthly data and the high volatility in the energy system, it also seems useful to create quarterly accounts.

For each of these permutations, we have defined for which years the accounts will be produced and the deadlines for each. Note that the years in italics are tentative because it is not 100% clear that there will be enough data to produce these tables. For the years in bold, we already know we will be able to provide energy accounts of great quality.

Table 5: Energy Accounts to be Produced

Energy Type	**Units**	**Time period**	
		Annual	**Quarterly**
Coal and electricity	Physical		*2014/15*
Liquid fuels and other	Physical	*2014/15*	
All energy	Monetary	*2014/15*	

There are a number of important by-products of this work:

- Monthly data (starting January 2010) for a great many energy variables
- Energy balances (2010/11-2014/15) will be produced on the basis of the energy accounts
- Air emission accounts (e.g. greenhouse gas emissions) that relate to energy activities can be produced quite easily once the physical energy accounts are produced for all energy types for the period 2014/15.

On the basis of this report, the DoE will present the results and the methodology to the Technical Working Group (TWG) and many other stakeholders.

7.3 Policy Analysis and Impact

The EnA are expected to contribute to better energy policies. Insights should be provided for the various planning strategies of Botswana, including the Energy Policy and its follow-up strategies; the National Strategy on Sustainable Development; NDP11 implementation and Mid-Term Review; the forthcoming Climate Change Adaptation Policy; and trade policies. It is also important to use consistent and coherent EnA data in models used by the Ministry of Finance and Development Planning. These relationships will have to be developed further.

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ANNEX 1: Indicators

Table 6: Key Indicators

KEY INDICATORS								
	Indicator	**Units**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**Change (%) (2010/11-2014/15**
Coal Supply (1)	Domestic production (1)	1000 Tonnes	969	909	1623	1449	1850	91%
Coal Use (=2+3+4)	Total uses (2)	1000 Tonnes	712	501	943	1312	1910	168%
	Coal Use (non electricity)	1000 Tonnes	428	354	488	405	572	34%
	Exports (3)	1000 Tonnes	16	15	14	14	18	11%
	Stock change (4)	1000 Tonnes	241	392	665	123	(78)	
Electricity Supply (1+2)	Domestic production (1)	MWh	439,159	275,601	985,783	2,051,186	2,682,994	511%
	From coal-powered plants	%	*92.39%*	*76.97%*	*90.02%*	*92.04%*	*97.77%*	*5%*
	From diesel-powered plants	%	*7.61%*	*23.03%*	*9.98%*	*7.96%*	*2.23%*	*-5%*
	From renewables	%	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00*	*(0,00)*
	Domestic share in total supply	%	*13.79%*	*8.50%*	*28.69%*	*55.22%*	*68.83%*	*55%*
	Imports (2)	MWh	2.744.502	2.964.896	2.449.938	1.663.235	1.215.274	-56%
	Share of imports from S.A.	%	*80%*	*78%*	*93%*	*88%*	*86%*	*6%*
Electricity Use (=3)	Domestic Use (3)	MWh	3.183.662	3.240.497	3.435.722	3.714.421	3.898.268	22%
	Industries	%	*73%*	*73%*	*73%*	*75%*	*74%*	*2%*
	Households	%	*27%*	*27%*	*27%*	*25%*	*26%*	*-2%*
Efficiency/ Intensity	Domestic Energy production (input/output)	%	18%	19%	25%	27%	25%	6%
	Efficiency Morupule A	%	*19%*	*23%*	*20%*		-	
	Efficiency Morupule B	%			*34%*	*33%*	*32%*	
	Electrical intensity	MWh/GDP	37.5	36.2	36.8	37.5	37.9	
CO2 emissions from coal and electricity production	Total domestic emissions	tonnes	733,970	431,858	1,197,792	2,290,768	3,232,104	340%
	Emissions from electricity production	tonnes	692,884	397,822	1,150,898	2,251,808	3,177,181	359%
	- From coal-powered plants	tonnes	663,698	343,974	1,063,539	2,117,049	3,126,284	371%
	- From diesel-powered plants	tonnes	29,186	53,848	87,359	134,759	50,897	74%
	Other emissions from coal use	tonnes	41,086	34,036	46,894	38,960	54,923	34%
	Embodied emissions in imports	tonnes	2,549,593	2,754,335	2,584,884	1,545,116	1,128,968	-56%

Table 7: Electricity Use (2012/13 and 2014/15)

	2012/13		2014/15		Change (%) (2012/13-2014/15
Industry	**MWh**	%	**MWh**	%	
Agriculture	22,450	1%	22,772	1%	1%
Mining	1,157,761	46%	1,251,484	43%	8%
Manufacturing	127,070	5%	135,445	5%	7%
Water & Electricity	235,723	9%	488,894	17%	107%
Construction	33,214	1%	24,599	1%	-26%
Trade, Hotels & Restaurants	238,545	9%	258,191	9%	8%
Transport & Communication	70,768	3%	84,821	3%	20%
Finance & Business Services	222,809	9%	228,761	8%	3%
General Government	219,896	9%	215,908	7%	-2%
Social & Personal Services	187,577	7%	210,308	7%	12%
Total	2,515,814	100%	2,921,182	100%	16%

Table 8: Electricity Use by Economic Sectors

Electricity Intensity			
	2012/13	**2014/15**	**Change (%) (2012/13-2014/15**
	(MWh/pula 2006)	**(MWh/pula 2006)**	
Agriculture	12.3	12.0	-3%
Mining	73.9	64.5	-13%
Manufacturing	7.4	6.9	-6%
Water & Electricity	117.3	241.4	106%
Construction	1.8	1.2	-31%
Trade, Hotels &Restaurants	10.8	10.1	-7%
Transport & Communication	10.1	11.6	15%
Finance & Business Service	6.6	6.0	-9%
General Government	13.9	13.3	-5%
Social & Personal Services	24.1	24.	3%
Average	17.8	18.4	4%

Table 9: Electricity Intensity of economic sectors (electricity use / value added)

	2012/13	2014/15	Change (%) (2012/13-2014/15
	(MWh/pula 2006)	(MWh/pula 2006)	
DIAMONDS	46	45	-3%
COPPER/NICKEL	143	111	-23%
SODA ASH	62	80	29%
COAL	170	56	-67%
OTHER MINING	54	45	-18%

ANNEX 2: Detailed Energy Supply and Use Tables

2010/11 Supply (Common Unit) (TJ)			Unit	Agriculture	Mining	Manufacturing	Water Supply	Electricity	Construction and trade	Hotels and Restaurants	Transport& Communication	Finance, Real Estate and Business Services	Government	International Organizations	Households	Import	residents abroad	Stock	Environment	Total
Natural inputs	Mineral and energy Resources	Coal	TJ																23,553	23,553
	Renewables	Solar power	TJ																0	0
Energy products	Coal	Thermal Coal	TJ		18,964															18,964
		Washed Coal	TJ		4,588															4,588
	Electricity	Electricity	TJ					1345								9,880				11,225
		-own use	TJ					236												236
	Liquid Fuels	LPG	TJ																	0
		Aviation fuel	TJ																	0
		Paraffin	TJ																	0
		Petrol	TJ																	0
		Diesel	TJ																	0
Energy residuals	Transformation losses		TJ					5,333												5,333
	Distribution losses		TJ					136												136
	Other energy residuals		TJ	166	10,201	357	228	496	620	1,445	259	582	4593	12	3,143					22,101
Total				166	33,754	357	228	7,545	620	1,445	259	582	4593	12	3,143	9,880	0	0	23,553	86,136

2010/11 Use (Common Unit) (TJ)			Unit	Agriculture	Mining	Manufacturing	Water Supply	Electricity	Construction and trade	Hotels and Restaurants	Transport& Communication	Finance, Real Estate and Business Services	Government	International Organizations	Households	Export	non Residents	Stock	Environment	Total
Natural inputs	**Resources**	**Coal**	**TJ**	**0**	**23,553**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**			**23,553**
	Renewables	**Solar power**	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**			**0**
Energy products	**Coal**	**Thermal Coal**	**TJ**	**0**	**6,180**	**0**	**0**	**6,906**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5,878**		**18,964**
		Washed Coal	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**1,239**	**0**	**0**	**2,970**	**0**	**0**	**394**	**0**	**-14**		**4,588**
	Electricity	**Electricity**	**TJ**	**166**	**4,022**	**357**	**228**	**9**	**620**	**206**	**259**	**582**	**1,622**	**12**	**3,143**					**11,225**
		-own use	**TJ**	**0**	**0**	**0**	**0**	**236**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**236**
	Liquid Fuels	**LPG**	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Aviation fuel	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Paraffin	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Petrol	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Diesel	**TJ**	**0**	**0**	**0**		**394**	**0**		**0**		**0**							**394**
Energy residuals	**Transformation losses**		**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5,333**	**5,333**
	Distribution losses		**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**136**	**136**
	Other energy residuals		**TJ**	**0**	**0**	**0**	**0**										**0**	**0**	**22,101**	**22,101**
Total				**166**	**33,754**	**357**	**228**	**7,545**	**620**	**1,445**	**259**	**582**	**4,592**	**12**	**3,143**	**394**	**0**	**5,864**	**27,569**	**86,530**

2011/12 Supply (Common Unit) (TJ)			Unit	Agriculture	Mining	Manufacturing	Water Supply	Electricity	Construction and trade	Hotels and Restaurants	Transport& Communication	Finance, Real Estate and Business Services	Government	International Organizations	Households	Import	Botswana	Stock	Environment	Total
Natural inputs	Resources	Coal	TJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22,086	22,086
	Renewables	Solar power	TJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy products	Coal	Thermal Coal	TJ	0	17,518	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17,518
		Washed Coal	TJ	0	4,568	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,568
	Electricity	Electricity	TJ	0	0	0	0	838	0	0	0	0	0	0	0	10,674	0	0	0	11,512
		-own use	TJ	0	0	0	0	154	0	0	0	0	0	0	0	0	0	0	0	154
	Liquid Fuels	LPG	TJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Aviation fuel	TJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Paraffin	TJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Petrol	TJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Diesel	TJ	0	0	0		0	0	0	0		0	0		727				727
Energy residuals	Transformation losses		TJ	0	0	0	0	2,763	0	0	0	0	0	0	0	0	0	0	0	2,763
	Distribution losses		TJ	0	0	0	0	76	0	0	0	0	0	0	0	0	0	0	0	76
	Residual heat losses		TJ	188	9,716	372	359	643	727	1,161	216	673	3,521	8	3,164	0				20,748
Total				188	31,802	372	359	4,473	727	1,161	216	673	3,521	8	3,164	11,401	0	0	22,086	80,151

2011/12 Use (Common Unit) (TJ)			**Unit**	**Agriculture**	**Mining**	**Manufacturing**	**Water Supply**	**Electricity**	**Construction and trade**	**Hotels and Restaurants**	**Transport& Communication**	**Finance, Real Estate and Business Services**	**Government**	**International Organizations**	**Households**	**Export**	**non Residents**	**Stock**	**Environment**	**Total**
Natural inputs	**Resources**	**Coal**	**TJ**	**0**	**22,086**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**22,086**
	Renewables	**Solar power**	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Energy products	**Coal**	**Thermal Coal**	**TJ**	**0**	**5,807**	**0**	**0**	**3,579**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8,131**	**0**	**17,518**
		Washed Coal	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**930**	**0**	**0**	**1,869**	**0**	**0**	**369**	**0**	**1,399**	**0**	**4,568**
	Electricity	**Electricity**	**TJ**	**187**	**3,909**	**372**	**359**	**13**	**727**	**231**	**216**	**673**	**1,653**	**8**	**3,164**	**0**	**0**	**0**	**0**	**11,512**
		-own use	**TJ**	**0**	**0**	**0**	**0**	**154**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**154**
	Liquid Fuels	**LPG**	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Aviation fuel	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Paraffin	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Petrol	**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Diesel	**TJ**	**0**	**0**	**0**	**0**	**727**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**727**
Energy residuals	**Transformation losses**		**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2,763**	**2,763**
	Distribution losses		**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**76**	**76**
	Residual heat losses		**TJ**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**20,748**	**20,748**
Total				**188**	**31,802**	**372**	**359**	**4,473**	**727**	**1,161**	**216**	**673**	**3,521**	**8**	**3,164**	**369**	**0**	**9,531**	**23,586**	**80,151**

2012/13 Supply (Common Unit) (TJ)			Agriculture	Mining	Manufacturing	Water Supply	Electricity	Construction and trade	Hotels and Restaurants	Transport& Communication	Finance, Real Estate and Business Services	Government	International Organizations	Households	Import	Botswana	Stock	Environment	Total
Natural inputs	Resources	Coal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	39,432	39,432
	Renewables	Solar power		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy products	Coal	Thermal Coal		34,028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34,028
		Washed Coal		5,404	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,404
	Electricity	Electricity		0	0	0	3,097	0	0	0	0	0	0	0	8,820	0	0	0	11,917
		-own use		0	0	0	452	0	0	0	0	0	0	0	0	0	0	0	452
	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	1,179	0	0	0	1,179
Energy residuals	Transformation losses			0	0	0	7,500	0	0	0	0	0	0	0	0	0	0	0	7,500
	Distribution losses			0	0	0	420	0	0	0	0	0	0	0	1,197	0	0	0	1,618
	Residual heat losses		186	11,897	400	441	1,232	686	1,019	270	713	4,844	8	3,306	0	0	0	0	25,003
Total			186	51,329	400	441	12,701	686	1,019	270	713	4,844	8	3,306	11,196	0	0	39,432	126,532

2012/13 Use (Common Unit) (TJ)			Agriculture	Mining	Manufacturing	Water Supply	Electricity	Construction and trade	Hotels and Restaurants	Transport& Communication	Finance, Real Estate and Business Services	Government	International Organizations	Households	Export	non Residents	Stock	Environment	Total
Natural inputs	Resources	Coal	0	39,432	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39,432
	Renewables	Solar power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy products	Coal	Thermal Coal	0	7,838	0	0	11,067	0	0	0	0	0	0	0	0	0	15,123	0	34,028
		Washed Coal	0	0	0	0	0	0	778	0	0	3,242	0	0	348	0	1,037	0	5,404
	Electricity	Electricity	186	4,059	400	441	4	686	241	270	713	1,602	8	3,306	0	0	0	0	11,917
		-own use	0	0	0	0	452	0	0	0	0	0	0	0	0	0	0	0	452
	Liquid Fuels	LPG	0	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	0
		Paraffin	0	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	0
		Diesel	0	0	0	0	1,179	0	0	0	0	0	0	0	0	0	0		1,179
Energy residuals	Transformation losses		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,500	7,500
	Distribution losses		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,618	1,618
	Residual heat losses		0	0	0	0										0	0	25,003	25,003
Total			186	51,329	400	441	12,701	686	1,019	270	713	4,844	8	3,306	348	0	16,160	34,121	126,532

2013/14 Supply (Common Unit) (TJ)			Agriculture	Mining	Manufacturing	Water Supply	Electricity	Construction and trade	Hotels and Restaurants	Transport& Communication	Finance, Real Estate and Business Services	Government	International Organizations	Households	Import	Botswana	Stock	Environment	Total
Natural inputs	Resources	Coal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	35,206	35,206
	Renewables	Solar power		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy products	Coal	Thermal Coal		30,624	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30,624
		Washed Coal		4,582	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,582
	Electricity	Electricity		0	0	0	6,429	0	0	0	0	0	0	0	5,988	0	0	0	12,416
		-own use		0	0	0	956	0	0	0	0	0	0	0	0	0	0	0	956
	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	1,819	0	0	0	1,819
Energy residuals	Transformation losses			0	0	0	14,814	0	0	0	0	0	0	0	0	0	0	0	14,814
	Distribution losses			0	0	0	442	0	0	0	0	0	0	0	0	0	0	0	442
	Residual heat losses		200	10,252	432	461	2,178	716	834	261	831	4,919	8	3,338	0	0	0	0	24,431
Total			200	45,458	432	461	24,819	716	834	261	831	4,919	8	3,338	7,807	0	0	35,206	125,290

2013/14 Use (Common Unit) (TJ)			Agriculture	Mining	Manufacturing	Water Supply	Electricity	Construction and trade	Hotels and Restaurants	Transport& Communication	Finance, Real Estate and Business Services	Government	International Organizations	Households	Export	non Residents	Stock	Environment	Total
Natural inputs	Resources	Coal	0	35,206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35,206
	Renewables	Solar power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy produc ts	Coal	Thermal Coal	0	5,942	0	0	22,030	0	0	0	0	0	0	0	0	0	2,652	0	30,624
		Washed Coal	5	0	0	0	0	0	577	0	0	3,326	0	1	347	0	326	0	4,582
	Electricity	Electricity	195	4,309	432	461	15	716	257	261	831	1,593	8	3,337		0	0	0	12,416
		-own use	0	0	0	0	956	0	0	0	0	0	0	0	0	0	0	0	956
	Liquid Fuels	LPG	0	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	0
		Paraffin	0	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	0
		Diesel	0	0	0	0	1,819	0	0	0	0	0	0	0	0	0	0	0	1,819
Energy residua ls	Transformation losses		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14,814	14,814
	Distribution losses		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	442	442
	Residual heat losses		0	0	0	0										0	0	24,431	24,431
Total			200	45,458	432	461	24,819	716	834	261	831	4,919	8	3,338	347	0	2,978	39,687	125,290

2014/15 Supply (Common Unit) (TJ)			Agriculture	Mining	Manufacturing	Water Supply	Electricity	Construction and trade	Hotels and Restaurants	Transport& Communication	Finance, Real Estate and Business Services	Government	International Organizations	Households	Import	Botswana	Stock	Environment	Total
Natural inputs	Resources	Coal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	44,952	44,952
	Renewables	Solar power		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy products	Coal	Thermal Coal		37,461	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37,461
		Washed Coal		7,491	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,491
	Electricity	Electricity		0	0	0	8,203	0	0	0	0	0	0	0	4,375	0	0	0	12,578
		-own use		0	0	0	1,455	0	0	0	0	0	0	0	0	0	0	0	1,455
	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	1,819	0	0	0	1,819
Energy residuals	Transformation losses			0	0	0	22,239	0	0	0	0	0	0	0	0	0	0	0	22,239
	Distribution losses			0	0	0	872	0	0	0	0	0	0	0	0	0	0	0	872
	Residual heat losses		182	10,847	411	454	1,916	1,229	1,092	249	771	8,148	22	3,595	0	0	0	0	28,918
Total			182	55,799	411	454	34,686	1,229	1,092	249	771	8,148	22	3,595	6,194	0	0	44,952	157,786

2014/15 Use (Common Unit) (TJ)			Agriculture	Mining	Manufacturing	Water Supply	Electricity	Construction and trade	Hotels and Restaurants	Transport& Communication	Finance, Real Estate and Business Services	Government	International Organizations	Households	Export	non Residents	Stock	Environment	Total
Natural inputs	Resources	Coal	0	44,952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44,952
	Renewables	Solar power	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy products	Coal	Thermal Coal	0	6,433	0	0	32,532	0	0	0	0	0	0	0	0	0	-1,503	0	37,461
		Washed Coal	0	0	0	0	0	0	858	0	0	6,597	0		435	0	-400	0	7,491
	Electricity	Electricity	182	4,415	411	454	12	1,229	234	249	771	1,551	22	3,595	0	0		0	13,126
		-own use	0	0	0	0	1,455	0	0	0	0	0	0	0	0	0	0	0	1,455
	Liquid Fuels	LPG	0	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	0
		Paraffin	0	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	0
		Diesel	0	0	0	0	687	0	0	0	0	0		0	0	0		0	687
Energy residuals	Transformation losses		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22,239	22,239
	Distribution losses		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	872	872
	Residual heat losses		0	0	0	0										0	0	28,918	28,918
Total			182	55,799	411	454	34,685	1,229	1,092	249	771	8,148	22	3,595	435	0	-1,903	52,029	157,201

ANNEX 3: Exchange Rate of Botswana Pula Against Major Currencies (2010-2014)

Year	US$	Br. Pound	Euro	SA Rand
2010	0.1553	0.1004	0.1162	1.0265
2011	0.1384	0.0885	0.1015	1.0840
2012	0.1310	0.0805	0.1012	1.0783
2013	0.1172	0.0728	0.0869	1.1697
2014	0.1080	0.0666	0.0852	1.2171

Note: Rates as per September/quarter 3 of each year.
Source: Bank of Botswana