



ASSESSMENT OF THE SCOPE AND APPLICABILITY OF BENEFICIATION AND VALUE ADDITION OF MINERALS IN ZIMBABWE¹

Study Report

Submitted to the African Development Bank

By

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EXECUTIVE SUMMARY

Zimbabwe is a mineral rich country with great potential for further discoveries. The country has a huge and highly diversified mineral resource base dominated by two prominent geological features namely the Great Dyke and ancient Greenstone Belts also known as Gold Belts. The Great Dyke is a mineral rich geological feature in the central part of Zimbabwe which stretches for about 550km in the SSW to NNE direction. It hosts, among other mineral resources, the second largest known resources of Platinum Group Minerals and chromite ore after South Africa in the world. These ore resources present Zimbabwe with a competitive advantage and a unique opportunity for developing world class mines and processing facilities which could form the backbone of a vibrant metallurgical and manufacturing industry and their beneficiation and value addition would provide a springboard for socio-economic development of the country.

A study aimed at assessing the scope and applicability of beneficiation and value addition of minerals in Zimbabwe was undertaken by the Zimbabwe Economic Policy Analysis and Research Unit (ZEPARU) during the period August to October 2017. The objective of the study was to provide Government with recommendations for a sustainable policy on beneficiation and value addition of minerals in Zimbabwe.

The mining sector contributes approximately 10% of the Gross Domestic Product in Zimbabwe and just over 50% of the export earnings, driven mainly by the production of Gold, Platinum Group Metals (PGMs), chrome, nickel, diamonds, copper, lithium, coal, graphite, granite stone, phosphates and limestone.

The study involved drawing up a questionnaire (Appendix I) which was distributed to the senior management of individual mines and manufacturing companies followed by on-site meetings and interviews for further clarification. Stakeholders in the value chain such as the Chamber of Mines (COM), Minerals Marketing Corporation of Zimbabwe (MMCZ), and the Confederation of Zimbabwe Industries (CZI) were also consulted to get their views. Questionnaires were completed by the majority of the different mines and companies approached, and submitted for analysis.

In this context, beneficiation of minerals is the processing of mined ore to separate valuable mineral products from the associated waste rock or impurities. The extent to which this is done determines whether the product is intermediate in its purity and should be processed further or is refined, ready for further value addition through manufacturing.

The study reveals that since the launch of the ZIMASSET economic blueprint by the Government in 2013 with one of its four main pillars being beneficiation and value addition,

some companies particularly those involved with Platinum Group and Base Minerals had made significant strides in upgrading their beneficiation facilities. Bindura Nickel Corporation had made progress in refurbishing its smelter which was at 83% completion level by October 2017. Commissioning was scheduled for mid-2018, and would enable the conversion of their current concentrate to converter matte, resulting in the upgrading of the product grade by a factor of ten (10). Unki Platinum mine wholly owned by Anglo American, had achieved 60% completion level in the installation of their smelter with commissioning scheduled by mid-2018. This would enable the conversion of concentrate to furnace matte, resulting in the upgrading of the PGM content by a factor of five (5). Zimplats, whose main shareholder is Impala Platinum of South Africa had embarked on and almost completed the refurbishment of its Base Metal Refinery, which had been mothballed since 2000 when the mine was acquired from BHP Minerals. This would enable the separation and refining of nickel and copper as marketable metals from the Platinum group metals which would continue to be shipped to South Africa, but only for Precious Metal Refining. Mimoso Platinum mine, which is jointly owned by Impala Platinum and Sibanye Gold of South Africa, had completed a feasibility study for the installation of a smelter. The commissioning of these beneficiation facilities would result in increased foreign currency revenue, employment and other socio-economic benefits.

Some Chinese investors such as Afrochine, had set up ferrochrome smelters along the Great Dyke, having been attracted by Zimbabwe's chromite resources and the ban on exports of chrome ore, which assured them of raw feedstock. However, when the Government lifted the ban on export of chrome ore in response to an outcry particularly by small scale miners who had built up large stocks of chrome ore which could be used to generate foreign currency, the newly established smelters were faced with feedstock shortages forcing them to integrate backwards and seek for mining claims to explore and mine, an area in which they had little expertise. A model has been proposed in the paper to address this situation in a sustainable manner.

Cross-cutting issues which had an impact on beneficiation and value addition included the need to clarify the indigenisation law vis-a-vis local content policies on procurement. The need to improve foreign currency availability by allowing exporters to retain more than 20% of their export revenues, the need to reduce the cost of doing business by sourcing low interest funds from international institutions, providing incentives for investors involved in beneficiation and value addition and also for companies and institutions involved in skills development, research and technological development. Stakeholders noted the need to expedite the refurbishment and upgrading of the railway network in order to reduce logistics costs.

ACRONYMS

AMV	Africa Mining Vision
BNC	Bindura Nickel Corporation
c/kWh	cents per kilowatt hour
COMZ	Chamber of Mines of Zimbabwe
CZI	Confederation of Zimbabwe Industries
DRC	Democratic Republic of Congo
DTC	Diamond Technology Centre
DTCB	Diamond Trading Company Botswana
FDI	investment
FPR	Fidelity Printers and Refiners
GDP	Gross Domestic Product
LBMA	London Bullion Market Association
MMCZ	Minerals Marketing Corporation of Zimbabwe
MW	Megawatt
NNE	North of North East
PGMs	Platinum Group Metals
PGMs	Platinum Group Metals
R&D	Research and Development
SADC	Southern African Development Community
SEZs	Special Economic Zones
SSW	South of South West
UNECA	United Nations Economic Commission for Africa
USD	United States Dollar
USGS	United States Government Geological Survey
ZIMASSET	Zimbabwe Agenda for Sustainable Socioeconomic Transformation
ZIMSTAT	Zimbabwe National Statistics Agency
ZMDC	Zimbabwe Mining Development Corporation

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1. INTRODUCTION

The research was undertaken under the African Development Bank assisted Governance and Institutional Support Project (GISP) as one of the activities that fell under the sub-component of the GISP: “Undertake Mining Sector Analytical and Advisory Activities to Strengthen Mining Sector Policies and Governance Arrangements” implemented by ZEPARU. The need for this research on ‘Assessment of the Scope and Applicability of Beneficiation and Value Addition of Minerals in Zimbabwe’ arose from the policy thrust undertaken by Government on beneficiation and value addition.

The Africa Mining Vision (AMV) which was adopted by African Heads of State in 2009 as a key continental framework to promote mineral resource based development and structural transformation on the continent, seeks to foster a “transparent, equitable and optimal exploitation of mineral resources to underpin broad-based sustainable growth and socio-economic development.” Aspiration one of the Agenda 2063 highlights the importance of the beneficiation of Africa’s natural resources just like the Africa Mining Vision which advocates for resource-based industrialization. The Southern African Development Community (SADC) Industrialization Strategy and Roadmap, (2015-2063) strategy number five prioritises minerals beneficiation and value addition.

Beneficiation and value addition has been identified as a key pillar of the Zimbabwe Agenda for Sustainable Socioeconomic Transformation (ZIMASSET). The Presidential 10-point plan² also emphasized the need to advance beneficiation and/or value addition of agricultural and mining resource endowments. Furthermore, the recently gazetted Special Economic Zones Act, 2016, focuses on promoting investment in the area of beneficiation and value addition. In this regard, Government’s policy position on mineral beneficiation and value addition is aligned with the regional and continental initiatives on mineral beneficiation and value addition as outlined in the Africa Mining Vision. Promoting local beneficiation and value addition of minerals provide manufacturing feedstock, requisite for driving industrial development and creation of jobs

The Government of Zimbabwe prioritizes beneficiation of diamonds, chrome, platinum group metals (PGMs), nickel and coal bed methane.³ However, very little policy analysis and research on the status of beneficiation and value addition in the country has been carried out to inform the design of the beneficiation and value addition strategy and its implementation. It is within this context that this study sought to assess the scope and applicability of beneficiation and value addition of minerals in Zimbabwe. The study documented the status of beneficiation and value addition on a targeted set of minerals; identified challenges currently being faced in implementing the beneficiation and value addition policy and the opportunities for beneficiation

² Unveiled in the State of the Nation address on 25 August 2015,

³ <http://www.mines.gov.zw/?q=value-addition-and-beneficiation>, accessed 10 march 2017

and value addition that need to be exploited. The findings of this study are expected to inform dialogue between the Ministry and Minerals Sector stakeholders on the need for a holistic minerals value addition beneficiation strategy that will enhance consistent and co-ordinated implementation of the beneficiation and value addition policy. Evidence informed implementation of beneficiation and value addition strategy is a critical driver for economic recovery, growth and transformation. Path consistency in the implementation of the beneficiation and value addition strategy is also avoids costly policy uncertainty caused by ad hoc policy reversals.

1.1. Objectives of the Study

The overall objective of the study is to undertake an evaluation of beneficiation possibilities across the major minerals in Zimbabwe, focusing on the beneficiation stages, enabling conditions, key stakeholders and feasibility for each targeted mineral to inform a mineral specific beneficiation strategy for Zimbabwe. The specific objectives of this research study include:

- To understand the current stages in beneficiation of key minerals in Zimbabwe;
- To identify readiness of all key stakeholders for beneficiation of minerals in Zimbabwe;
- To evaluate the possibility of replicating some beneficiation strategies adopted in other countries;
- To identify possible incentives and other measures that could be put in place to foster beneficiation and value addition in Zimbabwe; and
- To suggest some policy recommendations for a holistic beneficiation and value addition strategy for Zimbabwe.

1.2. Methodology

This study employed mostly qualitative research techniques based on extensive literature/document reviews, case studies; assessment of the various developments and industry progress with regards to beneficiation and value addition. This also included a review of research, consultancy reports and industry position papers that have been produced on the subject in recent years. The study also used quantitative analysis of available secondary data, especially published official data from the Zimbabwe National Statistics Agency (ZIMSTAT) as well as from the Chamber of Mines of Zimbabwe. The study documented and analysed policy pronouncements governing beneficiation and value addition as well as the impact that the policy pronouncements have had on the industry. While the study did not get into the deep technical details on beneficiation and mining, it incorporated such technical issues in as far as they have an impact in the design and implementation of the beneficiation and value addition strategy. Furthermore, a regional comparison of and benchmarking with the best practice in mineral

presented in Section 6. Section 7, 8 and 9 describe in turn the potential value chains in the mineral sector, benchmarking with selected regional mineral industries and beneficiation facilities that are available in Zimbabwe to determine the scope and readiness of various stakeholders. Constraints hindering the mineral beneficiation and value addition, incentives and other measures to promote beneficiation and value addition of minerals are tackled in Sections 10 and 11. Thereafter, the study examines the applicability of beneficiation and value addition to Zimbabwe and availability of markets in Sections 12 and 13 respectively. Policy recommendations and Conclusions are then presented in Sections 14 and 15.

2. BACKGROUND

2.1 Zimbabwe's Mineral resources and Contribution to the Economy

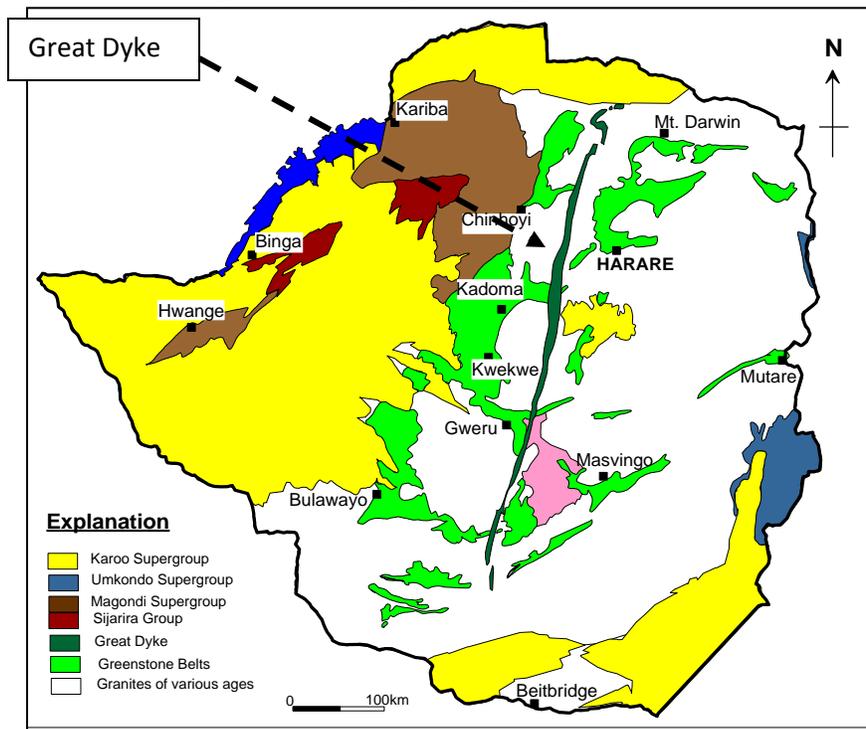
Zimbabwe has over 40 different exportable minerals which are not fully exploited and provide potential feedstock for beneficiation and value addition. Gold, platinum, chrome, nickel, copper, diamonds, iron and coal are the main mineral products extracted in the country. Not only is Zimbabwe endowed with a diverse mineral, it also holds vast quantities of many minerals such as:

- The world's second largest PGMs and **chromite** deposits, after South Africa.
- A high **gold** yield per square kilometre.
- Huge deposits of **iron ore**.
- Significant deposits of **Nickel & Copper ore**.

Zimbabwe also has huge potential in other industrial minerals such as granite, phosphates and limestone, and tantalite, tin, tungsten, lithium, asbestos as well as high-quality emeralds and energy minerals including uranium and coal (both metallurgical and thermal) and coal-bed methane gas. The Zimbabwe Geological Survey (1990) identifies more than 500 individual deposits of base metal and industrial minerals in Zimbabwe. There are over 800 operating mines ranging from artisanal and small-scale mines to world class large scale mines.

The Geological Map of Zimbabwe, showing coal basins in brown, mainly in the Hwange, Binga and Gokwe areas in the north west as well as the Tuli and Buby area in the south of the country. The green areas mark the greenstone zones where gold occurs. These include the Guruve, Mazowe, Shamva and Kadoma areas in Mashonaland, Kwekwe, Shurugwi and Zvishavane areas in the Midlands, the Gwanda and Esigodini areas in Matebeleland South, and the Mutare area in Manicaland. The Karoo supergroup of rocks shown in yellow generally host coal bed methane gas.

Figure 1: Geological Map of Zimbabwe



The most remarkable feature in the geology of Zimbabwe is the Great Dyke. The Great Dyke is a mineral rich geological feature in the central part of Zimbabwe which stretches for about 550km in the South of South West (SSW) to North of North East (NNE) direction. Most mineral production is from the ancient Archaean core of the country where most deposits are concentrated in the greenstone belts that contain gold, copper, tungsten, antimony and arsenic. Nickel with its by-products of copper and cobalt is also mined in the greenstone belts, while asbestos deposits are found in the serpentinized ultramafic intrusions.

These ore resources present Zimbabwe with a comparative advantage and a unique opportunity for developing world class mines and processing facilities which could form the backbone of a vibrant metallurgical and manufacturing industry. Given the growing demand for Platinum as a catalyst in reducing air pollution and in jewellery, increased production of PGMs, their beneficiation and value addition would provide a springboard for socio-economic development of the country.

Transparent, equitable and optimal exploitation of mineral resources to underpin accompanied by implementation of a robust beneficiation and value addition strategy is expected to support broad-based sustainable growth and socio-economic development. The extractive industry contributes an estimated 9% of Gross Domestic Product (GDP) and 5.2% of the total non-agriculture employment. Its importance is further highlighted in the composition of the country's

export basket with mineral exports constituting about 54% of the total export basket in 2016 (Table 1). Employment figure however, declined by about 7.5% to 36,800 jobs in 2015 from 39,800 jobs in 2013. Thus, despite a decline over the past years due to the falling international commodity prices, which have also affected mining sector profitability, minerals still account for the bulk of Zimbabwe’s total export basket. However, most of the minerals are exported in semi-processed form.

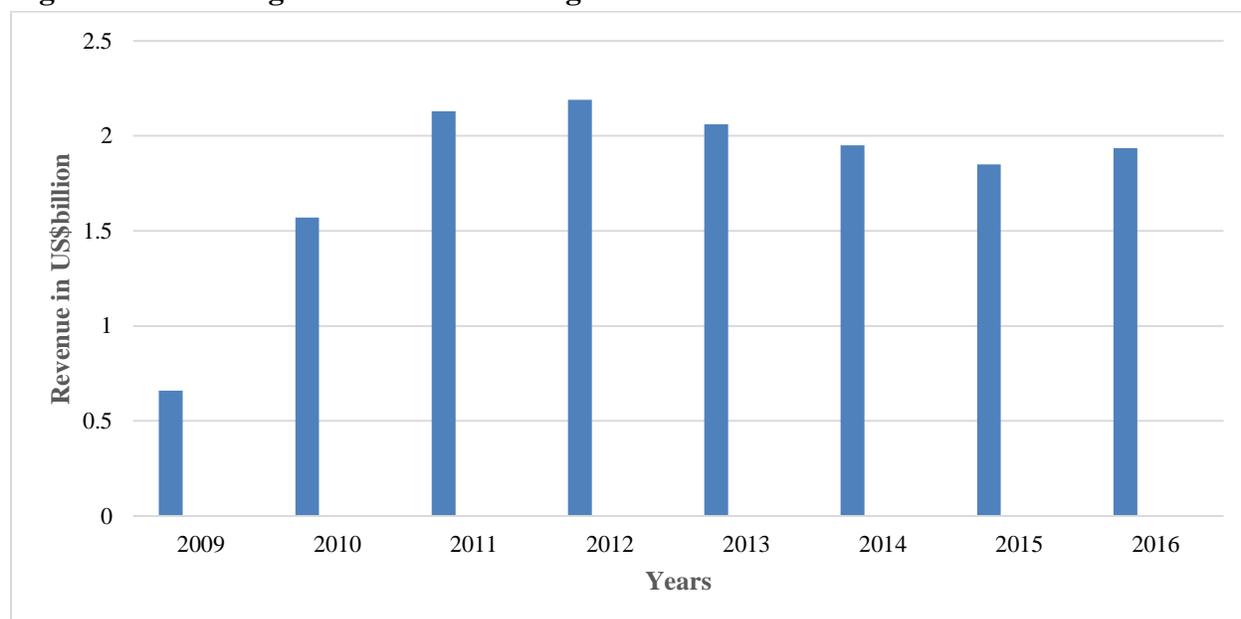
Table 1: Economic Contribution of the mining sector in Zimbabwe

	2013	2014	2015	2016
% of GDP	8.8	8.1	7.8	8.6
% of Exports	54.0	51.5	47.8	54.3
Formal Employment	39 800	39 200	36800	-

Source: ZIMSTAT

The total revenue generated from the mining industry has been just under US\$2 billion in the last three years to 2016, but is expected to exceed that level from 2017 onwards.

Figure 2: Revenue generated from mining in Zimbabwe



The main exports recorded in the country during the 2016 financial year are summarised in Table 2, revealing the unprocessed nature of the bulk of the mineral exports.

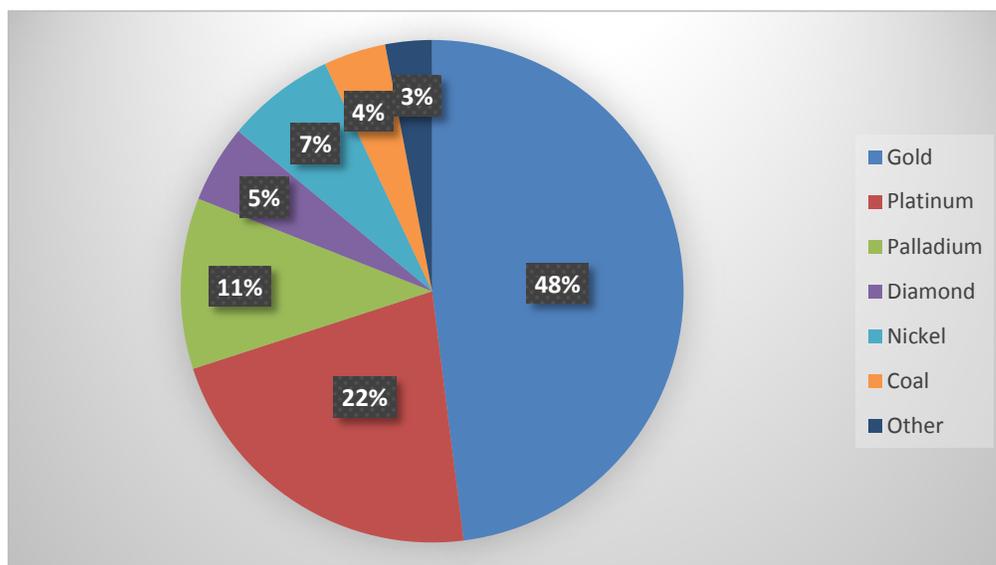
Table 2: Zimbabwe’s major export products, 2016

	Value (USD)	% of Merchandise exports
Flue-cured tobacco of the virginia type, partly or wholly stemmed/stripped	872,946,631	30.8%
Semi-manufactured gold (incl. gold plated with platinum), non-monetary	849,125,697	30.0%
Nickel ores and concentrates	293,548,934	10.4%
Ferro-chromium, containing by weight >4% carbon	118,168,661	4.2%
Diamonds unworked or simply sawn, cleaved or bruted	118,261,551	4.2%
Platinum unwrought or in powder form	50,842,115	1.8%
Nickel mattes	34,975,521	1.2%
Granite, merely cut into a square or rectangular shape	34,581,128	1.2%
Chromium ores and concentrates	20,908,800	0.7%
Other mineral substances, n.e.s	12,004,598	0.4%
Other exports	426,909,703	15.1%
Total exports	2,832,273,340	100%

Source: ZIMSTAT

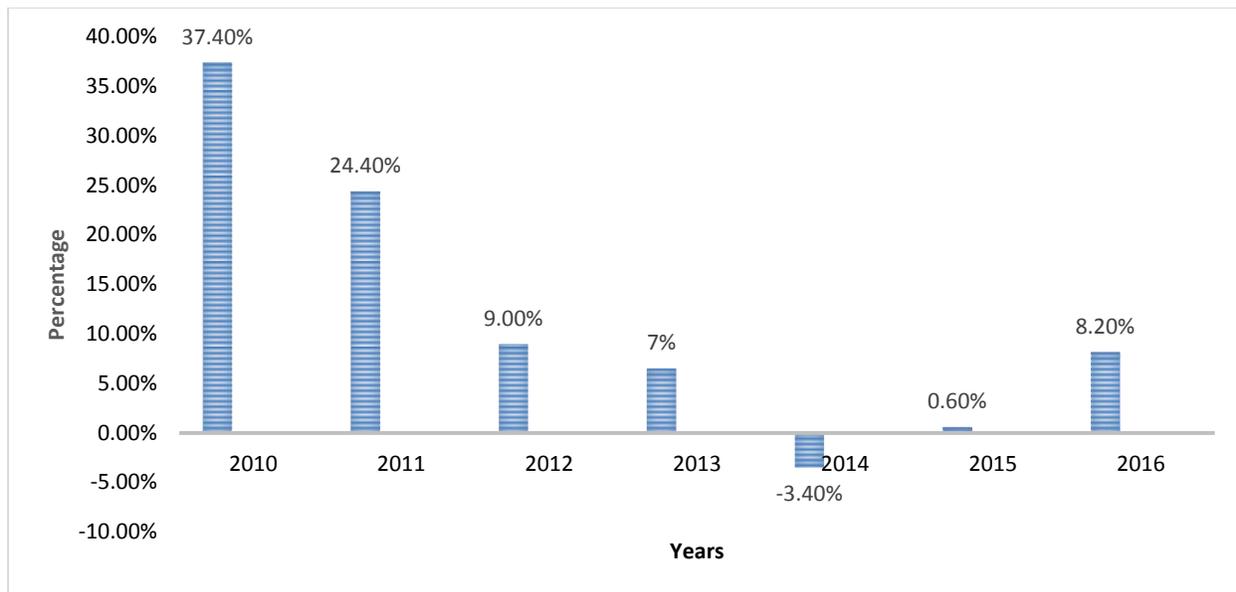
The contributions of various minerals to the export basket of the minerals in Zimbabwe are shown in Figure 3

Figure 3: Contribution of various mineral commodities to total mining exports, 2016



The annual growth rates of the mining sector in Zimbabwe are shown in Figure 4.

Figure 4: Annual growth rate Mining sector



Despite being negatively affected by a slump in mineral commodity prices particularly during the period 2012 to 2014, the mining sector has emerged as one of the key sectors identified as pivotal to driving economic development of the country.

Despite the country being richly endowed with different economically exploitable mineral resources, Zimbabwe has not fully exploited these mineral resources for growth and development, a case which is sometimes argued as resource curse. Other arguments which call for beneficiation of minerals are as follows:

- Zimbabwe is still characterised by a high dependency on exports of unprocessed or semi-processed mineral products, which results in the country being a price taker. The decline in commodity prices negatively affects revenue which ultimately impacts on government planning. However, it is common knowledge that the prices of value added metal products such as jewellery, electronic products, etc. seldom fall in response to the drop in the prices of gold, platinum or related metals from which the products are made.
- Trade theory argues that with time the price of primary commodities will decrease in relation to that of manufactured goods, resulting in countries specialising in primary commodity exports experiencing a detrimental economic effect. The fact that 60% of world trade is in intermediate products strengthens the case for value-addition and beneficiation in Zimbabwe, hence the need to move away from export of raw and semi-processed minerals.⁴

⁴ Southern African Development Community (SADC) Industrialization Strategy and Roadmap, 2015 – 2063

- The 2011 United Nations Economic Commission for Africa (UNECA) report on Africa’s mining regimes argues that the value of minerals/elements (un-beneficiated) can reach a factor of at least 400 if value added or beneficiated from the extraction to the final product. For instance, the unit value for copper in a motor vehicle can be 117 times value of copper in cathode form and 4 times higher in platinum if beneficiated and value added into auto catalyst.
- Most developed countries have managed to acquire significant benefits through local beneficiation and value addition of minerals, even when they do not possess natural resources. Countries like Belgium, Israel, Japan and the United States of America (USA) have developed sophisticated industries that conduct manufacturing value addition for minerals they import from foreign countries.

Hence mineral beneficiation and value addition will increase minerals’ contribution to growth and development, and ultimately lead to poverty reduction which is rampant in Zimbabwe.

2.2 Progress on Beneficiation and Value addition

Currently there are some companies that are already involved in some form of beneficiation of minerals, although not at full scale for different minerals which include chrome, PGMs, nickel and diamonds. The government has set some targets through ZIMASSET as outlined in Table 3.

Table 3: ZIMASSET Beneficiation and value addition Cluster

Objective	Target	Strategies
Increased supply of value added steel products	700,000 tonnes of liquid steel per annum produced	<ul style="list-style-type: none"> • Operationalise New Zim-Steel⁵. • Target financial support to SMEs in metal fabrication.
<ul style="list-style-type: none"> • Increased revenue from the diamonds industry 	1.2 million carats polished gem diamonds produced	<ul style="list-style-type: none"> • Establish Diamond cutting and polishing centres. • Diamond college established. • Diamond specialists produced.
Improved supply of highly trained mineral professionals for <ul style="list-style-type: none"> • Universities, • Research and development (R&D) institutions, • mining industry, and • Government of Zimbabwe 		<ul style="list-style-type: none"> • World-class training institution for R&D in mineral beneficiation and value addition established. • Establish Pan African Minerals University of Science and Technology (PAMUST).

Source: ZIMASSET

The government has also undertaken some initiatives to enhance beneficiation and value addition of minerals which include the following:

⁵ A report by the Herald of 29 August 2017 revealed that Government has secured US\$1 billion investment for the revival of steel giant from a Chinese investor, R and F Company. About one million tonnes of steel being produced in the next 18 months. This happened following the reversal of an Indian firm, Essar, which pulled out of the Ziscosteel deal after commitment in 2011.

- Platinum producers submitted their plans for the establishment of a refinery to the government. The government of Zimbabwe has attempted to impose a 15% export tax on un-beneficiated PGMs to push the platinum miners to engage in further beneficiation of their minerals. Currently Mimosa and Unki export PGMs in concentrate form whereas Zimplats export matte, a further step in the PGM processing. The introduction of 15% export tax on un-beneficiated platinum was suspended in several policy documents and was pushed to January 2018.
- Government imposed a ban on the exportation of chrome ore but later lifted the ban and levied 20% export tax in 2009.⁶ The ban was reintroduced in April 2011 to encourage local beneficiation and value addition of chrome ore and was removed again since it did not result in additional smelting operations of chrome ore due to lack of efficient and modern technology for processing chrome ore to ferrochrome, falling international prices of ferrochrome to sub-economic levels; and high electricity tariffs.
- Diamond beneficiation policy is now in place to ensure that at least 10% of all diamonds produced in Zimbabwe will be cut and polished locally as part of promoting beneficiation. The country is already constructing a diamond centre in Mount Hampden which will, among other functions, focus on cutting and polishing of diamonds as well as acting as a training centre for downstream diamond industries workers. Aurex, a subsidiary of the Reserve Bank of Zimbabwe has been recapitalized with a US\$2 million loan from CBZ Bank (Newsday, 11 January 2017). The company is expected to have signed a strategic partnership arrangement with a technical partner in form of a joint ventures. The Herald of 25 April 2017 reported that the company invested into a million-dollar diamond cutting and polishing machine with a capacity to cut and polish 10 000 carats per month.
- Government made some efforts to revive Zimbabwe Iron Steel Company (ZISCO) Steel through the ZISCO – Essar Africa Holdings deal that was signed between the Government of Zimbabwe represented by the Ministry of Industry and Commerce and Essar Africa Holdings in 2011. However, this did not materialize but at the moment there are reports that ZISCO Steel is undergoing some recapitalization process.

This frequent policy reversal by government calls for the need for research on beneficiation and value addition in order to achieve a win-win situation between government and beneficiating companies.

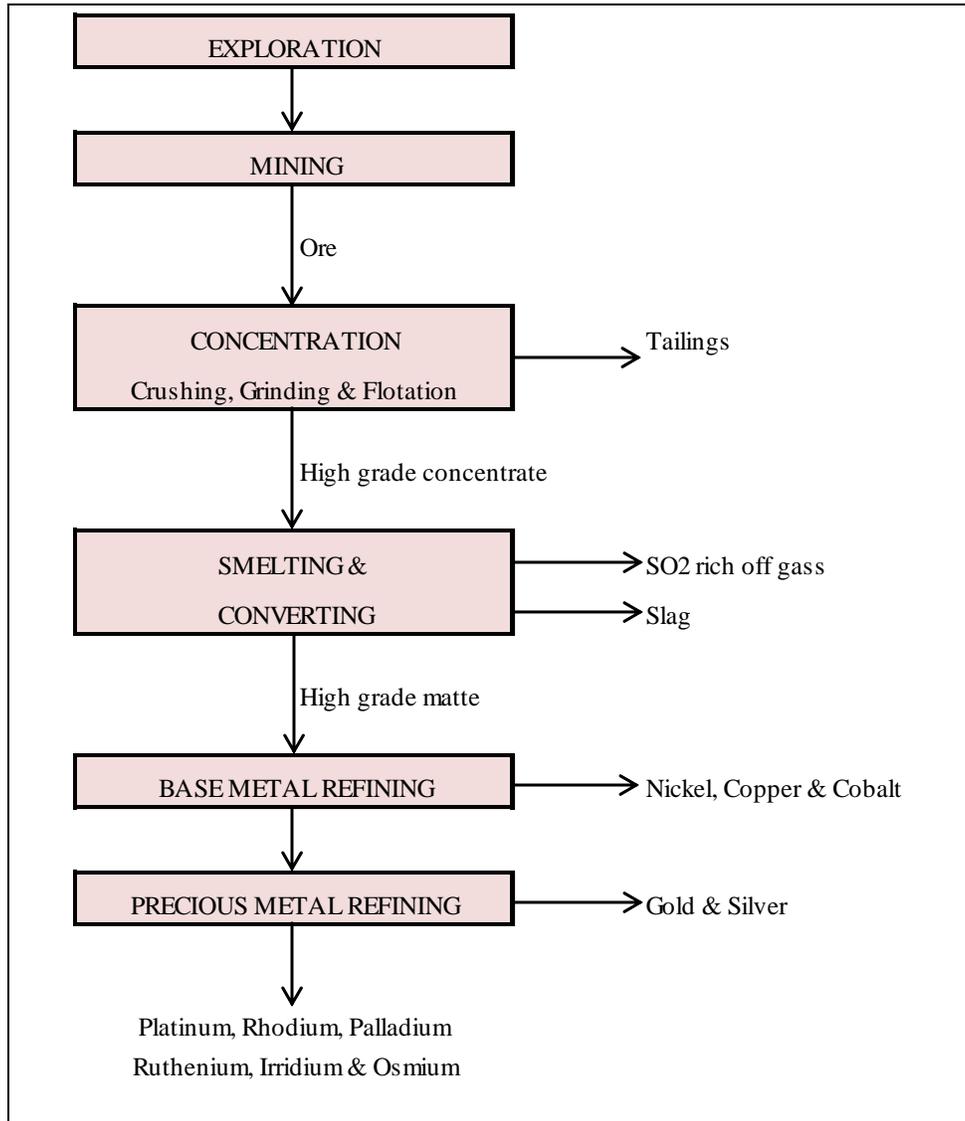
However, a number of factors are militating against beneficiation and value addition of minerals in developing countries. Chief among the identified constraints have been infrastructure. The deficits in the critical support infrastructure such as rail, water, communication facilities, ports and electricity supply have a material impact on sustaining current beneficiation initiatives and a

⁶ <http://www.mines.gov.zw/?q=press-statement-lifting-ban-export-chrome-ore>

major threat to future prospects of growth in mineral value addition. It has been noted that the bulk of early-stage beneficiation programs require large and uninterrupted supply of energy. Other factors include availability of appropriate skills level, R&D, technology and access to international markets for beneficiated products. Zimbabwe, being a landlocked country and a long distance away from the ports, suffers high logistics costs for the imports of raw materials and capital costs, as well as for exports. On the other hand, the lack of accurate geological information arising from inadequate exploration activities often results in disruptions to mining and ore supply, beneficiation and value addition chains. Such situations have been known to contribute to premature mothballing of sound beneficiation and value addition facilities eg. the ZMDC's Alaska Concentrator, Smelter and Refinery.

In Zimbabwe, it may be argued that the level of beneficiation and value addition was in many cases more extensive during the 1990's than it is currently for a number of mineral commodities particularly base metals especially nickel and copper, PGMs, and iron and steel. For the specific case of PGM's, for instance, an examination of the process steps involved in the beneficiation of PGM's in Figure 5 would be important to determine to what extent the country currently beneficiates its mineral resources, and what remedies it could take to realize the full value chain. It is noted, however, that some producers particularly Amplats employ slight variations in the process flowsheet, such as milling of Smelter matte and magnetic separation of PGMs from Base metals prior to base metal and precious metals.

Figure 5: Schematic Flow diagram for the beneficiation of PGM's



Source: Dzinomwa and Katiyo, 2014

A similar but mineral specific and applicable analysis needs to be carried out across the spectrum of all the major minerals in Zimbabwe, in order to identify those areas where the country has performed relatively well and those where more effort and resources need to be channeled to produce a positive impact on the economy on a sustainable basis.

3. LEGISLATIVE FRAMEWORK GOVERNING MINING AND BENEFICIATION IN ZIMBABWE

The Ministry of Mines and Mining Development oversees the mining sector in accordance with the Mines and Minerals Act (Chapter 21:05) and the Mining (General) Regulations, 1977.

There other sections that regulate mining are;

- ▶ Environmental Management Act of 2002 (Chapter 20:27) and its 2007 amendment,
- ▶ The Zimbabwe Mining Development Corporation Act
- ▶ Copper Control Act Chapter 14:06
- ▶ Base Minerals Export Controls Act: Chapter 21:01
- ▶ Precious Stones Trade Act Chapter 21:06
- ▶ Atmospheric Pollution Act Chapter 20:03
- ▶ Hazardous Substances and Articles Act Chapter 15:05
- ▶ Pneumoconiosis Act Chapter 15:08
- ▶ Forestry Act Chapter 19:05
- ▶ Zimbabwe National Water Authority Act Chapter 20:25
- ▶ Indigenisation and Empowerment Act
- ▶ Chamber of Mines Incorporation (Private) Act Chapter 21:02

Relevant Statutory Instruments include;

- ▶ Mining (Management and Safety) Regulations SI 109 of 1990
- ▶ Mining (Health and Sanitation) Regulations SI 182 of 1995
- ▶ Mines and Minerals (Custom Milling Plants) Regulations SI 239 of 2002

Of the minerals and mineral-based commodities produced in Zimbabwe, gold, platinum-group metals (PGMs), nickel, lithium, chrome and iron and steel are the most economically significant. The marketing of minerals is mostly through the Minerals Marketing Corp. of Zimbabwe (MMCZ). This is done in accordance with the Minerals Marketing Corp. of Zimbabwe Act of 1982 and the Precious Stones Trade Act of 1978. Notable exceptions are Gold and Silver which are marketed through Fidelity Printers and Refiners. Gold is sold to Fidelity Printers & Refiners (Private) Ltd., which is a subsidiary of the Reserve Bank of Zimbabwe (RBZ).

Beneficiation of minerals is being adopted by a growing number of resource- rich developing countries as a policy tool for industrialisation. Zimbabwe's mining sector regulatory framework generally supports beneficiation and value addition of minerals. While there is a plethora of laws that have implications on the mining sector, the Mines and Minerals Act (Chapter 21:05) enacted in 1961 is the principal legislation that governs mining legislation in Zimbabwe. The Act has

little provisions for beneficiation and value addition as it does not make it mandatory for minerals to be beneficiated before they are exported. Eunomix (2015) argues that the Act defines “approved beneficiation plant” and lays out how the owner of such a plant can have it approved and spell out the degree of beneficiation it seeks to achieve, in order to apply for a rate of rebate of royalty. The fact that the Government of Zimbabwe is in the process of amending the Mines and Minerals Act and finalising the Minerals Policy is a positive development. The fact that beneficiation and value addition has been crafted in ZIMASSET shows the commitment that the government has on beneficiation and value addition of minerals. Beneficiation and value addition is a key pillar of ZIMASSET and the ongoing process of amending the Mines and Minerals Act are expected to provide the legal framework that reinforces this policy priority.

The Special Economic Zones (SEZs) Act (Chapter 14:34) argues that potential investors’ application for investment approvals in SEZs, the SEZs Authority will consider the extent of beneficiation and value addition of local raw materials. The Act was gazetted and came into force on 1st November 2016.

The ZEPARU Mining Sector Policy Study of 2012 argues that through *‘Forward linkages, minerals could provide critical feedstocks for other job-creating sectors provided that they are beneficiated into appropriate intermediate products such as iron/steel, polymers and base metals for manufacturing; nitrogenous and phosphatic fertilisers for agriculture; cement, steel and copper for infrastructure and fossil fuels for power.’* Further, it also advocates for state facilitation in mineral beneficiation through incentives and disincentives, such as imposition of judicious export taxes if the next value addition step is commercially viable. It further points out that the potential for forward linkages needs interrogation especially in the ferrous, base and precious metal sectors, amongst others. If the feasibility study independently done indicates that the beneficiation project is viable (gives a reasonable return on investment), then the Government reserves the right to impose an equitable export tax on exports of the crude form.

The ZEPARU Mining Sector Policy Study (2012) also calls for a new Minerals Development Act that includes milestones for viable backward and forward linkages. It also recognises that further skills and technology development is critical to developing upstream and downstream economic linkages. In addition, it also proposes the use of producer power, together with other countries, to be explored to facilitate local value addition, where viable. This is in line with the African Union’s Africa Mining Vision of 2009 which also encourages resource rich countries to undertake beneficiation and value addition given that the mineral resources are finite. In an effort to boost sector specific approach to industrialisation, the SADC Industrialisation Policy Framework adopted in 2015 prioritized nine sectors, of which processing of mineral (metallic and non-metallic) products is selected to be critical given the region’s comparative advantage in minerals. The thrust to focus on competitive advantage through promoting the development of regional value chains and their linkages with global supply chains and coming up with strategic

instruments to promote mineral beneficiation was targeted for 2014 (SADC Industrial Development Policy Framework, 2013).

Under the SADC Mineral Beneficiation Cluster, Zimbabwe is earmarked for the mineral beneficiation of platinum, iron and steel and diamonds to strengthen the value chain (Table 4). This was outlined under the Action Plan for SADC Industrialisation and Roadmap.

Table 4: SADC Minerals and Beneficiation Cluster

Mineral cluster	Countries
Diamonds	Botswana, Namibia, South Africa, Zimbabwe
Copper	Democratic Republic of Congo (DRC), Zambia
Platinum	South Africa, Zimbabwe
Iron/Steel	Mozambique, South Africa, Zimbabwe
Soda Ash	Botswana
Oil and Gas	Angola, Madagascar, Mozambique, South Africa, Tanzania

Source: Southern African Research and Documentation Centre, 2016

In trying to domesticate the Africa Mining Vision’s thrust of beneficiation and value addition, Zimbabwe adopted a beneficiation and value addition cluster under its economic blue print, the Zimbabwe Agenda for Sustainable Socio-Economic Transformation (ZIMASSET). Its main objectives on beneficiation include:

- Improving capacity utilisation;
- Achieving a net trade gain;
- Creating employment; and
- Increasing fiscal revenues.

However, stakeholder consultations revealed that employment creation should not be the focus of beneficiation since only few jobs can be created due to high mechanisation of the process which required mostly skills labour.

Some measures have been put in place to ensure that the beneficiation of minerals such as gold, platinum and chrome is expedited, among others (Parliament of Zimbabwe, 2015). The government of Zimbabwe has taken some steps to minimise the export of unprocessed minerals, including an export ban on unrefined gold and raw chrome with the latter being suspended in June 2015. A ban on chrome ore export was intended to force mining companies to set up chrome smelters, as part of its broader beneficiation policy. Ferrochrome exports were, however, allowed as this was considered a significant value addition step. The removal of the ban was mainly pushed by calls by the small-scale miners who used to earn a living from chrome mining but had abandoned the trade due to lack of demand for the raw chrome among the smelting firms. In fact, smelting companies are only required to export raw chrome after satisfying their production capacity in the smelters.

The Government also intends to levy a 15% export tax for unprocessed platinum effective January 2018. The export tax on unbeneficiated platinum has been constantly deferred and platinum producers are in the process of setting up their smelters to comply with the Government's requirement of beneficiation. The requirement for gold is that it should be beneficiated up to about 95.6% purity before being exported out of the country. The aim is to encourage down-stream linkages into mineral beneficiation and manufacturing among other objectives.

The Zimbabwe Diamond Policy, 2012 is another attempt at beneficiation. Government set a quota system to promote local mineral beneficiation of diamonds at 10%. Local beneficiation of granite is also set at 10%. The policy states that the Government shall reserve a quota of all diamonds produced in Zimbabwe for local polishing and jewellery manufacturing. The regulations require the Minerals Marketing Corporation of Zimbabwe in terms of section 3(1) to set aside not more than 10% of gem quality diamonds and not more than 10% for all categories of diamonds. These local diamond manufacturers are required to cut, polish and crush or otherwise process the rough diamonds for gain or reward. Just like in the platinum sector, the Government of Zimbabwe gave a similar directive to diamond firms to come up with plans for establishing diamond cleaning facilities by 31 January 2014. The rationale behind forcing diamond companies to set up cleaning facilities was to ensure that the Government got more revenue. Those players that failed to comply would face punitive penalties. While diamond cleaning does not add significant value to the commodity, it is regarded as the first step towards beneficiation and value addition.

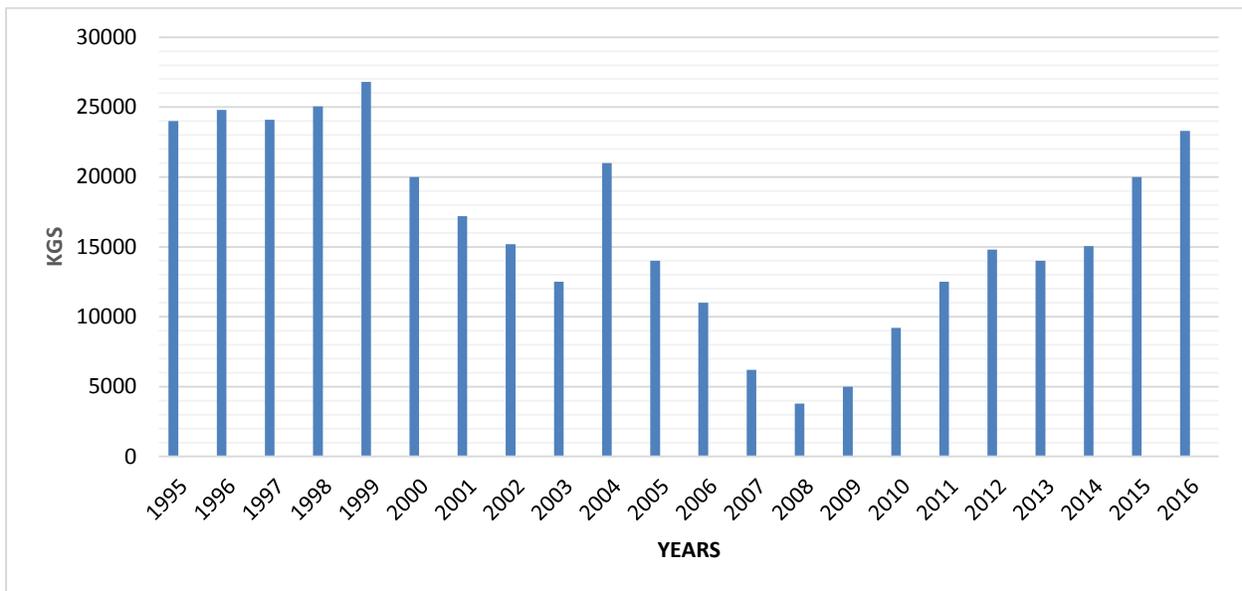
Zimbabwe's minerals endowment could catalyse wider economic development and industrialisation, but only if the minerals regime is overhauled and effectively administered to maximise all of the developmental opportunities associated with mineral extraction and processing. However, Eunomix (2015) argues that at the moment the government's beneficiation thrust focuses on establishing limited transformation downstream from mining, including smelting and refining. This differs, for instance, from South Africa's beneficiation policy, which includes the transformation of metals and other final products of mining and mineral processing into manufactured products. Hence the beneficiation and value addition policy for Zimbabwe should provide a linkage to manufacturing.

4. THE STATUS OF MINING AND BENEFICIATION OF DIFFERENT MINERALS

4.1 Gold

Gold deposits are found in all the districts in the country with the majority lying in the greenstone belts. The largest Gold producer in the country is Metallon Gold Zimbabwe, which is currently operating four mines in the country namely How Mine in Matebeleland South, Mazowe, and Shamva in Mashonaland, and Redwing Mine in Manicaland. Freda Rebecca mine in Mashonaland Central and Caledonia's Blanket mine in Matebeleland South are important players in gold mining producing above 40,000 ounces per annum each. Other significant players include RioZim's Renco mine in Masvingo, Bilboes' Buby mine in Matebeleland North as well as New Dawn's Dalny and Golden Valley mines in Mashonaland West.

Figure 6: Total Gold production in Zimbabwe, 1995 - 2016



Zimbabwe produced 23.4 tonnes of gold in 2016 (Figure 6), with 48% of it being contributed by small scale and artisanal miners. The artisanal and small scale miners scattered around the country have become a force to reckon with, spurred on by the Gold Fund loan facility recently introduced by the Government for this sector. The coming on line of various projects, including the US\$80million investment by Caledonia to sink a new shaft and improve underground infrastructure and logistics at Blanket Mine, and the commissioning of the Cam and Motor dump treatment project are likely to result in significant improvements in productivity and total gold output.

4.2 Platinum Group Minerals

Platinum was initially exploited by BHP Minerals at the Hartley Platinum Mine in the Makwiro area of Mashonaland West and disinvested in 1999. The coming in of Zimplats saw it exploiting platinum in the Mhondoro Ngezi by opencast methods, and later developing into underground mines.

Currently, production is dominated by three mines, namely

- ZIMPLATS whose main shareholder is Impala Platinum of South Africa,
- Unki Mine whose main shareholder is Anglo Platinum and
- Mimosa Mine whose major shareholders are Impala Platinum and Sibanye Gold of South Africa.

The annual production capacities of the mines as of December 2016 are shown in the Table 4 below.

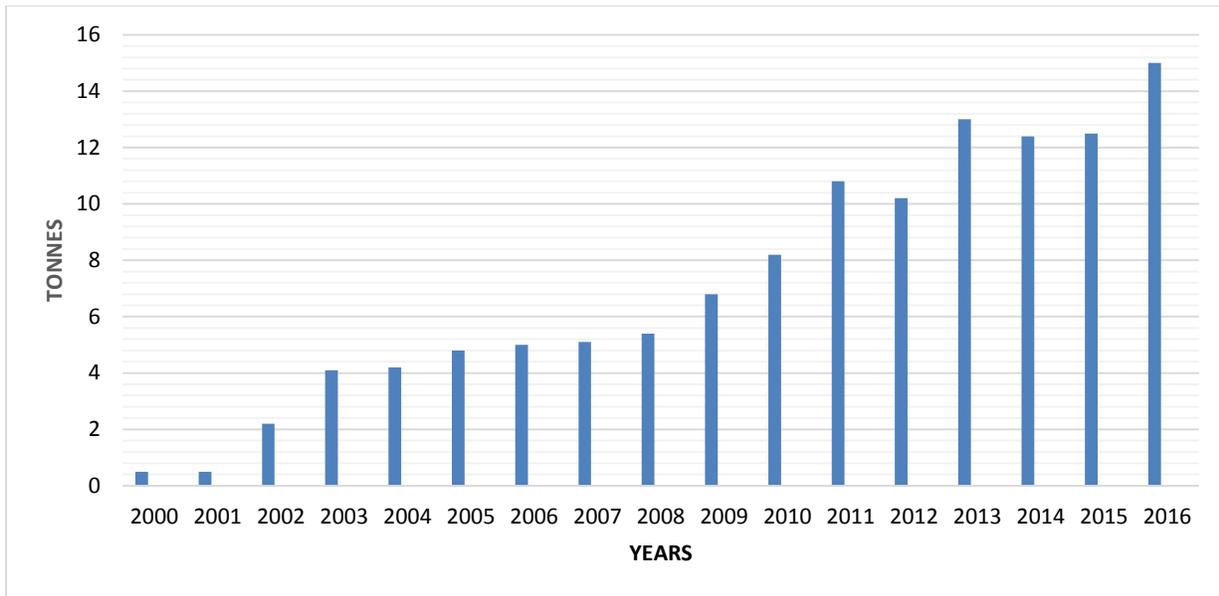
Table 5: Annual Production Capacity of Platinum by Zimbabwe Mines, 2016

MINE	ANNUAL CAPACITY (Pt Ounces/ YR)
Zimplats	270 000
Mimosa	140 000
Unki	75 000
TOTAL	485 000

Other Mines, under joint venture arrangements between the ZMDC and foreign investors are at different stages of development. These include Global Platinum Resources, Todal Mining, Shin Zim Platinum and Northridge Platinum. There are other projects that are being anticipated such as the Russians' Great Dyke project.

Due to the nature of the orebody, mining is carried out predominantly by underground mechanised bord and pillar method for the deeper Main Sulphide Zone (MSZ), and opencast method on the shallow ends. Figure 7 shows the annual production of platinum over the 17 year period from 2000 to 2016.

Figure 7: Platinum production, 2000 - 2016



The extent of beneficiation of the mined ore varies from mine to mine. ZIMPLATS operates two concentrators, one at Ngezi and another one at Makwiro. In these concentrating plants Platinum bearing ore is crushed, milled and processed by flotation technology to produce high grade concentrate. The concentrates are smelted into a higher grade matte at the Selous Metallurgical Complex at Makwiro, with the matte being transported by truck to the Impala Plants in South Africa for base metal followed by precious metal refining. Zimplats has announced plans to resuscitate a mothballed base metal refinery at Makwiro in the next two years. Both Unki and Mimosa mines treat mined ore in concentrators and transport concentrates to South Africa for further beneficiation, but Unki has embarked on a US\$62 million Smelter construction project). Mining companies that produce PGM concentrates and smelter matte in Zimbabwe directly ship the PGM concentrates and matte to processing facilities in South Africa.

In line with Government policy and the ZIMASSET, it is expected that the concentrates from both Unki and Mimosa mines will be smelted in Zimbabwe in the near future.

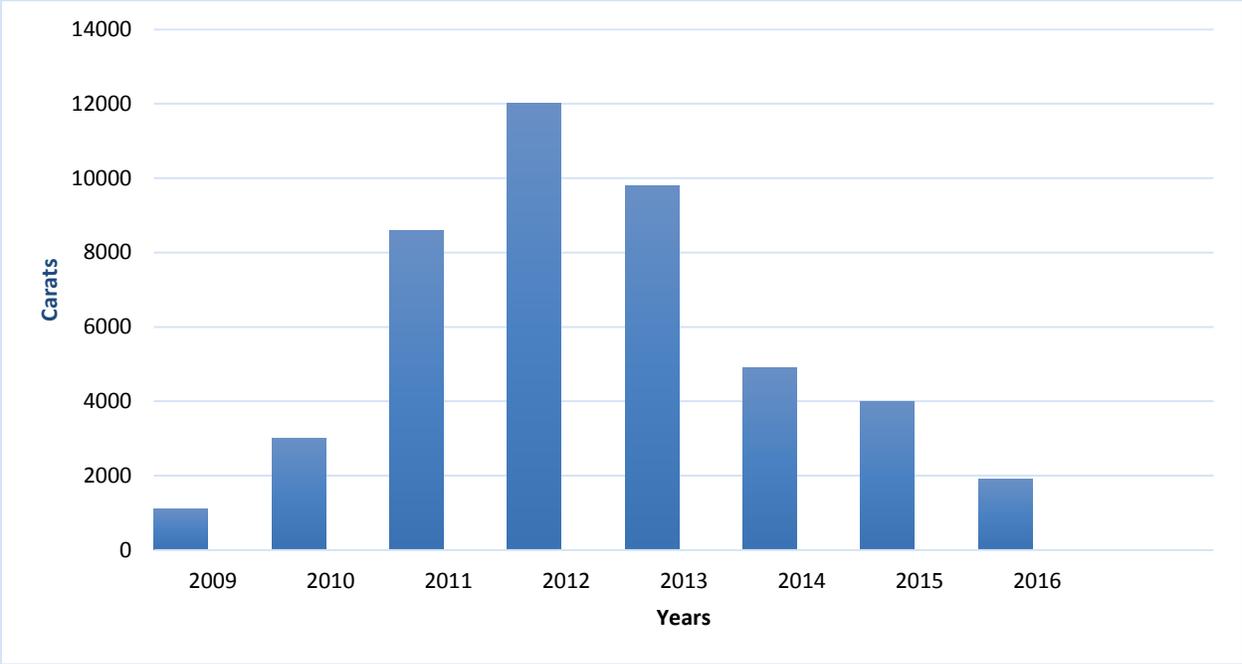
4.3 Diamonds

Diamond mining started with the establishment of River Ranch Mine in the Beitbridge area in the early 1990s by Auridium Zimbabwe. It continued to grow through the opening of several other mines in the country that include Murowa Diamond Mine by Rio Tinto in Zvishavane, Midlands Province. Other mines were opened in partnership with ZMDC which included Mbada Diamonds, Canadile which later became Marange Resources, Jinan, Kusena, Diamond Mining Company and Anjin Investments in the Marange area of Manicaland. As the alluvial deposits got

depleted, production plummeted due to lack of exploration and in 2015 all the diamond mining companies in Manicaland were consolidated by the Government to form one company, Zimbabwe Consolidated Diamond Company (ZCDC) in order to enable economies of scale and improve security and accountability of diamonds produced.

Figure 8. shows the production trends for diamonds in the country. The rough diamonds were sold in the uncleaned state until an acid washing facility was introduced in 2015. A 10% quota was also legislated for the local diamond cutting and manufacturing.

Figure 8: Production of rough diamonds in Zimbabwe ‘000’carats, 2009 - 2016



The world production of rough diamonds in terms of carats and value for the period that Zimbabwe was at its peak (i.e. 2011 to 2013) is as shown in Table 6.

Table 6: World Diamond Production - Weight (carats) and Value (US\$)

	2011		2012		2013	
Country	Carats	Value (USD)	Carats	Value (USD)	Carats	Value (USD)
	'000	(Millions)	'000	(Millions)	'000	(Millions)
Angola	8,329	1,163	8,331	1,110	9360	1.278
Australia	7,830	221	9,181	269	11,729	381,143
Botswana	22,945	3,902	20,555	2,979	23188	3,626
Canada	10,795	2,551	10,451	2,007	10562	1,906,
DRC	19,249	179	21,524	183	15682	139
Namibia	1,256	873	1,629	900	1,689	1,360
Russia	35,140	2,675	34,928	2,874	37,884	3,114
South Africa	7,044	1,389	7,077	1,027	8,143	1,185
Zimbabwe	8,503	476	12,060	644	10,412	538
Others	1,738	640	2,226	650	1,461	557
Total	122,829	14,065	127,962	12,643	130,482	14,085

Source: www.diamonds.com

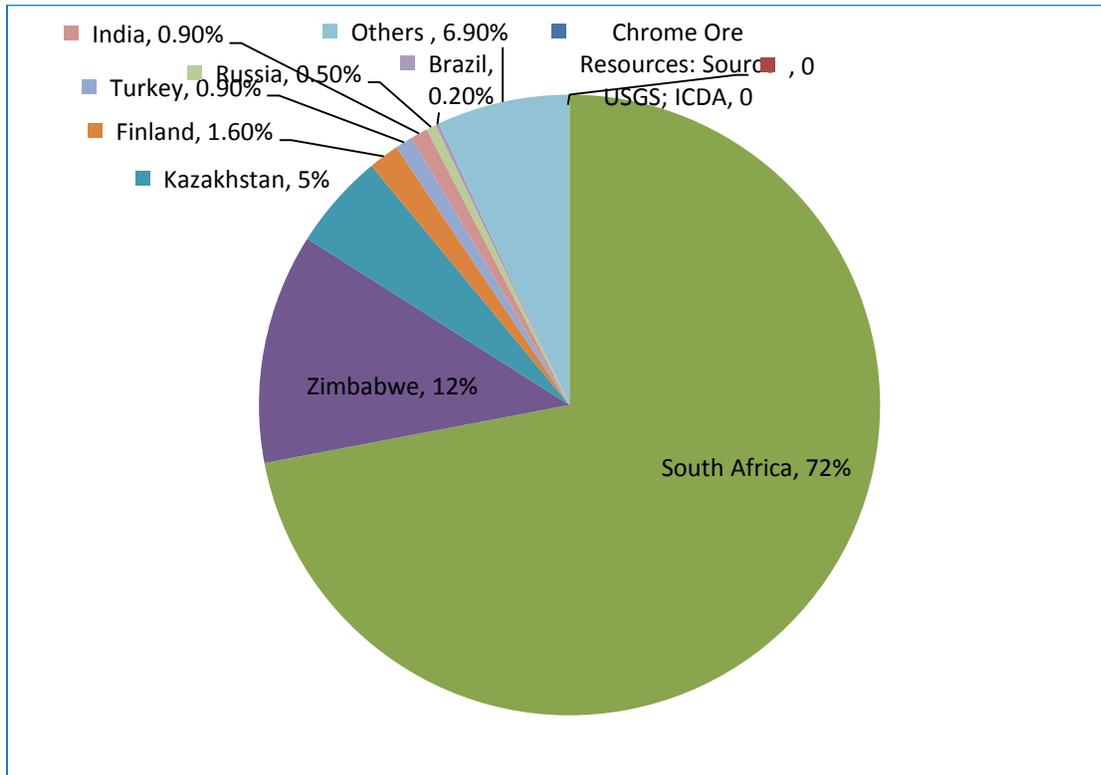
In 2012, Zimbabwe produced 9.4% of the world's total production of rough diamonds by volume, which amounted to 5% in terms of the value. Alluvial diamonds produced in Manicaland are generally of a medium quality with the average stone weighing 5-7 carats. It should be noted, however, that alluvial diamond production has been on the decline since 2013 due to depletion of high grade resource. Current efforts are aimed at extracting diamonds from conglomerate and kimberlite deposits in addition to value addition of diamonds through cutting and polishing, as well as jewellery manufacture by Aurex

4.4 Chrome

It is estimated, according to the United States Geological Survey (USGS) and Roskill⁷, that South Africa possesses 72% of the world's chrome ore (chromite) reserves, followed by Zimbabwe with 12% and Kazakhstan with 5%.

⁷ United States Government Geological Survey 2013

Table 7: Global Chromite Reserves Distribution



Source: USGS, ICDA

Exploitation of Chromium deposits is largely dominated by **ZIMALLOYS and ZIMASCO**. The two companies hold large mining concessions along the Great Dyke.

Zimasco (Private) Limited is an integrated ferrochrome producer which has an installed capacity capable of producing 180 000 tonnes of high carbon ferrochrome annually. Zimasco has traditionally carried out mining operations at Peak Mine and Railway Block in Shurugwi and also Valley Mine while tributor and co-operative miners are contracted to produce chromite ore from Zimasco-owned mining lease areas along the Great Dyke and Railway Block in Shurugwi. The chromite ore at Shurugwi has however been depleted.

Other mining operations are at Guinea Fowl, Lalapanzi, Mutorashanga and tributor operations along the Great Dyke of Zimbabwe. The chromite ore is mined and transported to Kwekwe where it is smelted in combination with reductants and fluxes to produce high carbon ferrochrome alloy.

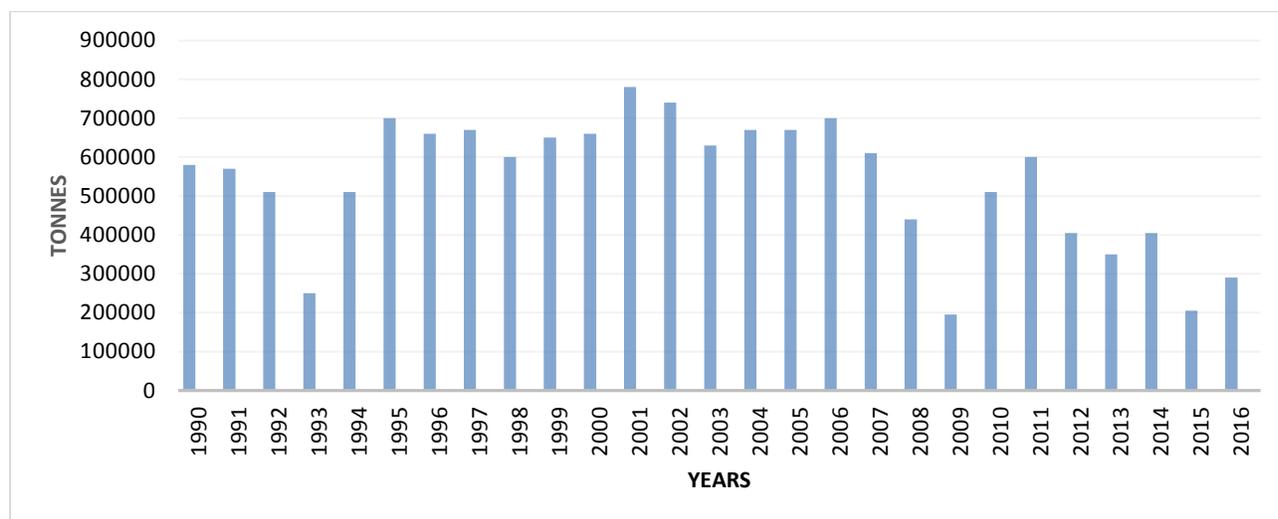
Chromite seam deposits span the entire Great Dyke which is itself divided into the North, Middle and South Dyke regions for ore reserves and geological monitoring purposes. At peak, a total of 600 000 tonnes per annum of chromite ore were produced from the Zimasco Mining Areas.

Zimbabwe Alloys is a former Anglo American Plc ferrochrome producer. The company, which was placed under judicial management in 2014, closed down its four furnaces due to poor global metal prices and escalating costs. There were plans to recover chrome from its dumps while seeking to inject fresh capital into the business. The company planned to upgrade its Lalapanzi plant near Gweru to increase production to 7 000 tonnes per month while new equipment would be installed at Sutton Mine in Mutorashanga to realize production at 14 000 tonnes of concentrate per month while a low carbon ferrochrome smelting furnace was under construction.

Other players that have also come into play are Maranatha Ferrochrome, Afro-Chine and Oliken who are into smelting. Afro-Chine, a subsidiary of Tshingsham Steel of China operates a smelter with a capacity of 50 000 tonnes of chrome alloy per annum in Makwiro.

Total chrome production in Zimbabwe is shown graphically in Figure 9.

Figure 9: Chrome production in Zimbabwe, 1990 - 2016



Low commodity prices against rising mining and processing costs, although showing an upturn, have impacted negatively on chrome production in Zimbabwe in recent years.

4.5 Coal

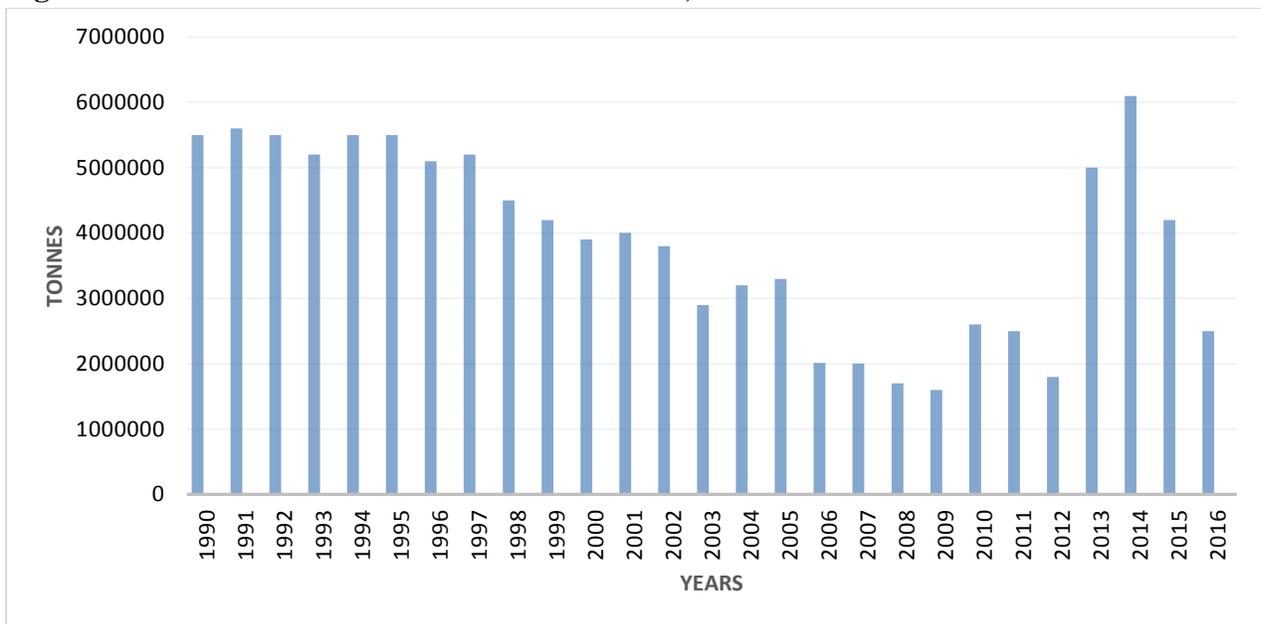
The Coal industry has been dominated over the years by Hwange (formerly Wankie) Colliery Company Limited, a public listed company whose largest shareholder is the Government of Zimbabwe. Coal resources are concentrated in the mid-Zambezi basin which includes Hwange, Binga and Sengwa areas, and the Limpopo basin which includes Bubyie and Tuli areas near Beitbridge. Currently coal mining is concentrated in the Hwange area with other players such as Makomo Resources, Coalbrick, Chilota Mining company and Zambesi Gas entering the

production race since 2010. The production capacity of Hwange Colliery company is pegged at 5 million tonnes per annum although the company has experienced various challenges which have forced it to produce significantly low volumes in recent years. Makomo Resources progressively increased its production capacity from 2012 to 2014, but faced major challenges during the last two years. Steel Makers Zimbabwe, has been mining coal in the Chiredzi area mainly for its own consumption at the steel plant in Masvingo.

Several projects for coal and coal bed methane gas extraction and beneficiation in the Gwayi, Lubimbi and Sengwa areas have been planned for implementation in the near future.

Coal production during the period 1990 to 2016 is shown in Figure 10.

Figure 10: Coal Production volumes in Zimbabwe, 1990 - 2016



Source: Chamber of Mines of Zimbabwe

Various coal mining projects are on the drawing boards, including the ones for the extraction of coal bed methane gas, and some of these are projected to take off by 2020.

4.6 Iron Ore

The country has huge known iron ore reserves grading 40% Fe and above. Iron and steel production faced mixed fortunes in recent years. The closure of Ziscosteel in 2009 impacted negatively on iron ore production. Following the failure of New Zimsteel, a joint venture between Government and ESSAR to resuscitate operations at the former Ziscosteel complex in Redcliff, Government has turned to the Chinese company R&F Properties for a deal to resuscitate the iron and steel operation.

Steelmakers Zimbabwe, which mines iron ore at its Simbi mine in Chiredzi, has a capacity to produce 100 000 tonnes of steel per annum and has plans to increase capacity to 300 000 tonnes per annum in the near future. However, it is currently not operational.

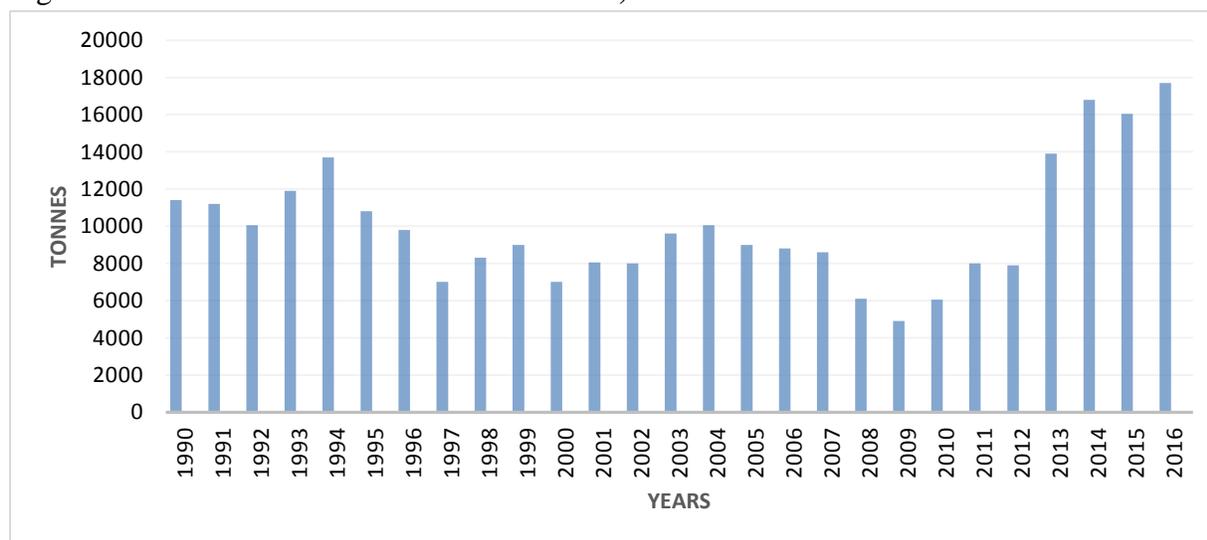
4.7 Nickel

Bindura Nickel Corporation has been in operation since 1966. The mine and plants were put on care and maintenance in 2008 due to viability problems caused by low metal prices. Following resumption of operations in 2012, Bindura Nickel Corporation's (BNC) Trojan Mine has seen a steady rise in the production of Nickel. Other Nickel operations namely Madziwa, and Epoch have been closed while Shangani mine is on care and maintenance. Two nickel deposits at Hunters Road and Damba-Silwane remain dormant.

Apart from BNC, nickel is produced by Zimplats, Mimosa and Unki Platinum mines as a by-product. Another significant player in the nickel sector is RioZim's Empress Nickel Refinery (ENR) in Kadoma which carried out toll refining of matte from BCL Limited in Botswana until 2016 when it was placed on care and maintenance pending disposal by the Botswana Government.

Figure 11 shows the production of nickel in Zimbabwe over the period 1990 to 2016, with a surge in the last three years due to rising prices.

Figure 11: **Production of Nickel in Zimbabwe, 1990 - 2016**



Source: Chamber of Mines of Zimbabwe

Bindura Nickel Corporation produced just over 7 000 tonnes of Nickel in 2016 at its Trojan Mine, and had plans to continue increasing production supported by favourable metal prices.

4.8 Phosphates

Dorowa Minerals in Buhera, Manicaland, which is a subsidiary of Chemplex Corporation, is the only phosphate mine in Zimbabwe. The opencast mining method is employed and involves ripping and dozing in soft rock and drilling and blasting in hard rock. The beneficiation plant consists of milling and flotation processes to produce phosphate concentrates which are converted into superphosphates which is used in the manufacture of fertilizers at ZimPhos, a sister company. Ore from the pit is at 6.5% P_2O_5 and the concentrates are dried and sent to ZimPhos in Harare at a concentration level of 37% P_2O_5 .

4.9 Copper

Copper is currently produced as a by-product by the PGMs (ZIMPLATS, Mimosa and Unki) and Bindura Nickel Corporation, with 2012 registering a tonnage of 6 665 tonnes valued at US\$39.2 million. Copper occurs mainly in Mashonaland West in the Mhangura area where full scale operations were stopped in the late 1990's due to depletion of reserves. Other occurrences are in the Umkondo Belt in Masvingo and various projects are in progress to resume production.

4.10 Black Granite

The distinctive Zimbabwe Black Granite is a much sought after dimension stone in the world. The resource is considerable and there is potential for investment by both local and foreign companies. The Government of Zimbabwe allocated a 10% quota of the total production to be cut and polished locally, leaving a lot of room for investment in the value chain.

The mining of black granite in Zimbabwe commenced in the mid seventies with small production quarries held by various miners. Up to 1988 the market was shared evenly among five main producers when the Natural Stone (Multistone) were able to secure finance to capitalize their operations and hence became the largest producer of the Zimbabwean material.

4.11 Lithium

Zimbabwe has been producing lithium at Bikita Minerals since 1952. It is estimated that over 11 Million tonnes of lithium/caesium/tantalite (LCT) - petalite resource exist at Bikita in Masvingo Province. Production at peak is about 50 000 tpa LiO_2 concentrate and plans are in place to increase capacity to 80 000 tpa.

Zimbabwe is the fifth largest producer of lithium in the world as shown by the production statistics in Table 8.

Table 8: Top five Lithium producers in the world, 2015

	Lithium Production (Tonnes)	World Ranking
Australia	13400	1
Chile	12900	2
Argentina	3800	3
China	2200	4
Zimbabwe	900	5

The country is set to increase its production levels once the AIM-listed Premier African Minerals' Zulu Project near Fort Rixon and Australian based Prospect Resources' Arcadia Project near Harare are brought into production.

4.12 Asbestos

Zimbabwe is a producer of long fibre asbestos, which is considered to be safe to human health. However, Europe and North America have placed asbestos under restriction in certain markets hence curtailing development of production of this mineral in Zimbabwe. Production of asbestos has dwindled from 250 000 tonnes produced in 1980 to 5 000 tonnes in 2009 and nil in 2013 to date. There are however sufficient reserves to match the 1980 production for many years to come provided that capital is invested in this sector.

The main player in the asbestos mining industry is Shabani and Mashaba Mines (SMM) which operated mines in Zvishavane and Mashava.

5. COUNTRY EXPERIENCES ON SELECTED MINERALS

5.1 Diamond Cutting and Polishing Country Experiences

The extreme hardness of diamonds requires that no other material, except other diamonds, can cut a diamond, thus diamond cutting calls for highly specialized artisans, tools, equipment, and techniques. Very few places in the world that specialize in the cutting and polishing of diamonds. The main diamond cutting centers are found in Antwerp and Amsterdam, the Netherlands, Johannesburg, South Africa, New York, the United States, and Tel Aviv, Israel. Due to the low cost of labor, diamond cutting centers have also been set up in China, India, and Thailand. The cutting center in Gujarat, India handles a large number of small diamonds due to the cheap labour costs. Large diamonds in smaller quantities are most likely to be sent for cutting and polishing in Europe and North America.

Cutting changes a rough diamond into a processed gem, ready for placement in jewellery; any mistakes at this point of the supply chain will lead to serious repercussions in profitability and supply. The planning stage of the diamond cutting process is more important than the actual cutting of the diamonds. A skilled cutter gets very few chances to make the right cut⁸. Thus at every stage of the diamond value chain the value of the diamond increases value.

Table 9: Value addition in the diamond pipeline

Stage of global value chain	% of original value
Producer selling value	100
Sorting and valuing	115
Cutting and polishing	127
Polished dealing	133
Jewellery manufacturing	166
Retail	320

Source: Even-Zohar (2007)

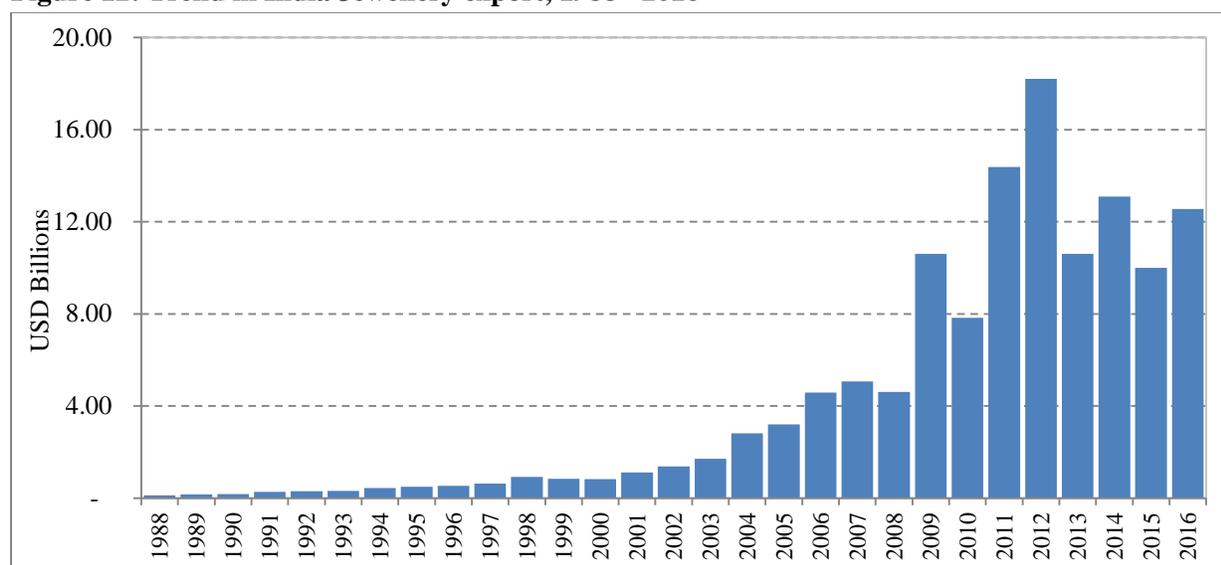
5.1.1 India

The diamond trade in India consists of the importation of rough diamond, cutting and polishing of rough diamond and export of polished diamond /diamond stud jewellery. The production or mining of rough diamonds in India is negligible, compared to the world total production.

⁸ http://www.laccei.org/LACCEI2010-Peru/published/ACC115_Rudnicka.pdf

Diamond cutting was first established in India in 1938. However, the cutting and polishing of diamonds widely developed further after 1962, based on the ability of Indian artisans to convert near-gem rough diamonds discarded by the rest of the world into diamonds. In the seventies, the wide adoption of technology in the late 1980s increased productivity in the diamond sector. India is the largest diamond processing center in the world and currently accounts for 85% of world's volume of processed diamonds and 57% in value (2014-2016)⁹. Since the 1960s, India has been the cheapest diamond processing hub in the world, at US\$10 a carat, 70% less than China and 10 times less than Tel-Aviv in 2007. India's Jewellery exports have grown from US\$ 112, 9 million in 1988 to US\$ 12.55 billion in 2016 (Figure 12).

Figure 12: Trend in India Jewellery export, 1988 - 2016



Source: TRADEMAP

Between the Fiscal year 2014/15 India's gem and jewellery constituted 13.30% of the country's total merchandise exports. The market in India is expected to grow at a compound annual growth rate of 16% over the period 2014-19¹⁰.

The diamond processing sector in India, is mainly located in Gujarat accounting for about 80% of country's diamond processing work. The diamond processing industry in India is located in one industrial cluster. The diamond producing countries sent their rough diamonds after sorting according to size, shape, colour and quality for cutting and polishing to India through networks such as the Diamond Trading Company certified through the Kimberly Process Certification. The industry has about 8,000 diamond cutting and polishing firms employing around 4.5 million

⁹ http://www.it.bton.ac.uk/Research/euindia/knowledgebase/positionpaper/germany/text/surat_diamond_industry.pdf

http://www.laccei.org/LACCEI2010-Peru/published/ACC115_Rudnicka.pdf

¹⁰ <http://www.makeinindia.com/documents/10281/114126/Gems+%26+Jewellery+Sector+-+Achievement+Report.pdf>

skilled and semi-skilled workers across India and is expected to provide employment opportunities to more than 8.23 million persons by 2022.¹¹

Box 1: Key Characteristics of Diamond Processing Industry in India

- Most of the firms in the Diamond processing industry in India are family owned businesses and usually small to medium enterprises.
- The diamond Industry is labor intensive relies heavily on cutting & polishing technology and inherited skills required for processing of diamonds that have been home grown
- The industry is export oriented but heavily dependent on imported rough diamonds from major diamond mining countries.
- Sector enjoys government support through discounts on export duties on capital equipment's, duty free on importation of precious metals, exemption of jewellery and gem exports from sales tax reduced income tax on profits.

Indian diamond industry has identified a niche of processing low grade (and low value) diamonds and small diamonds (below one carat) whilst other countries such as Belgium & Israel mainly focuses on processing high value diamonds. Given India's focus on small diamonds the cutting and polishing process have not been easily amenable to automation, hence through research and development the industry has developed machinery to suit these applications and also to take advantage of cheap skilled labor, which include the development of laser kerfing and sawing machines.

Institutional arrangement

In order to support the diamond cutting and polishing industry in India, a Diamond Industrial Park (DIP) was created in 2003. The park was initially incorporated as a co-operative but later registered as a company. The park has the capacity to accommodate 1,000 firms. The industrial park was established with the objective of providing the best production infrastructure and also a customs bonded import and export zone for rough and polished diamonds, bringing in industry players at every level of the process chain, hence the park is situated near the Surat airport in India.

¹¹ [http://www.isc.hbs.edu/resources/courses/moc-course-at-harvard/Documents/pdf/student-projects/India_\(Gujarat\)_Diamonds_2008.pdf](http://www.isc.hbs.edu/resources/courses/moc-course-at-harvard/Documents/pdf/student-projects/India_(Gujarat)_Diamonds_2008.pdf)

The Gem & Jewellery Export Promotion Council¹²

The export promotion council was set-up in 1966. The organisation seeks to consolidate the effort of the individual gem and jewellery polishers into a powerful engine driving India's export-led growth. The council has 6,500 members spread all over India. The roles and functions of the Gem & Jewellery Export Promotion Council are classified as follows:

Trade facilitation

The Council undertakes direct promotional activities and marketing linkages between the India Gem and jewellery industry with the international buyers and suppliers of rough diamonds through participation in international jewellery shows, and sustained image building exercises such as advertisements and publications. The Council provides market information to its members regarding foreign trade inquiries, trade and tariff regulations, rates of import duties, and information about jewellery fairs and exhibitions.

Advocacy and Government lobbying

The council is also involved lobbying government through aiding better interaction and understanding with the government. The Council takes up relevant issues with government and agencies connected with exports and submits documents for consideration and inclusion in the Exim Policy (export import policy). The Council also grants membership, registration certificates and performs other roles as per the Exim Policy.

Nodal Agency for Kimberly Process Certification Scheme

The Council has been appointed as the Kimberly Process Certification Scheme, Nodal Agency in India and thus works closely with the Government of India to implement and oversee the Kimberly Process Certification Scheme.

Training and Research

To ensure that the diamond industry in Indian remains competitive and achieves highest levels of technical competency the council has a number of institutes that conduct training in all aspects of manufacture and design.

Government Initiatives and Interventions

The government of India has put in place policies that promote foreign direct investment in the Gem and Jewellery value chain, FDI policies that allow for 74% in exploration and mining of diamonds and precious stones and 100% for gold and silver and minerals' exploration, mining, metallurgy and processing¹³. It processes an estimated 80 percent of world's requirement sourced from South Africa, Canada, Russia, Botswana and Australia though imported from Antwerp

¹² [http://www.isc.hbs.edu/resources/courses/moc-course-at-harvard/Documents/pdf/student-projects/India \(Gujarat\) Diamonds 2008.pdf](http://www.isc.hbs.edu/resources/courses/moc-course-at-harvard/Documents/pdf/student-projects/India%20(Gujarat)%20Diamonds%202008.pdf)

¹³ <https://vibrantgujarat.com/writereaddata/images/pdf/gems-jewellery-sector.pdf>

(Belgium). The government has created Special Notified Zones (SNZ) for the importation and exportation of rough diamonds. The Special Notified Zones have ensured that the country has regular and direct supply of rough diamonds in the country thus saving diamond manufacturers time and effort in procuring rough diamonds and also minimizing the role of middlemen and minimizing on commissions and eventually costs.

Furthermore, the Government of India has taken strides in improving the regulatory framework and taxation regime to encourage international mining companies to sell their rough diamonds directly in India. These include increasing customs duty on import of Imitation Jewellery from 10% to 15% with the view to protect local manufacturers, enhancing the ease of doing business by reducing the number of mandatory documents required for import and export to three and simplification of forms.

Skills development

The jewellery industry currently employs around 4.5 million skilled and semi-skilled workers across India and is expected to provide employment opportunities to more than 8.23 million people by 2022. In this regard the Gem and Jewellery export promotion council and the Government of India, have set up the Indian Diamond Institute to impart knowledge and training in diamond cutting and polishing as well as jewellery designing and manufacturing. The institute is also complemented by many other private institutes imparting training in diamond polishing and jewellery making. The Indian Diamond Institute offers training in Gem and Diamond Identification, Sorting & Grading, Gemology, Jewellery Designing, Manufacturing & Appraising and Jewellery Business management. These skills development programs have resulted in abundance of diamond cutters and polishers making India' cutting and polishing industry more competitive than the rest of the world. India has labour costs of US\$10 per carat compared to US\$150 per carat in Belgium (Antwerp).

The industry has also invested in Research and Development, with the establishment of a number of laboratories and research centers equipped with world class sophisticated instruments required for gemstones. The research institute provides a Gem Certification service, conduct educational activities on gem related subjects and also act as an information center for the gem and jewellery industry. Furthermore these R&D institutions have helped the industry develop machinery suited to India's niche market and for its abundant cheap skilled labor. These include the development of laser kerfing and sawing machines.

Lessons for Zimbabwe

- Skills development establishment of a gemology excellency centre/Diamond Institute to support skills development as well as Research and Development centers for the development of equipment suited to the local industry needs.

- Identifying and developing niche markets in the diamond cutting and polishing industry, for instance, India specializes in cutting the smallest, low grade (and low value) diamonds due to its competitive advantage in low labour costs per carat.
- Government support: There is need to improve the regulatory framework and taxation regime, enhancing the ease of doing business to encourage polished diamonds exports, protecting local manufacturers and encouraging investment in the local cutting and polishing industry

5.1.2 Botswana

The discovery of diamonds and subsequent exploitation of the mineral in Botswana and the prudent management of diamond revenues that accounted for half of national fiscal revenues enabled the development of the country from a poor economy that largely depended heavily on the agricultural sector to a middle-income country. Historically, the government of Botswana through a joint venture with DeBeers (Debswana Mining Company) was responsible for mining all diamonds in Botswana. The diamonds were largely exported as rough diamonds with minimal value-addition taking place in the country.

Recently the government sought to change the mining trajectory by the creation of a vibrant local diamond cutting and polishing industry to create downstream competencies. In this regard the government of Botswana came up with a beneficiation policy that requires that local processing of diamonds be equivalent to 15 percent of the country's total rough diamond production. The policy aims to create local jobs since diamond cutting and polishing is more labour intensive than diamond mining. The diamond beneficiation policy stipulates that the cutting and polishing industry has to hire and train locals in cutting and polishing skills.

In this regard, the government of Botswana has established a Diamond Office to support government's primary objective of diamond beneficiation in Botswana. The Diamond Office and Hub falls under the Ministry of Minerals, Energy and Water and oversees the implementation of the mineral beneficiation policy. The office focuses on building strategic alliances, developing infrastructure and enabling a favourable fiscal regime in order to support diversification in the diamond industry.

The beneficiation policy also aims to create linkages with the rest of the economy by creating a supply chain network for the industry, hence the diamond hub has been tasked with the responsibility of attracting and assisting suppliers that provide the Botswana industry with goods and services. A Diamond Technology Park has been established and this houses various ancillary businesses which include banking, logistics, gemology, security and brokering companies. The

Diamond Office is responsible for the inspecting and monitoring of diamond exports, ensuring compliance with the Kimberley Process Certification Scheme¹⁴.

Firms in the cutting and polishing industry are classified as manufacturing companies hence they are subjected to a lower corporate tax rate of 15 percent compared to 20 percent paid by other companies operating in Botswana. In addition, through the Diamond Hub, cutting and polishing firms are able to bring in skilled labour into the country to train locals and repair equipment on multiple entry business visas in order to make it easier for them to enter the country when their services are required. Furthermore, the firms are exempt from paying training levies and qualify for rebates claim on the training expenses if their training programmes are accredited.

Given that the general industry rule of thumb for cutting and polishing is that the cost of cutting and polishing should not exceed 10% of the value of the rough diamond, accordingly, in 2009 the government of Botswana imposed an implicit tax of US\$31.17/carat or equivalent to 4.5% of the value of the rough diamond imports to promote local beneficiation in Botswana. Thus, if the differential price of rough diamonds on the secondary diamond market is greater than the differential cost of cutting and polishing in Botswana, then manufacturers will agree to beneficiate and process their diamonds in Botswana.¹⁵ The diamond cutting and polishing firms are exempt from paying taxes on polished diamonds exports and only have to pay taxes if they export rough diamonds (unprocessed) or partly polished diamonds. This provides an incentive for the companies to process their diamonds in the country. The companies do not have to pay import duties on their technology imports.

Supply of rough diamonds

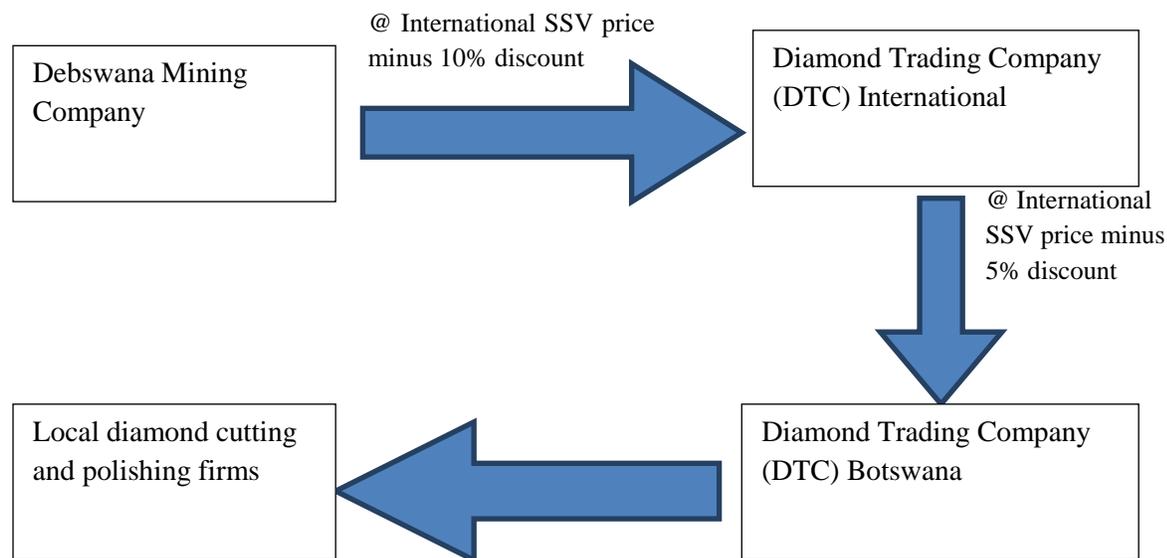
The allocation of rough diamonds to local cutters and polishers is critical to the success of the diamond cutting and polishing industry in Botswana. The allocation of rough diamonds also needs to complement the local cutting and polishing firms' training activities as often firms train locals on smaller stones to minimize their costs. In this regard DTC Botswana has come up with an ingenious supply chain of rough diamonds to support the local cutting and polishing industry. In 2011, the Government of Botswana (GRB) and De Beers signed a 10-year contract for sorting, valuing, marketing and selling of Debswana diamond production¹⁶. Debswana mining company sells its rough diamond production to DTC International at a 10 percent discount. DTC determines each firm's allocation in terms of size, type and quantity of stones and sends them to DTC Botswana to sell to the 'sightholders'. The sales to sightholders are at the same selling prices (SSV) as those paid by DTC clients elsewhere. DTC Botswana purchases the diamonds back from DTC International at the standard selling value (SSV) minus 5% discount.

¹⁴ http://www.prism.uct.ac.za/Papers/MMCP%20Paper%206_0.pdf

¹⁵ <http://ecdpm.org/wp-content/uploads/2013/11/DP-142-Future-of-Diamond-Beneficiation-Botswana-2013.pdf>

¹⁶ <http://www.bitc.co.bw/sites/default/files/Botswana%20World%20Diamond%20Centre%20Investment%20Opportunities.pdf>

Figure 13: Rough Diamond Supply Chain in Botswana



Lessons for Zimbabwe

The government of Botswana has adopted a stick and carrot approach in its beneficiation thrust. The strategy is characterized by a bigger carrot (incentives) and smaller stick (penalties), in this case the incentives include tax exemptions and preferential treatment whilst the penalties include an implicit tax on the exportation of rough diamonds.

- a. Lower corporate tax on cutting and polishing firms to attract new players and investors in the sector.
- b. Implicit tax on rough diamonds exports whilst there is an exemption on polished diamonds to encourage local beneficiation.
- c. Training levy exemptions and rebates on training expenses by accredited training program. Zimbabwe can exempt diamond cutting and polishing firms with accredited training programs from paying Manpower development levy.
- d. Special visa/ immigration arrangements for expatriates who are engaged in training locals on diamond cutting and polishing as well as repair of local beneficiation equipment.
- e. Sale of rough diamonds to domestic firms at discounted prices for them to be competitive at the international market.
- f. Establishment of a dedicated diamond office within the ministry of mines and mining development to spearhead the diamond beneficiation policy as well as the establishment of an integrated diamond industrial hub.

5.2 Nickel

The World Directory of Nickel Production Facilities by the International Nickel Study Group (2017) reported that there were 187 nickel mines operating in 30 countries and 122 nickel

smelters and refineries operating in 32 countries. Most important nickel producers include Russia, Canada, New Caledonia, Australia, Indonesia, Cuba, China, South Africa, Dominican Republic, Botswana, Columbia, Greece and Brazil. Some critical nickel refineries operate in Norway, Finland, France, Japan and the United Kingdom.¹⁷ The majority of nickel deposits occur in two geographical environments, magmatic sulphides and laterites. About 40% of world nickel resources are in magmatic sulphide and around 60% are in laterites (British Geological survey, 2008). However, laterites contribute only 40% of world production (British Geological survey, 2008). Nine countries account for 75% of global nickel reserves (Nickel Institute, 2016). Laterite-type (or oxide-type) resources are found in Indonesia, the Philippines, Brazil, Cuba and New Caledonia whereas sulphide-type deposits are found in South Africa, Russia and Canada. Australia has the biggest nickel resources with both sulphide- and laterite-type ore deposits.

After mining, nickel ores (1-4% Ni) are further processed to upgrade their nickel content. The next stage of concentration to produce concentrates may result in nickel content in the range of 10-20% (British Geological survey, 2008). Nickel matte which is produced in smelters usually contains approximately 70% on Nickel. Pyrometallurgical or hydrometallurgical processes may be used in processing ores at refining stage although different procedures may be preferred in processing magmatic sulphide ores and laterite-hosted ores due to their chemical and textural differences. Refined nickel metal is at least 99% of Nickel.

Nickel is a versatile metal that readily forms alloys suitable for numerous applications. Nickel bearing alloys are most valued for their corrosion resistance, high melting point, ductility, malleability and magnetic properties. Around 80% of first use nickel (excluding recycled nickel) is alloyed (British Geological survey, 2008).

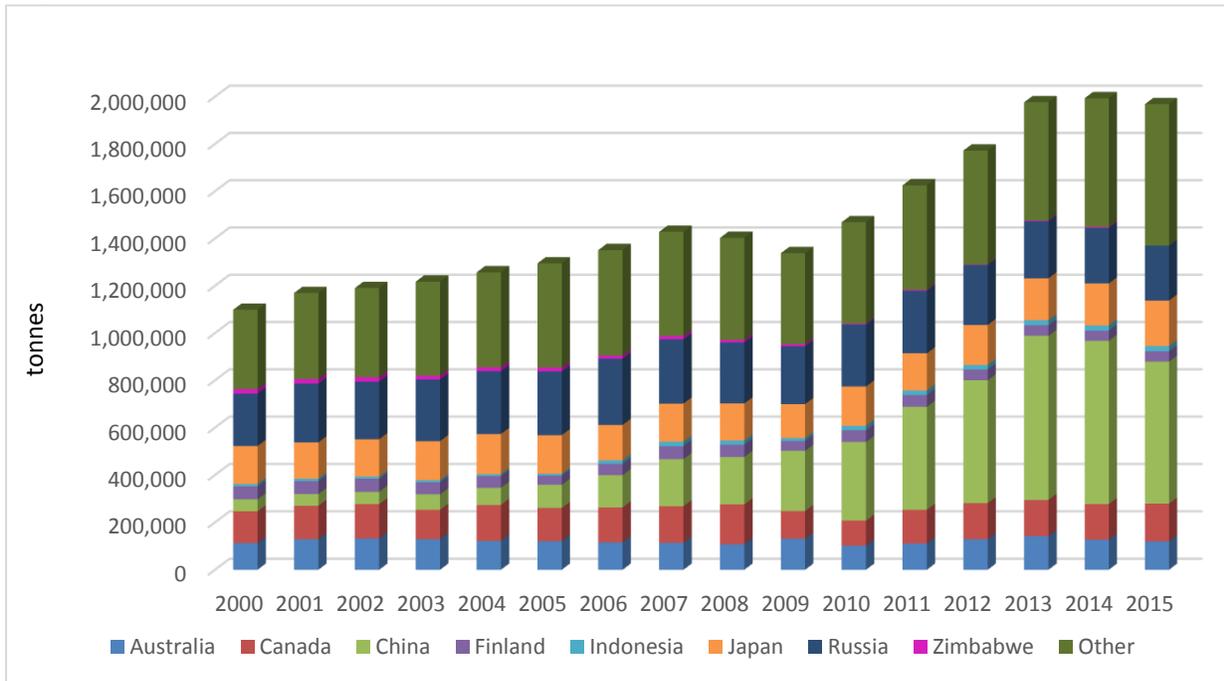
Unlike most other metals, nickel ores are found in diverse geological formations, in different mineralogical forms, at different depths, with varying percentages of nickel content, and often with other metals present. The processing techniques used depend on these variables which yield different rates of metal recovery.

Global nickel smelter and refinery production has generally been increasing over the years registering about 1.09 million metric tonnes in 2000, to 1.968 million metric tonnes in 2015, translating into a 79.2% increase in global production (Figure 14). However, Zimbabwe registered a negative growth of about 76.5% whereas China, the global leader in nickel smelting and refining registered an astronomical increase of 1256.6% during the same period. However, in 2000 Zimbabwe was contributing about 1.78% of the global smelting and refinery production figures whereas China was contributing slightly higher at 4.6% during the same period. China

¹⁷ <https://www.nickelinstitute.org/NickelUseInSociety/AboutNickel/HowNickelIsProduced.aspx>

has overtaken some giants in nickel smelting and refinery such as Russia, Japan, Canada and Australia over the years, with a contribution of about a third of the global production in 2014 and 2015. In 2015 China contributed about 30.5% of global production of nickel concentrates and matte down from its peak of 34.6% in 2014.

Figure 14: Global Nickel Concentrates and Matte Production, 2000 - 2015

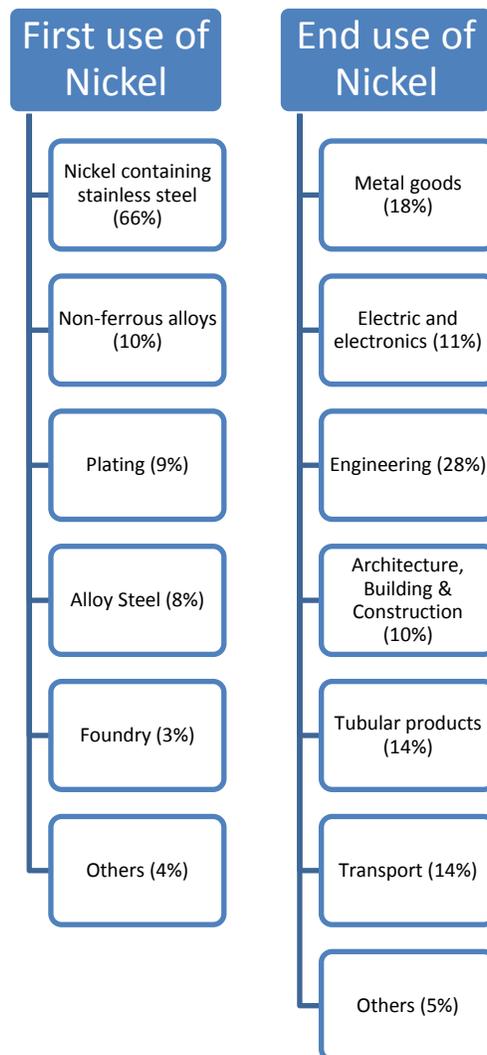


Source: <http://www.insg.org/stats.aspx>

Nickel metal's key characteristics include high melting point (1453 °C), resists corrosion and oxidation, very ductile, alloys readily, magnetic at room temperature, can be deposited by electroplating, and has catalytic properties. Nickel based alloys like stainless steel, but with higher nickel contents, are used for more demanding applications such as gas turbines, some chemical plants and specialist engineering. Alloys based on nickel have excellent corrosion resistance and high temperature resistance, which make them suitable for chemical plants and also allowed the practical realisation of the jet engine. For instance, in the European Union (EU), a number of important, high-skill 'end use' manufacturing sectors are critically dependent on nickel such as the manufacture of jet engines and gas turbines, the production of process plant equipment used in important industries such as food and drink, oil, chemicals, and pharmaceutical production, and the pressing of compact disk (CDs) and digital versatile discs (DVDs). Most nickel-containing products have long useful lives averaging 25-35 years, with many applications lasting much longer. At the end of their useful life, nickel-containing products can be collected and recycled for future use and re-use.

According to Nickel Institute (2016), about 66% of the nickel which is produced is used to manufacture stainless steels (Figure 15). Another 10% is used in other steel and non-ferrous alloys often for highly specialized industrial, aerospace and military applications. About 9% is used in plating and alloy steel and foundries consume about 8% and 3%, respectively. About 4% is used in other uses, including coins, electronics, and in batteries for portable equipment and hybrid cars. In many of these applications there is no substitute for nickel without reducing performance or increasing cost. The first use of nickel is defined as the conversion of nickel products into intermediate products, which form the basis for nickel-containing end-use products. In nearly all cases, these first-use products undergo further processing before they are ready for use.

Figure 15: First and End use of Nickel



Source: Nickel Institute, 2016

5.2.1 Nickel Beneficiation in Indonesia

In February 2012 the Indonesian government issued Regulation No. 7/2012 entitled ‘Improving Value Added Mineral Processing and Purification through Mineral Activities’, which imposed limitations on the export of unprocessed copper, gold, silver, nickel, tin, bauxite and zinc. The ban on export of nickel ore was effective January 2014. The regulation also imposed an obligation on mining companies and mineral processors to consider investments in additional smelting and refining facilities. The stated purpose of this mandatory in-country processing requirement was to increase the value of the minerals for export and preserve the country’s resource supplies. The idea behind the export ban strategy is that it is a logical, natural progression for a country exporting raw materials to move downstream into the processing of these materials, and therefore policies encouraging such downstream processing can improve trade performance and accelerate structural transformation of the economy.

Depending on the stage of development of the mining project, the requirement to process would be extended until 2014, 2015 or 2016. The progressive export duty applies to copper, iron, manganese, lead, zinc, ilmenite, and titanium. The export duty was set at 20% to 25% for the 2014 fiscal year, which increased gradually on a semester basis, at the rate of up to 60% by the second semester of 2016 (Table 10).

Table 10: Concentrate export duties for Indonesia (%), 2014-2016

Concentrate	2014		2015		2016	
	H1	H2	H1	H2	H1	H2
Copper	25	25	35	40	50	60
Iron (Hematite)	20	20	30	40	50	60
Iron (Laterite)	20	20	30	40	50	60
Manganese	20	20	30	40	50	60
Lead	20	20	30	40	50	60
Zinc	20	20	30	40	50	60
Limenite	20	20	30	40	50	60
Titan	20	20	30	40	50	60

Source: www.metalbulletinresearch.com

For nickel the regulation set out a requirement to process to a nickel matte product with greater than 70% nickel content (International Nickel Study Group, 2012). Copper cathode should be beneficiated to at least 99.9%. The regulations would have a major impact on the export of nickel ore mainly to China given that China was consuming a large chunk of Indonesia’s nickel ore. The stated intention behind these new regulations was to encourage the processing and smelting of ores within Indonesia.

Although Indonesia is not a big producer of refined nickel in world terms, with production of 22.2 thousand metric tonnes in 2015 out of about 1.968 million tonnes global nickel production

(translating to 1.13% of the global total), it has by far the greatest potential in the coming years regarding refined nickel production growth and minable reserves. This is because Indonesian nickel resources are not only huge, but they are also high-quality. The archipelago concentrates more than 40% of the global total of high-grade lateritic nickel ore (1,8% Ni content and above), which is strategically very important.¹⁸

The ban of the export of nickel ore in Indonesia resulted in more than 250 companies applying to set up a smelter plant with 100 companies already having a licence to export ore despite only about 20 companies dominating the ore export (Rirt-Carlton, 2013). This may be an indicator that there are companies that are willing and able to do beneficiation if they are guaranteed of getting the feedstock in their country of operation.

By issuing these laws and regulations, the Indonesian Government aimed to increase the mining commodities price received by Indonesian mining companies for mineral commodities (by requiring the adding of value through domestic processing or beneficiation); increase Indonesia's tax revenue; and create more jobs through the increase of production capacity in Indonesia.

However, Nathan Associates Inc (2013) argued that an export ban would cause domestic prices of unprocessed minerals to fall, providing an incentive to processors. Hence a better approach would be a selective policy, aimed at downstream processing in specific minerals with profitable investment profiles and with some competitive promise in raising export earnings rather than an export ban on unprocessed minerals. The policy should call for targeted interventions directed at the competitiveness of downstream processing, rather than indirect interventions, such as an export ban on all unprocessed minerals, to subsidize downstream processing through declining domestic prices of these minerals.

Nathan Associates Inc (2013) further argued that forward-linkage strategies, such as an export ban to stimulate downstream processing, were a poor guide for formulating export development policy. They pointed out that international experience showed that forward linkage based policies did not work as intended, and they did not make much sense in a world where trade costs had fallen substantially and supply chains made it easier to insource and outsource links in the production chain.

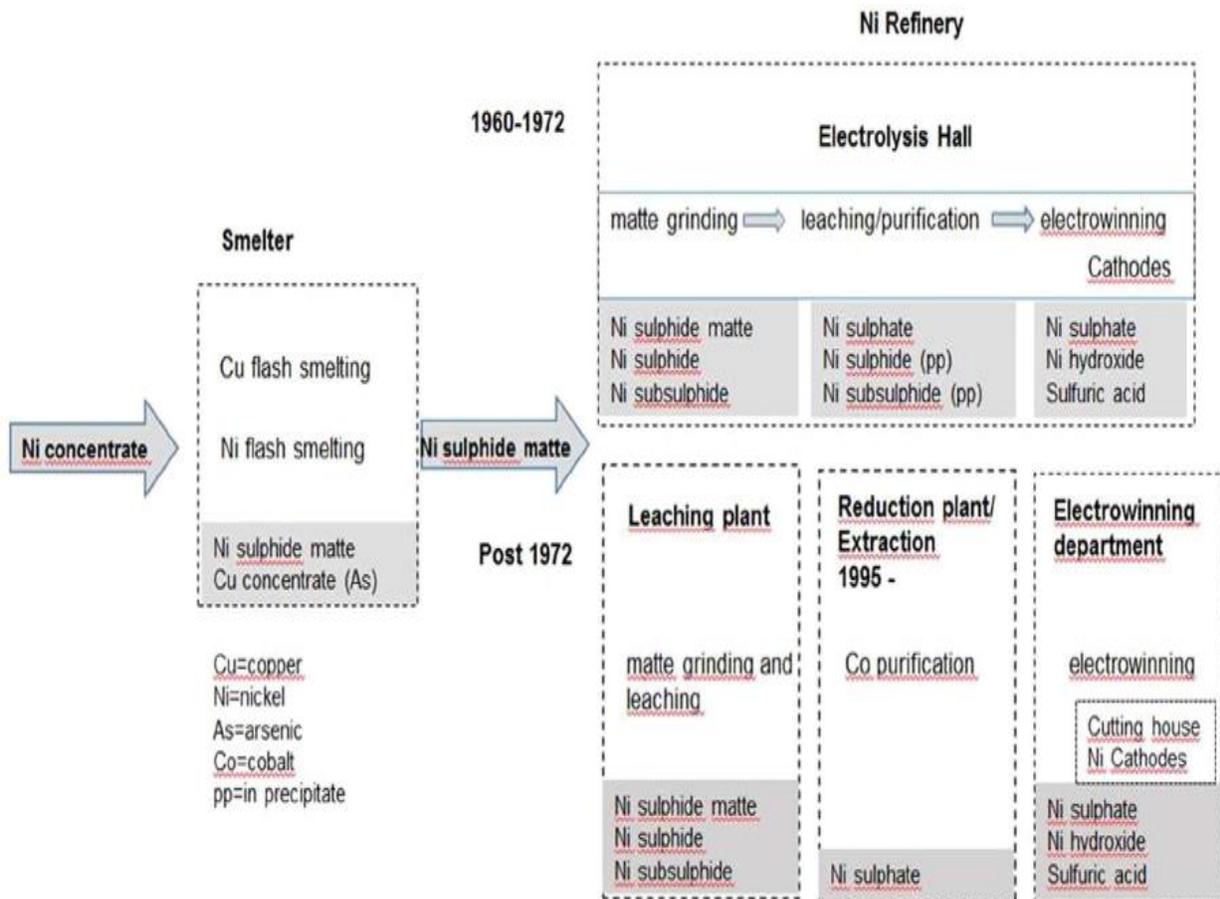
It was reported that the ban was lifted in January 2017, following a huge budget deficit in 2016 (Reuters, 12 January 2017). It was argued that exports would be allowed for up to five years and would be restricted to volumes decided by the government and independent inspectors.

¹⁸ www.metalbulletinresearch.com

5.2.2 Nickel Beneficiation in Finland

Nickel is produced in Finland in the city of Harjavalta, located in Southwestern Finland. The nickel matte has been produced from nickel concentrate since 1959 by using the flash furnace smelting method, and the production of nickel cathodes started in 1960. The copper electric smelting which started at Harjavalta in 1945 was replaced by flash furnace smelting process in 1949. There are two companies involved in the production of nickel in Harjavalta (Pavela, et al., 2016). The Boliden Company (smelter) produces nickel matte from nickel concentrate, and Norilsk Nickel Harjavalta processes nickel matte in the nickel refinery to metallic nickel and nickel salts. The end products of the post 2001 nickel chemical factory are nickel sulfate and hydroxide (Figure 16). In the electrowinning process, nickel is precipitated from a nickel sulfate solution into metallic nickel by electric current. The resulting products are nickel cathodes.

Figure 16: The nickel process flowsheet and end-products at copper/nickel smelter and nickel refinery in Harjavalta, Finland



Source: Pavela, et al., 2016

5.2.3 Nickel Beneficiation in Botswana

Construction of the first ever Base Metal Refinery (BMR) at Tati Mine in Botswana valued at US\$482 million together with construction of a Dense Media Separation plant upgrade to the Tati concentrator (US\$114 million) and power infrastructure installation (US\$24 million) gave Botswana a stance to process nickel.¹⁹ The project was a result of 85% LionOre shareholding and 15% Government of Botswana which included the Phoenix open pit nickel mine and the Selkirk underground nickel mine. The project life of mine was estimated at 11 years, with the potential to increase to more than 20 years when the Selkirk resource was factored in. Full nickel metal production was expected towards end of 2009.

Norilsk Nickel acquired 85% shares of Tati Nickel in Botswana to the tune of US\$6.8 billion as a result of the acquisition of LionOre Mining International Limited on 28 June 2007. In 2014, Norilsk Nickel Mining Company vacated Tati Nickel Mining Company site and the Botswana government, through the BCL Mine, bought the mining company²⁰. In 2016, Tati Nickel Mining Company was put on care and maintenance,²¹ retrogressing Botswana's efforts of beneficiation of nickel.

5.3 PGMs experience

The world's PGMs come from South Africa, Russia, North America and Zimbabwe. Only South Africa and Zimbabwe extract PGMs as primary minerals, with the other players producing PGMs as by-products from nickel-copper operations. PGMs in Zimbabwe are currently produced and marketed as concentrates (Mimosa and Unki) and matte (Zimplats). Experience worldwide suggests that value addition in the platinum industry requires significant capital and a competent and experienced human resource base.

PGM smelting takes place exclusively in electric furnaces. Rectangular 6-in-line sub-merged-arch electric furnaces are the most widely used (Mintek, undated), although there are also some circular 3-electrode furnaces in operation such as that Zimplats. In South Africa, smelting typically takes place at temperatures around 1350°C, although smelting of UG2 concentrates can require temperatures in the region of 1600°C or higher.

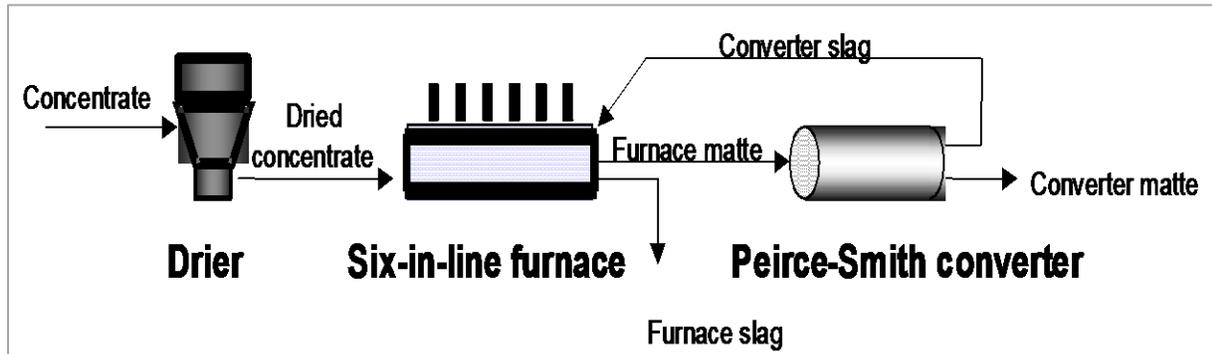
A simple representation of **conventional matte-smelting process** is shown in Figure 17.

¹⁹ <http://www.marketwired.com/press-release/lionore-approves-activoxr-refinery-and-dms-plant-at-tati-nickel-for-620-million-tsx-lim-607226.htm>

²⁰ http://www.ide.go.jp/English/Data/Africa_file/Company/botsuwana01.html

²¹ <http://www.mmegi.bw/index.php?aid=64014&dir=2016/october/21>

Figure 17: Schematic representation of a typical platinum smelting process



Source: Mintek

The electrical power consumption in the furnace is approximately 600 to 1100 kWh per tonne of concentrate, but depends on the nature and grade of the material being treated, as well as the operating conditions in the furnace. Electrical power accounts for approximately 40% of the direct smelting costs (Mintek, undated). During the converting process, air is blown into the molten matte, over a period of a few hours, in order to remove much of the iron and sulphur by oxidation. The converters in operation at present are of the Peirce-Smith type. The converter matte is usually milled prior to treatment in the base-metal refinery, where the copper and nickel are extracted by a sulphuric-acid leaching route. The matte is treated hydrometallurgically to separate the base metals from the precious metals. In most plants, the leach residue makes up the high-grade PGM concentrate that is provided to the precious metals refinery for final separation of the pure precious metals.

PGM recovery is typically about 85% in the concentration stage, 95 to 98% in smelting, and 99% in refining. During each separation stage of the process, there is an increase in the concentration of PGMs – about 30:1 in the concentrator, about 10:1 in the furnace, about 3:1 in the converter, and about 200:1 in the base-metals refinery. For South African producers, the approximate distribution of the operating costs for each stage is Mining (72%), Concentrating (10%), Smelting (9%) and Refining (9%). This is in line with Engelbrecht (2012) who argues that the associated costs for PGM processing as a percentage to total costs are mining (65-75%), milling and flotation (9-12), smelting and converting (6%), base metal refining (7) and precious metal refining (4-5%). An overview of beneficiation process of different South African companies is discussed in turn as follows:

Amplats

Amplats has two smelter plants. The largest is the Waterval Smelter at the Rustenburg Section, having furnaces and converters. The other is the Mortimer Smelter at the Union Section, which has one furnace (used primarily for smelting UG2 concentrates) but no converters.

The first electric furnace installation for platinum matte smelting was commissioned in 1969 whereas a second furnace was installed in the early 1970s. During the 1990s, most of the smelter was upgraded to lower the cost of smelting. The gas produced in the Peirce-Smith converters during blowing is rich in SO₂ (4 – 6%) and is routed to the single-contact-absorption sulphuric acid plant. PGMs are processed directly in a precious metals refinery, without the need to first pass through a base metals refinery.

Impala Platinum

Impala has four rectangular six-in-line submerged-arc furnaces, which requires a high operating temperature of 1460°C for slag and 1260°C for matte. The converter matte from the smelter is granulated and supplied as the feedstock for the Impala Refineries. Impala's Base Metals Refinery uses Sherritt Gordon ammonia leach technology.

Lonmin Platinum

Operations at the Western Platinum Smelter commenced in December 1971 with the commissioning of a 7.5 MVA Merensky six-in-line furnace which has been subsequently upgraded to 10 MVA.

Separate smelting plants were erected for treating UG2 concentrate, but UG2 furnace matte is combined with Merensky furnace matte for converter operation. UG2 concentrate is smelted in a circular three-electrode furnace with a higher power flux than is used in the Merensky furnace. A higher than usual smelting temperature is used.

All the converter matte is processed at the base-metal refinery, using Sherritt Gordon technology from Canada, to produce nickel sulphate crystals, pure copper cathodes, and a high-grade PGM concentrate. The capacity of the BMR was expanded in 1991 to be able to treat 54 tonnes of converter matte per day (Mintek, undated).

Northam

Northam's first smelting was carried out in August 1992, with first production in 1993. It uses a very conventional smelting process. Concentrate is dried in a flash drier, and the dry feed is pneumatically fed to the furnace. The six-in-line furnace, supplied by Davy, is rated at 16.5 MVA (15 megawatt (MW)), with a normal operating range between 11 and 12 MW. The smelter produces about 360 tons per month of converter matte (Mintek, undated).

In the first leaching stage, nickel is removed as a sulphate. The PGM concentrate is removed as the residue from a pressure leaching stage. Finally, copper is removed by electrowinning. The PGM concentrate is refined by Heraeus in Germany.

6. FINDINGS OF THE SURVEY

6.1 Platinum Group Metals

Anglo American Zimbabwe has divested from other business areas and invested the proceeds from the disposed assets to the development of Unki, and were continuing to receive additional resources and support from the parent company. Unki Platinum mine was commissioned in 2009, and was on a production ramp up which saw it producing about 75 000 Pt Oz metal in concentrate in 2016, with an employment capacity of 1200 people.

Following the Government of Zimbabwe's imposition of a 15% tax on sale of unprocessed concentrates in 2014, and its subsequent suspension until January 2018, Anglo American made a decision to divert smelter equipment that had originally been bought for South Africa to Zimbabwe. By mid-October the US\$63 million Smelter project had reached a 60% completion level. A 12MVA electric furnace would be installed with a capacity to treat approximately 68 000 tonnes of concentrates producing about 15 000 tonnes of matte per month. It was estimated that an additional 50 people would be employed to operate the Smelter.

On the issue of refining the matte, AACZ were of the opinion that, due to lack of economies of scale, they preferred that a SADC-wide perspective should be adopted, allowing them to continue to make use of their parent company's facilities in South Africa. They would also consider using any refining facilities available in Zimbabwe provided these were on the same or better commercial terms as those provided by Amplats in South Africa.

Their submission was that consideration should be given to the fact that the mining business required long planning times, hence the Government should allow progressive investment and development of beneficiation facilities along the value chain over a realistic time scale, rather than imposing a tax on unprocessed concentrates or matte at once.

The challenges faced included;

- a. high electricity tariffs
- b. Shortage of foreign currency which was exacerbated by the increase in foreign currency retention by the Reserve Bank of Zimbabwe from 50% to 80%, leaving the producers with only 20% of their foreign currency receipts.
- c. Policy inconsistency and predictability particularly with respect to right of tenure and indigenization law. There was a need to enact a law incorporating the 75% local spent compliance route that had been announced by Government.

6.2 Nickel and Copper

The main producers of Nickel and Copper in the country are Bindura Nickel Corporation, which started operations in 1966 under the ownership of Anglo American Corporation and the PGM producers. At its peak, BNC comprised four underground mines, namely Epoch in Matebeleland South, Trojan and Madziwa mines in Mashonaland Central and Shangani mine in Matebeleland North as well as Bindura Smelter and Refinery Complex adjacent to Trojan mine. At the time of reporting, Epoch and Madziwa mines were closed due to depleted reserves while Shangani was on care and maintenance due to low commodity prices. The Hunter's Road opencast prospect in the Midlands was not developed, and remained in that state to date. Ore from the mines was concentrated by crushing, milling and flotation from a grade of 0.5 -2% Ni to a concentrate of approximately 11% Ni.

The Smelter and Refinery operations were discontinued in the early 2000's. Plans were subsequently made to resuscitate the Smelter and by October 2017, the Smelter was reported to have reached 83% completion level. Notably the concentrate dryer, conveyor structures, the six electrode furnace, the aisle crane and a converter had been renewed.

BNC believed that smelting and refining operations would be successful in an environment where;

- The electricity tariffs were lower (3 - 5 cents per kilowatt hour (c/kWh)) than current level of 9.86c/kwh, with the proviso that as the commodity prices varied, so would the tariff under an agreed formula. This would essentially be a commodity price linked electricity tariff.
- The existing capacity of the Smelter at 160 kt/annum of concentrate feed and the refinery at 15 kt/annum of Nickel cathode was not filled. Perhaps this could be achieved through a Joint Venture with local PGM producers who did not have refining facilities.
- A package of incentives such as those applicable to SEZs was provided by the Government.

6.3 Ferrochrome

The Chrome industry had a number of players, including small scale miners, with two main export products, chrome ore/concentrates and ferrochrome alloy. The main producers of ferrochrome alloy, however, were Zimasco with its Smelter complex in Kwekwe, and Afrochine with its smelting facilities in Makwiro near Chegutu. Although traditionally one of the main producers of ferrochrome alloy, Zimbabwe Alloys' smelting capacity had dropped significantly. However, it remained the second largest player in terms of mineral resources held.

6.3.1 Zimasco

Zimasco owned five (5) electric furnaces and were operating two (2) while leasing three (3) to Portnex of South Africa. The chrome ore concentrate feed to the two furnaces amounted to 20kt per month, while another 20kt of chrome ore concentrate was exported unprocessed. They maintained a relationship with small scale miners with whom they had tribute agreements to mine Zimasco claims and sell the ore to Zimasco. The quality of chrome ore feed into the Smelter was 40% Cr₂O₃ with a Cr:Fe ratio of 2.25:1, while that of washed concentrate feed was 48% Cr₂O₃ with Cr:Fe ratio of 2:1. The quality specification of Cr in the High Carbon Ferrochrome alloy product was at least 58% with a maximum Carbon content of 6-7%.

Zimasco's future plans included the construction of a second slag retreatment plant at a cost of \$6 million scheduled for the year 2018, and the construction of a fines agglomeration plant at a budgeted cost of US\$20 million scheduled for 2019. The long-term goal was to ensure that all its concentrates were smelted into ferrochrome alloy which had the benefits of generating more foreign currency and developing skilled manpower.

At operational level, Zimasco faced the challenges listed below;

- there was a need for extensive exploration to establish more reserves, especially less friable ore
- a more productive method of mining ore from the narrow chromite rich seams was required. Assistance from Government was necessary.
- Huge capital costs, especially for the smelting of fines generated by friable ore.
- Input costs (local Real-time gross settlement (RTGS) based) were ever rising due to foreign currency shortages. Logistical costs were US\$100 - US\$120 per tonne of product shipped to China, which was not competitive.
- Electricity costs constituted about 40% of the company's operational budget, which was rather high. They preferred a tariff reduction from 6.7 to 4 c/kWh.
- uncertainty of chrome ore exports. Prefer indexing of smelted alloy: unprocessed chrome ore export.

At a national policy level, Zimasco recommended that

- there be investment incentives such as National Project Status for capital projects
- an increase in the foreign currency retained by the exporter from 20% to at least 50%.
- the introduction of a lower electricity tariff which could be linked to commodity prices.
- the Government should clarify by way of enacting a law, its announcement on 75% local spent in lieu of 51% share ownership for indigenization compliance.

- a regional initiative to approach beneficiation in a co-ordinated manner, rather than to have South Africa exporting unprocessed chrome ore concentrates when Zimbabwe, a smaller player, bans same.
- A national initiative to mobilise the iron ore, coal, nickel, ferrochrome and manganese resources in the country to beneficiate them and value add to produce stainless steel.

6.3.2 Afrochine

Afrochine is a subsidiary of the Tsingshan Group, a Chinese company that manufactured 6 million tonnes of stainless steel per year. Afrochine was established in 2012, and it commissioned three electric furnaces each of capacity 16.5MW in 2014 at an investment of US\$60 million. They were smelting 30 000 tonnes of chrome ore per month, producing about 9 000 tonnes per month of ferrochrome alloy. They also operated two spiral washing plants, one in Darwendale and another in Shurugwi valley. A total of 500 people was employed.

The company had plans to expand by installing five (5) similar sized furnaces and increase ferrochrome exports to their parent company in China. This second expansion phase was budgeted to cost US\$100 million. It was noted that Tsingshan Stainless Steel group purchased ferrochrome from Afrochine at the same price as other independent suppliers.

The main challenges experienced by Afrochine were

- shortage of chrome ore which they attributed to a lack of adequate high grade resources and claims. This led them to procure chrome ore concentrates from independent miners and also to enter into a tribute arrangement with Zimalloys. Since the lifting of the ban on export of chrome ore, however, independent miners preferred to export directly and receive foreign currency.
- High logistics costs of US\$100 per tonne of alloy shipped to China. 80% of this charge was due to road freight arising from poor availability of rail facilities.
- Shortage of foreign currency caused mainly by the 80:20 retention ratio between RBZ:Exporter. This was accentuated by the fact that most of the spares were imported, requiring forex.

Afrochine recommended that

- Government should enforce the use it or lose it policy with respect to resource claims and preferentially allocate to producers who had access to smelting and value addition facilities.
- Exporting of chrome ore should be restricted to only those situations when available smelting capacity was exhausted. This would promote beneficiation and value addition. **They preferred that the ban on exports be re-introduced.**

6.4 Gold

6.4.1 Fidelity Printers and Refiners

Fidelity Printers and Refiners (FPR) have the mandate to mobilize all gold produced in Zimbabwe, refine it and export or sell to local jewellers.

FPR were administering the Gold Fund, which was a loan facility introduced by the Reserve Bank of Zimbabwe initially for small scale and artisanal miners but had been opened up to large scale miners too. It was targeted at those with track record of delivery. A three year payment period applied at a 10% interest rate, and collateral security in the form of fixed assets was required.

FPR had a refining capacity of 50 tpa working 8 hour shifts for 4 days a week, and had the potential to reach 100 tpa at full capacity. Bullion received typically contained 85% Au and 12% Ag. It was refining gold delivered at as low as 85% purity to achieve 99.5% purity which was sold to Randgold refinery in South Africa. Additional and more advanced refining equipment had been sourced and was being commissioned.

Payments for gold deliveries were made on the basis of the London Bullion Market Association (LBMA) price plus 10%. Small scale and artisanal miners were paid in cash and on the spot once quality had been ascertained by gravity methods. They were paid 60% in United States Dollar (USD) notes and the balance of 40% in Bond notes plus the 2.5% export incentive.

FPR was meeting the LBMA requirements and exceeding the minimum tonnage of 10 tonnes per year but had not yet been granted membership. The disadvantage was that FPR gold had to be sold to end users through another accredited laboratory in this case Randgold refinery.

Policy issues

- Differential treatment of producers in the same industry had a negative impact on the large producers, eg. forex incentives more favourable for small scale and artisanal miners, royalties 5% for large scale miners and 1% for small scale miners
- Develop local consumer market as well as the export markets regionally and internationally.
- Improve the Ease of Doing business by ensuring that investors are able to repatriate dividends in order to attract investment
- Introduce incentives to attract investment for beneficiation and value addition facilities eg. jewellery manufacture, etc.
- Create security of investment by ensuring policy consistency and predictability. Avoid seemingly arbitrary policy changes

- Decriminalise possession of gold within the country so that producers and intermediate dealers are free to travel and submit their gold to FPR, which is supposed to buy on a 'no questions asked' basis.

6.5 Diamonds

6.5.1 Diamond Beneficiation Association (DBA)

After mining and concentration of diamonds by DMS and or sorting by X-ray technology, the rough diamonds are cleaned via a process of deep boiling, acidification, ultra sound, and steam cleaning. Cutting and polishing follows in the value chain, prior to jewellery manufacture, retailing and sales.

They noted that the National trade policy, Industrial Development Policy (IDP) and the ZIMASSET policies support mineral beneficiation and value addition in Zimbabwe.

However, they noted and stressed that whilst policies are in place there is no strategy to support beneficiation and value addition.

The major issue the association is concerned with is the lack of skills development in the sector. They pointed out that government needs to support beneficiation of the precious stones through establishment of Centres of excellence (gemology Centre) as education is the responsibility of the government hence the government should take a leading role in the training of gemologist and diamond evaluators.

Only one private sector player is training gemologist (Zimbabwe Diamond Education) in Mt Hampden

Out of 12 registered and licensed polishers and cutters only 4 are operational due mainly to lack of feedstock

In order to take the beneficiation agenda further they proposed that:

- Government sets up a gemology Centre;
- Review the tender system towards a toll processing(manufacturing) where diamond mining firms engage cutting and polishing firms to semi process diamonds eg through deep boiling process and cut and polish for a fee (toll fees);
- Need for clarity in the diamond tender system as well as the overall policy environment
- Invest in R&D for viable beneficiation and value addition; and
- Review the high cost of licenses USD 20,000 per 10 years not viable compared to USD 150 per 5 years in Botswana and R5000 per 5 years in South Africa. This results in loss of competitiveness.

6.6 Coal and Coal Bed Methane Gas

Zambezi Gas Colliery

Zambezi Gas commenced mining coal in the Entuba coalfield of the Hwange area in 2015. They were producing 65 000 tpm of made up mainly of steam coal (95%) sold to the power generation, cement manufacturing, sugar and agricultural industries; and coking coal (5%) for coke making by local coking plants. They were engaged in exploration to establish more reserves, and were pursuing plans to construct a coke oven battery in partnership with Chinese chrome smelting company that was operating in the Gweru area.

Zambezi Gas had conducted some exploration work for coal bed methane gas around 2005 but had run out of resources and discontinued. A Government co-ordinated effort was recommended in order to unlock the value of coal bed methane gas deposits in the country.

Beneficiation and Value addition of coal, iron ore, chrome, nickel and manganese resources in the country to produce stainless was recommended.

Figure 18: A crude tar and crude benzole refinery in the Midlands



Beneficiation and value addition of products from coal: refining of by-products from conversion of coal to coke involves refining crude benzole to benzene, toluene & xylene and refining crude tar to creosote, road tar and soft pitch

6.7 Iron and Steel

- Started operating in Zimbabwe in 1996, and usually relies on scrap metal from mines and have been in a strategic relationship with ZISCO steel
- Ever since the collapse of ZISCO steel the firm have been facing challenges in accessing raw materials in the production of steel
- Ferroalloys supply - there are low inventories from the mining sector and output had declined
- Firm used to employ 2500 people but currently employing +/- 500 employees
- Firm have invested in a s steel plant and have integrated a coal mine to ensure reliable supply of coal
- Steel makers have an installed capacity to produce 7000 tonnes of steel per month, however currently operating between 1000 and 1200 tonnes per month.
- Main products are suited for the cottage industry window sections
- Currently facing foreign currency challenges to import raw materials
- They relied on Clay Products from Bulawayo for refractories
- The firm have a 400 tonne foundry which is currently under utilised
- Indicated that banks were not being supportive in the industry's thrust to value add
- Local large mining firms were not being supportive of the iron and steel industry, preferring foreign suppliers over local suppliers due to influence from major foreign shareholders
- With regards to standards of their products steelmakers highlighted that they are certified by the British standards board
- With regards to access to regional markets they highlighted that due to the low ease of doing business in Zimbabwe they have not been cost effective to compete with regional competitors (costs build up high in Zimbabwe compared to regional countries)
- Other challenges include high borrowing costs, lack of industry support ZISCO and NRZ currently exporting scrap metal outside the country
- There was need to enforce quality standards in the country since there had been an influx of poor quality products accompanied by low prices made from poor quality inputs
- Noted that the supply of electricity was satisfactory, there was need however to address the electricity pricing matrix
- The reliance by mining houses on third parties/middlemen in the supply or procurement of materials had been an obstacle in strengthening linkages between mine houses and manufacturers
- With regards to skill, the iron and steel manufacturing industry was not short of skills, Zimbabwe has an abundant technical skills base which is supporting other countries
- One major challenge in promoting regional marketing of steel was that the MMCZ classified it as a mineral hence faces a lot of bureaucracy when it comes to exporting yet

technically it was not a mineral. The export process needs approval and export permits from MMCZ

- 30% of the firm's steel production was supplied to equipment manufacturers for the agriculture sector
- The firm highlighted that whilst mining houses faced challenges in the disposal of used oil Steelmakers was a ready market for the used oil which they highlighted was a key raw material in the steel making process, however the presence of middlemen was a hindrance as most of the mine houses preferred to transact through agencies and middlemen.

6.8 Other stakeholders

6.8.1 Minerals Marketing Corporation of Zimbabwe (MMCZ)

The main functions of the MMCZ are

- To act as the sole marketing and selling agent for all minerals (except Au and Ag);
- To investigate or cause to be investigated marketing conditions, whether inside or outside Zimbabwe, for minerals in general or for any particular mineral;
- To purchase and acquire any minerals for its own account and to sell or dispose of such minerals;
- To encourage the local beneficiation and utilization of any minerals;
- To advise the Minister on all matters connected with the marketing of minerals; and
- To do all things which by this Act or any other enactment are required to be done by the Corporation.
- They noted that although there was a statutory instrument which allocates 10% for local value addition, sometimes Government granted exemptions to producers to forego the allocation of product, which often left the local manufacturer without feed material.
- Government should provide and/or promote training in gemology.
- For granite a 10% allocation for local value addition has been legislated. However, a funding mechanism should be put in place for importation of equipment and machinery for value addition.
- Chrome being a low value high volume commodity attracts high logistics charges, about US\$120 per tonne.

- Exporting of chrome ore fetches US\$100/ t whereas ferrochrome fetches US\$1000/ t (ten times more value)
- Given that South Africa is the largest exporter of chrome ore concentrates (mainly to China the largest consumer), there is a need to adopt a regional approach towards beneficiation of the chrome ore concentrates
- Small scale miners need capacity for mining and quality control. Apple Bridge was formed for the purpose of consolidating product from small scale miners and create economies of scale.
- 15% ban on unprocessed PGM concentrates was a good policy, however, it should have been given a more realistic timeframe. Shipment costs for PGM concentrates at about US\$110/t including moisture are not justifiable, hence need for further beneficiation.
- The Kell process strategy needed to be clarified, so that PGM producers who plan to invest in conventional technology could do so with confidence that a Government directive would not be announced rendering their facilities redundant.
- The 20% forex retention directive by the Reserve Bank had created a shortage of foreign currency for exporters who needed more to import equipment and machinery spares.
- There was a need to reduce the cost of doing business in Zimbabwe by
 - ensuring that there was policy consistency and hence reduced country risk
 - reducing the number and quantum of various taxes and levies applicable to different mineral commodities.

6.8.2 Institute of Mining Research (IMR)

- Highlighted that Beneficiation was a subset of value addition in the mining sector with Value per unit of mineral increasing at every stage
- Fidelity refinery currently refining to 99.5% purity hence making it eligible to trade on the London Bullion market
- The country has limited capacity to value add mineral products into manufactured products e.g Aurex Jewellery
- Diamond beneficiation was taking place but it was basic processing and was limited due to inadequate diamond allocation from the mining houses
- Furthermore not enough diamonds being allocated to support diamond cutting and polishing training
- Chrome beneficiation currently taking place processing chrome ore into ferrochrome

- Zimplats currently refurbishing its base metal refinery
- BNC also refurbishing its smelter
- The country was currently at a low stage of mineral beneficiation
- Government was pushing mineral beneficiation but did not have a beneficiation strategy
- There was need for a beneficiation policy that was between mining policy and the industrial policy
- In addition there was need for an act of parliament to regularise and operationalise the beneficiation policy
- In addition, beneficiation requires a lot of money funding for indicative costs for required smelter, base and precious metal refinery ~US\$1billion based on the optimal size for a refinery. Capital costs are prohibitive
- However, these optimum size facilities also required large and consistent power supply, which was costly in Zimbabwe
- Beneficiation requires high skill, and there are not enough skills to support the beneficiations thrust
- Need adequate and reliable bulk water supply for cooling processes
- Transport - there was need to resuscitate NRZ to ensure bulk movement of raw material to a central point (usually the refinery or smelter)
- There was need for a phased approach towards mineral beneficiation, short term goals focusing on mineral smelting, Medium goals focusing on base metal refining and Long-term goals focusing on precious metal refining
- Base metal refinery could be achieved, since there was a base metal refinery at Zimplats and there was a base metal refinery at BNC
- With regards to incentives to support the beneficiation process there is need for a carrot and stick approach
- Carrot - tax incentives, foreign currency allocation prioritisation for importation of equipment for use in the value addition process, provision of land @ cheaper rates
- Stick - export taxes for certain minerals where beneficiation is easier
- There was need to address barriers and constraints
 - address power supply by increasing permits for Independent Power Producers (IPPs)
 - revisit the investment policy especially the Indigenisation and Economic Empowerment (IEE) Act on infrastructure investment
 - convince skills abroad to come and work in Zimbabwe e.g. through high remuneration
 - invest in R&D to improve mineral beneficiation technology, this should be government led or led by the academia, there is need to establish R&D section aimed at beneficiation and value addition process

- revamp and boost mining production/ output (short term), through promoting new mineral exploration, production of concentrate, production of matte to enjoy economies of scale
- educational institutions need to emphasize science, technology, engineering, mathematics (STEM) skills, it's not about the number of people produced but about the quality of graduate, need to focus more on the hard skills
- skills development should support every stage / entire mineral value chain from exploration to manufacturing.

6.8.3 MineEntra 2017 - Exploring Linkages in the Mining Value Chain

Researchers undertaking the study attended the Mine Entra 2017 in Bulawayo. A summary of the Conference proceedings and the selected interviews conducted with Exhibitors at MineEntra 2017 are summarised in tabular form in Table 11 and 12:

Table 11: Key issues from the Presentations at Mine Entra 2017

Topic	Presenter	Issues of Interest
Keynote address - Exploring Linkages in the Mining Value Chain	Minister of Mines and Mining Development	<ul style="list-style-type: none"> -Recent changes to the indigenisation policy with consideration of compliance through Local Content of inputs - Government's thrust for further beneficiation and value addition in the mineral industry esp. PGM and Base metals - Target revenues from US\$2bn to US\$3bn - Computerised Mining cadastre being developed - Mineral development policy being finalised
Zimbabwe Mining Sector update	Chamber of Mines President	<ul style="list-style-type: none"> - Mineral production statistics and projections -Issues affecting industry include need to finalise mineral development policy, foreign currency shortages, high cost of funds and electricity -Development of Local Content Policy and capacity of local manufacturers to supply the mining industry
Private Sector initiatives for Enhancing Linkages in Mining	Confederation of Zimbabwe Industries President	<ul style="list-style-type: none"> - Promotion of local procurement - Carrot and Stick System recommended, only 11% of supplies in mining industry from local manufacturers -Promotion of local content, an index needed to measure progress - Foundry product consumption research by ZEPARU - Iron and Steel shortage (Min of Industry - ZISCO revival with separate downstream industries - Impact of SI64 on capacity utilization eg. General Belting
Quality and Precision as an Imperative for Local Content Procurement	Buy Zimbabwe CEO	<ul style="list-style-type: none"> - Need to export local products with at least 30% local content -Rating system to be certified in terms of process and product quality i.e ISO9001, SAZ
Enabling Mining Sector Growth through Recapitalising Zimbabwe's Rail Service	National railways of Zimbabwe GM	<ul style="list-style-type: none"> - Recapitalization efforts to raise US\$400m - 50% of rail wagons to be rehabilitation - Target reduction in transportation tariff 6.6 c/t.km to 4.5 c/t.km
The Rebound of Diamond Production in Zimbabwe	Zimbabwe Consolidated Diamond Company CEO	<ul style="list-style-type: none"> - Plans to move from alluvial to conglomerates to kimberlites mining -US80m recapitalization underway

Table 12: Key issues from Interviews with Selected Exhibitors

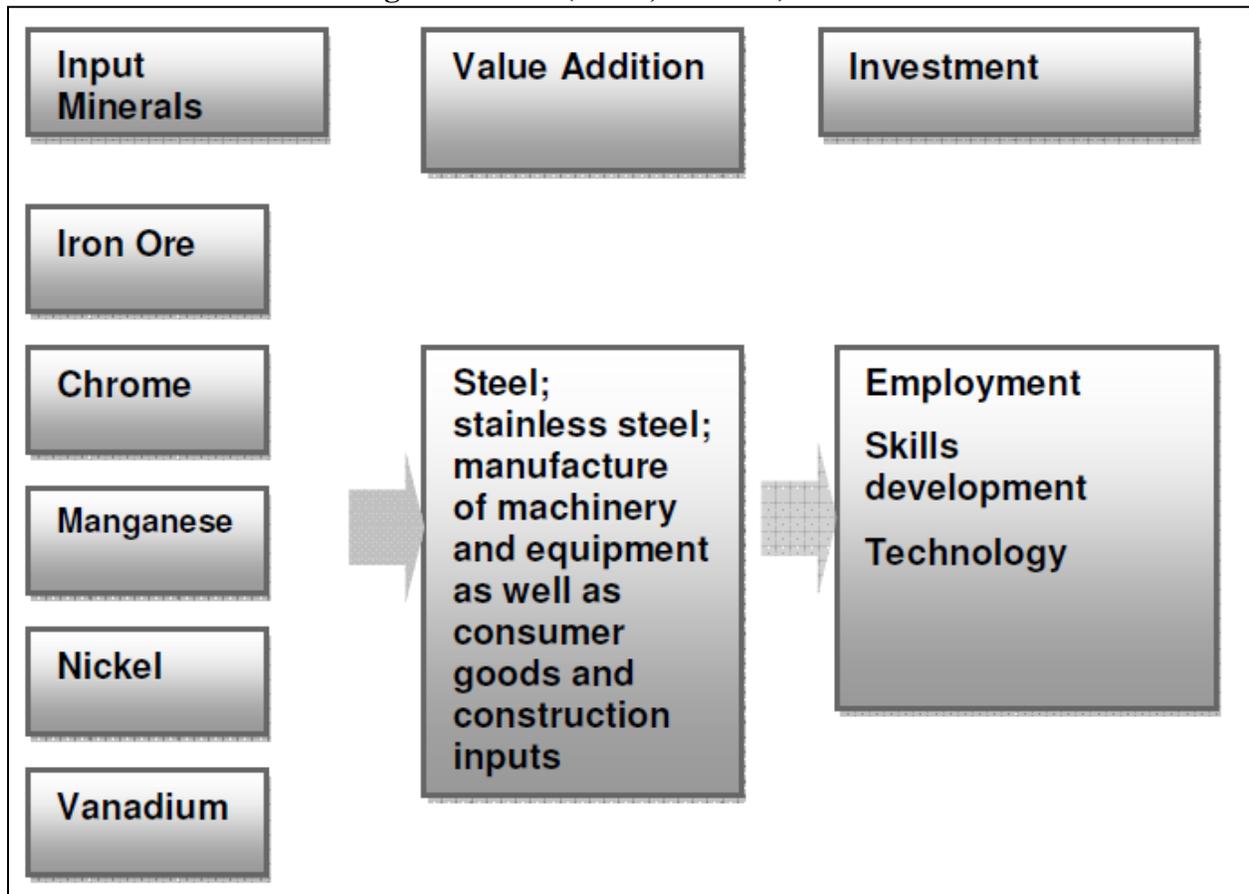
Company and Interviewee	Nature of Business	Extent of Value Addition	Issues of Interest
Shepco Industrial Suppliers	-Supply of Industrial components and equipment	-manufacturing of components in Bulawayo factory	-shortage of foreign currency and cash for procurement of raw materials
Barzem Enterprises (Pvt) Ltd	- Supply of earthmoving equipment and generators	- Service and maintenance of equipment	- Shortage of foreign currency for importing stock - lack of credit facilities due to country risk esp. 2014 to date - skills flight
HPC Africa	- Supply of conveyor belt components	- Service and maintenance of equipment	- shortage of foreign currency to import stock
Midlands Metals	- Supply of foundry products eg. mill balls, hammer mills, manhole covers	- manufacture of mining and processing machinery eg. crushers, mill balls and other mining equipment	- raw materials from local suppliers usually reserved for export -poor availability of iron and steel inputs
ABJ Engineering (Pvt) Ltd	-Supply of crushers, screens, etc	- manufacture of mining and processing machinery eg. crushers, ball mills, stamp mills, liners, shakers, etc	- lack of credit facilities both locally and externally - shortage of cash for certain spares and raw materials - shortage of forex to import drive motors for machinery
Hilmax Engineering -	- Supply of Pneumatic and Hydraulic equipment, power packs, electric drives and controls, eg. conveyors and components	- Installation, Repair and maintenance (Vulcanising,) -conveyor design and manufacture	- Cumbersome Import procedures ie. Delays in procurement of import licences (about 2 weeks) plus inspection by Veritas -Inclusion of certain rubber products under SI64 which are not manufactured in the country eg. hydraulic hoses which have to be imported from Europe - General Belting has limited capacity vs National demand for conveyor belts
Boltgas Pvt Ltd	-Supply of Engineering equipment and spares	- manufacturing conveyor rollers in Zvishavane - cutting and machining of	- cumbersome import regulations - forex shortages for importing raw materials -steel imported as raw material for manufacturing rollers in the

		<p>steel products/spares</p> <p>-Recently acquired a foundry in Byo to manufacture high Cr and Mn mill balls</p> <p>- planning to manufacture street lighting poles</p>	<p>country is charged duty, which makes the locally manufactured rollers uncompetitive compared with 'zero-rated' rollers from SADC. Same challenge applies to 'zero duty rated' SA manufactured mill balls</p>
ACOL Chemicals	- Supply of process chemicals eg. cyanide	-process advice	- foreign currency shortages for importing stock
SMM Instruments	- Supply of process instrumentation eg. Atomic Absorption Spectrometer (AAS)	- equipment service	- foreign currency shortages for importing stock
GML Explosives (formerly Dyno Nobel)	- Supply of explosives to the mining industry	- manufacture and storage of explosives at the Shamwari factory in Kwekwe	- the market is experiencing challenges of purchasing expensive handling licence (\$500) in addition to storage licence (\$500) per annum

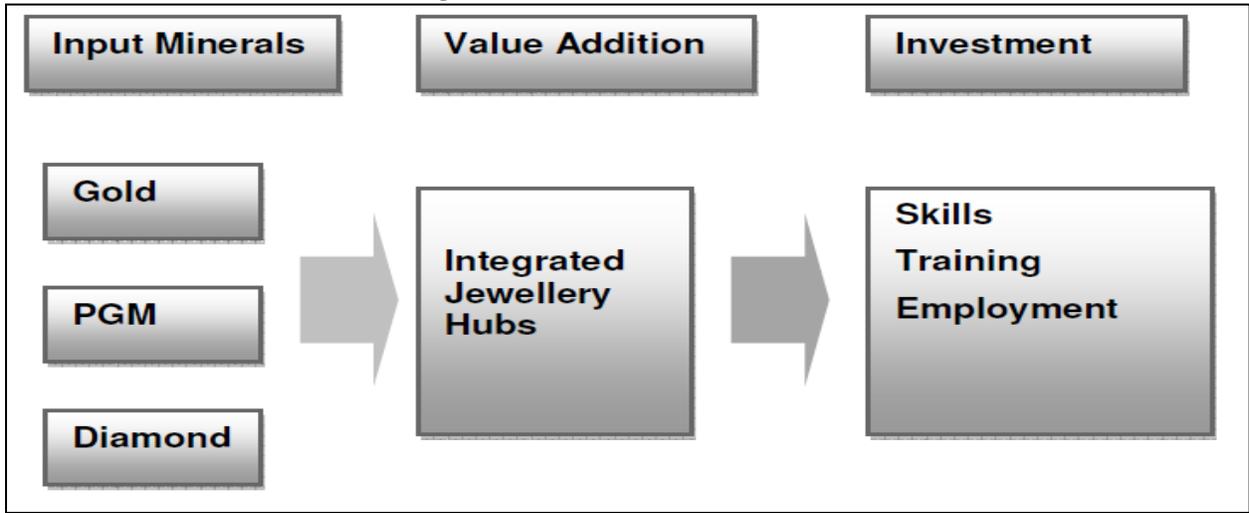
7. POTENTIAL VALUE CHAINS IN THE MINERAL SECTOR

An approach by the Department of Mineral Resources of South Africa has grouped stainless steel to form one main strategic outcome, while precious minerals have also been grouped for their common output.

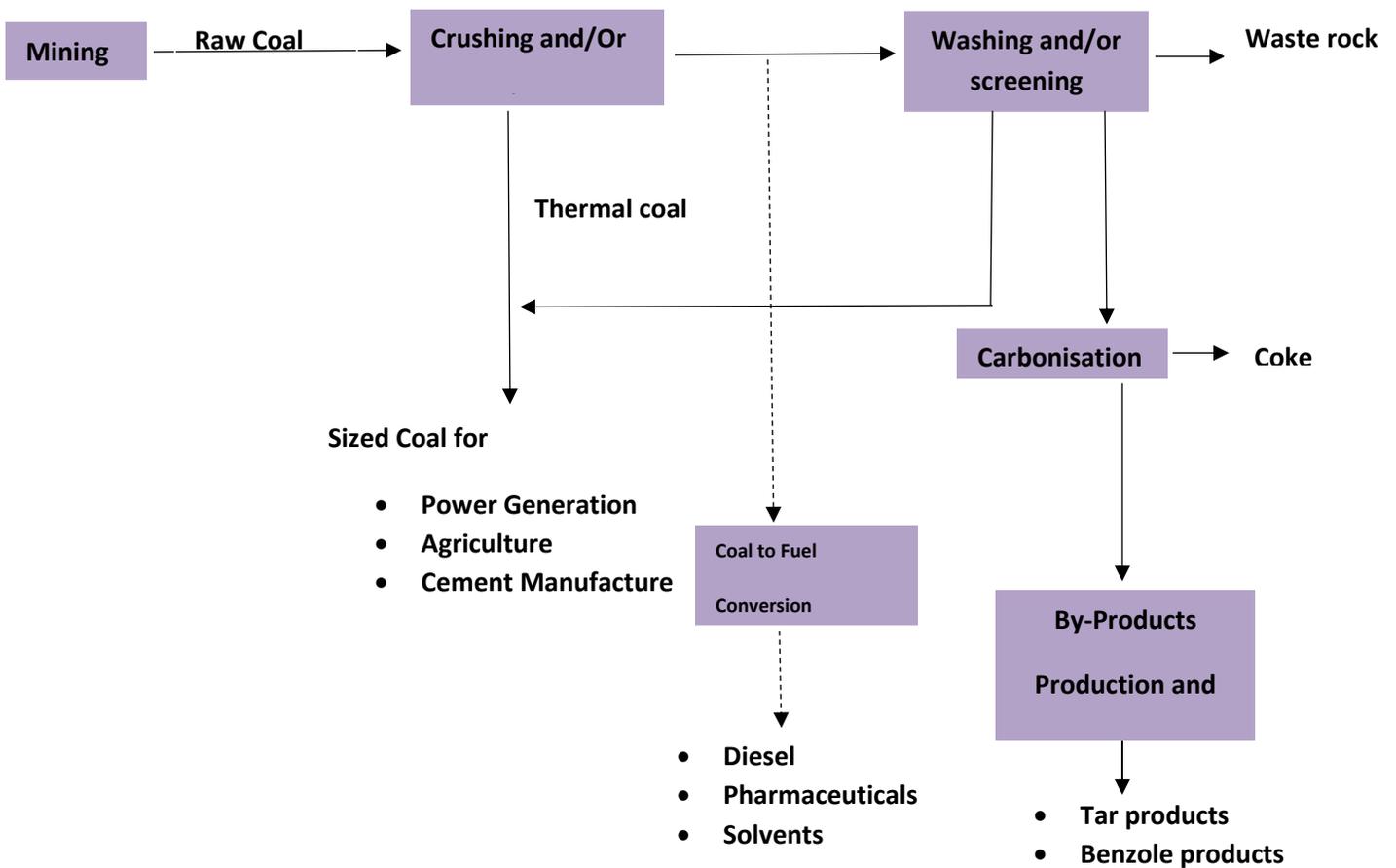
7.1 Iron and Steel Strategic Outcome (DMR, SA 2011)



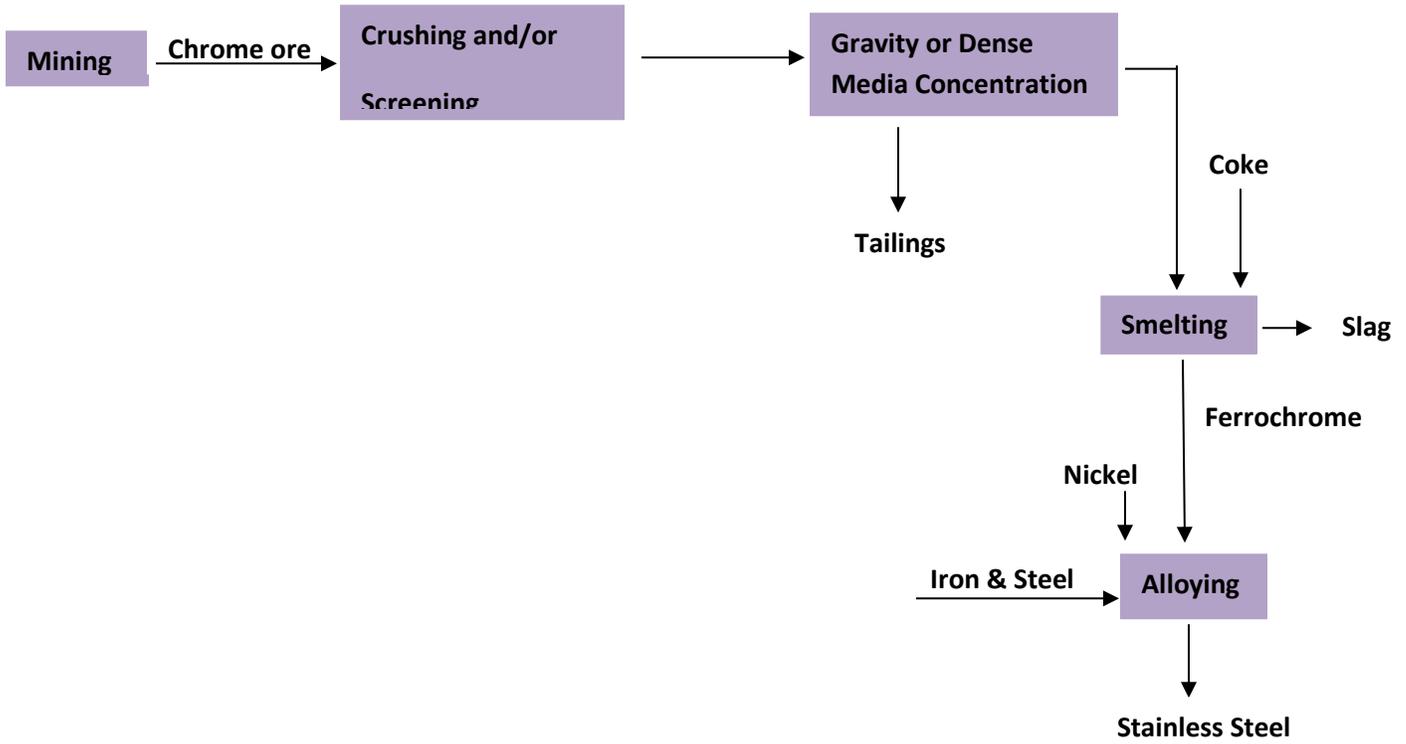
7.2 Precious Minerals Strategic Outcome



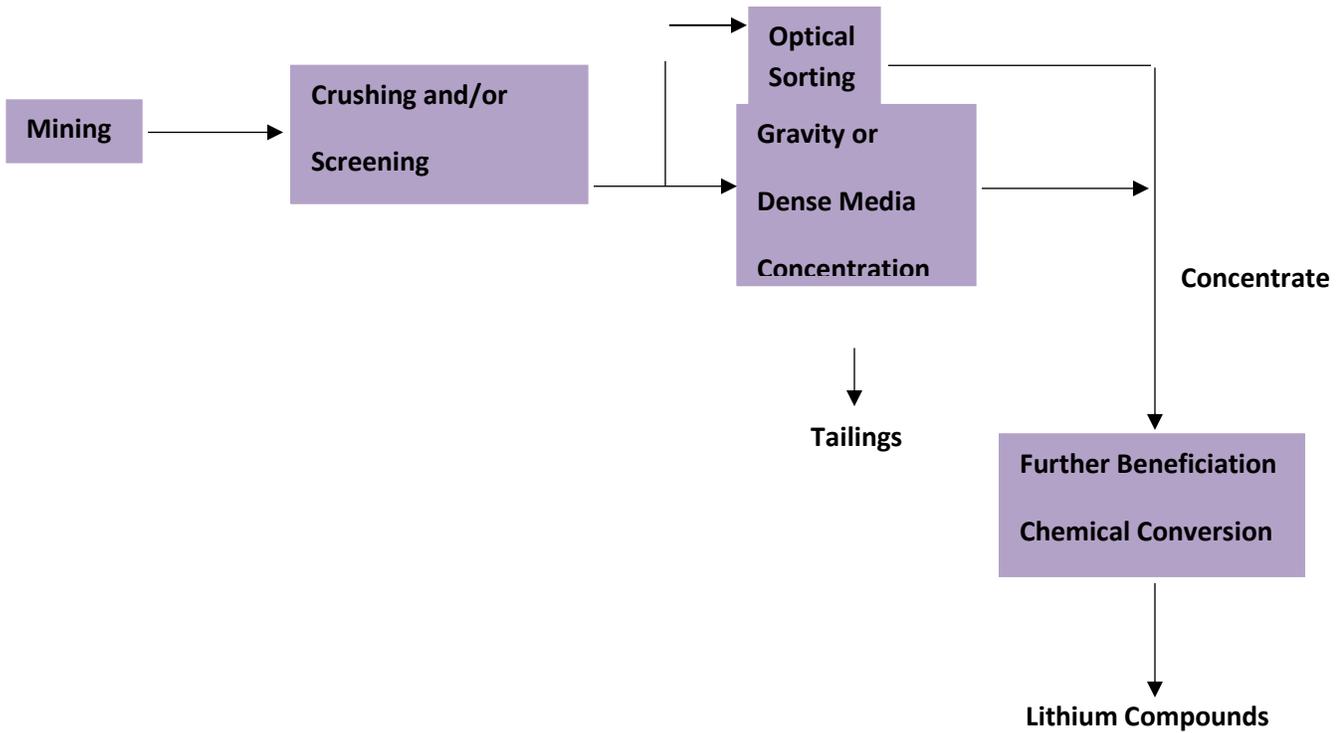
7.3 Coal Beneficiation of Value Addition



7.4 Chrome Beneficiation & Value Addition

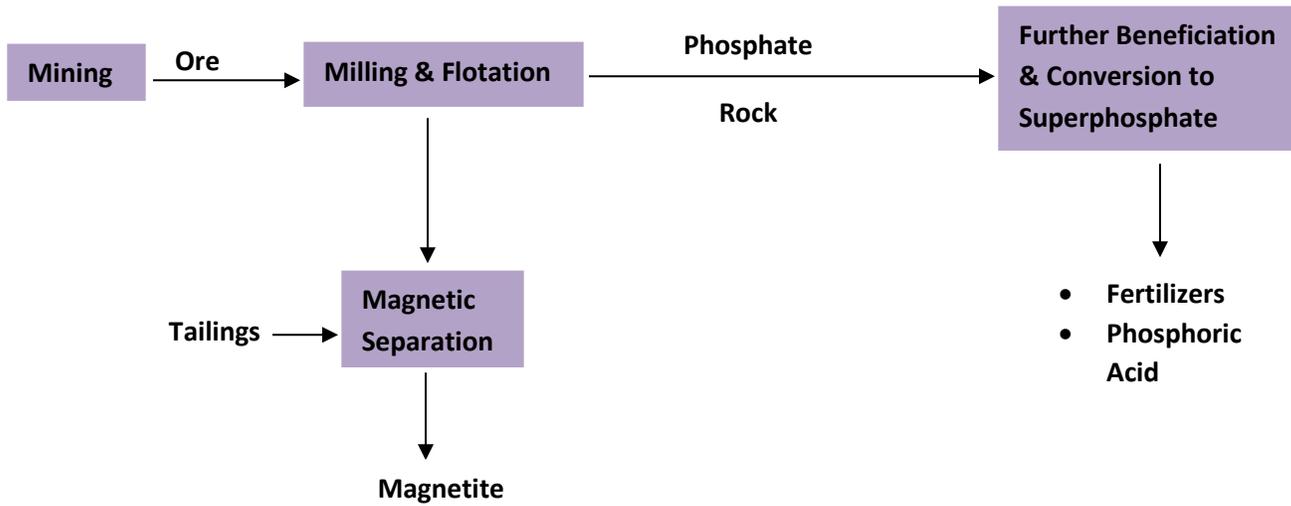


7.5 Lithium Beneficiation & Value Addition

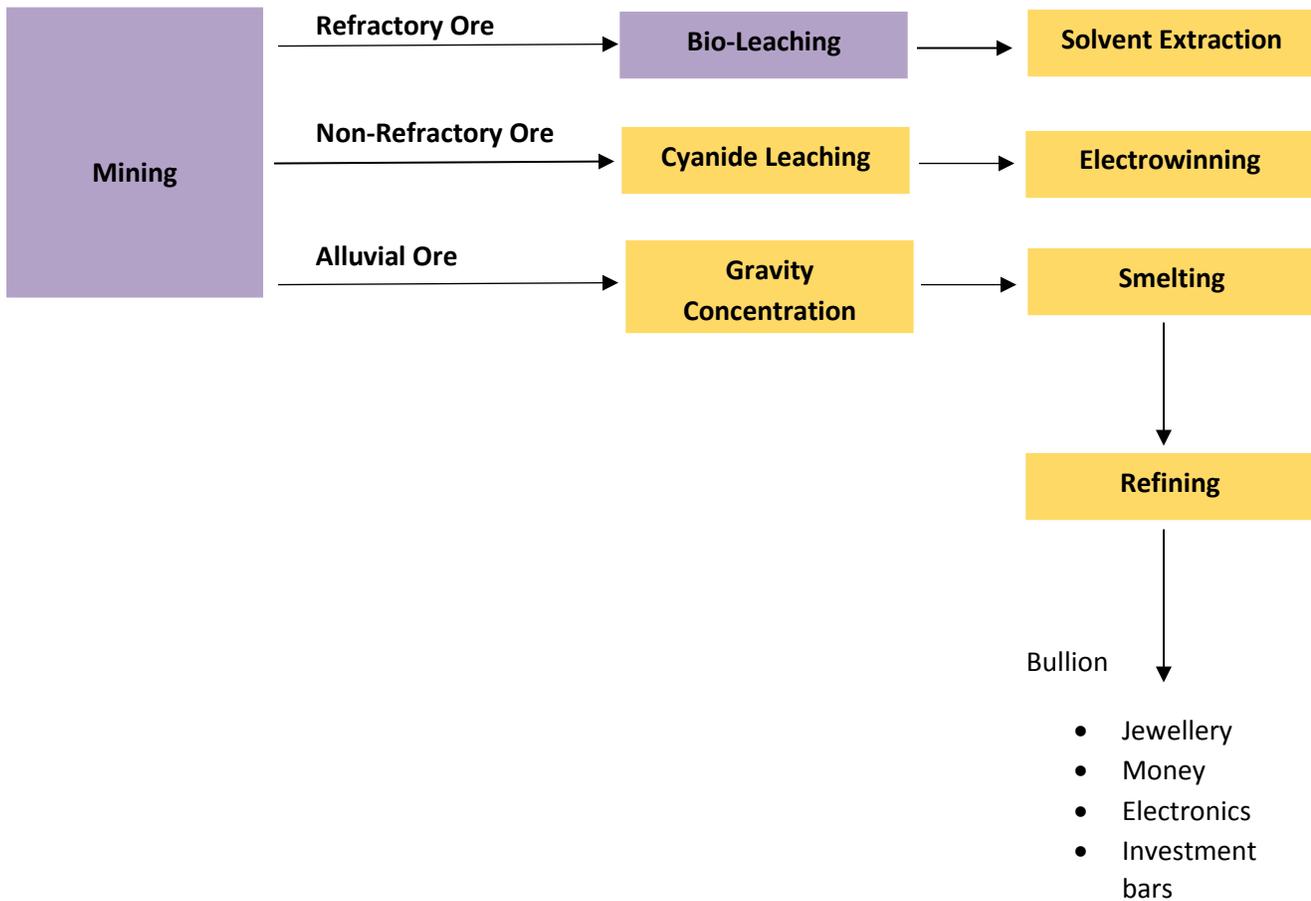


- Batteries
- Pharmaceuticals

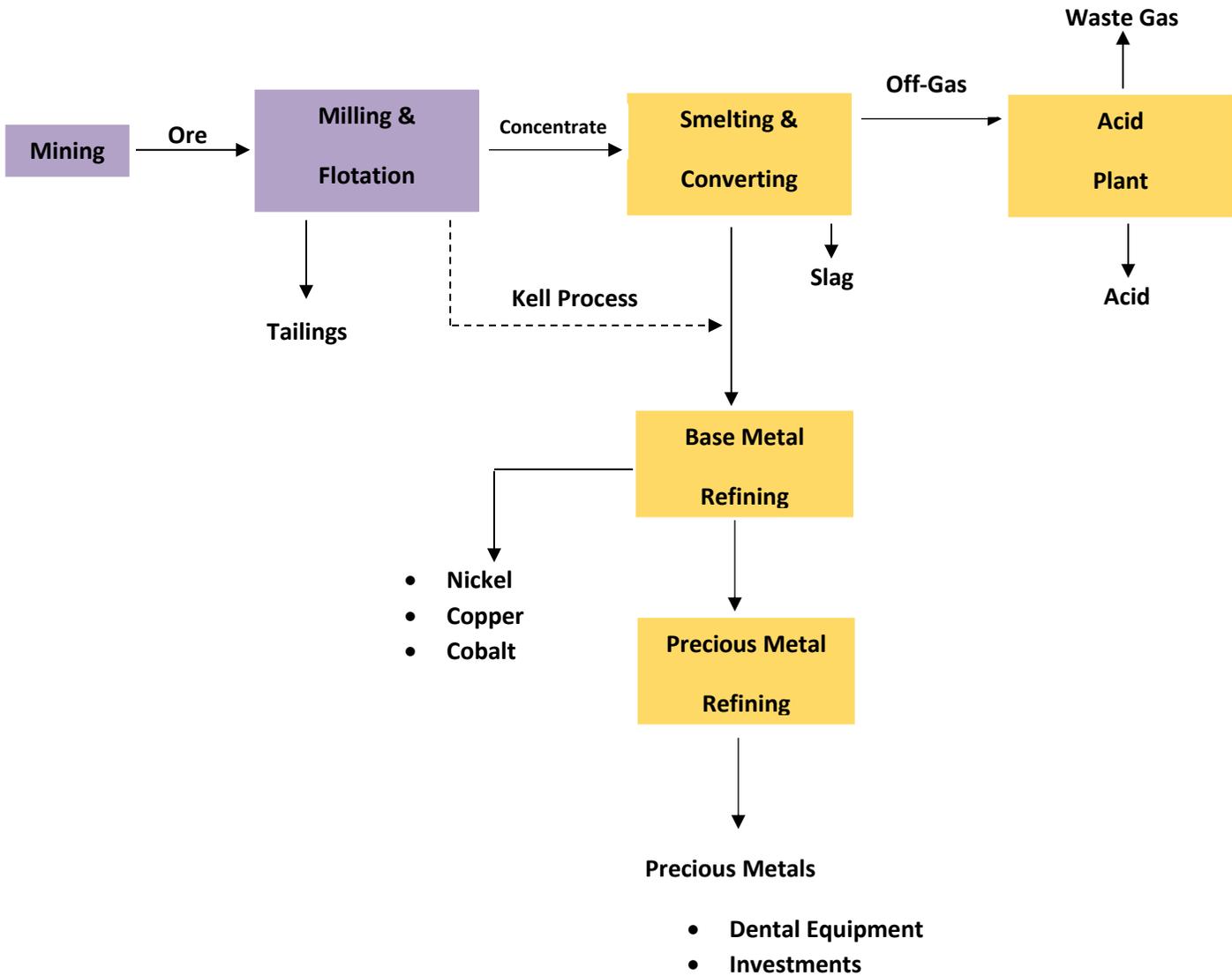
7.6 Phosphate Beneficiation & Value Addition



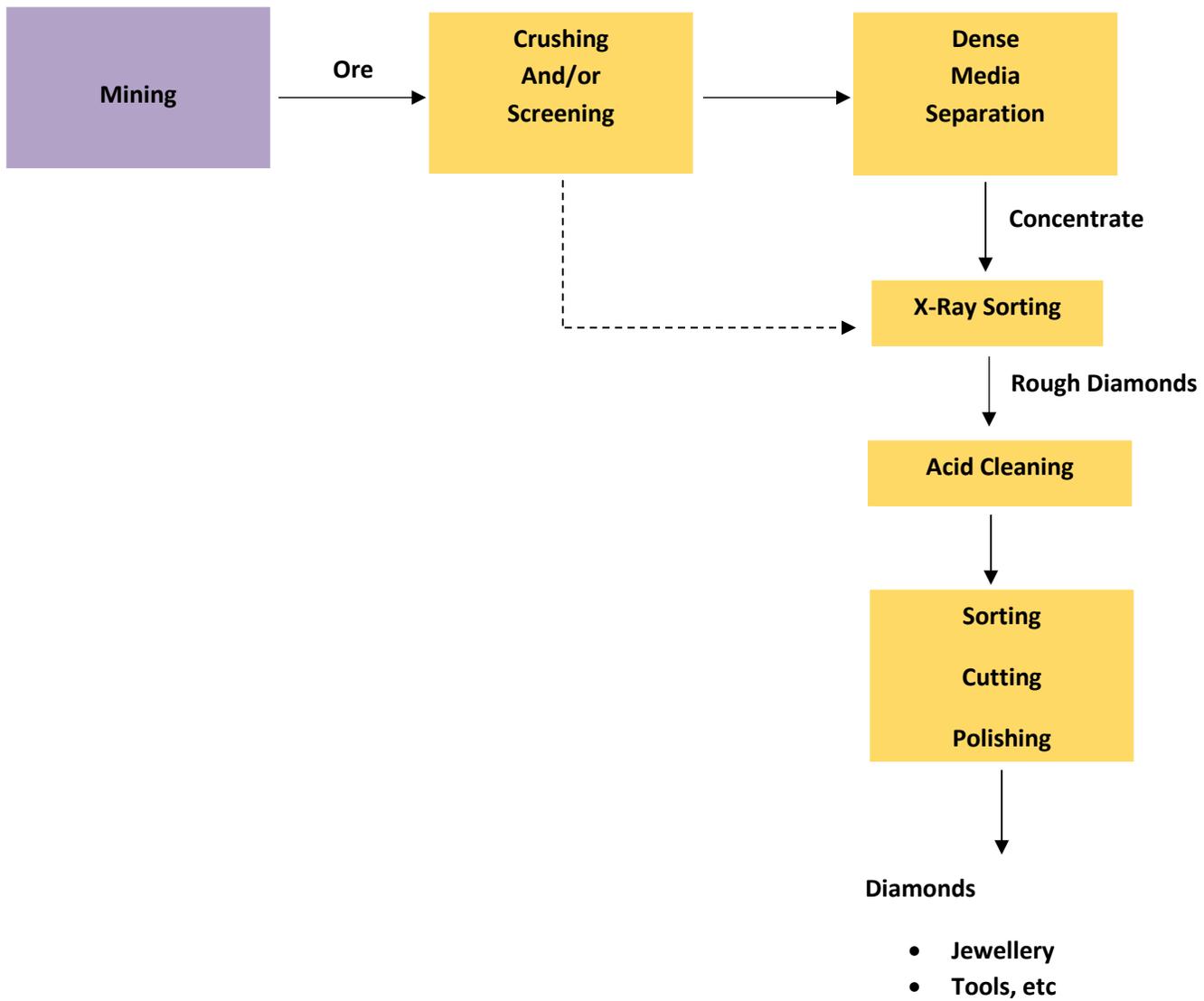
7.7 Gold Beneficiation & Value Addition



7.8 PGMs and Base Metals



7.9 Diamond Beneficiation & Value Addition



8. BENCHMARKING WITH SELECTED REGIONAL MINERAL INDUSTRIES

8.1 Ferrochrome - South Africa

South Africa has the largest deposits of chrome ore in the world (constituting 72% according to USGS and ICDA) and the country's chromite mines are operated by a number of smaller companies that focus on the production of chromite and a few integrated ferrochrome producers, notably the Glencore-Merafe Chrome Venture, Samancor Chrome, and Heric Ferrochrome. The ferrochrome producers are involved in the upstream activities of mining and beneficiation of chromite, as well as the downstream activity of smelting chromite to produce ferrochrome. Although local ferrochrome companies are among the lowest-cost producers in the world mainly because chrome ore is mined as a by-product during the mining of PGMs in the UG2 ore, the slump in commodity prices since 2013 has meant that only four of the seven South African ferrochrome producers are currently operational. Sales of ferrochrome to China, the world's largest importer of South African ferrochrome, are being negatively affected by increased exports of South African chromite, which is enabling the growth of the Chinese ferrochrome industry.

The largest importer of both South African chrome ore and ferrochrome alloy is China. In terms of logistics, South Africa enjoys lower logistics costs than Zimbabwe since the distance to the ports is shorter. In terms of ferrochrome, an alloy of chromium and iron-ore, Racon states that South Africa is the world's second largest producer, as it was surpassed by China in 2012. "Last year, South Africa's ferrochrome production accounted for 33% of the global production compared with China's 36.7%."

For South Africa's ferrochrome producers, the primary problem is the lack of reliable power supply from State-owned power utility Eskom (Racon, 2016). However, this problem appears to have largely been resolved after the commissioning of new power stations.

In general, however, the South African mining sector has undergone a noteworthy transformation from largely exporting raw minerals to the establishment of mineral beneficiation and value addition (manufacturing) facilities. The country continues to improve essential infrastructure, including an extensive transport network of roads, rail, ports and pipelines, information and communications infrastructure. This is backed by a well-developed and efficient financial and banking system, reputable technology and training institutions.

8.2 Diamonds – Botswana

Botswana hosts two of the top ten mines by reserves in the world with Orapa mine topping the list at 151 million carats and Jwaneng mine coming second at 149 million carats. Both belong to

Debswana, the 50:50 Joint venture company owned by De beers and the Botswana Government. In 2016, Botswana produced 20.5 million carats valued at US\$2.8 billion, which revenue exceeds that of the whole Zimbabwean mining industry.

Table 13. SADC Diamond Production 2016

Country	Carats	Value (\$)	\$/ct
Angola	9,021,467	\$1,079,411,359	\$120
Botswana	20,501,000	\$2,845,948,820	\$139
DRC	23,207,443	\$246,700,973	\$11
Lesotho	342,014	\$364,546,093	\$1,066
Namibia	1,717,658	\$914,827,141	\$533
South Africa	8,311,674	\$1,248,912,618	\$150
Tanzania	241,669	\$86,628,689	\$358
Zimbabwe	2,102,873	\$105,143,675	\$50
Total SADC	65,445,799	\$6,892,119,368	\$105
Total World	134,070,686	\$12,400,756,598	\$92

Source: KPCS Public Statistics

SADC countries produced a combined 48.8% of the world's rough diamonds by volume, contributing 55.6% of the value. Zimbabwe's production had decreased to 1.6% by volume and a mere 0.8% by value.

The Jwaneng and Orapa mines were visited during the study and it was noted that they employed dense medium separation and X-ray technology to separate the rough diamonds from rock. Diamond sorting, cleaning, packaging and weighing takes place in an automated Fully-Integrated Sorthouse (FISH) in order to maximise diamond sorting and security. The diamonds are then sold to the Diamond Technology Centre (DTC) Botswana in Gaborone for sorting into different categories before being sold by the DTCB to De Beers who, in turn, sell them to their clients at "sights" in Gaborone.

Thereafter, rough diamonds find their way to cutting and polishing centres where they are sold to manufacturers who produce diamond jewellery destined for the leading consumer markets.

Other diamond mines in Botswana are Letlhakane and Damtsha owned by Debswana, and Karowe mine owned by Petra Diamonds all in the north-western part of the country.

9. BENEFICIATION FACILITIES IN ZIMBABWE: SCOPE AND READINESS OF VARIOUS STAKEHOLDERS

9.1 PGMs and Base Metals

- Bindura Nickel Smelting and Refinery,

The Bindura Smelter was undergoing refurbishment was 83% complete. The concentrate dryer, electric furnace, converter and conveyors had been renewed, with the main outstanding unit being the electrostatic precipitator to trap dust from the off-gases.

The refinery, though on limited care and maintenance, was in a poor state of repair and would need refurbishment.

- The Zimplats Selous Metallurgical Complex (SMC) PGM smelter,

The Zimplats concentrators and smelter were in very good shape and fully operational.

It is worth noting, however, that the adjustment underground mines namely North and South Portal had been left on care and maintenance since 2000 due to uncertainty regarding ground stability, and the lack of a viable method to extract the ore in a safe and sustainable manner.

- Zimplats Base Metal Refinery,

The Zimplats Base Metal Refinery, which was constructed during the BHP Minerals era, was undergoing refurbishment and modification, with the work being scheduled for completion in 2018.

- Mhangura Copper Smelting and Refinery Facilities

The facilities were closed and placed on limited care and maintenance. The Smelter was in a dilapidated state while the refinery tankhouse infrastructure remains solid. However, the rest of the refinery infrastructure needs refurbishment.

- Empress Nickel Refinery,

The Empress Nickel Refinery was placed on care and maintenance after the supply of nickel-copper matte from BCL in Botswana dried up. The refinery facilities need refurbishment.

9.2 Gold

- The Fidelity Printers and Refinery facilities were in a good state and commissioning of new facilities is underway to expand the capacity as well as efficiency.

- Gold mines around the country are equipped with process plants to beneficiate gold prior to selling to FPR.
- However, there are no facilities in the country to treat refractory gold ores

9.3 Ferrochrome

- Chromite smelting facilities (Zimasco, Zimalloys, Afrochine and other smelters) were in serviceable condition although various levels of refurbishment was required for a significant number of them.

9.4 Asbestos

- SMM Asbestos beneficiating facilities have been in operation for several years and had been placed on care and maintenance.

9.5 Iron and Steel

- Zisco Steel blast furnaces and steel mills had reached a state where the cost of refurbishing them might well exceed the cost of constructing new facilities,

9.6 Tin

- Kamativi Smelting facilities were in a poor state of repair and a new smelter would need to be constructed

9.7 Phosphates

- Dorowa Minerals' milling and flotation facilities were available and operational

9.8 Lithium

- Bikita Minerals's concentration plant was reported to be undergoing expansion. However, in terms of further beneficiation the Chief Executive Officer of the mine had been quoted as saying, "The proposal to set up a beneficiation plant by Government is a noble idea considering the importance of the lithium group minerals to the economic growth of any country. However, I believe we do not have enough deposits for a beneficiation plant at the moment. We don't have enough spodumene, the deposits are too small therefore extensive exploration work must be undertaken to make sure we discover more deposits before we can think of setting up a beneficiation plant," said Mr Hudson (Musiiwa, 2016).

10. CONSTRAINTS TO MINERAL BENEFICIATION AND VALUE ADDITION

A number of constraints to mineral beneficiation and value addition have been identified as

- A challenging fiscal environment characterised by a shortage of foreign currency required to import vital equipment and machinery spares
- Limited access to raw material for local beneficiation, particularly by some ferrochrome smelters and granite and diamond cutters. It has been reported that some ferrochrome smelters have limited access to mining areas and raw chromite ores. This requires strengthening and enforcing existing legislation such as the diamond and granite local cutting and polishing quotas, as well as chrome and PGM processing requirements to promote reliable and competitive access to raw material.
- Infrastructure – Inaccessibility of critical infrastructure such as rail, ports and electricity supply have a negative impact on promoting and sustaining beneficiation and value addition. The National Railways of Zimbabwe's network and signalling system were in a poor state of repair with only 3 369 serviceable wagons out of a fleet of 7269 wagons.
- Research and Development: limited exposure to innovative research and technological development programs impedes creation of new products and systems for beneficiation. Stakeholders need to promote and support and develop competitive technologies.
- Skills for local beneficiation - a sustained brain and skills drain has been experienced in Zimbabwe for over a decade and the supply pipeline for geologists, chemists, mining engineers, metallurgists and other engineers required to drive beneficiation has not matched the rate of loss. Development of the technical skills required for mineral beneficiation and value addition need promotion.
- Access to international markets for beneficiated products – the current trade barriers (both tariff and non-tariff) in some prospective markets of beneficiated products limit access to these markets. There is need to review existing and ensure that future trade agreements with China and other trading partners adequately support foreign direct investment (FDI) in beneficiation and value addition in Zimbabwe, as well as providing access to markets in China and other countries.
- Cost of doing business - the cost of doing business in Zimbabwe is generally higher than its neighbours (rated 161 out of 189 countries by the World bank in 2016), resulting in FDI flows to other countries.
- Beneficiation and Value Addition strategy - the lack of a clearly defined beneficiation and value addition strategy such as the one drafted by South Africa in 2011 is a constraint.
- Inadequate supply coupled with a fairly high cost of electricity pushes the cost of beneficiation and value addition up.

11. INCENTIVES AND OTHER MEASURES TO PROMOTE BENEFICIATION AND VALUE ADDITION OF MINERALS

Comparative studies on beneficiation show that it is possible to industrialise by leveraging on a country's natural resources with Government driving the beneficiation initiative as it was done in the NORDIC countries (DMR, SA 2011).

Zimbabwe's comparative advantage arising from its natural endowment with mineral resources needs to be deliberately translated into a competitive advantage, through implementation of a policy that enables beneficiation and value addition of the minerals. If managed in a coordinated manner. This can be achieved through the optimisation of linkages, which will in turn derive optimal benefit for the source countries, as indicated by the experience of the Nordic countries.

There is need to attract investment required to convert this endowment of mineral resources into technological hubs and mineral related industries to support side-stream and downstream value addition. In addition

- Incentives based on local content of procured goods and services would promote beneficiation and value chain.
- Tax breaks and preferential foreign currency allocations should be considered for capital goods and equipment imported for beneficiation and value addition plants.
- A reduction in electricity tariffs in order to reduce the cost of beneficiation and value addition.
- Government supported exploration in order to establish sustainable mineral resources on an ongoing basis.
- Government supported program of skills development such as apprenticeships for artisans, gemologists, technicians and other essential skills.
- Access to international markets for beneficiated products – removal of trade barriers (both tariff and non-tariff)
- An enabling Policy and Legal (Regulatory) Framework which promotes investment and property rights and includes a clearly articulated mineral beneficiation and value addition policy.
- Upgraded and expanded road, rail and communication networks would act as an incentive for investment in beneficiation and value addition facilities.
- National Project Status and Special Economic Zone Incentives should be applied to greenfield and brownfield projects related to mineral beneficiation and value addition

12. APPLICABILITY TO ZIMBABWE

In essence, Zimbabwean mineral industry can broadly be described as one with low levels of mineral beneficiation, in that most of its minerals are exported as ores or semi-processed minerals rather than high value intermediate to finished products.

Walker (2004) reports on the analysis of the Finnish experience of resource based industrialization. Part of this analysis includes the basic metals industry where despite a long history of mining in Finland, the industry remained insignificant until the mid to late 20th century when Government made key investments in areas such as production efficiency and capacity amongst others, and placed an emphasis on the export of intermediate and finished products. These interventions grew the sector to become one of the three most economically significant economic clusters in Finland alongside forestry and electronics"

In the case of Zimbabwe, beneficiation and value addition of minerals would apply in a situation where economies of scale are created through expansion of production and/or consolidation of available raw materials. This should be supported by a lowering of the cost of electricity through development of more relatively cheap power generation units especially hydroelectric power stations.

Government should make a concerted effort to create an environment of Policy consistency and predictability.

Competitive access to minerals for local beneficiation is one of the key success factors for the country's industrialisation initiative.

The concept of beneficiation and value addition is a well established one in Zimbabwe. For an example, the bulk of the country's electricity is generated from coal fired power stations, which consume more than 50 percent of the country's annual production of coal. Consequently, the country's economic growth was sustained over long period.

Currently, new forms of beneficiation opportunities are sought to compliment the conventional electricity generation in the country, which will underpin the much needed economic growth. For instance, beneficiation of PGMs to enable development of alternative forms of energy sources, such as PGM fuel cells, present an opportunity to ultimately become a role player in global manufacturing and distribution of fuel cell components. In due course, the Coal-To-Liquid technology further augments the need for investment in research and technology for the manufacture of fuel from coal, given the abundance of coal in the country.

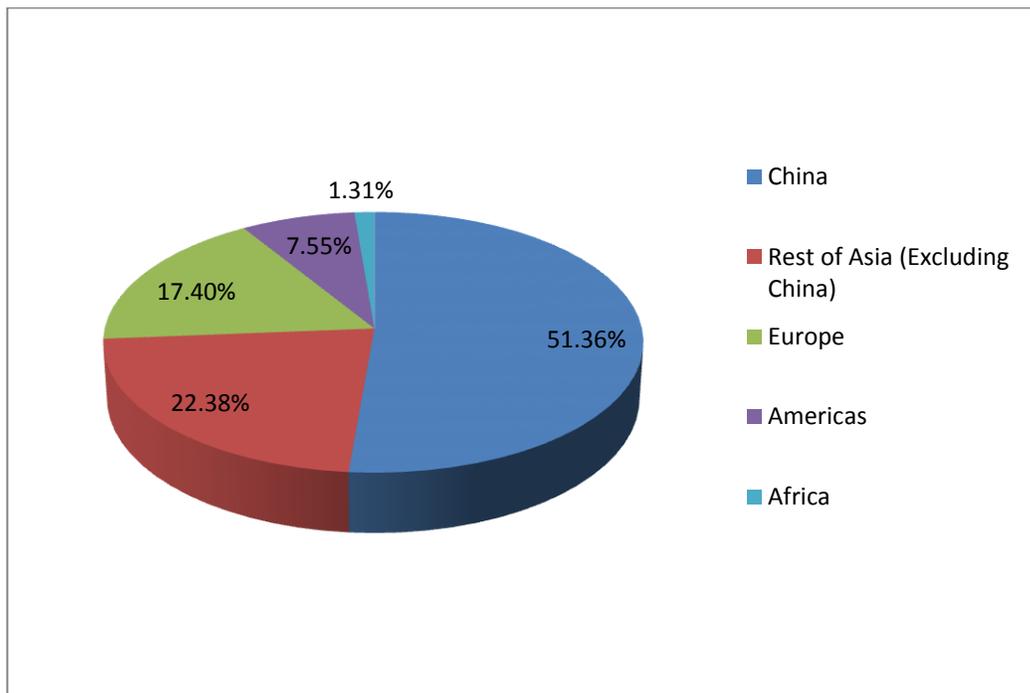
13. MARKETS AND PRICES

Prizes of most commodities are on the rebound following a dip that reached its bottom during the last two to three years.

The MMCZ markets directly in some regional and international markets e.g. Diamonds to Belgium, India, Dubai, RSA; coal products into Zambia, South Africa and DRC, Ferrochrome in Italy; Chilled pool Iron in South Africa, Prime Steel to various regional markets and Chrome Concentrates to South Africa and China. Export sales are done only pursuant to a tripartite sales agreement between the producer, MMCZ and the customer.

Global stainless steel production is expected to increase by about 3% a year for the next three years – according to Finnish stainless steel producer Outokumpu – the country’s chromium sector is well positioned to grow on the back of the forecast improvement in market conditions (Racon, 2016). Chrome markets were mainly in China, USA and Europe where stainless steel production continued to grow.

Figure 19: Distribution of Global Stainless Steel Production, 2014



Rough diamond production volumes and prices in 2012, reveal that although Zimbabwe was producing significant volumes the volume was however, relatively low.

Table 14: Production of Rough Diamonds in SADC, 2012

Country	Carats	Value (\$)	\$/ct
Angola	8,330,996	\$1,110,222,942	\$133
Botswana	20,554,928	\$2,979,400,297	\$145
DRC	21,524,266	\$183,135,862	\$9
Lesotho	478,926	\$301,452,475	\$629
Namibia	1,628,780	\$900,497,644	\$553
South Africa	7,077,431	\$1,027,131,960	\$145
Tanzania	127,174	\$33,826,691	\$266
Zimbabwe	12,060,163	\$644,033,522	\$53
Total SADC	71,782,664	\$7,179,701,392	\$100
Total World	127,965,785	\$12,645,625,167	\$99

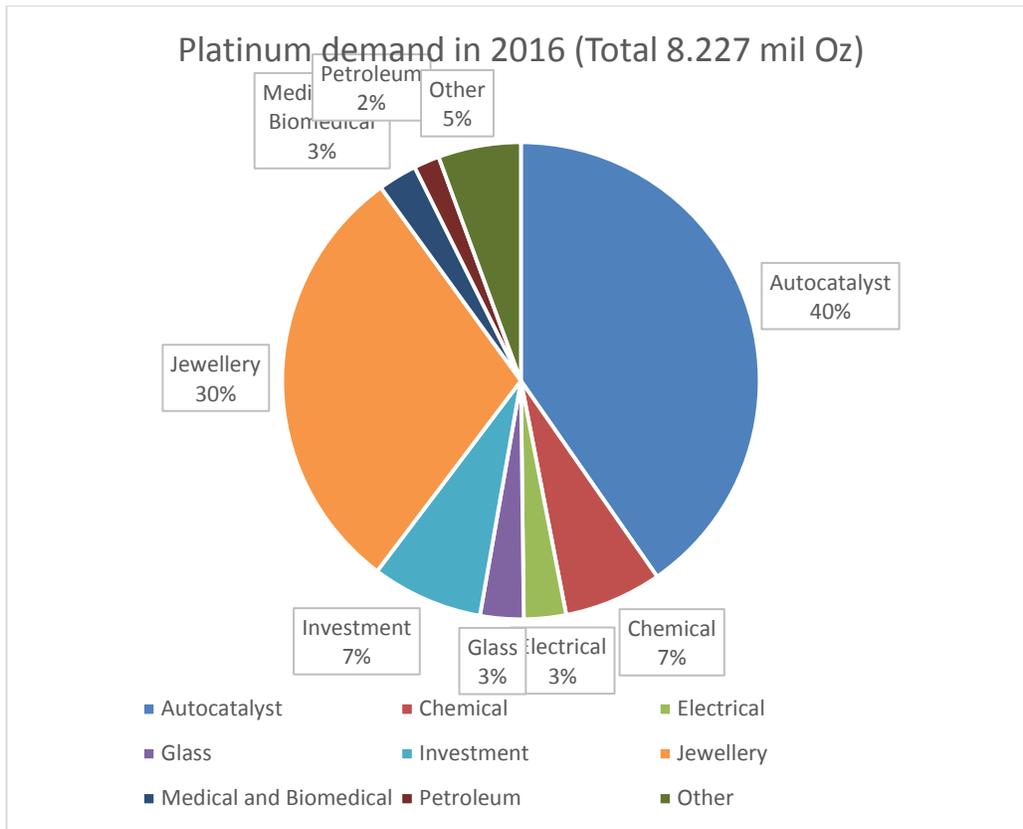
SADC countries contributed 56.1% of the world's rough diamonds by volume and 56.8% by value. Zimbabwe's production reached its highest at 9.4% of the volume contributing 5.1% by value.

Possibilities for the future markets include the development of downstream industries to:

- manufacture fertilizers and chemicals from Sulphuric acid;
- PGM based catalysts and fuel cells;
- Platinum and Gold based jewellery;
- Precious Metal based electronic components;
- Stainless steel products; and
- Copper cables and other products.

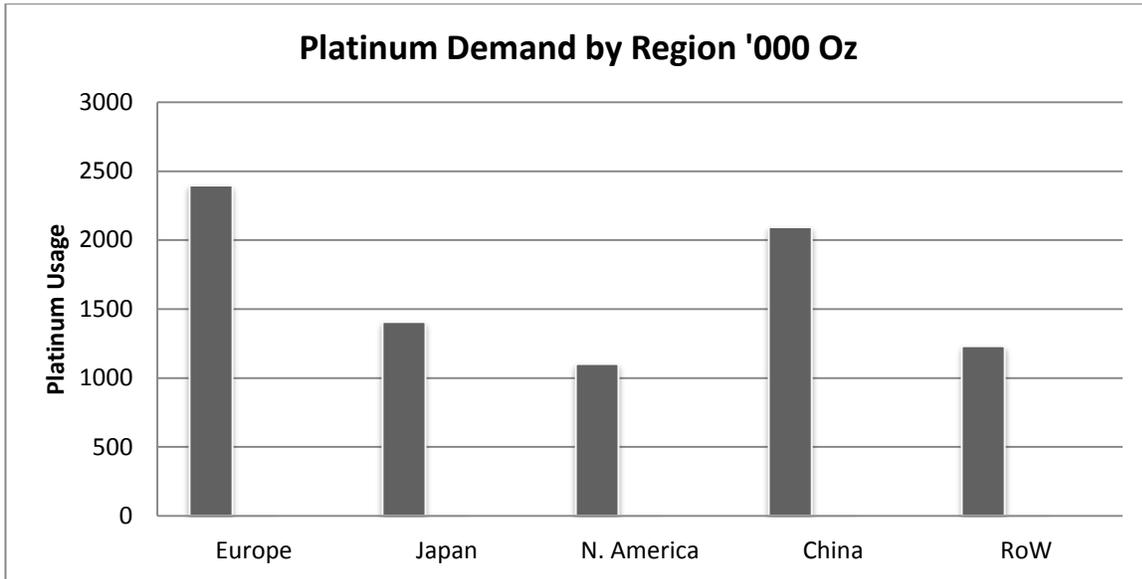
In 2016, the Global Platinum demand for Platinum, including from recycled sources, reached 8.227 million Troy ounces and was dominated by autocatalysts and jewellery.

Figure 20: Global Demand for Platinum in 2016, including recycled



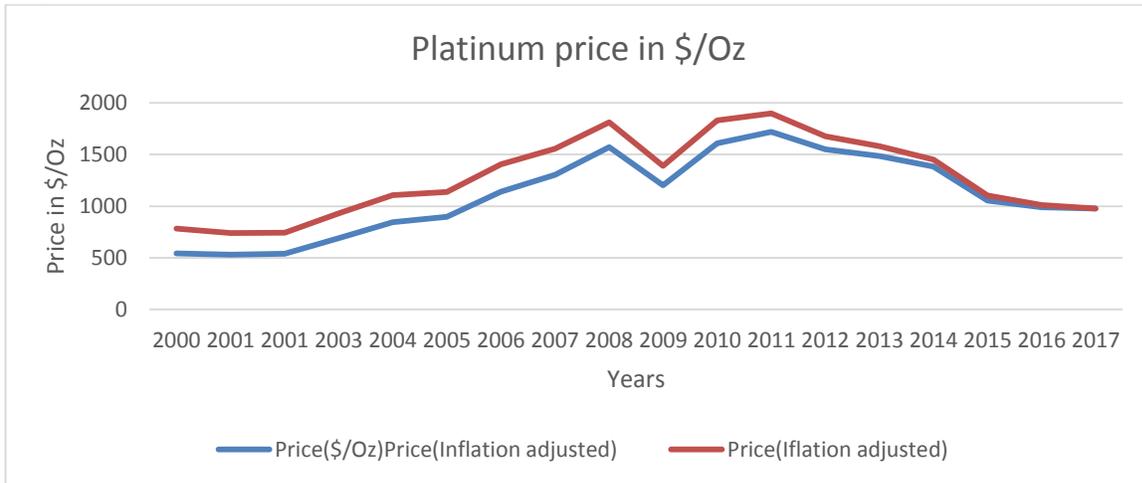
The regional distribution of the demand for Platinum products is dominated by Europe, China, Japan and North America (see Figure 21)

Figure 21: Consumption of Platinum products by region



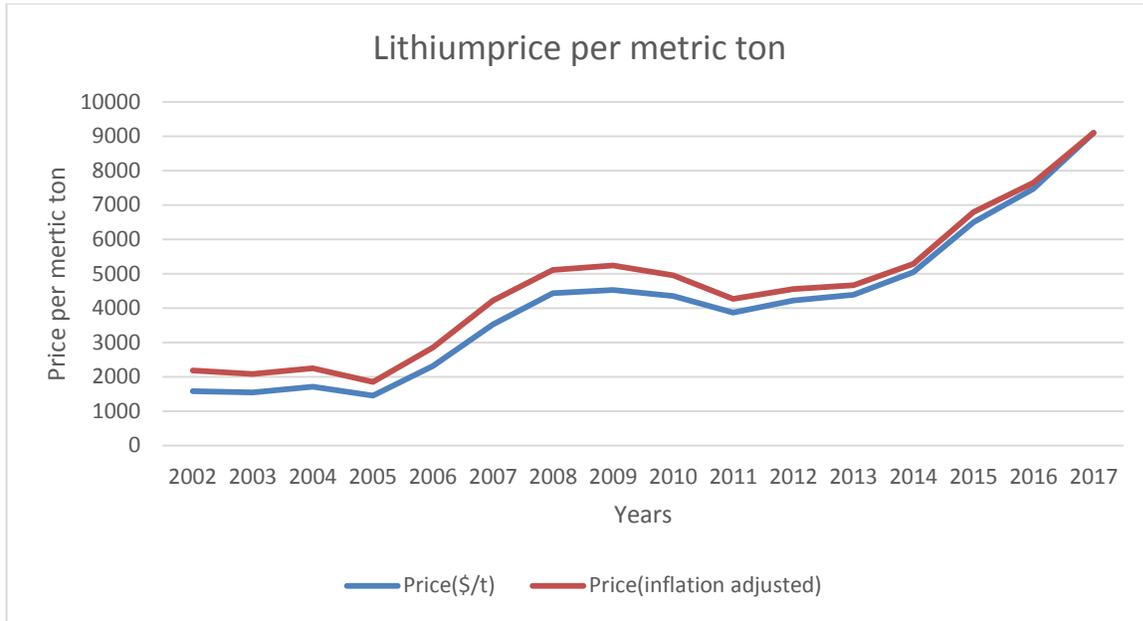
The rise in the demand of lithium ion fuelled electric vehicles, however, presents a potential threat to the demand for Platinum which seems to have a significant influence on the Platinum price (Figure 22)

Figure 22: Platinum Price, 2000 - 2017 (Metalary)



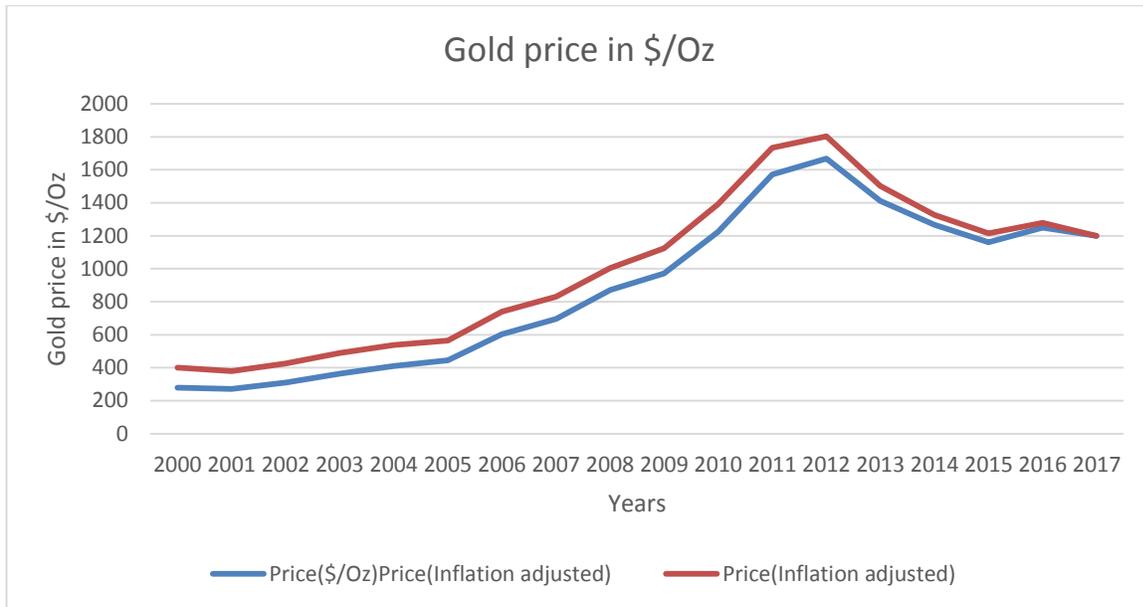
On the contrary, the demand for electric vehicles has pushed the Lithium price on a steep upward trend since 2014.

Figure 23: Price of Lithium, 2002 - 2017 (Metalary)



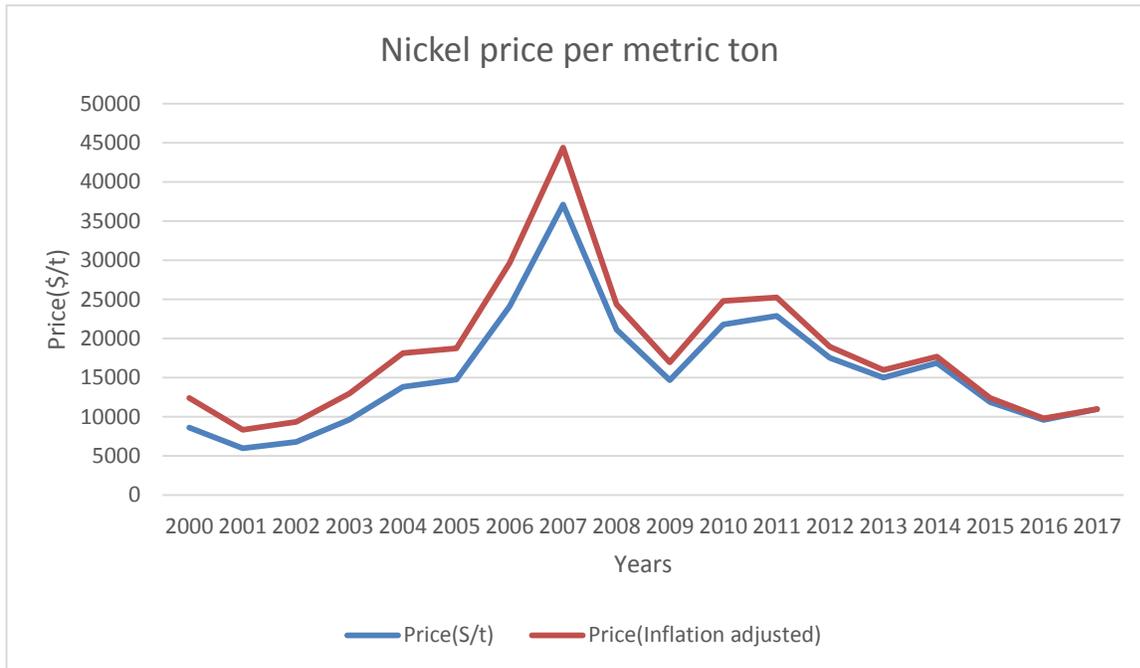
The price of Gold has remained stable around US\$1 200 per Oz since 2014, after dropping from the high levels attained in 2011 and 2012.

Figure 24: Price of Gold, 2000 - 2017 (Metalary)



The demand for stainless steel, particularly from China, has remained stable. However, the price of nickel, a key ingredient in stainless steel, has largely remained low although it has shown signs slow signs of recovery in 2017.

Figure 25: Price of nickel from 200 to 2017 (Metalary).



14. POLICY RECOMMENDATIONS

It is recommended that the Government should develop a Mineral Beneficiation and Value Addition Policy that aims to provide a framework to convert the country's comparative advantage it has inherited in the form of its mineral wealth, into a national competitive advantage. The policy should be aligned to the regional industrialisation programme, which aims at enhancing the quantity and quality of exports, promoting the creation of employment and diversification of the regional economies, reducing environmental pollution and promoting the knowledge economy.

The Policy should aim to provide the incentives required to mitigate identified constraints such as; access to raw materials for beneficiation at competitive prices, infrastructure (rail, road, ports and communication), limited research and technological development, shortage of critical skills, high cost of doing business and shortage of foreign currency and electrical power.

The successful implementation of the Beneficiation and Value addition Policy will depend on the support and co-operation across Government and all the role players in the mining and manufacturing industries as well as other stakeholders. A Strategy should be put in place to implement the Policy.

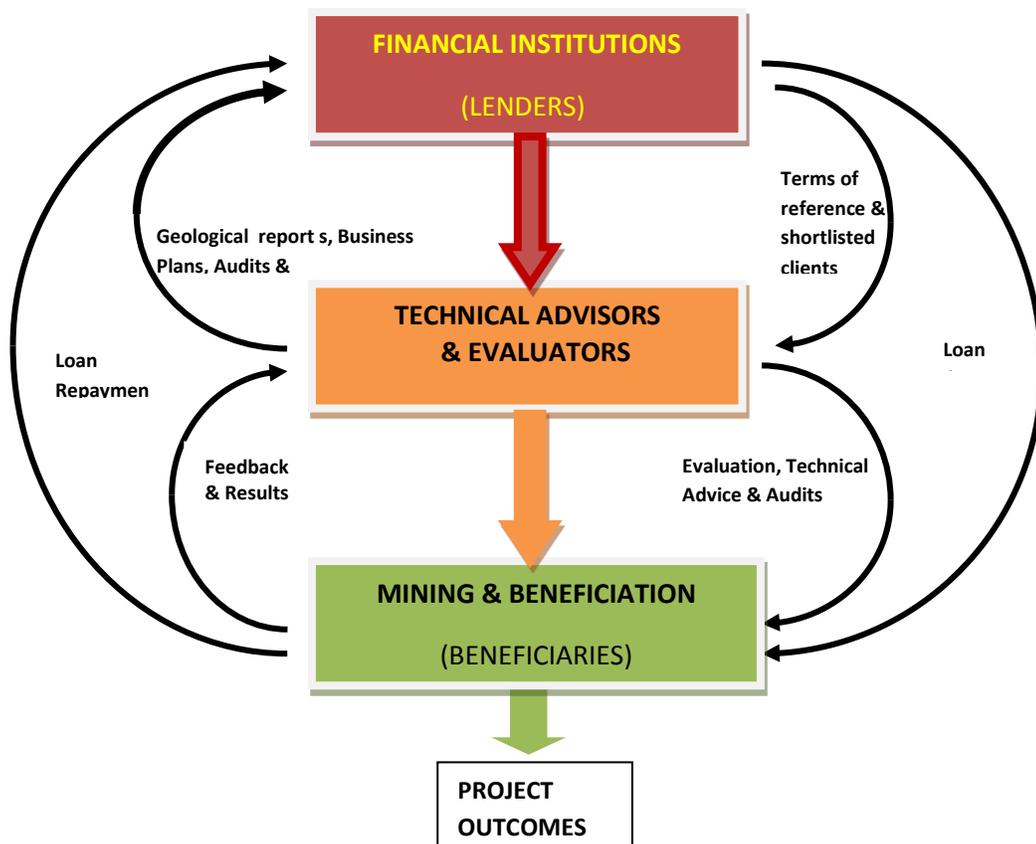
The Policy should seek to promote

- i. Extensive exploration in order to provide reserves for sustainable mining and beneficiation of minerals. This should also help to map and quantify the mineral resources potential in Zimbabwe.
- ii. economies of scale in order to enhance efficiencies and reduce costs of production.
- iii. research and technological development through provision of appropriate incentives such as tax rebates for funds spent on such R&D. Areas that require urgent attention include the high productivity methods for mining chrome seams in the Great Dyke, methods for improving rock stability during mining of PGMs along the Great Dyke, treatment of refractory gold, and reduction of beneficiation electrical power requirements and hence energy costs.
- iv. attraction and/or development of skills in craftsmanship, gemology and skills related to beneficiation and value addition. Skills development could be implemented through the provision of scholarships or tax incentives for companies that provide relevant training facilities.
- v. access to competitive markets
- vi. protection of the environment. This should incorporate treatment of off-gases from smelters, coke making and other facilities in order to reduce pollution preferably by converting the gas to usable products.

- vii. competitive electricity tariffs which could be linked/pegged to commodity prices. This would ensure that the electricity authority enjoys higher tariffs during times of high commodity prices and the beneficiation facility enjoys low tariffs during times of low commodity prices thus ensuring viability of both businesses.
- viii. reduce the cost of doing business through streamlining and reducing the various taxes, royalties and levies applied to the mining industry
- ix. equitable access to mining claims and ore concentrates for established beneficiation facilities. This may call for restrictions of low value commodity exports in order to promote beneficiation and value addition. Where there are no underutilized beneficiation facilities investors should be attracted to set up independent beneficiation facilities to compete on equal commercial terms with traditional foreign based facilities in order to process concentrates and mattes in the country.
- x. categorization of the beneficiation and value addition initiatives into short, medium and long term horizons, and to craft clear, realistic and achievable timelines for the execution of the beneficiation and value addition initiatives for the specific mineral value chains. Duties on unbeneficiated exports should be on a sliding scale related and inversely proportional to the level of upgrading or beneficiation achieved, i.e duty on converter matte should be lower than that on concentrates, etc.
- xi. establishing national best practices for mineral beneficiation and value addition, that are developed and benchmarked against global best practices.
- xii. Providing a distinct but seamless interface between mineral beneficiation for which the mining industry is responsible, and manufacturing which is traditionally the responsibility of the manufacturing industry.
 - The small scale sector needs support in order to build capacity for mining and quality control. The small scale mining industry is an integral sector of the Zimbabwean economy yet service providers tend to shun this sector. Loan and service providers such as financial institutions and fuel suppliers can play their part by promoting this sector and at the same time create business and long lasting relationships. It was recognised that service providers and financial institutions were concerned about the risk associated with this sector. A model could be developed to minimize this risk while maximising production. Under this model (Figure 26), for example, suppliers would provide goods on credit terms and the beneficiaries (small scale miners) would pay upon sale of their product and the latter's capacity would be enhanced. Mining and beneficiation experts would come in as technical advisors to the suppliers who:
 - i. From a technical point of view, would carry out proper evaluation of prospective projects in terms of geological resources, technology (equipment and processes) and human expertise (key personnel).
 - ii. Carry out due diligence studies on mining and beneficiation projects and operations

- iii. Advise the suppliers of loan finance, goods and services on possible risks that are associated with each and every mining project that the supplier would be evaluating.
- iv. Provide technical expertise to recipients so that they have the capacity to pay back the loans received. This should benefit both the lender and the miner.
- v. Ensure that there is compliance with the Mining, Environmental and other relevant legislation
- vi. Monitor operations in the pre- and post-lending phases.

Figure 26: Funding and Project implementation model for small scale mining projects

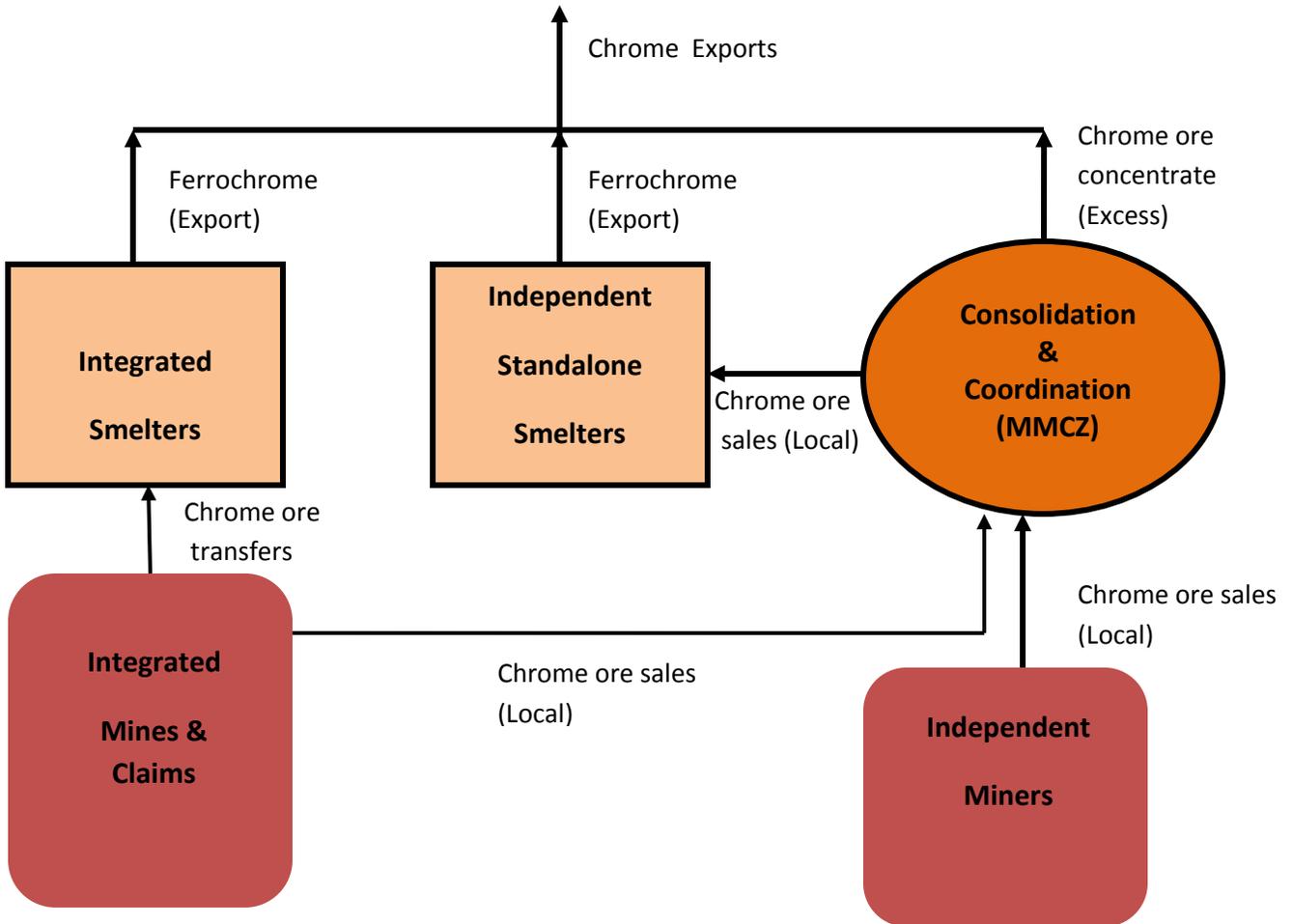


Source: Dzinomwa, et al 2014

It is clear that through this model the risk associated with lending to the small scale miners is minimized and at the same time if such a model is adopted by the Government of Zimbabwe as well as other stakeholders it will have a significant impact in the production and beneficiation capacity in the country.

- Investment in beneficiation and value addition facilities should be incentivised through provision of conditions such as National Project Status for capital equipment above given threshold or those applicable to Special Economic Zones.
- The SADC regional industrialisation strategy adopted in Harare in 2015 should be enforced and beneficiation should be approached in a co-ordinated manner, rather than to have for example South Africa exporting unprocessed chrome ore concentrates when Zimbabwe, a smaller player, bans the export of same.
- Development and mobilisation of the iron ore, coal, nickel, ferrochrome and manganese resources in the country and their beneficiation and value addition to produce stainless steel and related products.
- There is a need to maintain Policy consistency and predictability, so that investments in beneficiation and value addition may be assured. Investors need to be assured of repatriation of their dividends when they fall due.
- There is a need to quantify the economic benefits of mineral beneficiation and value addition within the specific mineral value chains while taking into account all the critical linkages. The broad economic benefits should be encompassing in line with the ZIMASSET economic blueprint. The value proposition matrix to define the true mineral value at the primary, secondary and tertiary levels of the mineral value chains needs to be developed and reviewed each time key parameters such as input costs change significantly.
- The fiscal policy should allow for viable operations. Foreign currency shortages hinder investment, production and beneficiation initiatives. The foreign currency retention level by exporters should be adequate in order to enable importation of spares, machinery and equipment required for beneficiation and value addition.
- In the case of chrome, the model below is recommended (Figure 16). The model proposes that only high grade chrome ore or concentrates which are excess to the smelting capacity in the country should be exported through a central marketing entity (MMCZ). The rest of the chrome ore and concentrates should be smelted into ferrochrome, and
 - i. the ore stocks at the smelters should be monitored to ensure that there is no shortage
 - ii. each producer should be allocated the same portion of foreign currency as if they had exported directly.
 - iii. The selling price of chrome ore to the smelters should be negotiated so as to maintain viability by both parties and should be market related, while taking into account local costs. The price of chrome ore or ferrochrome on the global market should be monitored and communicated to all producers for the sake of transparency (similar to the Gold industry)

Figure 15. Proposed model for promoting chrome beneficiation and total exports



15. CONCLUSIONS

In line with the Government's ZIMASSET economic blueprint, it is required that beneficiation and value addition of minerals be carried out in the country. The study reveals that since the launch of the ZIMASSET economic blueprint by the Government in 2013, with one of its four main pillars being beneficiation and value addition, some companies particularly those involved with Platinum Group and Base Minerals had made significant strides in upgrading their beneficiation facilities. Bindura Nickel Corporation had made progress in refurbishing their smelter and had achieved 83% completion level by October 2017. Commissioning was scheduled for mid-2018, and would enable the conversion of their current concentrate to converter matte, resulting in the upgrading of the product grade by a factor of ten (10). Unki Platinum mine wholly owned by Anglo American, had achieved 60% completion level in the installation of their smelter with commissioning scheduled by mid-2018. This would enable the conversion of concentrate to furnace matte, resulting in the upgrading of the PGM content by a factor of five (5). Zimplats, whose main shareholder is Impala Platinum of South Africa had embarked on and almost completed the refurbishment of its Base Metal Refinery, which had been mothballed since 2000 when the mine was acquired from BHP Minerals. This would enable the separation and refining of nickel and copper as marketable metals from the Platinum group metals which would continue to be shipped to South Africa, but only for Precious Metal Refining. Mimosa Platinum mine, which is jointly owned by Impala Platinum and Sibanye Gold of South Africa, had completed a feasibility study for the installation of a smelter. The commissioning of these beneficiation facilities would result in increased foreign currency revenue, employment, skills development and other socio-economic benefits. This means that, in the case of PGMs and base metals, smelting, base metal refining and precious metal refining and as much further value addition as possible should be undertaken within the country.

Some Chinese investors had set up ferrochrome smelters along the Great Dyke, having been attracted by Zimbabwe's chromite resources and the ban on exports of chrome ore, which assured them of raw feedstock. However, when the Government lifted the ban on export of chrome ore in response to an outcry particularly by small scale miners who had built up large stocks of chrome ore which could be used to generate foreign currency, the newly established smelters were faced with feedstock shortages forcing them to integrate backwards and seek for mining claims to explore and mine, an area in which they had little expertise. A model has been proposed to address this situation in a sustainable manner.

The small scale sector requires support, both financial and technical in order to enhance their production and quality control capacity. The latter has been a key missing link thus rendering them unable to pay back loans. A recommendation which encompasses an operational model to address the capacity constraints has been submitted in this report.

For diamonds and granite stone, enforcement of the stipulated quotas for local value addition should be implemented as a starting point, with progressive reviews being conducted as the skills base improves in the country.

Cross-cutting issues which have an impact on beneficiation and value addition include the need to clarify the indigenisation law vis-a-vis local content policies on procurement. The need to improve foreign currency availability by allowing exporters to retain more than 20% of their export revenues, the need to reduce the cost of doing business by sourcing low interest funds from international institutions, providing incentives for investors involved with beneficiation and value addition and also for companies and institutions involved with skills development, research and technological development. The railway network in the country required refurbishment and upgrading in order to reduce logistics costs.

To achieve this, significant investment is required to put up the necessary beneficiation and value addition plants, support infrastructure and increase power generation. This could be facilitated by a Government policy and legislation which

- create a stable and predictable investment climate
- provide investment incentives in order to attract initial capital for beneficiation and value addition.
- promote detailed exploration of the Great Dyke and other parts of Zimbabwe.
- promote skills development and to attract specialist skills that are in short supply in the country.
- promote research, innovation and technology development.
- minimize pollution and wastage of mineral values, and protect the environment.

This research study recommends a mineral beneficiation and value addition policy and implementation strategy which lead to investment and technological development, resulting in socio-economic benefits that include increased revenue flows, industrialisation and employment levels.

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16. APPENDIX 1: SURVEY QUESTIONNAIRE

**STUDY: AN ASSESSMENT OF THE SCOPE AND APPLICABILITY OF
BENEFICIATION AND VALUE ADDITION OF MINERALS IN
ZIMBABWE**

Beneficiation and Value Addition of Minerals in Zimbabwe is considered to be one of the key factors that are set to transform and develop the country's economy. In order to come up with suggestions aimed at improving the status quo, the Zimbabwe Economic Policy Analysis and Research Unit (ZEPARU) has embarked on a study of the Mining and Related industries. We are therefore asking you to answer the questionnaire with utmost openness. Your answers shall be used for the purpose of the study only, to help advise Government on an appropriate policy which will enable stakeholders in the industry to pursue appropriate levels of beneficiation and value addition of minerals in the country. Thank you for your usual cooperation.

1. Name of Mine/Organisation.....
2. Name of Official
3. Position.....
4. Type of Organisation: (i) Mine and/Process Plant (ii) Association of Companies (delete the inapplicable).....
5. Please state the Mineral Product(s)/Metal(s) produced by your organisation.....
.....
6. Development Stage: Exploration/Development/Production

Current production levels:

.....Per Month

Production Plans;

.....

Tonnes/month in the next 5 years

.....

Tonnes/month in the next 10 years

If on development/feasibility, what is the likely date of commissioning.....

If on development/feasibility, what is the anticipated production level on commissioning.....

7. What are your capital expansion plans

8. What are the final uses of your product?

9. Describe the beneficiation/value addition process steps that your organisation undertakes. What is the progressive value gained/contribution in US dollars of those steps?

UNIT PROCESS	PRODUCT	INTRINSIC VALUE (US\$)		
Mining	Ore			
Concentration	Concentrate			
Smelting	Matte			
Base Metal Refining	Base Metals -----			
Precious Metal Refining	Precious Metals -----			
Shaping/ Manufacturing	Finished Product -----			

10. What is the next process step following your organisation's current last one?.....

11. State the plans that your organisation has for further beneficiation/value addition?.....
.....
12. What barriers does your organisation face in implementing further beneficiation/value addition?.....
.....
13. What incentives do you recommend to enable further beneficiation/value addition.....
.....
14. State the benefits you anticipate with further beneficiation/value addition of minerals.....
.....
15. State the disadvantages you anticipate from further beneficiation/value addition of minerals.....
.....
- 16.** State your suggestions on the improvements required in the supply of raw materials and technology:.....
.....