The impact of electricity price increases on the competitiveness of selected mining sector and smelting value chains in South Africa

Has it incentivised mining-related companies to invest in renewable energy, cogeneration and energy efficiency?

August 2014

Policy Paper prepared for the Economic Development Department and the Department of Trade and Industry

Disclaimer:

The views and analysis expressed in this paper are those of the authors and do not represent the views of the Economic Development Department and the Department of Trade and Industry. Additionally, the views and opinions of the authors expressed in this paper do not necessarily state or reflect those of the Global Green Growth Institute.

Acknowledgements

This research project was jointly commissioned by the Economic Development Department (EDD) and the Department of Trade and Industry (the dti). The Global Green Growth Institute (GGGI) was tasked with implementing the project as part of a partnership to support the South African government's green growth planning efforts. TIPS was the primary research partner and service provider. This project is the result of the collaboration of all of these institutions.

The South African government's Inter-departmental Green Growth Committee, chaired by EDD, served as the project steering committee for this research. A multi-stakeholder Technical Reference Group was also established to offer inputs on various drafts of the report.

This policy paper represents a condensed version of an earlier report, which was the result of extensive fieldwork and interviews with stakeholders across the selected mining value chains.

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Inputs and comments were received from a number of colleagues and experts on previous versions of this work, including members of the steering committee and the technical reference group, and Zavareh Rustomjee as a special consultant.

Last but not least, special thanks go to the numerous government departments, stakeholders and companies which were consulted and interviewed as part of the project and which provided invaluable information. The analysis presented in this policy paper would not have been as rich and insightful without their participation.

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List of acronyms

ATIC	AngloGold Ashanti Technology Innovation Consortium
CDM	Clean Development Mechanism
CO_2	carbon dioxide
DoE	Department of Energy
GDP	gross domestic product
GHG	greenhouse gas emission
GJ	gigajoule
GW	gigawatt
IPP	independent power producer
ISMO	Independent System and Market Operator
kWh	kilowatt-hour
m^2	square metre
MPRDA	Minerals and Petroleum Resources Development Act No. 28 of 2002
MW	megawatt
NEMA	National Environmental Management Act No. 107 of 1998
PGM	platinum group metal
REIPP	Renewable Energy Independent Power Producer
the dti	Department of Trade and Industry
USD	United States of America dollar
ZAR	South African Rand

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Executive Summary

The development path of South Africa's mining value chains toward a sustainable energy profile is at a turning point. The industry constitutes a critical pillar of the South African economy and society, and will continue to be so in the foreseeable future. However, with the current coal-based electricity supply, the sector remains a constraint to the country's transition to a green economy. South Africa's mining and linked manufacturing companies are heavily energy- and carbon-intensive, and existing efforts to positively alter this situation have been limited despite rising electricity price increases and supply interruption concerns.

Electricity price increases have had a varying impact on mining value chains in the country and, overall, have not been sufficient to trigger substantial changes in behaviour and processes. On the one hand, surface mining activities, which rely more on diesel than electricity, have been less affected than deep-shaft mining. The coal sector has only been marginally impacted, due to its small share of electricity in operating costs and strong market conditions, and iron ore companies have not been jeopardised by the moderate effect on the sector due to a booming market environment. On the other hand, electricity represents a much larger share of the energy mix of underground operations, exposing companies to more drastic consequences. While some ability to pass on costs and good overall performance levels have enabled platinum companies to absorb the impact of electricity price increases, gold mining houses, which already face difficult conditions, have been strongly affected. At the beneficiation level, such as steel production, price increases have had severe negative consequences on firms' competitiveness (with the exception of Rand Refinery owing to its monopolistic position or industries relying essentially on gas, such as catalytic converter producers).

Cost savings and security of supply concerns have actually driven investments in energy efficiency and alternative sources of energy. Companies across value chains have primarily adopted traditional solutions, such load shifting and diesel-run back-up generators, as well as low-cost, low-hanging fruits in terms of energy efficiency (i.e. the optimisation of non-core activities and processes). While some pioneering mining-related companies are investigating deeper, game-changing innovations around the implementation of new energy-efficient technologies and designs, and the use of cogeneration and renewable energy, these efforts remain limited at this stage. Much of the potential is still untapped. As such, companies in South Africa's mining value chains, supported by Government through the appropriate mix of instruments (including both 'carrot' and 'stick' types of measures), have the opportunity to meaningfully engage with the issues around their energy mix. As mining and linked manufacturing companies face the same challenges globally, the South African industry has a unique opportunity to be at the forefront of transformation and reap the long-term benefits of transitioning to a sustainable energy path (which include increasing competitiveness, reduced energy costs, diminished exposure to price volatility and supply interruptions, increased governmental support, etc.).

As no single policy instrument or price signal is sufficient to trigger a meaningful transformation, a varied and complementary set of measures must be implemented by the South African Government, in collaboration with business and labour partners. Primarily, access to finance and available technology should be facilitated, notably through increased collaboration and information sharing. Investment in energy efficiency should be pushed through more stringent enforcement and binding requirements, while the use of renewable energy and cogeneration technologies should be encouraged with the establishment of an enabling regulatory framework. The potential to import clean energy from neighbouring countries should also be investigated further as a longer-term solution. In the meantime, facilitating the use of natural gas through adequate pricing, instead of diesel- and coal-based solutions, would contribute to the transition to greening the energy profile of the mining and linked manufacturing industry in South Africa.

The implementation of the right set of policies, collaboratively with all stakeholders, can efficiently contribute to steering mining and industrial sectors towards a green development path. Ultimately, given their scope and essential role, the transition to a green economy will not fundamentally challenge the central position of mining value chains in South Africa's (and the world's) development path. Nevertheless, the shift to a green economy will structurally affect both the demand for mineral-based products (in divergent trends depending on the ore), i.e. *what to produce*, and the means to providing them, i.e. *how to produce*, and will require proactive responses from the industry and Government.

Mining and linked manufacturing companies, while unsustainable in their nature, have an instrumental role to play in the transition to a green economy. Beyond their impact on energy structures, mining value chains are the heart of economic, social and environmental considerations in South Africa. The contribution of the mining sector is primordial and an indispensable prerequisite to a successful shift to a green growth path. In addition to contributing heavily to the country's economic performance, mining and linked manufacturing companies are intertwined with the sustainable management of South Africa's natural capital and the achievement of social development objectives.

Moreover, substantial business opportunities for South African mining value chains will follow in the near future from the global move towards a green development path. The mining sector in South Africa is set to benefit from the global transition towards renewable energy and the drive for energy efficiency, given that required technologies are built from minerals, of which South Africa is a major producer.

In the end, the response of mining value chains to the shift to a green economy cannot be business-as-usual. Successful management of the global green transition will require short-term pragmatism and longer-term planning in the South African mining industry, linking business, Government, labour, non-governmental organisations and the research community in support of sustainable development.

1. Introduction

As South Africa remains confronted with multiple challenges on economic, social and environmental fronts, sustainable development, notably through the transition to a green economy, has been acknowledged as the way forward. As part of this paradigm shift, the transformation of the mining and linked manufacturing industry, as a key contributor to the economy and society, appears instrumental to any successful transition. In this respect, the improvement of energy efficiency and the use of clean, renewable sources of energy are at the crux.

This paper aims to investigate the relationship between South Africa's mining value chains and a greener development path, focusing on energy issues. Effectively, it explores whether recent electricity price increases have triggered a shift towards greener behaviours and practices by local mining and linked manufacturing companies.

Although not directly associated with the transition to a green growth path, recent trends in South Africa's electricity supply industry, which has been characterised by energy supply problems since a load shedding crisis in 2008 and drastic price increases (i.e. a trebling of the average electricity price from 2009/2010 to 2017/2018), provide an opportunity to investigate the shift to a greener path. Using these developments as an entry point, this paper investigates the impact of electricity price increases on the competitiveness of mining-related companies and the mitigation measures which have been implemented by various firms in the four most important mining value chains in South Africa, namely platinum,[1] gold,[2] iron ore[3] and coal.[4] Particular attention is paid to the role that electricity price increases and energy security concerns have played in fostering investments by mining-related firms in renewable energy and energy efficiency.

Owing to the particular energy profile of each value chain and company in the mining and linked manufacturing industry, a firm-level approach is best suited to provide the appropriate insight.[5]

[1] This assessment covers the catalytic converter industry, accounting for up to 40% of platinum demand, but does not include jewellery and other industrial products.

[2] The scope of the study is limited to gold mining and refining and does not include the jewellery and retail sector.

[3] In addition to steel products, the iron ore value chain produces a range of other products that can be alloyed, for instance, ferrochrome and ferromanganese. These products and associated value chains are not discussed in this study, and the focus is here limited to the use of iron ore in carbon steel making. Ferrochrome and ferromanganese, both of which are electricity-intensive in their production processes due to smelting requirements, have been identified as candidates for a proposed Phase 2. The impact of increases in electricity prices have allegedly led to ferrochrome smelters in South Africa operating at below 50% capacity and some shutting down/relocating (as such, Assore, Assmang's co-parent company, is establishing ferrochrome smelting operations in Malaysia). In addition, in 2012, Eskom entered into negotiated agreements with major energy-thirsty ferrochrome smelters which allow Eskom to turn off power to the smelters for up to three months in return for what has been termed by the media as 'handsome' payments to the smelters by Eskom. These are essentially 'buy-back schemes' for the smelters to not use their allocated power provisions and to redirect this capacity into the grid. Furthermore, the stainless steel value chain, in which Columbus Stainless is the sole producer in the country (and of which the catalytic converter industry is the largest consumer, exceeding 38% of local consumption) (Dewar, 2012) as well as the merchants or trader level of the value chain (which includes players like Macsteel, Trident and Robor) are not assessed in this study.

[4] The study does not cover the complex coal-to-fuel process in the coal value chain.

[5] In addition to the companies' annual reports and the numerous sources cited in this paper, a series of direct interviews was held with most companies in the investigated value chains. A detailed questionnaire was also administered.

Section 1 elaborates on the changing environment in which mining and linked manufacturing companies have been operating in South Africa. Section 2 assesses the impact that electricity price increases have had on mining-related companies, highlighting the differences between deep-shaft (i.e. platinum and gold) and open-cast (i.e. coal and iron ore) mining, and linked manufacturing activities. Section 3 reviews the mitigation strategies implemented by companies and illustrates the focus on low-cost, low-impact solutions and the potential to engage in more meaningful substantial initiatives. Section 4 puts forward recommendations in order to further incentivise investments in energy efficiency and renewable energy by mining and beneficiation companies. Section 5 concludes.

1.1. A changing environment for mining and beneficiation in South Africa

Mining value chains are at the heart of society's material quality of life, providing resources which are integrated in almost every product and service around the world. Mining and related downstream manufacturing remains one of the world's two fundamental industries (the other being agriculture) at the root of economic development and represents a strategic driver of growth and development, notably through its multiple forward and backward linkages with other key industries.

South Africa is one of the most mineral-rich countries and mining activities historically form part of the domestic economic structure, with mineral reserves to the value of USD 2.5 trillion according to a 2010 Citibank report (Blaine, 2012). The beneficiation industry flourished in the second half of the 20th century as part of the Minerals-Energy Complex (Fine & Rustomjee, 1996), notably on the basis of affordable and abundant supply of coal-based electricity. The sector has generated significant benefits to the South African economy and society, from increased output (accounting for 8.3% of the gross domestic product (GDP) in 2012 and around 17% when the indirect contribution is considered), revenues, investment (11.9% of total investment in 2012), exports (accounting for 38% of total merchandise exports in 2012) and foreign exchange, to employment (over 520 000 direct jobs), local economic development, training opportunities and new technologies (Chamber of Mines, 2012). Table 1 details the contributions of the four most significant mining value chains in terms their key characteristics and contribution to the economy. Platinum group metals (PGMs), gold, iron ore and coal accounted for 81% of South Africa's total mineral sales in 2012.

The conditions under which mining value chains developed in South Africa have however evolved in the last two decades due to shifts in global and local conditions,[6] forcing mining and linked manufacturing companies to adapt their operations (Davenport, 2014). Since 1994, South Africa has achieved far-reaching political, economic and social changes. Government has demonstrated an increasing commitment to sustainable development, with the aim of addressing the country's triple developmental challenge of unemployment, poverty and inequality, while correcting the country's resource- (both in terms of water and energy) and carbon-intensive economic growth model. The South African economy has indeed developed on the back of a coal-based electricity mix (around 90%) and historically low electricity and water prices. The transition to a green economy, stemming from the concept of

[6] South Africa's democratic dispensation, the unbundling of large mining finance houses, black economic empowerment, the rise of labour rights, increased economic, social, environmental, health and safety regulation, the introduction of the 'use it or lose it' principle for mining rights, rising operating and input costs and the contraction of the industry are a few examples of changing conditions.

sustainable development, has been recognised as a ground-breaking way forward for the country, combining economic development, social welfare and environmental protection.[7]

Table 1: Key statistics of South Africa's most important mining sectors

Indicator	Platinum Group Metals	Gold	Coal	Iron Ore
Global production (rank and share in 2011)	1st (59%)	5th (6.5%)	7th (3.3%)	6th (3.2%)
Global mineral reserves (rank and share in 2011)	1st (95.5%)	2nd (11.8%)	8th (3%)	10th (0.7%)
Contribution to gross domestic product (direct and indirect in 2012)	4.1%	2%	1.8%	0.7% (2008)
Share of mining exports (in 2012)	23%	23%	19%	18%
Share of total merchandise exports (in 2012)	9%	10%	7%	7%
Total sales (in ZAR million in 2012)	69 204	71 962	96 148	52 643
Local sales (in ZAR million in 2012)	8 285	4 863	43 921	4 445
Total exports (in ZAR million in 2012)	60 919	71 962	52 227	48 194
Exports as a percentage of total sales (in 2012)	88%	94%	54%	92%
Production (in tonnes in 2012)	217.8	177.8	258.6	67.1
Employment (in 2012)	197 847	142 201	83 240	23 380
Share of mining-related electricity consumption	33%	47%	20% (all other sectors)	

Sources: TIPS, based on Chamber of Mines, 2012, Eskom, 2012 and Kumba, 2011

Along with its involvement in international negotiations, South Africa has accordingly developed its own national framework for a shift to a green economy, building on the mandate enshrined in the country's 1996 Constitution (Section 24 of the Bill of Rights recognises 'sustainable development' as a human right). While enforcement remains highly problematic, legislative and regulatory requirements, as prescribed by the National Environmental Management Act No. 107 of 1998 (NEMA) and the Minerals and Petroleum Resources Development Act No. 28 of 2002 (MPRDA), have favoured the emergence of social and environmental 'licences to operate'. Firms increasingly have to address their adverse impacts on social (such as health and community development issues) and environmental (such as acid mine drainage and the pollution, degradation or complete loss of ecosystems, species' habitat and biodiversity) structures. In addition to MPRDA and NEMA requirements, the mining sector is impacted by a number of other environmental requirements related to air, water, waste, heritage resources, protected areas, biodiversity and municipal planning. These regulations form part of the broader regulatory and policy framework shaping the development of the mining and beneficiation sector detailed in Box 1.

Furthermore, social matters, pertaining to human rights, health, safety and employment conditions, remain of prime importance. Mining activities, despite contributing significantly to the country's

[7] The Brundtland Report defined in 1987 sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UNWCED, 1987). Building on this definition, a green economy is "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2011). Practically speaking, in a green economy, growth in income and employment are driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services.

development, do not necessarily boost growth in an inclusive and sustainable manner, owing to *inter alia* low and declining labour intensity (Tregenna, 2010), precarious and indecent employment, the use of mostly imported technology, high market volatility of minerals, competition with agricultural and tourism sectors (during and after mining operation),[8] and institutional corruption and mismanagement. Benefits are not always equitably shared and communities in the surroundings of the source of minerals can suffer negative externalities (WRI, 2003). Labour matters have been the most important issue for mining companies in recent years. For example, in light of the series of strikes over the last few years and the fatal miners' strike at Lonmin's Marikana mine in August 2012, the Platinum Sector Peace and Stability Accord 2013 was signed between Government, mining houses and labour representatives. The industry is nevertheless still experiencing prolonged strike action and wage disputes, as illustrated by the historical nearly six-month long strike in 2014.

Box 1: Strategic policies and action plans shaping the development of the South African mining sector

Reflecting the strategic role of the mining sector in the South African economy, all national key policy documents, such as the National Development Plan, the New Growth Path and the Industrial Policy Action Plan, highlight the importance of the industry. In addition, a number of strategic policies and regulations specifically frames the development of the mining sector and associated beneficiation activities in the country.

The Minerals and Petroleum Resources Development Act No. 28 of 2002 (MPRDA), promulgated in May 2004 (replacing the Minerals Act of 1991) is the main legislation regulating the mining sector in South Africa. It aims at promoting a sustainable, safe, environmentally responsible, growing and transformed industry and regulates the granting of reconnaissance permissions, prospecting rights, retention permits and mining rights. An Amendment Bill is being introduced (as of July 2014, it has been approved by the Parliament and the National Council of Provinces but remained to be signed into law by the South African President). While the original aim was to improve the current construct of the Act, some provisions have created much debate in the industry. After lengthy discussions, most points of contention appear nevertheless to have been resolved. In its current state, in order to promote local beneficiation, the Amendment Bill should introduce a mine gate pricing, i.e. an export parity pricing without transportation costs (free-on-rail) for minerals declared as strategic by the Minister of Mineral Resources. Mining-related discussions are still under way on taxation issues, such as the potential implementation of an export levy.

The Mining Charter, originally published in 2002 and revised in 2010, complements the MPRDA and aims to facilitate the sustainable transformation and development of its mining industry. It particularly sets a target of 26% black ownership for South Africa's mining assets to be met by 2014, along with 40% total employment equity across all levels of management.

[8] For example, at Northam's Booysendal mine in the North West province, challenges have been faced due to community members rejecting and moving onto company-owned land earmarked for power supply installations. Contractors responsible for erecting power installations on an Eskom-registered servitude have had to suspend these activities. Northam and Eskom are nevertheless working to resolve the situation with the community (Northam, 2013).

The National Infrastructure Plan of the Presidency includes two strategic integrated projects of direct relevance to mining value chains. The Saldanha-Northern Cape development corridor plans for the expansion of iron ore mining production and beneficiation, along the upgrade of the iron ore rail line between Sishen in the Northern Cape and Saldanha in the Western Cape, and the increase of iron ore handling facilities in Saldanha. The unlocking of the northern mineral belt, with the Waterberg as the catalyst, aims to boost the exploitation of mineral resources (such as coal, PGMs and chromite) and includes the development of rail, water, energy generation and transmission infrastructure.

With the goal of further developing mining-related manufacturing in South Africa, the Department of Mineral Resources produced *A Beneficiation Strategy for the Minerals Industry of South Africa* in June 2011. The strategy identifies five value chains, namely energy commodities (coal, uranium and thorium); iron and steel; pigment and titanium metal production; autocatalytic converters and diesel particulate filters; and jewellery fabrication (which includes gold and platinum). The strategy seeks to translate the country's comparative advantage inherited from mineral resources endowment to a national competitive advantage. It aims to enhance the quantity and quality of exports, promote and create decent employment and the diversification of the economy, including the promotion of a green economy and the strengthening of the knowledge economy. It identifies constraints that prevent effective beneficiation and proposes instruments that aim to provide an enabling environment for beneficiation, including in terms of access to raw materials at developmental prices and other aspects that affect competitiveness, such as infrastructure (access, costs and logistics), innovation, research and development and critical skills.

Value chain-specific developments have also shaped the development of some sectors. For example, competition policy has had a significant impact on the iron ore and steel value chain. South African competition authorities have, over the past 5-10 years, intervened extensively in the steel industry against anticompetitive practices, such as abuse of dominance, manifesting in pricing behaviour, to widespread cartel conduct at various levels of the steel value chain. Furthermore, the Inter-Departmental Task Team on iron and steel recommended in 2012 to increase competition in the sector and introduce at least one more producer, with the aim to lower the cost of strategic inputs into manufacturing and industrial customers. The Industrial Development Corporation, one of South Africa's development finance institutions, is currently in advanced stages of introducing a foreign investor, introducing technology development into the sector and attempting to ensure that developmental ore prices are passed through as a competitive advantage to the manufacturing sector. In the platinum sector, the export, without local beneficiation, of unwrought and semi-fabricated PGMs has been restrained by the Precious Metals Act No. 37 of 2005 and the MRPDA in order to foster local beneficiation. Furthermore, the current beneficiation policy looks to earmark a percentage of platinum sales to the local market for beneficiation. Interventions to promote beneficiation range from laws to ensure the supply of PGMs, to research programmes around unlocking the intrinsic value within the sector, to skills development and investment promotion initiatives.

Sources: TIPS, based on mentioned acts, Presidential Infrastructure Coordinating Commission, 2012 and DMR, 2012

In addition to socio-environmental regulations, South Africa's international commitments in the global climate regime are of particular relevance to the industry. South Africa has pledged to peak its greenhouse gas (GHG) emissions between 2020 and 2025 at 34% and 42% respectively below a business-as-usual trajectory, plateau for approximately a decade and decline in absolute terms thereafter, subject to the adequate provision of financial resources, technology transfer and capacity building support provided by developed countries (UNFCCC, 2011). In order to meet these objectives, the South African Government is considering a set of measures, including the introduction of an economy-wide carbon tax (planned for 1 January 2016) and the implementation of carbon budgets.

Mining and linked manufacturing industries, which are heavy GHG emitters and contribute to South Africa being the 13th largest GHG emitter in the world,[9] are expected to be particularly impacted by this new regulatory framework. The consumption of a large share of the country's coal-based electricity (which results in 45% of South Africa's emissions) partly explains this role. The mining sector consumes approximately 15% of national state-owned utility Eskom's annual electricity output, with gold (47% of the total) and platinum (33%) mining being the heaviest users (Eskom, 2010). Beneficiation activities, which require large and uninterrupted supply of energy, consume a considerable share of the country's electricity.[10] For example, BHP Billiton's aluminium smelters account for about 5.5% of Eskom's nominal capacity (TIPS, 2013). In addition, the mining and beneficiation sector is also partly accountable for rail, port and pipeline state-owned enterprise Transnet's emissions.

As such, Sasol, BHP Billiton, ArcelorMittal South Africa, Anglo American and Anglo American Platinum are the main GHG emitters listed on the Johannesburg Stock Exchange in terms of South Africa-based Scope 1 and 2 emissions.[11] Gold Fields and AngloGold Ashanti also feature in the leading ten GHG emitters in the country (Incite Sustainability, 2012). However, as explained in more detail in Section 2, processes vary greatly in their electricity (and energy) requirements. Intensity between mines and plants producing different minerals and metals, and indeed even between different sites producing the same output, also differs substantially. Changing characteristics, such as ore grade (for instance, off-grade iron ore requires greater processing than on-grade) and characteristics (such as the location and depth of the ore body and the size and spread of the mineralised system), and mine and plant age, designs and technologies have considerable repercussion on the energy profile of a given site (ICMM, 2012).

[9] Nevertheless, the country only accounts for 1.5% of global GHG emissions.

[10] Mining-related manufacturing activities are aggregated with other industrial activities in available data. It is therefore difficult obtain an exact picture for beneficiation activities.

[11] Scope 1 emissions are all direct GHG emissions, i.e. emissions from sources that are owned or controlled by the reporting entity. Scope 2 emissions are indirect GHG emissions from consumption of purchased electricity, heat or steam. Scope 3 emissions covers other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g. transmission and distribution losses) not covered in Scope 2, outsourced activities, waste disposal, etc. (Greenhouse Gas Protocol, 2012).

Box 2 : Why are electricity prices increasing in South Africa?

Real electricity prices have sharply increased from 2008, following a progressive decline between 1978 and 2008. As illustrated in Figure 1, the real average price of electricity fell by more than 40% from ZAR 39.7 cents per kilowatt-hour (kWh) in 1978 to ZAR 22.7 cents/kWh in 2008 (in 2011 ZAR). In contrast, real prices increased by 75% from ZAR 22.7 cents/kWh to ZAR 40.3 cents/kWh between 2008 and 2011 and the average standard price is expected to treble from 2009 to 2017.

The primary driver of electricity price movements has historically been Eskom's investment decisions (especially the type of technology selected, and the timing and scale of new generation capacity building), Eskom's financial policies and administrated price-setting methodologies. Current price spikes can be traced back to Eskom's sub-economic over-investment decisions in the 1970s and 1980s, and a Government-backed system which allowed the utility to externalise the cost of its poor investment decisions. Pricing electricity below its full economic cost for a sustained period (i.e. below the long-run marginal cost) while pursuing policies that increased the consumption of electricity made it difficult for Eskom to build up sufficient financial reserves to fund future investment in generation capacity. Hence, the factors contributing to Eskom's success in the 1990s (Eskom's over-investment in generation capacity resulted in very affordable electricity prices and was turned into one of South Africa's comparative advantages) ultimately laid the foundation for current supply shortages and price increases.

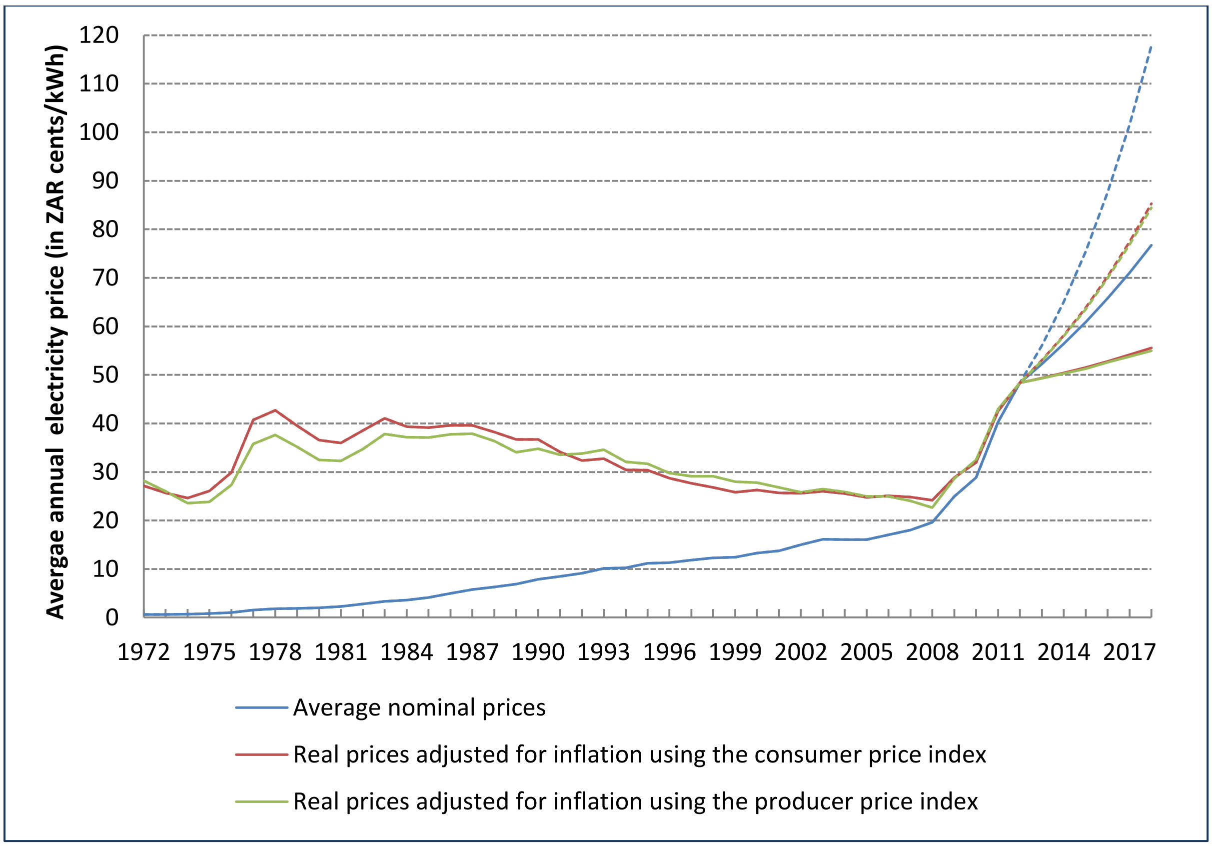
As reserve margins started to dangerously tighten, the South African Government, through Eskom, started in 2005 a belated major generation expansion programme valued at ZAR 340 billion, excluding capitalised borrowing costs. Coupled with the progressive move towards cost-reflective tariffs, the corporatisation and commercialisation of the utility in 2001 (which started to pay dividends and taxes), a higher cost of capital (due to higher debt levels and weaker credit metrics) and the need to use expensive energy generation capacity (such as Open Cycle Gas Turbines, which are 10 times more expensive than baseload coal stations) in the meantime, the new build programme is at the origin of recent price increases. Going forward, these factors, compounded by the additional short-term costs associated with the development of renewable energy, the probable introduction of a carbon tax, delays and increase in construction costs of new large power stations, increasing operational expenditure due to an aging fleet of power stations and degrading operational efficiencies and a projected increase in the purchase price of coal, will result in further electricity increases. While the history of the price determination process shows that predicting future costs accurately and their effect on Eskom's required revenue (which determines price increases) is difficult, general price increases will probably be within an 8-16% band in the 2013/2014 to 2017/2018 period. In the meantime, as electricity prices were kept at sub-economic levels for three decades, the average price of electricity in South Africa is not particularly high compared to international standards despite successive price shocks since 2008.

Sources: TIPS, based on Steyn, 2013; Storer & Teljeur, 2003; Steyn, 2003, 2012; Newberry & Eberhard, 2008; NERSA, 2010, 2013; Pickering, 2010; Deloitte, 2012; Eberhard, 2012, 2013; Eskom, 2012

Climate change imperatives have accordingly commanded significant changes in South Africa's energy policy. South Africa has embarked on a journey to install 17.8 gigawatt (GW) of renewable energy-based generation capacity from 2010-2030, accounting for 42% of the new additional capacity over the period or 9% of the total electrical energy in 2030 (DoE, 2011a). As detailed in Section 3, at the sectoral level, Government, in collaboration with business and labour constituencies, has made some efforts to support investments in renewable energy and energy efficiency.

Nevertheless, the transformation of the mining and linked manufacturing industry appears instrumental to any successful transition to a green growth path. The shift to a green economy will durably affect both the demand for mineral-based products (in diverging trends depending on the ore) and the means to providing them. One critical aspect revolves around the energy profile of companies, and their potential to become energy efficient and switch to clean, renewable sources of energy.

Figure 1: Average annual electricity prices between 1972 and 2018 (in ZAR cents per kWh)



Sources: TIPS, based on Eskom's price history tariff books (1970-2013), Investec's 2014 Market Predictions for consumer and producer price indexes, and multi-year price determinations from 2012/2013-2017/2018

Note: from 2012 onwards, prices are projected following annual increases of 8% (lower band) and 16% (upper band)

1.2. Electricity price increases and supply issues as an entry point

Recent developments in South Africa's electricity supply industry, although not linked to the transition to a green economy, provide an opportunity to investigate this issue. As explained in Box 2 and illustrated in Figure 1, energy security concerns, presented by electricity shortages and load shedding since 2008, and the trebling of the average electricity price from 2009/2010 to 2017/2018 have drastically changed the environment in which mining value chains operate in South Africa.[12]

Although differences exist at the operational level, changes in the electricity supply industry are particularly relevant as electricity constitutes (and will remain) the main energy source for mining and linked manufacturing companies. In 2008, energy demand in the mining sector was dominated by electricity (67.3%), followed by coal (29.8%), petroleum products (2.7 %) and natural gas (0.2%). According to the Department of Energy (DoE), mining-related demand for energy and electricity from 2010 to 2050 is estimated to increase by 38% to a total of 250 petajoules and 40% to 170 petajoules respectively. Energy consumption in mining should grow steeply until 2018 before plateauing. Energy demand from the mining sector will continue (until 2050) to be dominated by electricity. Electricity demand for the platinum is predicted to increase by 25% by 2050 (based on a 2010 baseline), compared to a marginal single-digit rise in the coal sector and a 10% decrease in the gold sector. The rest of the mining sector is likely to follow a similar trajectory to the platinum sector (DoE, 2011a).

Based on the assumptions that current rapid electricity price increases, coupled with protracted supply interruptions challenges, present an incentive for companies to invest in appropriate mitigation strategies; the situation in the South African electricity supply industry and its impact on mining and industrial sectors provide the perfect platform to examine the role that clean and efficient energy technologies play in the South African mining value chains. The prolonged nature of the issues facing the electricity sector also offers an opportunity to analyse the trends in investment, the real potential of mitigation actions, the (policy) drivers and the existing bottlenecks.

[12] Between 1996 and 2013, the average electricity price paid by mines has closely followed the average electricity price. For most of the period, mines nevertheless paid a slightly lower price, owing to a combination of factors, such as the legacy of special negotiated pricing deals and the lower cost to supply mines. This is set to remain unchanged in the foreseeable term.

2. A varying impact of electricity price increases from one company to another

In order to appreciate the potential for energy efficiency and renewable energy in South African mining value chains and the mechanisms required to incentivise such investments, understanding the place of electricity (and energy) in companies' operations and the impact of electricity price increases on the industry's competitiveness (as defined in Box 3) is a prerequisite. Given the structural differences from one sector to another, and even from one company or site to another, analysing the aggregated and lumpy cost contribution of electricity across a whole industry is not robust.[13]

Box 3: Competitiveness in mining and downstream manufacturing industries in South Africa

Competitiveness generally has been defined as the productivity with which a nation or firm utilises its human, capital and natural resources. Productivity is related to the value of a nation or firm's products and services in terms of prices achievable in the market and by the efficiency with which they can be produced. Electricity costs and availability are but one of a number of factors that affect the competitiveness of firms in mining and linked manufacturing industries. The competitiveness of the South African mining value chains is affected by both controllable and uncontrollable factors. Controllable factors include infrastructure (including energy), the regulatory environment, management efficiencies, the labour market, etc. while uncontrollable factors take into account geology, ore grades, the location relative to surface, etc. While South Africa has a significant comparative advantage in terms of uncontrollable elements (with the exception of the distance to world markets), the country's situation is more precarious with regards to controllable factors.

In 2013, South Africa ranked 64th out of 97 mining jurisdictions surveyed by the Fraser Institute in terms of attractiveness, while Botswana, for instance, ranked 17th. South Africa benefits from a powerful financial sector, a sound fiscal environment, generally efficient goods and services markets, and reasonably good infrastructure. However, South Africa appears badly positioned in terms of crime and theft, as well as an inadequately educated labour force, particularly with respect to skilled engineers crucial for the mining industry. This compounds labour issues, associated with rising labour wage demands, strikes and loss of productivity. Some analysts have suggested that given cost overruns in emerging markets, including as a result of wage hikes and strikes, investment in mining is deterred in countries like Australia and South Africa, with preference to invest in other countries, such as the United States of America. In addition, challenges have emerged in the pricing of certain inputs, particularly with respect to rapidly rising electricity prices, and the provision of rail (notably for coal, manganese and ferrochrome sectors) and electricity infrastructure.

Source: TIPS, based on Baxter, 2011; Deloitte, 2013; Fraser Institute, 2014

A detailed assessment based on firm-level data, covering surface mining (coal and iron ore), underground mining (platinum and gold) and linked manufacturing activities, provides the most

[13] According to a 2001 study commissioned by the Chamber of Mines, electricity comprised at the time almost 5% of total input costs of firms in the mining and quarrying sector. Similarly, a 2009 survey conducted by Eskom of its 31 Key Industrial Customers found that electricity contributed roughly 18% and 8% towards the total operating expenditure of metal manufacturers and mines respectively. These results, while informative to some extent, only provide a distorted and inaccurate understanding of the role of electricity in mining and linked manufacturing operations.

accurate insight into the value chains.[14] As illustrated in Box 4 with the case of aluminium, an increase in electricity prices at a specific level in the value chain can have very diverse consequences on downstream players. An analysis of trends in electricity costs as a percentage of operating or total costs provide an indication of the effect on overall costs.[15] This impact is put into perspective with the companies' ability to pass on increased costs in the form of higher prices[16] and their overall financial health.[17]

2.1. A moderate impact on open-pit coal and iron ore operations but strong implications for downstream steel-making activities

Open-pit operations, such as coal and iron ore mining, appear marginally affected by electricity price increases due to their limited use of electricity. The increase of diesel costs, which account for a substantial share of operating costs could nevertheless impact the iron ore sector in the future. While the companies' ability to pass on costs is narrow, favourable market conditions in both sectors have cushioned any potential impacts. The situation of the steel industry is radically different with electricity accounting for a fair share of operating costs. Electricity price increases are likely to further deteriorate the already challenging situation of the sector, although the ability of steel-making companies to pass on cost increases may mitigate some of the impact. Nonetheless, secure and efficient electricity supply has arisen in the iron ore and steel value chain as a main energy concern.

2.1.1. Coal mining has been marginally impacted

South Africa's coal mining, operated largely through surface mining, appears indeed to be one of the least affected mining industries to increases in electricity prices, owing to the small share of electricity as part of operating costs and positive current market conditions.

Electricity accounts only between 3% and 5% of coal mining companies' operating costs. For example, Exxaro's energy component stood at 6.2% of operating costs in 2012, evenly split between diesel and electricity. Although this varies from one mine to another, electricity (directly purchased from Eskom) only accounts for about 3% of operating costs (particularly for conveyor belt operations). Similarly, the utility electricity expenditure of Sasol Mining (which has a direct electricity contract with Eskom at the Megaflex rates and is connected internally to Sasol Synfuels) accounts for 5% of total production costs.

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[14] As notably illustrated in Table 1, the value chains were chosen given their energy-intensive nature, their prominence and size in terms of contribution to GDP, balance of payments, employment, etc., as well as their important linkages to other industries.

[15] This approach is used as a best available proxy. It is understood that this does not reflect in its entirety the notion of competitiveness. Importantly, the price elasticity of demand, i.e. the direct market response to electricity price increases, is not available quantitatively.

[16] At an aggregate level, according to a 2009 Eskom survey, 85% of mines estimated in 2009 that they could not pass on a 50% nominal increase in electricity prices to their customers and as did 57% of metals producers. Such a response from mines would be expected and such results must be put in perspective.

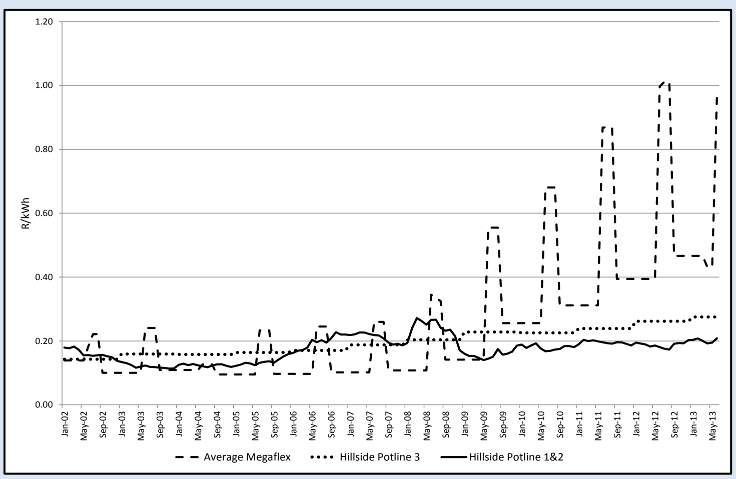
[17] Mining and associated manufacturing industries operate through cycles, with peaks and troughs, and profitability varies accordingly. Ideally, the analysis of the impact of electricity costs over an entire cycle would be useful. However, most companies are not willing to provide such disaggregated cost breakdowns for extended periods (usually seven to ten years would be required), and such data is not available in the public domain. The indirect effect of electricity cost increases on *other* cost items faced by the companies has also not been assessed.

Box 4: Costs and benefits of cancelling BHP Billiton's special pricing agreement with Eskom

Unlike the rest of the economy, the aluminium smelting industry in South Africa, under the monopoly of BHP Billiton, has not experienced significant increases in electricity prices over the last few years due to pricing contracts. Eskom entered into 25-year Special/Negotiated Pricing Agreements (SPAs/NPAs) in the 1990s with BHP Billiton, which currently accounts for about 5.5% of Eskom's nominal capacity, ensuring electricity supply at prices linked to the internationally-quoted aluminium price and the rand/dollar exchange rate, i.e. not related to Eskom's costs in any way. These NPAs were struck at a time of electricity surplus for Eskom (about 40% reserve margin), as a way of targeting surplus electricity storage problems, industrial policy objectives (substituting the import of significant volumes of aluminium for South Africa's developing industrial base) and making a contribution to the balance of payments. Until 2008, the BHP price and Megaflex were more or less in line. This changed drastically from late 2008, as a result of the global recession which saw falling aluminium prices and recent Megaflex price increases. Since then, the BHP Billiton price has been significantly lower than the average Megaflex tariff, and even below Eskom's cost since 2009. In addition, BHP Billiton's smelters are not subject to the seasonality applied to the Megaflex tariff where in high demand months, a higher tariff is charged and are protected from load shedding. BHP Billiton is however subject to an interruptibility provision, which allows Eskom to stop power supply (without compensation) to the smelters for two hours each week during periods in which the national electricity grid is under pressure.

In light of current electricity price increases and supply issues, investigating the impact of amending or cancelling BHP Billiton contracts (to increase electricity prices to Megaflex rates) provides a valuable insight of potential value chain repercussions.

BHP Hillside potlines 1, 2 and 3 electricity costs compared to average Megaflex tariffs



Source: TIPS, based on data from the London Metal Exchange, the South African Reserve Bank, Eskom and Statistics South Africa. Average Megaflex is the average of the three daily time-of-use periods (peak, standard and off-peak) and the spikes due to seasonality (high demand from June-August and low demand from September-May).

A legal assessment of amending or terminating the contracts reveals that it will be difficult for Eskom to unilaterally terminate the agreements, as it will then, in all probability, be susceptible to huge contractual damage claims. It is also unlikely that the agreements can be declared void and unenforceable on the basis that they are against public policy. NERSA however has the power to review these contracts in terms of the Electricity Regulation Act No. 4 of 2006. NERSA would obviously be mindful of the kind of message that is sent to international and domestic investors and others when an agreement of this nature is terminated or amended.

Impact of an electricity price increase to BHP Billiton on the aluminium value chain

BHP Billiton	Secondary smelters	Foundries	Semi-fabricators and fabricators
Smelters have allegedly shown losses in the last years. Plant closures are considered and no further investment is planned. An increase in electricity costs would exacerbate these losses and led the smelters to bankruptcy. BHP Billiton is dominant on the local market and shows significant market power. It is however a price taker on export markets and is unlikely to pass on costs.	Secondary smelters mainly use scrap and should not be directly impacted. Indirectly, scrap prices may rise as a result of a decrease in virgin (and scrap) material availability and an increase in the demand for scrap. The main concern for secondary smelters remains electricity mark-ups applied by municipal distributors, as they have a limited ability to pass on cost increases.	Of the three largest aluminium foundries (all supplying automotive industry), only Hayes Lemmerz, which is the largest foundry, still buys virgin material from BHP Billiton. Borbet stopped sourcing from BHP Billiton in 2012 due to contamination concerns. Other foundries use scrap and have the same concerns as secondary smelters. They also face competition from imported castings.	Wispeco is unlikely to be impacted since they mainly do their own re-melting of scrap and only buy small volumes of basic ingots (virgin) from BHP Billiton. Hulamin, despite some ability to pass on costs, is likely to be strongly impacted as it purchases large volumes of slab from BHP Billiton. Importing slab is much more expensive than buying locally (unlike importing basic ingots).

While there would be a direct impact on some downstream industries, such as Hulamin and Hayes Lemmerz, most companies appear to import aluminium product in any case or use mainly scrap aluminium as opposed to virgin aluminium from BHP Billiton. As such, although having a local primary aluminium producer in the country is more beneficial than not having one, this benefit (and any other benefit provided by the State, such as subsidised electricity costs) has to be filtered throughout the value chain.

Source: TIPS, based on TIPS, 2013

In addition, the percentage breakdown of mining cost and the electrical energy usage (divided between mining operations for 65% and beneficiation plants for the remaining 35%) have stayed fairly constant over the past five years.

Despite only accounting for a small proportion of operating costs, increases in energy costs (electricity and fuel) have impacted the industry, according to Exxaro and Sasol Mining, and have been absorbed through reduced profits. Sasol also claims that rising electricity prices have had a negative impact on the economic viability of its capital investments. Overall, labour costs, which represent the largest expenditure factor (and have increased faster than inflation and labour productivity according to Exxaro), and domestic and export sale levels (i.e. ensuring continual purchases from Eskom and addressing the bottleneck in rail capacity to transport coal stocks to the Richards Bay Coal Terminal) have a much larger impact on the industry.

Moreover, coal mining companies in South Africa appear to have limited ability to pass on costs to export markets which make up the bulk of coal sales, as prices are linked to international spot markets. Coal export prices are also more volatile than local prices, as a result of the impact of exchange rate and export costs. Local sales are tied up in long-term contracts with Eskom and are mainly on a cost-plus basis (nine of these contracts are on a cost-plus basis and three are on a fixed-price basis),[18] suggesting some ability to pass costs through. The timing of electricity cost increases may not necessarily coincide with the contractual times when costs can be adjusted. According to Exxaro, local coal contracts (generally for 20 years) are negotiated and agreed on individually with Eskom. They are structured on a base price with escalation mechanisms on a cost-per-tonne basis for defined tonnages, but do not generally include a 'production cost adjustment' consideration, which would allow the passing on of electricity cost increases immediately to Eskom. Only Sasol Mining, which supplies Sasol Synfuels and Sasol Infrachem through an internal, undisclosed transfer price, is most likely to be able to revise its contractual in-house arrangements.

Nevertheless, buoyant export markets and higher coal prices have cushioned most cost increases and protected the profitability of major coal mines.[19] Over the 2008-2013 period, Exxaro registered net operating profits averaging ZAR 2.6 billion per annum and Anglo American's thermal coal operations have remained highly profitable (although cyclical with peaks in 2008 and 2011). A combination of increased production volumes and newly negotiated coal sales prices has also helped Sasol Mining absorb electricity price increases.

Overall, recent electricity price increases have thus only marginally impacted coal mining companies. Electricity does not account for a large enough share of companies' operating costs in order for price escalations to have a notable impact on the competitiveness of the sector. Booming marking conditions have moreover enable companies to absorb any marginal impact without disruptions.

[18] Under the cost-plus contracts, Eskom and the coal supplier jointly provide capital for the establishment of the colliery. Eskom pays all the costs of operation of the colliery and the supplier is paid a net income by Eskom on the basis of a return on the capital invested by the coal supplier in the colliery. Therefore, it is a catch-22 situation. Increased electricity prices increase the costs of coal mines, which in turn is passed on to Eskom through their cost-plus pricing. Eskom then through its MYPD pricing, assuming these contracts are based on Megaflex pricing basis, passes on costs back to the customer coal mines or collieries. Under the fixed price contract, coal is supplied at a predetermined price, a base price which is escalated by means of an agreed formula. It is unclear what the base price is made up of at this stage.

[19] These findings corroborate Deloitte's (2012) conclusion that the coal industry is one of the least reliant on electricity, with electricity costs constituting approximately 1% of total costs in this industry as per 2002 estimates. They also accredit Pan African Investment and Research Services's (2011) estimation that a 24.8% increase in the electricity price would in the long run reduce output and increase unskilled employment in the coal industry by 0.2% and 0.5% respectively.

2.1.2. Iron ore mining has been moderately impacted on the back of booming markets

Iron ore companies, which essentially run diesel-based surface mining operations, have also not been significantly impacted by electricity price increases, primarily thanks to a favourable business environment.

Similar to the coal sector, iron ore companies do not rely heavily on electricity for their energy supply. For example, the share of electricity (purchased directly from Eskom) in Kumba Iron Ore's cash costs stood at 3.2% in 2012, although increasing from 2.9% in 2009. However, energy, mainly diesel, accounts for a substantial and increasing share of cash costs. Energy indeed comprised 20.4% of Kumba Iron Ore's cash cost to produce a tonne of product in 2012 (based on its Sishen mine which represents about 94% of production). Diesel accounted for close to 85% of these energy costs, essentially due to the reliance of surface mining on diesel-powered machinery and trucks. Over the 2009-2012 period, the share of energy in Kumba's cash costs has moreover increased, from 15.2% to 20.4%, essentially driven by diesel costs. Assmang also uses diesel as its main energy source in iron ore production, with electricity consumption constituting only around 5% of working costs. Most of the electricity, used in the value addition process (around 85% of Assmang's electricity requirement), is sourced directly from Eskom. Increasing diesel prices are therefore of greater significance to the iron ore sector than rising electricity prices. Nonetheless, according to Kumba, changes in electricity pricing have had an impact on long-term capital investment plans, affecting operating costs for both existing and future projects.

The profitability of iron ore companies suggests that the burden of increased energy (both electricity and diesel) costs has not been felt too severely owing to very favourable market conditions providing a buffer against rising costs. Although falling back to some extent in 2012, Kumba's profitability and profit per tonne have multiplied more than five and fourfold respectively from 2007-2011, as a result of increasing global and domestic iron ore prices and rising export sales volume (Kumba also benefited from a weak rand/dollar exchange rate in 2008 and 2009). Similarly, Assmang has maintained a strong profitable (yet erratic) profile over the 2008-2012 period.[20]

In the event that market conditions deteriorated, potentially increasing cost pressures of iron ore producers, Kumba Iron Ore and Assmang appear to have limited ability to pass on cost increases and influence prices (which are determined by spot markets) in global markets. On the local market, Kumba benefits from some ability to do so for its captive Thabazimbi mine, given the 'cost plus 20%' pricing agreement with ArcelorMittal South Africa applied since January 2014.[21] ArcelorMittal South Africa's countervailing power, as a large customer, does nevertheless reduce the ability to pass on substantial price increases.

[20] Given the consolidated nature of Assmang's financial reporting (which agglomerates iron ore, manganese and chrome operations), trends specific to iron ore can however not be isolated.

[21] Historically, ArcelorMittal South Africa procured iron ore at 'cost plus 3%' from Sishen and Thabazimbi mines based on a contractual agreement with Kumba Iron Ore.

The impact of electricity price increases on South African iron ore companies has therefore been fairly moderate. Positive market dynamics have maintained the competitiveness of the sector, which appears more subjected to the rise of diesel prices than events in the electricity supply industry.

2.1.3. Electricity-intensive steel-making companies are under strong pressure

At the beneficiation stage, electricity costs are a larger proportion of operating costs for steel players than for iron ore producers, and have been increasing over time, strongly impacting the competitiveness of companies. Methods of production (as illustrated in Box 4) and steel plants nonetheless vary vastly in their electricity consumption, ranging between 4% and 21%.

Even within ArcelorMittal South Africa, all plants have different electricity requirements. This variation is due to the variance in the electricity intensity[22] of different steel production processes, varying electricity requirements in parts of the production process, as well the direct costs associated with different steel products and processes. Electricity requirements account for approximately 10% of the energy basket for the conventional route used at ArcelorMittal South Africa's Newcastle and Vanderbijlpark Works, 11.5% for the electric arc furnace used in Vereeniging and 18% for Saldanha's operations which makes use of the Corex/Midrex and Conarc route. Requirements for the conventional route may even be lower if off-gases are used to generate the cold blast air for the blast furnaces. Bearing in mind the caveat on using averages across ArcelorMittal's plants, electricity costs as percentage of total operational costs for the company's steel-making processes have nearly double from 2007 to 2013, from 5.3% to 9.3%.[23] ArcelorMittal South Africa only generates 3% of its electricity requirements and has thus not been spared by recent electricity price increases. The company purchases the bulk of its electricity from Eskom at the Megaflex tariff (for three sites out of five) and from Tshwane and Emfuleni municipalities, in the Gauteng province, which add a surcharge of between 3 and 5% (see Box 5 for more details on municipal issues). According to ArcelorMittal, the steep rise in the cost of electricity and stringent environmental legislation forced the closure of the arc furnaces in Vanderbijlpark, which was producing at 35% of its capacity. More than electricity, coking coal, which is largely imported and subject to exchange rate volatility, constitutes a major cost component, oscillating between 16.5% and 25.4% of operating costs. In addition, technological fuels account for a substantial share (9.3% in 2013).

Comparatively, the proportion of electricity out of operational costs is much higher for Highveld Steel and Vanadium than for ArcelorMittal South Africa, owing to Highveld using a different steel-making process and reporting costs on a consolidating basis across its iron ore, steel-making and vanadium operations. Energy as a proportion of operating costs for Highveld Steel and Vanadium increased from 9.3% to 15.9% between 2008 and 2012. Despite lower production volumes, electricity costs increased by 16.5% in one year due to a reduction in usage efficiency and Eskom's tariff increase.

[22] The electricity intensity is the ratio between the electricity consumption and the value added.
[23] This is nevertheless considerably lower than the 20% figure reported in Deloitte's (2012) aggregated study.

Box 5: Factors influencing iron and steel energy intensity in developing countries

Raw materials represent the majority of production costs, estimated at between 70 to 80% in the production of steel. In developing countries, iron ore mining to produce steel represents the second largest sector in terms of energy use. Worldwide, secondary steel production from steel recycling requires 8 gigajoules (GJ) per tonne of steel, less than half the 20.6 GJ per tonne of steel that is needed for primary steel production mined from iron ore. Recycling materials creates similar results for aluminium smelting, glass and paper manufacturing. For developing countries, the amount of scrap available for recycling is limited, and depends particularly on levels of consumption in the preceding years or decades. Subsequently, the availability of scrap lags behind steel demand. As a consequence, the share of steel production from virgin iron ore is much higher in developing countries than in developed countries, resulting in a higher level of average energy use per tonne of steel produced.

Source: TIPS, based on UNIDO, 2010

Scaw Metal uses a different process in its long steel production and differs from the two market leaders. Scaw's process involves the use of scrap steel which is re-melted, requiring far less electricity (as explained in Box 4).[24] Despite the use of a more energy-efficient process, electricity constituted 21% of Scaw Metal's operating costs in 2012. From 2009 to 2012, electricity costs from Eskom and City of Johannesburg have moreover shot up at a compound annual growth rate of 15% and 26% respectively, much faster than any other cost component. According to Scaw, the increase in electricity prices has strongly impacted its competitiveness, resulting in margin erosion because of the differential between the cost base increases and sales price decreases. Like ArcelorMittal South Africa, Scaw sources electricity from municipalities and is faced with higher purchasing prices.

The steel industry appears in a difficult situation, suggesting that any increase in energy or electricity costs (which account for a noteworthy share of firms' operating costs) could further jeopardise the competitiveness of the sector.[25] For example, ArcelorMittal South Africa's profit per tonne has remained weak (varying between –ZAR 200 000 and 300 000) over the 2009-2012 period, and the company experienced a loss in 2009 and 2012, as a result of high financial costs as well as increases in input (including raw material and energy) and maintenance costs.[26] Evraz Highveld Steel and Vanadium has also experienced losses (in 2010 and 2011) and the company's profitability (encompassing both steel and vanadium operations) has decreased over time between 2008 and 2011. Profits improved in 2012 on the back of higher production numbers, due to increased availability of iron ore and improved stability of Evraz's steel plant.

[24] Given that the export of scrap has historically commanded higher prices, there has been less scrap available locally, escalating the local price although there recently has been an International Trade Administration Commission of South Africa policy which requires scrap merchants to first supply local customers at preferential rates prior to exporting.

[25] The competitiveness of the sector has additionally been impacted by labour issues, as illustrated by a four-week strike in 2011, the health of the market and production stability.

[26] It is important however to note that the accounting methods employed by different companies to report their profits vary, and particularly for large multinationals, certain financial line items may be reported in head office or group financial accounts, and not necessarily under the South African operations. This is often also done for tax purposes. So what appears as losses in financial statements may not necessarily be the case if revenue is accounted for in another jurisdiction for tax purposes.

Counterbalancing the potential impact of electricity price increases, steel companies, most notably ArcelorMittal South Africa, appear to have significant market power[27] in the South African market and be able to pass on costs to local customers.[28] Competition cases, which found ArcelorMittal South Africa guilty of excessive pricing in the local flat steel market and revealed extensive collusion in the local long steel market, are two clear illustrations of this market power (Competition Tribunal, 2007; Competition Appeal Court, 2009; Roberts, 2008). In addition, ArcelorMittal South Africa's Chief Executive Officer Paul O'Flaherty has indicated that, should a carbon tax be implemented in South Africa, the company will "pass the price onto [its] consumers" (Reuters, 2014), illustrating the capacity of the company to influence local prices.

In the end, the impact of electricity price increases on the competitiveness of South Africa-based steel-making companies is stringent, due to the electricity-intensive nature of iron ore beneficiation activities and the present difficult market conditions.

2.2. A substantial impact for deep-shaft platinum and gold mining but a marginal factor for the gold refining monopoly and catalytic converter industry

Unlike open-pit operations, deep-shaft mining, such as platinum and gold, rely primarily on electricity for its energy requirements. Electricity is a major energy source for the transport of personnel, material and ore, production machines and mineral processing. Electricity is also critical for health- and safety-related applications, such as the pumping of water, ventilation and refrigeration. In the gold sector, the refrigeration plant and the ventilation fans system consume around 27% of the total power used by these deep-level operations.[29] In addition, electricity constitutes the cost component which has registered the fastest increase in the last few years. The noteworthy impact of rapid electricity price increases has moreover compounded the existing labour problems of both sectors. At the beneficiation level, the catalytic converter industry does not consider electricity as a key factor impacting on competitiveness and is more concerned by the price of liquid petroleum gas. Similarly, Rand Refinery does not appear to have been impacted by electricity price increases.

2.2.1. The performance of platinum mining companies has cushioned a notable impact

Platinum mining companies, which operate electricity-intensive underground activities, have had to deal with the severe cost implications of recent electricity price increases. The leading position of South Africa on the platinum market and the overall good performance and competitiveness of companies have nevertheless moderated the impact.

[27] Market power refers to the ability of a firm (or group of firms) to raise and maintain price above the level that would prevail under optimal competition.
[28] The pricing of domestic steel remains nevertheless a contentious issue on which agreement was not reached in the project.
[29] This is mainly because the underground working environment requires a continuous supply of breathable air, and refrigeration is required to maintain temperatures at a maximum of 28.5°C (because ambient temperatures may reach up to 55°C).

Given the deep-shaft nature of operations, electricity makes up between 70 and 90% of total energy consumed by platinum miners in South Africa. Recent company financial reports show that electricity costs as a share of total costs stand between 10-11% on average.[30] Utilities accounted for 12% of the Anglo American Platinum's operating cash costs in 2012 and 2013.[31] Electricity, used in similar proportion at the mining, concentrating and smelting stages, makes up around 90% of utilities costs, resulting in the share of electricity costs being around 10%. Impala Platinum displays a similar profile, with energy accounting for 12% and 11% of operating cash costs in 2012 and 2013 fiscal years respectively. Lonmin's electricity as a percentage of the operating cost base is lower than the two industry leaders, but has been increasing rapidly from 2.9% in 2008 to 5.8% in 2012 (Lonmin, 2012).

According to the Chamber of Mines, electricity is also the cost component that has registered the largest inflation from 2007-2012 in the platinum industry (with an average annual cost increase above 25%), ahead of diesel and reinforcing steel. Labour and wages, which remain the primary cost component (at 41% and 38% of operating costs in 2012 and 2013 respectively in the case of Anglo American Platinum), have also grown by 60% in total over five years or by 12% per annum. While liquid fuels are a secondary concern in terms of energy costs for most platinum mining companies, diesel costs have increased on average by 15.7% per annum in the five-year period leading to 2013, on the back of higher international oil prices (Baxter, 2014).

Increasing input costs, including electricity, are therefore a key concern for the platinum mining industry which already operates in difficult conditions locally. A breakeven analysis based on cash costs and maintenance capital expenditure reveals that, at an average price of USD 1 555 per ounce of platinum in 2012, 59% of platinum mines were in a loss-making or break-even position. Recent estimates adjust this figure to 45% (Chamber of Mines, 2014). All three producers have experienced a decline in profit and profit per ounce, with both Anglo American Platinum and Lonmin displaying a deficit in 2012.

Over the last ten years, South Africa's platinum industry has reduced its domination over the market, from a position where it used to hold two-thirds of the global platinum supply in 2004 to just over half in 2013. A combination of factors, notably the falling global demand and commodity prices, and labour issues (illegal strike actions and demands for increased wages in 2012-2014), have negatively impacted the competitiveness and sustainability of the South African operations. Rapidly increasing input costs, including electricity, reduced productivity, increasing mine depth, declining head grades and increasing capital intensity have additionally put pressure of platinum companies and contributed to the average cost of producing an ounce of platinum increasing by 18% annually over the past five years (Baxter, 2014; Chamber of Mines, 2014). As such, electricity costs, as a critical input for extraction and processing in the mining and value-add stages, have a strong impact on strategic business decisions of major platinum players.

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[30] This differs from previous aggregated research results. Altman *et al*., 2010 claim electricity costs account for 15% of the platinum value chain costs while Deloitte (2012a) finds that the share of total costs attributed to electricity for platinum mining companies ranges between 3 and 7%.

[31] Reporting in previous years is not comparable to 2012 and 2013.

Box 6: Electricity supply and pricing by municipal distributors remain a key problem

The structure of the South African electricity distribution industry is fragmented. Eskom distributes more power than municipalities (60% of the total against 40% in 2012/2013) but serves a fewer number of end-users, with contracts with mining companies and large industry players. Municipalities purchase electricity in bulk from Eskom and sell it, at a premium, to all other commercial and residential customers. The sectoral and geographical split of end-users between Eskom Distribution and municipal distributors has resulted in the majority of the country's mines and smelters being supplied by Eskom, whereas municipalities service most of the smaller firms, across the various mining value chains, typically involved in the final manufacturing stages.

As the Constitution allows municipalities the right to apply surcharges over and above the electricity price determined by the National Energy Regulator of South Africa, municipalities have tended to increase tariffs in order to maximise revenues and subsidise other expenses. In addition, while the 12 largest municipalities, which accounted for 76% of all bulk purchases in 2010/2011, have the skills and assets to provide a reliable, good quality service, the other 266 smaller municipalities, which collected 24% of bulk purchases, generally have inadequate access to resources and operations cannot benefit from economies of scale, making it difficult to absorb costs. As a result, consumers are charged a different tariff for a similar service or the same tariff for a different level of service depending on their distributor. In addition, industrial users in municipal areas bear the brunt of tariff increases because they are regarded as a better source of revenue than residential users. In the end, municipal electricity tariffs for business and industrial users are higher than Eskom's tariffs, providing a cost advantage to mines and smelters supplied by Eskom Distribution over downstream manufacturing firms served by municipalities. For example, an industrial user, for a given load profile and consumption pattern, would pay ZAR 39 million if billed by Eskom compared to ZAR 65 million if billed by City Power Johannesburg.

In addition to pricing issues, electricity supply by municipal distributors is compromised by a lack of maintenance of, and investment in, the grid, resulting in a ZAR 27-billion municipal maintenance and refurbishment backlog that grows at an estimated ZAR 2.5 billion per annum. South Africa's best managed metropolitan municipalities are significantly above the international benchmark for distribution losses (3.5%). In 2011/2012, the most efficient municipality, eThekwini, achieved a distribution loss of 5.0%, whereas the two largest municipalities, the City of Johannesburg and the City of Cape Town, achieved 11% and 9.3% respectively. Differences between municipalities can be traced back to historical-political circumstances (municipalities in socio-economic disadvantaged areas generally inherited a poor asset base and a weak tax base, making it difficult for them to raise funds from providing services to address infrastructure backlogs) rather than the underlying cost of supply or consumers' ability to pay for the service. Institutional arrangements, especially disparate municipal electricity surcharges, have entrenched tariff discrepancies between Eskom and municipalities, and across municipalities, for the same service.

Sources: TIPS, based on Steyn, 2012; NERSA, 2013; Rustomjee, 2013; Das Nair, Montmasson-Clair & Ryan, 2014

Nonetheless, over the 2008-2012 period, the sector has maintained an overall strong performance and production appears to have only been affected marginally, due to a continual supply deficit on the global platinum market and steady outputs at firm level. In addition, the dominating nature of the South African platinum industry suggests some ability to influence prices, although global demand conditions, the increasing role of recycled platinum and the loss of market share have reduced this ability. Anglo American Platinum and Impala Platinum appear to have the strongest position in the market to pass on costs, followed by smaller companies, such as Lonmin and Northam Platinum (Deloitte, 2012).

Locally, the pricing methodology also depends on the types of contractual relationships between mines and key customers. Contracts by platinum mines entered into with global car manufacturers and industrial fabricators also suggest a degree of market power and some ability to pass on increased costs through higher prices. For example, the new contract between Anglo American Platinum and catalytic converter leader Johnson Matthey introduced in 2014 does not attract any discount, unlike its predecessor which was based on the London Metal Exchange price less a discount. Furthermore, the procurement of market research from Johnson Matthey is now separated from the contract and at a fixed fee. For the financial year ending 31 March 2013, Johnson Matthey estimated that the full-year impact on the group will be a loss of commission income of approximately GBP 35 million (Johnson Matthey, 2013).

Ultimately, despite the importance of electricity in companies' energy mix and some difficulties at the local level, the combination of good global market conditions and the dominating role of the South Africa industry (although eroding) have prevented the industry from being too severely impacted. The present moderate impact is however expected to strengthen in the years to come and is a definite concern for the platinum industry in South Africa.

2.2.2. Gold mining has been severely impacted while the refining monopoly has been spared

The South African gold mining sector, which relies extensively on electricity for its deep-shaft operations, has been hard-hit by recent steep electricity price increases. Difficult local and market conditions have moreover not afforded companies the opportunity to reduce the impact on their competitiveness.

Similar to platinum mining, electricity is the main component in the energy use basket of South African gold mines, accounting for 95.0% of the mix in 2013. For illustration purposes, the electricity required by AngloGold Ashanti's Mponeng mine, in the Gauteng province, is equivalent to the energy required by the entire city of Bloemfontein, in the Free State, which hosts close to 750 000 people. Electricity is therefore a critical input for gold mining in South Africa and electricity costs range from 6 to 14% of total costs for gold mining companies (Deutsche Securities, 2010 in Deloitte, 2012).[32] Following a decline from

[32] Harmony Gold and AngloGold Ashanti clearly reported the production cost, per mining company, while Gold Fields production costs were aggregated into Group operating performance figures, making it difficult to isolate the production costs associated with mining in South Africa. Lastly, Sibanye Gold came into existence in 2012, and there is very little time series data to analyse.

11% to 7% on the 2004-2008 period, Harmony Gold's electricity costs as a proportion of operating costs have risen significantly to 15% in 2012. A similar trend is witnessed for AngloGold Ashanti, with energy and water accounting for 19.4% of operating in 2012, rising from 10.9% in 2007. Coal (2.9%) and diesel (1.9%) complete the energy mix. While representing small components, other energy costs have also been spiralling. For example, diesel costs have increased by 69.3% in the five-year period, or an average of 15.7% per annum, on the back of higher international oil prices, as reported by the Chamber of Mines (2013).

Gold mines have been under a fair amount of pressure over the 2004-2012 period and struggled to turn a profit, especially for the larger players in the industry. Some of South Africa's mines even exhibit the highest mining cash costs among all major gold producing regions (York, 2011). For example, on the back of plummeting production numbers (from 94 tonnes in 2004 to 34 tonnes in 2012), Harmony Gold registered a net operating loss for four of the nine years (running from 2004-2012). The company's profit per tonne oscillated between -ZAR 30 000 and ZAR 20 000. The resulting losses cannot be attributed solely to the rising cost of electricity alone (increasing production costs and falling gold prices also impacted the sector), but electricity is likely to have played a role in the relatively poor performance. Over the last few years, Harmony closed four marginal shafts, where payable reserves did not meet rising energy costs (Ross, 2014).

AngloGold Ashanti's profitability measures display a slightly better picture, as the company only reported a net loss in 2009. While production also severely nosedived (from 81 to 34 tonnes) over the same period, AngloGold Ashanti averaged a profit of approximately ZAR 2.5 billion (thanks to a net increase from 2010 onwards). The company profit per tonne has also significantly picked up from 2010. In Sibanye Gold's first two years of operations, the company has posted significant profits, while Gold Fields struggled to return to profitability since the 2013 unbundling.

The overall difficult situation of the South African gold sector is attributable to a number of factors that include the rising cost pressures faced by mines, the decline in the gold price, as well as challenges in the output for the gold mines. Labour costs, which constitute the major cost component, have notably increased substantially over the last few years, while not being matched by a corresponding increase in the relative output per worker, according to the Chamber of Mines (2013). These though circumstances have driven gold mining houses to cut costs wherever possible in order to remain viable and have anchored energy efficiency as a business imperative.

In addition to challenging conditions, the ability to pass on cost increases through higher prices seems limited. Although South Africa is a significant global producer, the price is determined by the market, which the members of the London Bullion Market Association report twice a day.[33] Also, the South African gold sector has little influence on the price of gold due to large above ground gold reserves, South Africa's falling percentage of world production and South African gold being already seen as relatively expensive (Deloitte, 2012). On top of difficult business conditions, rising electricity prices have thus had a strong impact on gold miners' competitiveness in South Africa.

[33] At the time of writing, the five banks that are members of the LBMA were the Bank of Nova Scotia-Scotia Mocatta, Barclays Bank Plc, Deutsche Bank AG, HSBC Bank USA NA and Société Générale.

Table 2: Overall impact of electricity price increases on selected mining-related companies

Sectors and companies	Electricity as a share of operating costs	Ability to pass on costs	Performance and competitiveness	Impact of electricity price increases
Platinum Group Metals				
Anglo American Platinum	10-12% (2011-2012)	moderate	good	moderate
Impala Platinum	11-12% (2012-2013)	moderate	good	moderate
Lonmin	2.9-5.8% (2008-2012)	moderate	good	moderate
Gold				
Harmony Gold	7-15% (2009-2012)	weak	at risk	strong
AngloGold Ashanti	19.4% (2012)	weak	at risk	strong
Rand Refinery	n/d	strong	monopolistic	marginal
Iron Ore				
Kumba	2.9-3.2% (2009-2012)	moderate	strong	moderate
Assmang	≈5% (2012)	limited	strong	moderate
Steel				
ArcelorMittal South Africa	5.3-9.3% (2009-2013)	strong	stable	strong
Evraz Highveld Steel and Vanadium	9.3-15.9% (2009-2012)	moderate	stable	strong
Scaw Metals	21% (2012)	moderate	stable	severe
Coal				
Exxaro	≈3% (2012)	limited	strong	marginal
Sasol Mining	≈5% (2012)	limited	strong	marginal
Anglo American Thermal Coal	≈3% (2009)	strong	strong	marginal

Source: TIPS

Note: colour shapes characterise visually the influence of the variables on the impact of electricity price increases on the competitiveness of selected firms, from reducing (green and yellow shapes to some extent) to aggravating (red and especially black shapes) any potential impact. The ability of firms to pass on costs is considered weak, limited, moderate or strong, while the current performance and competitiveness of firms is evaluated from at risk or stable to good or strong/monopolistic. Overall, the impact of electricity price increases is assessed as marginal (i.e. having minimal implications on competitiveness), moderate (i.e. having some non-disruptive implications), strong (i.e. having implications susceptible to durably affect competitiveness) or severe (i.e. having drastic long-term implications on competitiveness).

At the second stage of the gold value chain, the electricity consumption of Rand Refinery does not seem to have been impacted by electricity price increases. Despite rising (almost doubling) electricity costs (from ZAR 7 million in 2008 to ZAR 19 million in 2012), Rand Refinery has not reduced its consumption of electricity, increasingly moderately from 29 to 32 GW. In addition, Rand Refinery's price of gold, which it publishes twice daily and which forms the reference points for purchases of semi-fabricated products by jewellery manufacturers and other end users, is based on the gold fix price plus a premium. This allows costs to be passed on to an extent through the premium, given that Rand Refinery is the monopoly refiner of gold (Short & Radebe, 2008).

2.3. Security of electricity supply: An issue at least as important as electricity prices

As summarised in Table 2, electricity price increases have had a notable yet varied impact on the competitiveness of mining value chains in South Africa. As important as prices increases (if not more vital), security of electricity supply constitutes a key issue for mining and linked manufacturing operations, as outages have serious cost implications (see Box 7 for an account of Zimbabwe's experience in this respect).

Box 7: The cost of power outages and back up generation in Zimbabwe

Zimbabwe's electricity sector has been a challenge to the development of the country for decades. No new generation assets have been installed for the past 30 years. And while the country has 2 099 megawatt (MW) of installed generation capacity, only between 1 500 MW and 1 960 MW is operational, to meet the 2 200 MW national electricity demand. The critical shortage of energy has affected all sectors of the country, and industry operates at 40% partly because of the shortage of electricity and the obsolete equipment. In addition, mining and manufacturing processes are highly energy intensive, with energy costs accounting for 40% of total production costs in aluminium alloys, 30% in steel, 10% in magnesium and 5% in copper.

Against this backdrop, the mining sector reported in 2008 a total loss of USD 251 million due to power outages. Lost output accounted for 86%, followed by idle labour for 9%. High-capacity (largely large-scale) mines are less affected than low-capacity (largely small-scale) mines. On average, high-capacity mines have experienced production losses of USD 7 per kWh of power not supplied, compared to USD 12 per kWh for low-capacity mines. High-capacity mines also benefit from a greater availability to uninterrupted power supply (i.e. fewer and shorter power outages) and an advance warning arrangement. Gold and diamond mining appear as the most impacted sectors in terms of costs, while iron ore and coal mining are the least affected.

In an effort to mitigate the negative impacts of power outages, private electricity generation by mining companies is seen more as an insurance, and less so as an additional cost. However, private generation does increase the setup costs of mining companies. Large mines generally have one or two generating (and conserving) sets including generators, solar panels, Uninterrupted Power Supply systems, battery back-ups or diesel pumps. Generators constitute the most costly equipment, on average costing 10 times more than Uninterrupted Power Supply systems and around 4 times more than diesel pumps. In 2010, the majority of the mines (71%) had only generators as back-up power supply, around one-fifth (19%) had generators and Uninterrupted Power Supply systems, 6% had generators and diesel pumps and only 1.5% of the mines had generator, diesel pump and Uninterrupted Power Supply systems. In contrast, low-capacity mines are largely unable to finance the cost of back-up systems and end up bearing the brunt of power failures because with losses from power outages as high as one-fifth of their total revenue.

Sources: TIPS, based on Eberhard et al., 2011; Mungwena & Rashama, 2013

In general, load reduction by Eskom has significantly affected production in the value chains, resulting notably in production loss and the damage of capital equipment. Estimated losses due to electricity disruptions of about ZAR 115 million a day were reported by Kumba Iron Ore and ZAR 0.9 million per hour by ArcelorMittal South Africa. Exxaro estimates the cost of unserved supply at ZAR 18 000 per megawatt-hour for its operations. According to Kumba, numerous processes, such as thickener dams, ferro-silicon services, dewatering, fire prevention, diesel refuelling and distribution, and water and sewerage, pose critical risk to operations if stopped. Similarly, ArcelorMittal South Africa's coke plant cannot be stopped as the temperature needs to be kept constant throughout the process with the basic oxygen furnace on hot idle. In addition, the starting and stopping of furnaces, due to electricity interruptions, contributes to reducing the average lifespan of furnaces from fifteen to nine years. This has cost implications of about ZAR 100 billion in the long run, which is the cost required to reline furnaces. Scaw also highlights concerns with the lack of electricity supply. Due to load reduction by Eskom, Scaw experienced a loss in production in terms of steel manufacturing and the disruption in electricity supply has had spill over effects, affecting delivery time and compromising relationships with suppliers.

3. Mitigation strategies, a real potential to do much more than low-cost, low-hanging fruit initiatives

Against the diversity of the situations in terms of electricity usage across and within mining value chains, mitigation strategies implemented by mining and linked manufacturing companies in South Africa to cushion the impact of electricity price increases and security of supply issues appear relatively standard and only vary at the margin. Firms tend to broadly have four options to mitigate the negative impacts of increasing input costs, such as electricity, labour, output and profit. They can either pass the cost onto the consumer; initiate energy conservation or increase the use of alternative/self-generation of energy; cut costs in production and other areas; or reduce hours of production. The timing and magnitude of their response to these price and security of supply shocks however differ, reflecting the variations in their business models (such as the age of existing equipment, the availability and cost of finance, market forecasts, competition in local and international markets, etc.) and their projections of electricity prices, level of uncertainties about future electricity prices and security of supply.

As summarised in Figure 2, South African mining and linked manufacturing companies have primarily focused on traditional mitigation initiatives, such as load shifting and alternative fossil fuel-based energy sources. Companies are progressively turning their focus towards energy efficiency improvements and the use of renewable energy to improve their energy profile and their energy security. While these initiatives are supported by the South African Government, companies have largely limited their investments to low-hanging fruits and further efforts are required to meaningfully alter the energy profile of mining value chains and integrate them into South Africa's green growth path trajectory.

3.1. Traditional strategies as a first port of call

As a primary mitigation measure against electricity price increases, companies, particularly in electricity-intensive deep-shaft platinum and gold mining and beneficiation industries, have engaged in load shifting. Load-shifting ensures that energy-intensive operations are carried out during the most inexpensive power phases, at the same time concentrating operational activity with the most energy-efficient infrastructure during the relatively more expensive power phases (for example, operating the most efficient pumps at peak times). This does not reduce the use of energy and is more a short-term measure to reduce electricity costs, and an immediate response to the rising electricity prices.

The unbundling of the Megaflex tariff with the possible introduction of a Critical Peak-Day Pricing tariff (which is being piloted by Eskom in 2014/2015) will probably incentivise mining-related industries to further manage their level of consumption in response to price movements. Under the Critical Peak-Day Pricing, customers would pay a higher price for electricity when the system faces critical peak demand. Eskom would inform customers a day ahead whether the system would experience a critical peak day. Customers could either decide to curtail consumption on the critical peak day, or consume electricity and pay a substantial premium above their standard tariff rate (Eskom, 2014).

Figure 2: A summary matrix of mitigation strategies implemented by mining-related firms

Mitigation Strategies	Description	Uptake	Cost Saving	Energy Saving	Sustainability Level	Company examples
Traditionational Mitigation Initiatives						
Load shifting	shift of comsumption to most inexpensive power phases (e.g. night)	widespread	yes	unchanged	unchanged	underground mining companies in PGMs and gold sectors
Alternative fossil-fuel based energy	use of diesel-run back-up generators	widespread	cost increase	none	increase in GHG emissions	Exarro; Kumba Iron Ore; ArcelorMittal South Africa
	investment in fossil-fuel based independent electricity production	limited	variable	possible	dependent on fuel source	Jubilee Platinum (11-MW gas-fired plant); ArcelorMittal South Africa (25-32% target of energy from IPPs by 2017)
Energy Efficiency Improvements						
Energy Audits	use of energy management (including ISO 50 001 standards) and metering programmes	some companies	in the medium term	potential	foundation for energy efficiency improvement	AngloAmerican Platinum, ArcelorMittal South Africa, AngloGold Ashanti
Non-core Activities	improvements of buildings (e.g. solar water heaters, new geysers, heat pumps, improved insulation)	widespread	yes	limited	reduction in electricity use	all companies
	use of energy-efficient lighting	widespread	yes	limited	reduction in electricity use	all companies
Process Optimisation	optimisation of processes and equipment (e.g. motors, shaft pumps, conveyors and feeders)	widespread	yes	noteworthy	reduction in electricity use	all major producers
	optimisation of ventilation (through fan settings and design), cooling and refrigeration systems	some companies	yes	large gains	reduction in electricity use	all major producers
Optimised Industrial Insulation	implementation of hybrid insulation solutions	rare	yes	yes	reduction in electricity use	Goldfields; BHP Biliton
Equipment Changes and Process Changes						
Equipment Changes	switch to water-operated systems for rock-drill operations	limited	yes	yes	reduction in electricity use, reuse of water	AngloGold Ashanti
	technology research and development	limited	significant potential	significant potential	potential	AngloGold Ashanti (Technology Innovation Centre)
Process Changes	research into new shaft and plant design	limited	significant potential	significant potential	potential	deep-shaft mining companies
	implementation of new mining and beneficiation processes	sector specific	large gains	large gains	reduced electricity use	Anglo Gold Ashanti (reef-boring technology); Palinghurst (Kell process); Jubilee Platinum (ConRoast process); Evraz Highveld Steel and Vanadium (sizing method)
Cogeneration and Renewable Energy						
Cogeneration	use of cogeneration plants	some companies	yes	yes	reduced electricity use	Scaw (68-MW waste-to-energy plant in Germiston); Exarro (14-MW plant at Namakwa Sands smelter); AngloAmerican Platinum (at Waterval smelter)
Renewable Energy	investment in renewable energy	rare	in the medium to long term	yes	use of clean, renewable energy	AngloAmerican Platinum (furnace in Polokwane), Exxaro (through Cennergi)

Source: TIPS

Note: colour shapes characterise visually the degree of the uptake of mitigation strategies, as well as their impact on cost savings, energy savings and sustainability, from positive and/or large (green and yellow shapes to some extent) to negative and/or minimal (red and especially black shapes).

In order to decrease their reliance on the national utility, both in terms of price and supply, companies in mining value chains have also been historically investing in alternative fossil fuel-based energy sources. Reliability of electricity supply is a factor affecting the mining and linked manufacturing sector in South Africa, particularly since the 2008 load shedding crisis during which a number of industries were forced to shut down or scale back production. In addition to load shedding, the breakdown and maintenance of power stations, transformers and distributions network have also impacted operations. For example, in 2013, a transformer fire cut 400 megawatt (MW) of electricity supplies to platinum mines in the North West Province (Reuters, 2013). Most companies, such as Exxaro, Kumba and ArcelorMittal South Africa, have therefore invested in diesel-run back-up or emergency generators as a contingency measure against electricity outages. However, these are not to sustain production, but only to ensure workers' health and safety and prevent loss or damage of equipment (critical cooling and exhaust systems).[34] Sasol Mining constitutes an exception in the industry, as it does not use back-up

[34] The use of back-up generators and self-generation plants are however limited compared to some regions. More than half of large industrial firms in sub-Saharan Africa have back-up generators, and self-generation by such firms represents a significant proportion of installed capacity – as much as 19% on average in West Africa (Eberhard *et al*., 2011).

generators, due to all mines having incline shafts for conveyors which can also be used as an alternative exit for people.

Beyond emergency measures, companies have invested in independent generation capacity to reduce their reliance on Eskom. Based on financial considerations, companies have favoured investment in traditional fossil fuel-based technologies. For example, Braemore Platinum (a subsidiary of Jubilee Platinum) supplies the entirety of the electricity requirements at its Middelburg smelter in Mpumalanga through an on-site 11-MW gas-fired plant owned by Power Alt (of which Jubilee Platinum controlled 70% until May 2013). The company supplies 5 MW of power to the facility and sells its surplus power to Eskom through a power purchasing agreement (Matthews, 2013). Similarly, ArcelorMittal South Africa aims to have between 25 to 32% of its total energy use supplied by independent power producers (IPPs) by 2017. ArcelorMittal South Africa has prospects of sourcing electricity at a price lower than Eskom's Megaflex and is investigating the use of open-cycle gas turbine, waste heat recovery and combined-cycle gas turbine technologies. The company is also is in the process of implementing measures to reduce the risk of lack of availability of consistent electricity supply from the national grid by importing compressed natural gas to its Saldanha Works.

Implementing load shifting and investing in fossil fuel-based independent generation capacity (for emergency and operational purposes) have therefore been the first mitigation strategies implemented throughout the mining sector. While addressing some of the impact of electricity price increases and supply interruptions, these endeavours appear more as temporary answers to pressing issues than long-term solutions to the energy challenges of the sector, notably from the perspective of the transition to a green growth path.

3.2. A growing interest for energy efficiency improvements and renewable energy projects driven by financial motivations and Government's support

More recently, companies in South African mining value chains have turned their attention towards improvements in energy efficiency to complement traditional mitigation measures. The use of renewable energy as a credible source of electricity is also being increasingly investigated by mining and linked manufacturing companies.

This new focus has essentially been driven by financial motivations. A survey conducted on 33 firms (the majority of which were large industrial and mining firms) shows that higher electricity prices are the primary factor motivating firms' investment in electricity efficiency technologies, as illustrated in Table 3 (DNA Economics, 2011). Correspondingly, 23% of mines strongly agree and 77% agree that they have realised gains from electricity efficiency, according to an Eskom's 2009 survey. As a reaction to electricity price increases and energy security concerns, investments have substantially increased over the 2008-2010 period, compared to the 2005-2007 period, and will continue to do so from 2011-2015. Energy efficiency is clearly a driver for enhanced profitability, competitiveness and performance, notably through productivity improvements, cost savings, improved energy security, lower taxation costs, reduced vulnerability to energy price increases and climate change response measures, better reputation and ultimately freeing up resources for alternative investments (Maia, 2013). According to the United Nations Industrial Development Organisation, energy efficiency improvements in developing countries display on average a payback period of less than two years and a five-year internal rate of return of more than 40% (UNIDO, 2011).

Table 3: Firms' rationale for investment in energy efficiency and renewable energy

Technology	Main reasons for investment		
Energy efficiency	**Cost reduction** 33 responses (21 votes as primary reason)	**Sustainability** 33 responses (3 votes primary reason)	**Energy security** 13 responses (7 votes as primary reason)
Renewable energy	**Sustainability** 33 responses (7 votes as primary reason)	**Cost reduction** 22 responses (10 votes as primary reason)	**Energy security** 13 responses (8 votes as primary reason)

Source: DNA Economics, 2011

In addition, from a social point of view, renewable energy and energy efficiency have the potential to *inter alia* create numerous employment opportunities, foster skills development, improved health and life expectancy and create better working environments. A study from the Industrial Development Corporation, the Development Bank of Southern Africa and Trade and Industrial Policy Strategies thus estimates that renewable energy and resource efficiency have the potential to respectively generate about 68 000 and 130 000 new direct employment opportunities by 2025 in South Africa (Maia *et al*., 2011). Renewable energy and energy efficiency also bring substantial environmental benefits, such as reduced use of natural resources (fossil fuels, water, etc.), decreased GHG emissions and ecosystems/biodiversity impacts.

In this respect, investments in both renewable energy and energy efficiency have been prioritised by the South African Government. A national energy efficiency improvement target of 12% by 2015 has been set by the National Energy Efficiency Strategy, first approved in 2005 and reviewed in 2008. Mining and industrial sectors have both been assigned an energy efficiency improvement target of 15% by 2015 (DME, 2008). As part of the strategy, 36 companies and eight industry associations, including several in the mining sector (such as Anglo American, Anglo Coal, Anglo Platinum, AngloGold Ashanti, BHP Billiton, Exxaro, Gold Fields, Implats, Sasol, Xstrata, etc.) have signed an energy efficiency accord with the DoE and Eskom.

This objective is supported by governmental programmes, such as the National Cleaner Production Centre's Industrial Energy Efficiency Improvement Project,[35] Eskom's Integrated Demand Management programme[36] and the Department of Trade and Industry's (**the dti**) Section 12-I Tax Allowance

[35] The National Cleaner Production Centre's Industrial Energy Efficiency Improvement Project aims to contribute to the sustainable transformation of industrial energy usage practice in South Africa, reduce carbon dioxide emissions, and demonstrate the impact of energy efficiency practices as a means of increasing sustainability. It focuses on agro-processing, chemicals and liquid fuels; metals processing and engineering, automotives and mining. See http://ncpc.csir.co.za/?page_id=278 for more details on the project.

[36] Eskom's Integrated Demand Management programme coordinates and consolidates the enterprise's various initiatives aimed at optimising energy use and balancing electricity supply and demand (e.g. the promotion and implementation of more energy-efficient technologies, processes and behaviours). See http://www.eskomidm.co.za for more details on the Demand Side Management initiatives comprising Eskom's Integrated Demand Management programme. Eskom however placed its energy efficiency rebates for businesses and homes on hold in October 2013, pending a review of the incentive programmes in light of financial constraints. A new list of programmes is expected in 2014 (Webb, 2013).

incentive.[37] A tax incentive for energy savings, allowing businesses to claim a deduction against taxable income equivalent to the monetary value of proven energy efficiency savings, has also been announced by the DoE in December 2013. Under the Regulations on the Allowance for Energy Savings in terms of Section 12-L of the Income Tax Act, businesses would receive a ZAR 0.45 tax deduction for every kilowatt-hour (kWh) saved (Greve, 2013). The Industrial Development Corporation, one of South Africa's development finance institutions, and the German Development Bank (KfW) have also partnered to establish a ZAR 500-million Green Energy Efficiency Fund. The fund supports the introduction of energy efficiency and self-use renewable energy technologies by small- and medium-sized companies[38] through credit financing at preferential rates[39] and free technical assistance (for energy assessment). Privately-run schemes exist too, such as the National Business Initiative's Private Sector Energy Efficiency project,[40] which aims to raise awareness and assist in the uptake of best practices on energy management in about 2 500 small companies, 1 000 medium-sized enterprises and 60 large companies (PSEE, 2014).

The South African Government is also considering more constraining options to mitigate GHG emissions for industrial and mining sectors in the country. For example, while the National Treasury is promoting the introduction of an economy-wide carbon tax, the Department of Environmental Affairs advocates for a carbon budget approach. In addition, the DoE is considering the mandatory provision of an energy management plan by companies. Eskom's proposed Energy Conservation Scheme, which aims to reduce the annual consumption of South Africa's largest 500 users, could fast-track future gains. Eskom and affected users would set energy-usage targets drawn from baseline energy consumption profiles. End-users would then be responsible for implementing and managing their own energy savings, ultimately paying additional fees if they exceed their monthly energy allocation.

The development of renewable energy technologies has also received support from the South African Government. At the national level, the installation of 17.8 GW of generation capacity (solar and wind technologies essentially) from 2010-2030 is planned under the Integrated Resource Plan for Electricity 2010-2030 (DoE, 2011a) and implemented notably through the Renewable Energy Independent Power Producer (REIPP) procurement programme, which aims at procuring 6 725 MW of new capacity by 2020. In addition, fiscal instruments promote investment, such as an accelerated depreciation allowance at the rate of 50%-30%-20% over three years for capital equipment used for renewable energy generation (wind, solar, small-scale hydro and biomass) under Section 12(b) of the Income Tax Act No. 58 of 1962, as amended by the Taxation Laws Amendment Act No. 22 of 2012.

Internationally, several support mechanisms have been established to assist developing countries' investments in low-carbon initiatives, such as the Clean Development Mechanism (CDM) of the Kyoto

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[37] The Section 12-I Tax Allowance Incentive of **the dti** is aimed at supporting investment in the manufacturing sector improving the productivity of the sector. Projects must realise a 10% energy efficiency improvement to qualify for the scheme.
See http://www.thedti.gov.za/financial_assistance/financial_incentive.jsp?id=45&subthemeid=26 for more information of the incentive.

[38] Priority is given to companies that have less than or equal to: ZAR 51.0 million turnover; ZAR 55.0 million assets; or 200 employees.

[39] Rand-denominated loans from ZAR 1 to ZAR 50 million are available at a rate of prime minus 2%. Term is up to 15 years, depending on the pay-back period of the technology used.

[40] See http://www.psee.org.za for more details about the Private Sector Energy Efficiency project.

Protocol.[41] In February 2014, 347 CDM projects had been submitted in South Africa and 12 projects received certified emissions reductions. CDM projects range from energy efficiency projects to cogeneration and renewable energy initiatives. In the platinum sector for example, Impala Platinum's fuel switching and biomass power generation projects (submitted in 2012) are currently being investigated by the CDM Executive Board (DoE, 2014).

All these mechanisms contribute to make end-users more aware of the economic cost of their consumption. Both negative and positive incentives aim to change companies' behaviour and encourage greater investment in electricity efficiency technologies, renewable energy and cogeneration. The development of multiple policies has, however, raised the issue of the coordination of all existing and considered measures and instruments, so as to trigger positive spillovers and co-benefits and avoid redundancy and adverse side-effects (notably on economic and social structures).

3.3. A primary focus on low-cost, low-hanging fruit initiatives in terms of energy efficiency

In order to complement traditional mitigation strategies, companies have turned their attention to the optimisation of operations in terms of energy consumption. Firms in South Africa's mining value chains have essentially focused on implementing low-cost, non-disruptive solutions. While laudable, these initial efforts do not carry significant savings and will unfortunately not alter the energy profile of companies.

At the firm level, most large companies in the mining sector have approached the issues around energy efficiency using the 'Six Sigma' methodology and the following sequence of initiatives: behavioural change strategies for all staff; process changes; equipment changes; and lastly, larger scale and more complex and expensive technology changes.

A number of companies have thus adequately adopted a clear strategic approach to energy management in order to instil a culture of energy efficiency, and developed energy and carbon management strategies throughout their operations, as opposed to a project management approach.

[41] The CDM was established by the United Nations Framework Convention on Climate Change in 1997, allowing industrialised countries to meet their emissions reduction commitments by investing in projects in developing countries that target GHG emissions reduction. It requires a Designated National Authority to verify and see to the successful implementation of CDM projects, which is regulated in South Africa by Section 25 of the NEMA.

Box 8: Energy audit, the basis of an energy conservation strategy

Firms' lack of awareness of their energy consumption patterns has been a clear hindering factor for a shift towards using energy more conservatively. In an effort to address this gap, many governments have promoted the use of energy audits, which is a survey done on an organisation to examine its energy use and the conservation options. The audit aims to raise energy consumption awareness, as well as motivate suppliers to improve the efficiency of machinery used in energy-intensive firms. A typical audit analyses the energy consumption patterns to establish a database by firm, industry and/or sector, and identify the most energy-intensive processes across the value chain of a finished product. The audit also reviews the month-to-month electricity bills to identify peak months and factors influencing the changes in use. Lastly, the audit monitors the energy consumption of various machines used across firms to identify which existing equipment in the market is more efficient. The aim is to make audits compulsory and to have the assessments published annually to raise awareness of energy consumption patterns and existing efficient equipment, and in turn motivate suppliers to improve on their equipment.

Source: TIPS, based on UNIDO, 2010

The Anglo American Group has an energy and carbon management programme (ECO2MAN) that enables the group to understand how energy management can be used to create additional business value. Each mine has a programme in place to continually improve how it manages energy usage, with targets to reduce consumption in relation to a business-as-usual projection. This includes the mitigation of methane emissions.[42] Similarly, all major gold companies have set up energy efficiency units at various mines, with representation at the most senior levels of management. Gold Fields (through Sibanye Gold) has developed an integrated energy and carbon strategy which seeks to transform energy management and carbon through direct interventions and changes in operational behaviour (Cornish, 2014). Likewise, Sasol Mining has created an Energy Forum to coordinate energy efficiency initiatives while Exxaro has made energy efficiency a requirement for performance, linked to remuneration. In an effort driven from the Board level, key performance indicators include energy efficiency and carbon footprint targets for the various tiers of management within Exxaro. Although the impact of such initiatives depends on the role given to coordinating entities and the weighting of energy efficiency targets versus other indicators, they represent a positive move in the long-term goals towards greater energy efficiency.

Such companies have generally complemented this approach with the implementation of energy (or electricity) metering systems. Energy use monitoring involves improving energy consumption at business unit level, through the utilisation of sophisticated energy management software. Anglo American Platinum has installed 598 metering points in 2010 in a ZAR 40-million project. This system allows for

[42] Methane emissions are a significant challenge to the underground coal mining operations in South Africa. As methane is 21 times more damaging to the environment than CO_2, the group has made it a priority to identify and implement technologies that will mitigate the impact of this GHG and transform an environmental liability into an asset. In South Africa, the New Denmark mine has helped to design and develop a 'world first' mobile flaring system that will reduce its annual methane emissions from ventilation boreholes by an expected 15%. Flaring burns off methane, rendering it 18.5 times less harmful to the environment than venting. At its Goedehoop mine, Anglo American has reduced GHGs related to ventilated air methane by improving how these systems are managed. By isolating the areas underground that require ventilation and identifying and addressing any leaks, Anglo American has reduced the amount of methane flushed out of the mine as well as the electricity required to run the ventilation system. During 2012, Anglo American established a carbon steering committee to coordinate activities that lower exposure to carbon compliance costs, including building capacity to buy and sell carbon allowances.

live tracking of electricity use across the operations of the mines and operations. Further development of the system, in order to account for energy consumption beyond electricity, is still required. Meaningful integration of this system to measure the consumption of fuels, such as diesel, beyond a basic stock (accounting) system is also needed to establish more useful data for the company. Likewise, AngloGold Ashanti uses a programme called 'Chart Runner' which provides daily energy updates and detail the actual saving contributed by each business unit. In terms of diesel consumption, some open-cast mines, particularly in iron ore and coal sectors, have implemented diesel management systems, including the analysis of loading and haul truck fuel performance, the use of more efficient motors, improved driving practices, the use of electric power on up-ramps,[43] and the increased use of conveyors and draglines rather than diesel trucks for haulage. Exxaro is even considering replacing diesel-run processes by electricity-based operations (despite substantial electricity price increases in recent years) due to the steeply rising costs of diesel.

All major companies have then focused on improving the energy efficiency of non-core activities. Change houses, mine houses and hostels have been equipped with solar water heaters, new geysers (matching hot water requirements), heat pumps and improved insulation. Throughout operations, energy-efficient lighting, through the use of light-emitting diodes, compact fluorescent lights, electronic ballast, motion sensors, day/night switches, and the removal of unnecessary lights, has been installed. Energy efficiency gains associated with peripheral activities, although noteworthy, are however not going to fundamentally the energy profile of mining value chains.

Following non-core activities, companies have all turned their attention to the low-cost optimisation of processes and equipment in their core operations. Even though the age and depth (as well as ore grades) are key cost drivers, significant gains are to be made from retrofitting old mines and plants in terms of new equipment as energy efficiency was not prioritised in older mining and manufacturing operations.

All major companies have improved processes around shaft pumps, dust management, conveyors and feeders (through improved power-factor correction equipment, variable speed drives, more efficient motors, power and length optimisation, change from electro-mechanical to brute force equipment). Interventions at the process level carry significantly higher benefit in terms of energy savings than transportation and building-related activities. As such, Exxaro's shift from a dust management system to a dust suppression system, which uses smaller motors, triggered an energy saving potential of 30 758 gigajoules (GJ) per year, against only 6 186 GJ per year for a truck fuel management system and respectively 2 490 and 39 GJ per year for the installation of solar water heaters at change and mine houses and mine hostels.

The management of compressed air systems, notably for underground operations,[44] has been given much attention. Companies, in the gold and platinum sectors particularly, have engaged in the

[43] Although this shift increases the consumption of electricity, it reduces overall costs and emissions.

[44] Compressed-air systems represent a fundamental aspect of mining operations. Compressed-air is mainly used for ventilation, pneumatic rock drills, ore loaders, loading boxes, liquid agitation, and refuge bay air supply. Moreover, compressed air is a notoriously inefficient energy commodity, with typically only 19% of its power being usable. Furthermore, the five-year life

optimisation of air networks. Anglo American Platinum has, for instance, optimised compressors by closely matching the generation of compressed air with demand from the mine. Installing control systems that minimise demand when air leaks are detected has also contributed to improving the performance of the air network. In a similar vein, Sibanye Gold has invested in a three-chamber pump system which recovers energy from incoming water and uses it to pump water out of the mine, and installed hydraulic power-recovery turbines at various shafts.

At the level of rock drill operations, some mining companies, such as AngloGold Ashanti, have switched to water-operated system for mining applications, whereby hydropower is used as a medium of supplying energy to rock drills and other equipment that works on compressed air in underground mines (Cloete, 2008).

Above the ground, there have been strides to better manage compressed air systems, given that most mines use unsophisticated pressure control systems that ensure delivery of air at constant and equal pressure on all mining levels (Liebenberg, Velleman & Booysen, 2012). The compressor delivery pressure set-point is usually set to meet the requirements of the highest pressure end-use load, resulting in unnecessary wastage of compressed-air and electrical power. This is countered by the installation of surface and underground compressed air-control valve units and hydraulic equipment to monitor, optimise and automatically control demand.

Significant gains have been made by mining companies that have investigated the design of cooling, refrigeration and ventilation systems, through *inter alia* improved fan and throttle settings, resized motors, the use of fiberglass fan blades with improved power factor, cleaning ventilation return airways, optimising underground ventilation layouts, stopping unnecessary ventilation fans and the use of backfill.

Process optimisation has been pursued at all levels of the value chains. ArcelorMittal South Africa, at its Saldanha Works, has been one of the five volunteer host plants of the Industrial Energy Efficiency Improvement Project, launched in 2010 by the United Nations Industrial Development Organisation and the National Cleaner Production Centre of South Africa. As part of the project, ArcelorMittal implemented an ISO 50 001-aligned energy management system, the centrepiece of standards relating to energy efficiency and management (Bissoon, 2012). Other examples include Anglo American Platinum improving concentrate drying and furnace control at its smelters and Northam Platinum optimising its ore pass capacity by improving cycle efficiencies and selecting optimised equipment for each section.

Overall, most companies in South Africa's mining and beneficiation industry have however limited their focus to low-hanging fruits in terms of energy efficiency. Larger improvements, based on innovative technologies and complete performance overhaul, have been rare. This initial and largely voluntary effort, while noteworthy, remains insufficient to drastically improve the sector's energy efficiency. As illustrated below in Section 3.4, a lot more could be achieved by mining firms through the implementation of process and equipment changes.

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cycle of a new compressed-air system indicates that electricity consumption accounts for as much as 80% of total life cycle costs of the compressor.

3.4. Untapped saving opportunities in process and equipment changes are the new energy efficiency frontier

Over and above process optimisation, opportunities to engage in meaningful process and equipment changes exist. However, innovative technologies have only been implemented by a handful of companies and an increased support for research and development into technologies that can reduce the impact of the electricity price increases is required.

Promising examples include the AngloGold Ashanti Technology Innovation Consortium (ATIC), which was formed to identify and define areas of opportunity in collaboration with proven technology providers and research institutions. The ATIC's mandate is to develop mine designs that use automated equipment to reduce the dependency on energy and improving kWh/tonne ratios. Others companies, such as Impala Platinum, are also investigating new shaft design with high-level specifications for energy efficiency and power management.

In the same vein, AngloGold Ashanti also recently announced the development of a new reef-boring technology that will reduce its consumption of electricity by extracting the gold-bearing ore from the reef, replacing it with cement and chemicals that stabilise the mining structure, removing the energy costs associated with transporting tonnes of rock and material that is often removed in the development of the shaft. Moreover, the new technology removes the need to blast rock, reducing the need to ventilate, which has a knock-on effect on electricity demand. In addition, considerable efforts have been made in the investment into research on mechanised mining, which has the potential to reduce the cost of refrigeration, cooling and the electricity costs.

Similarly, Evraz Highveld Steel and Vanadium has implemented technologies to reduce electricity use in iron ore making through sizing methods (smaller and consistent ore particle size), which enhances pre-reduction rates achieved in kilns, resulting in the reduction of energy consumption in furnaces. Evraz Highveld also aims to bring kilns back to standard, thus improving pre-reduction energy consumption in furnaces. Other benefits of this technology are a reduction in kiln atmospheric emissions, an improvement in engineering availability and process stability as well as the reduction in maintenance costs.

In the platinum sector, junior producers have pioneered new production processes with substantial energy savings potential. Pallinghurst is implementing the Kell process, a patented smelting technology innovation. The process is able to handle the chrome content of the PGM concentrate which removes the need to smelt. Overall benefits include reduced power costs, ease of processing and environmental benefits, allowing a saving of 80% of energy costs for smelting (Creamer, 2014a). The technology uses only 14% of the electricity used in conventional smelting methods and also cuts out the milling stage, further reducing emissions (Liddell *et al*., 2010). In order to add to energy savings, Pallinghurst has designed a shallow and largely mechanised, open-pit platinum mine. While it will eventually go underground, the mine will operate 1 500 metres above industry average for the first 30-40 years.

Braemore Platinum, a wholly-owned subsidiary of Jubilee Platinum, is operationalising for the first time the ConRoast process. The process was first developed by national research institution Mintek[45] and has been commercially licenced to the company until 2020. The process involves removing sulphur from metal sulphide concentrate prior to smelting in a direct current arc furnace (making it a more environmentally-friendly process) and enables furnaces to accept any proportion of chromite, resulting in more efficient and cost-effective platinum production. The company reports that since 2012 and the installation of the arc furnaces, overall production has improved by 45% (Jubilee Platinum, 2014).

Industrial energy insulation, which can be implemented through two complementary processes, is another perfect illustration of the availability and potential of innovative technologies. Traditional insulation involves thick (from 5 to 20 centimetres) rock wool wrapping, surrounded by a metal jacket. A new method uses insulation coatings, i.e. thin paint cover of 5 to 12 millimetres containing little beads filled with air. The technology, a spin-off of research conducted by the National Aeronautics and Space Administration, was developed in the United States of America. Johannesburg-based Sharpshell Industrial Solutions offers hybrid solutions combining both traditional and new insulation technologies to reduce thermal losses to a maximum. In the mining and linked manufacturing industry, hybrid solutions can be used to convert energy from boilers and connected steam pipes (i.e. preventing heat losses) and refrigeration and cooling system (i.e. maintaining cold air). Hybrid solutions allow for substantial improvement in energy efficiency (from 15% for refrigeration plants to 20% for boilers on average) by insulating the entirety of the system and thus preventing losses.[46]

While installation cost per square metre (m^2) for hybrid system are higher than for traditional insulation, the significant improvement in energy efficiency leads to pay-back of less than 24 months. For example, Gold Fields, which used hybrid insulation for illusion tanks, benefited from an eight-month pay-back period on its installation. For an installation cost of about ZAR 1 700/m^2, Gold Fields saved around ZAR 2 500/m^2 annually. Besides small installation (a typical boiler installation is around 200 m^2), sizeable projects can be implemented, such as BHP Billiton's Mozal smelter where the whole hot gas transport system (more than 5 000 m^2) was insulated with a hybrid solution. For cold air solutions, successful tests leading to similar results were conducted with Impala Platinum.

[45] Mintek is an autonomous statutory organisation which reports to the Minister of Mineral Resources. It is South Africa's national mineral research organisation specialising in mineral processing, extractive metallurgy and related areas. Working closely with industry and other research and development institutions, Mintek provides service testwork, process development and optimisation, consulting and innovative products to clients worldwide.

[46] Traditional methods based on rock wool and metal jackets offer only a partial insulation, leaving parts of the system uncovered (such as the sides of boilers and valves situated on pipes), therefore creating leakage points. Sides of boilers and valves located on transportation pipes are generally left open due to the need to maintain easy access to these parts of the system for recurrent maintenance. The use of insulation coatings to insulate these points of the system left open by traditional insulation methods allow to fully close the structure and improve energy efficiency. In addition, the use of paint maintains easy access to boiler sides and valves for potential repairs. In the case of a leak in the system, the use of insulation coatings also gives the opportunity to easily locate the source of the problem and proceed with repairs immediately. Traditional insulation methods, by covering the system with a metal jacket, prevent from locating the exact source of the problem and generally lead to inefficient maintenance practices as repairs can only take place during production down-time once a year. Hybrid systems are ideal as they combine the advantages of both traditional and new insulation methods. Traditional insulation, which is more affordable to install, can be used where possible and is required for some equipment for physical protection purposes (as paint would not resist impact). The use of insulation coatings perfectly complements rock wool by covering part of the system which cannot be insulated otherwise. By removing leakage points and closing off systems, hybrid insulation improves significantly energy efficiency and is financially relevant.

As illustrated by the above examples, numerous technologies and innovations are therefore available to mining-related companies to meaningfully improve their energy profile. Nevertheless, the rollout of these cutting edge improvements remains very limited to a few firms and insufficient to set the industry on a greener growth path. Further efforts, with the support from the South African Government, are therefore required to incentive the development and implementation of new technologies and processes across the industry.

3.5. Alternative clean and efficient sources of production, while remaining nascent, are increasingly investigated

Complementing energy efficiency improvements, mining companies have also the opportunity to investigate and optimise their supply of energy through alternative sources of production, such as cogeneration and the use of renewable energy. This has however remained very limited so far and much more commitment from both companies and the South African Government are necessary to create an enabling environment and upscale the use of alternative low-carbon sources of energy.

The first entry point generally is cogeneration,[47] particularly at the beneficiation stage. Investing in cogeneration can bring many benefits to companies in mining value chains. Such projects generate energy efficiency gains (by improving the fuel conversion efficiency and using free by-product or waste resources, such as heat or gas), ultimately reducing the energy bill of the company as well as its reliance on external source of energy (i.e. improving its energy security profile and cushioning against supply interruption as well as recent and future electricity tariff increases). Accordingly, cogeneration also contributes to reducing GHG emissions (DoE, 2010), which is becoming increasingly important for all South Africa-based companies in line with the introduction of a carbon tax in the country in 2016 and the probable implementation of carbon budgets. Under the ministerial determination of the Medium-Term Risk Mitigation Project IPP Procurement Programme 2012 released on 19 December 2012, the DoE intends to procure 800 MW of electricity generation capacity from cogeneration (resulting from biomass, industrial waste and combined heat and power sources). Further details on the procurement process are expected in 2014 with the publication of the Request for Proposals by the DoE (Creamer, 2014b). This upcoming programme should constitute an opportunity for South African mining and beneficiation companies to invest in cogeneration projects with Government's support.

For example, steel manufacturer Scaw Metals is investigating the possibility of developing a 68-MW cogeneration plant at its Germiston facility in the Gauteng province to convert waste heat and gases into electricity. The plant is expected to provide up to 60% of the site's power demand (Barradas, 2013). Exxaro also recently invested in a 14-MW cogeneration plant at their Namakwa Sands mineral sand smelter in the Western Cape province (Exxaro, 2013a). Likewise, Evraz Highveld is investing in a cogeneration capacity to convert carbon monoxide-rich off-gasses from furnaces and kilns to electrical power. In its first phase, the cogeneration plant will generate approximately 24 MW (with a maximum of

[47] Cogeneration can be of two kinds. Waste Heat Recovery Systems utilise process energy which would otherwise be underutilised or wasted, such as waste heat or waste flue gas from industrial processes, while Combined Heat and Power Systems, linked to a power plant, produce consumable heat, such as process steam, in addition to the electricity generated.

30 MW), at a cost significantly below Eskom's anticipated tariffs, progressively from 5 to 50% lower, over the lifecycle of the plant (Evraz Highveld Steel and Vanadium, 2012). Anglo American Platinum is implementing a thermal harvesting technology at its smelting operations to generate 20 MW by extracting waste heat from the high-pressure water system used to cool the converter off-gas. Sibanye Gold has expressed an interest in the development of a methane extraction system at their Beatrix mine in the Free State. Should this investment be approved, it will have the capacity to generate close to 4 MW of electricity (Cornish, 2014). Similarly, Rand Refinery also plans to use more natural gas to generate its own electricity by using natural gas and recovering waste heat. It is estimated that the project will cost ZAR 50 million over the next five years (from 2012) (Rand Refinery, 2013).

Furthermore, some mines have been investigating the use of the deep shafts and water gravity to generate power in underground (gold and platinum) mining. AngloGold Ashanti has a centralised electro-hydraulic system as its primary source of energy production. Harmony is also investigating the conversion of its turbines to allow them to generate energy. Likewise, Anglo American Platinum has installed a waterwheel generator in the overflow pipe to make use of fluid gravitation overflows already in the production process as an energy source.

Beyond cogeneration, companies in mining value chains in South Africa are progressively looking at meeting a share of their electricity requirements through the use of renewable energy. Despite current technologies at this stage unable to fulfil the entirety of energy requirements, they represent an efficient electricity generation options when installed as a modular technology (i.e. not wheeled for long distances) and combined with baseload energy generation options, such as cogeneration. While the use of renewable energy by mining and linked manufacturing companies remain at its infancy, the decreasing cost of renewable energy technologies, coupled with rising energy (notably electricity and diesel) prices, has turned renewable energy projects financially more and more attractive. Sibanye Gold for example intends to source as much as 15% of its energy from solar power to reduce reliance for electricity supplies from Eskom. To this effect, the company has just completed a study on the costs of setting up an 80-MW solar plant (Crowley, 2014). While the focus has been on solar and wind technologies, companies are also increasingly looking at other renewable energy sources, such as biomass (Harmony Gold and Sibanye Gold for example), fuel cells (such as Anglo American Platinum) and hydroelectricity.

Mining companies however differ in their *modus operandi* to enter the renewable (and more broadly alternative) energy market. While the opportunity to dispose of a grid-connected generation plant outside of the government-run programme is currently limited to *ad hoc* power purchasing agreements with Eskom or trading through Amatola Green Power, the country's sole energy trading entity as explained in Box 9, three models exist to invest in off-grid generation or participate in Government's procurement programme.

First, mining operators have the possibility to strike power purchase agreements with third-party IPPs to supply off-grid energy on a take-or-pay basis. This model does not require mining companies to expend capital and transfers what would have been a balance sheet investment to an operating expenditure. The responsibility is shifted to the IPP, which provides power at a rate reflecting its levelised cost of electricity including all installed capital costs, its own cost of capital and the plant operating expenses. This route is currently being explored by Anglo American Platinum for its furnaces in Polokwane in the Limpopo province. Through power purchase agreements, the company aims to secure a minimum of

30 MW (i.e. 3% of the site's electricity requirement) from renewable sources of energy by 2015. To this effect, Anglo American Platinum published a call for expression of interest for solar photovoltaic-based electricity generation (ranging from 5 to 50 MW) at a capped rate of ZAR 1/kWh. The company received an overwhelming number of proposals and is investigating most cost-effective opportunities with the aim of further reducing proposed tariffs. In addition to solar energy, the company has been exploring opportunities in the field of wind energy (with Promethium and Vestas), biomass and biodiesel (from cooking oil and moringa plant).

Second, companies can directly, or via a wholly-owned holding company, invest in renewable energy, essentially on an off-grid basis at the moment, generally through a turn-key engineering, procurement and construction solution. This model has already gained some momentum for coal-fired power plants and diesel-run generators (particularly in remote locations), and more and more companies are exploring this route for electricity generation from renewable energy. While this option requires mining companies to carry the capital expenditures on their balance sheet, it offers higher and faster returns, reducing intermediaries (as no separate IPP is used) and financing costs (as the one-time fixed cost is capitalised and depreciated on the balance sheet). From a fiscal perspective, such projects, which benefit from specific depreciation rules, can also be used to offset income taxes on core-business activities. Concessional finance from development finance institutions can additionally reduce the cost of capital and improve the profitability of on-balance-sheet projects. For example, Crominet installed a 1-MW off-grid solar photovoltaic facility at its Thabazimbi-based chrome mine in the Limpopo province. The hybrid installation, which is run in complement of diesel-based generators, supplies 60% of the 1.6 MW of power required for the mine's operation and is expected to displace 450 000 litres of diesel per annum (Creamer, 2013; Judd, 2013).

Third, in a variant of the second model, mining companies can enter into joint ventures dedicated to build renewable energy-based power capacity, therefore sharing associated costs and risks between several partners. South Africa-based IPP Cennergi, which was established in 2012 by Exxaro and Tata Power (through its wholly-owned Mauritian-registered subsidiary Khopoli Investments Limited) on a 50/50 basis, is one such example. Cennergi is implementing two grid-connected wind energy projects (the 134-MW Amakhala Emoyeni and 95-MW Tsitsikamma Community Wind Farms in the Eastern Cape) as part of the REIPP procurement programme for a total of 229 MW. Cennergi is also investigating the possibility of two solar parks, the Letsati (11 MW) and Lephalale (30 MW) solar projects in the North West and Limpopo provinces respectively (Cennergi, 2013; Exxaro, 2013b).

These three options for investing in renewable energy are truncated by unresolved developments regarding the distribution and transmission of electricity that is meant to be clarified by the Independent System and Market Operator (ISMO) Bill. The introduction of an unbundled ISMO (i.e. outside of Eskom) to invest, operate and maintain the country's high voltage transmission grid is vital to the further development of renewable energy and cogeneration in the country. It would empower IPPs to sell electricity directly to third party consumers, such as mining and industrial complexes, and provide the platform for South African companies (most notably in mining value chains) to generate their own electricity and sell potential surplus to the utility and a third party.

Box 9: The South African 'willing-buyer, willing seller' market

While the current electricity industry in South Africa and the Renewable Energy Independent Power Producer (REIPP) procurement programme are structured around Eskom as the single buyer of electricity (as per the model prevailing in the country), space for the development of a unique business model, i.e. trading in electricity facilitating a 'willing-buyer, willing-seller' model, has emerged in the last decade. This alternative model, based on a small voluntary market for renewable energy outside of the REIPP procurement programme, has been made possible thanks to a partnership with municipal structures, allowing the connection of independent power producers (IPPs) and industrial customers by a trading entity, Amatola Green Power. An increasing demand for renewable energy from industrial customers (i.e. outside of the REIPP procurement programme), competitively priced supply and the delivery of internationally-tradable 'green' certificates, have enabled the development of this market on a small scale. Some key issues for the sustainability of Amatola Green Power's business model however persist, such as the price competitiveness of the renewable energy generated (as IPPs are at this time unable to compete with Eskom's pricing agreements to most large stakeholders in the country's mining value chains) and the reliance on partnerships with municipal institutions. Even though this alternative model remains limited to only one company at this stage, it does open up the opportunity for industrial and commercial customers, including mining and beneficiation companies, to buy electricity from IPPs (i.e. outside of Eskom) and demonstrates the potential for a voluntary market to further develop renewable energy in South Africa.

Source: TIPS, based on Montmasson-Clair, Moilwa & Ryan, 2014

While the 2009 Electricity Regulations on New Generation Capacity split the six functions of a system operator (planning, allocation, procurement, buyer, system operator, transmission) between Eskom, the Minister of Energy and the Minister of Finance, they do not however identify the entity responsible for the buyer function. This function is currently carried out by a fully ring-fenced ISMO within Eskom's System Operations and Planning Division. On 6 September 2009, Cabinet designated Eskom as the single buyer from IPPs, but no policy explaining the market architecture of the electricity supply industry in detail has been published as yet, leaving unclear the role and function of the ISMO. Some policy statements indicate that an ISMO will be created separately from Eskom to act as a single buyer of electricity, removing potential conflict of interest as both a buyer and a seller of electricity. Other policy statements indicate that an ISMO will also be responsible for planning, procurement and scheduling of generation.

The passing of the ISMO Bill is meant to consolidate policy and address discrepancies by establishing the ISMO as a national public entity, responsible for: (a) generation resource planning in accordance with the Integrated Resource Plan for Electricity; (b) transmission service and implementation; (c) buyer of power from generators, including Eskom, co-generators and IPPs; (d) system operations and expansion planning; and (e) electricity trading at a wholesale level. The ISMO Bill was published by the DoE on 13 May 2011 for public comments (DoE, 2011b), approved by Cabinet on 16 March 2011 (GCIS, 2011) and tabled for Parliament in the same month. The Bill was revised and re-submitted in Parliament in March 2012 (DoE, 2012). While the ISMO Bill has been discussed and agreed on by the Portfolio Committee on Energy at two occasions, it has been stalled in Parliament, being removed from the

National Assembly Order Paper twice in June and November 2013 (Pressly, 2013). In March 2014, the motion to revive the ISMO Bill was once again dismissed.

The introduction of an ISMO would open the door for customers to choose their suppliers, i.e. Eskom or an IPP[48] (Abrahams *et al*., 2013). The creation of an ISMO outside Eskom, although remaining fully-owned by Government, would contribute to levelling the playing field by eliminating the potential bias created by the current structure in which the DoE procures energy and trading occurs within Eskom (Unlimited Energy, 2013).

However, the current version of the Bill does not cater for the transfer of transmission assets from Eskom to the ISMO. The ownership of the transmission grid by the ISMO is essential to avoid conflicts with Eskom. In the proposed structure, on the one hand, the ISMO would be tasked with procuring sufficient electricity from a variety of generators, but would rely on a high voltage transmission grid owned and maintained by Eskom. On the other hand, Eskom would maintain its monopolistic position in generation while retaining ownership and competency over the maintenance of the high voltage and distribution grids under its control. This setting does not allow the ISMO to be truly independent from Eskom, which would be in a position to maintain its control over the electricity supply industry. The National Energy Regulator of South Africa would then be responsible for setting tariffs for the electricity purchased by the ISMO from Eskom, the transmission charges that Eskom would levy against the ISMO for the electricity transmitted, and Eskom's charges for connecting IPPs to the grid, as well as establishing rules for the maintenance and extension of the grids owned by Eskom but operated by the ISMO. This situation could open the door for numerous conflicts of interest between the ISMO and Eskom, which would have to be settled by the regulator, and limit the ability for IPPs to play a stronger role on the South African electricity market outside of government-run programmes (Davie, 2013).

As recommended in Section 4.4, sorting out the issues around the ISMO Bill and the creation of a 'willing-buyer, willing-seller' electricity market in South Africa is thus a prerequisite to a widespread uptake of renewable energy and cogeneration by mining and linked manufacturing companies.

In the longer-term future, other opportunities may also arise for mining and linked manufacturing companies to import clean energy from neighbouring countries. Most notably, the Zambia Electricity Supply Corporation, which essentially relies on hydropower to generate electricity, eyes export in the next few years (Odendaal, 2014). Building on cross-border transmission infrastructure being built as part of the Southern African Power Pool, large users in South Africa may be in a position to enter into a power purchase agreement with the Zambia Electricity Supply Corporation. At this stage, some obstacles nevertheless remain, such as the negotiation of wheeling agreements with affected countries as well as a back-up agreement in case of supply interruption.

In summary, beyond traditional cost savings opportunities, such as load shifting, and low-hanging fruit optimisation initiatives, numerous projects are taking place in South Africa's mining value chains to meaningfully alter the energy, and particularly electricity, profile of the sector. The availability of innovative technologies and processes and the business case for their implementation have been

[48] This would also allow companies to potentially avoid carbon taxation by preferring renewable energy producers.

demonstrated at the firm level by a few pioneering companies. Nevertheless, investments in process and equipment changes (such as new mine and plant designs, and the retrofit of core machinery) and alternative energy supply (such as cogeneration and renewable energy) have remained limited throughout mining value chains. Most mining companies have responded to energy challenges by optimising operational efficiencies that can be summarised as demand side management. Non-capital intensive opportunities and equipment replacements have been prioritised, owing to their ease of implementation as well as their limited cost and complexity. Further efforts are needed from both the South African Government and local companies to seize all existing opportunities and address the remaining bottlenecks. Only then will South Africa's industrial and mining sectors be in a position to adopt a more sustainable development path.

3.6. Hindering factors at the firm level remain to be addressed

In addition to the need to address policy shortcomings to create an enabling and conducive environment, the focus on traditional mitigation strategies as well as low-hanging fruits and low-cost initiatives can largely be explained by a series of bottlenecks at the firm level.

Indeed, reluctance at the firm level, rooted in technical and financial considerations (such as capital expenditure requirements, operational and implementation risks, perceived long payback periods), behavioural characteristics (such as short-termism, the lack of motivation and buy-in, and the path dependency to business-as-usual) and execution capabilities (such as the access to finance, firm-specific decision-making processes and skills requirements), remains a problem to be addressed by Government and industry stakeholders (Maia, 2013).

Most importantly, the lack of capital for investment into the energy space appears as a key bottleneck. Energy efficiency and renewable energy projects must compete on equal footing with other plant projects (both domestically and internationally) which yield much higher rates of return, particularly in global companies, such as Sasol and ArcelorMittal. Decisions on implementing energy efficient technologies are not necessarily policy-driven, but the availability of capital to invest and returns on investments drive all projects. Energy projects usually lag behind due to longer payback periods and lower returns potential. For example, ArcelorMittal South Africa faces particularly high maintenance costs, such as, in 2013, ZAR 27 million for replacing and maintaining Newcastle Works' blast furnace gas holder, ZAR 59 million for the replacement of other machinery and ZAR 157 million for the relining of the blast furnace, as well as ZAR 158 million at Vanderbijlpark Works for the repair of the basic oxygen furnace. On the back of these expenses, considering new technologies and business models is considered to be a challenge by ArcelorMittal, particularly because the steelmaking process is very capital intensive. Conversely, replacement expenses could be seen as opportunities to retrofit equipment and improve the energy profile of operations.

In addition, as most of the mines and manufacturing facilities in South Africa are old and/or have not been designed to be energy efficient, radical improvements are extremely capital intensive and appear disproportionate, complex and disruptive in comparison to already sunk capital costs. Unlike low-hanging fruit initiatives focusing on hostels or administrative offices, installing technology to improve the electricity efficiency of pumping, cooling and ventilation processes, which account for a substantial share of the power consumption of mines, requires operations to be reconfigured, which disrupts production (HSRC, 2010).

On the back of continually increasing electricity prices, the long-term benefits arising from implementing electricity efficient technologies and/or investing in renewable energy nevertheless outweigh their cost, taking into account the cost of disrupting production processes (i.e. the opportunity cost of lost production). Also, higher electricity prices over a sustained period and the high level of energy intensity of mining operations improve the net present value and the payback period of energy efficiency and renewable energy investments, making grounds for a stronger business case.

Companies also argue that processes for heavily electricity-dependent smelters and refineries are difficult to alter to make significant changes to electricity consumption. While studies done by the International Energy Agency and the Energy Research Centre at the University of Cape Town have estimated potential energy savings by companies of around 27%, mining companies underline that a 10% reduction in energy consumption is more realistic. Mining and industrial operations claim to have already achieved half of this potential, essentially driven by financial considerations, and that improving efficiency further appears extremely challenging. For example, saving even 0.1% in the aluminium smelting business has been qualified as a major achievement by industry players. Likewise, Impala Platinum argues that limited opportunities exist at the smelter and refinery levels.

Consequently, answers and solutions must be provided by Government and industry stakeholders to overcome these financial, technical and behavioural hindering factors. A pro-active approach aimed at addressing human perceptions and resistance, and unlocking financial and technical blockages, while improving the regulatory and legislative framework, must be adopted. Accordingly, as explained in Section 4, public intervention, through a set of targeted, phased and coherent policy instruments, could accordingly contribute substantially to this objective.

4. Policy considerations

Drawing from the analysis of the impact of electricity price increases on the competitiveness of South Africa's leading mining value chains, the mitigation strategies that companies have implemented so far, the remaining bottlenecks and the existing potential, a series of policy recommendations emerges. As mining-related companies have primarily engaged in traditional (fossil fuel-based) and low-cost initiatives, policies should focus on incentivising firms to look at cleaner, renewable and energy-efficient solutions to cushion the risks associated with electricity price increases and supply interruptions (a factor that has clearly been raised as more damaging than rising prices).

As no single policy instrument or price signal is sufficient to trigger a meaningful transformation, a varied and complementary set of measures is necessary. Primarily, access to finance and available technology should be facilitated, notably through increased collaboration and information sharing. Investment in energy efficiency should be pushed through more stringent enforcement and binding requirements, while the use of renewable energy and cogeneration technologies should be encouraged with the establishment of an enabling regulatory framework. The potential to import clean energy from neighbouring countries should be investigated further as a longer-term solution. In the meantime, facilitating the use of natural gas from companies through adequate pricing, instead of diesel- and coal-based solutions, would contribute to the transition to greening the energy profile of the mining and linked manufacturing industry in South Africa.

4.1. No silver bullet: A mix of instruments is required

As illustrated in Section 3, electricity price increases have not been sufficient to meaningfully trigger investments in energy efficiency and renewable energy by mining-related companies in South Africa. Solely relying on increasing electricity prices to stimulate the transition to a greener economy is unlikely to result in the transition happening at a desirable pace. This may be due to several factors. As explicated in Section 1, firms in mining and manufacturing industries in South Africa are coming from a position of historically low electricity costs, and to some extent, still face some of the lowest electricity prices in the world. What appears to be more of a threat to competitiveness is not the level of the electricity prices, but the unpredictability of price increases and costs associated with interrupted supply. In addition, price increases are still recent in time and their influence may not have yet fully trickled down and be felt at the firm level.

In any case, domestic and international experience has demonstrated that no single policy instrument or price signal is powerful enough to trigger a significant change in practices at the industrial level. As highlighted in Section 3, the response of South African mining and linked manufacturing companies to recent electricity price increases and existing public and private programmes has been insufficient. A thought-through combination of measures, including both 'carrots' (such as tax breaks, exemptions, etc.) and sticks (such as compulsory targets, fiscal penalties, etc.), is required to adequately support the transition to greener processes and behaviours from mining and industrial companies. The complementarity of the different instruments that can be used is a critical factor in achieving further energy-related gains in the mining sector. For example, as illustrated by China's Top 1 000 Energy Consuming Enterprises Programme, regulatory approaches, with set energy saving and energy efficiency targets, can be suitably complemented by energy efficiency standards for equipment, energy use reporting systems and energy conservation plans (IPCC, 2014). Importantly, the policy mix must be tailor-made to the specificities (context, bottlenecks, financial aspects, etc.) of targeted value chains. As illustrated in the Australian case in Box 10, any assistance mechanisms must consider the overall situation of a sector, so as not to support inefficiencies or only address the issue for which it has been designed. Such assistance measures are nevertheless crucial to ensure that the competitiveness of the targeted companies is not impaired in the short term.

In other words, the policy framework must reflect the complex interplay between transitioning towards a green economy and maintaining an industrial structure dominated by energy- and carbon-intensive industries. A set of trade-offs indeed arises from the interface between industrial policy and industrialisation on the one hand, and green economy and sustainability principles on the other hand. First, the energy-intensive mining and production practices that have traditionally characterised the South African economy must be balanced with economic activities that are directly conducive to climate change mitigation and sustainability. Although this incompatibility may seem daunting in the short term and may require some adjustments, numerous opportunities are presented in the longer term by the need to transition to cleaner and more efficient production techniques. Moreover, green economy activities can potentially become the springboard for more extensive South African participation in the international knowledge economy. Second, the issue of competitiveness is at the heart of the interplay between industrial development and green economy. The costs arising from transitioning to cleaner, more energy-efficient production may potentially impact negatively on the competitiveness of South African firms in the short term. By embracing this reality, measures can however be put in place to support South African companies to transition to greener and cleaner production processes. Such a pro-active approach is preferable as the need to set the country, and particularly mining value chains, on a greener pathway will not dissipate. Delaying the transition in question will however increase substantially the efforts (and finance) required while reducing the associated competitiveness and market advantages and raising the risks (Montmasson-Clair, Ryan, Smith & Schoon, forthcoming).

4.2. Facilitating access to capital and technologies: One-stop shop and collaboration as an avenue

Companies in South Africa's mining value chains raised the availability of funds for investments in energy-related initiatives, particularly for capital-intensive projects, as the main bottleneck to be addressed at all levels. Mining and linked manufacturing industries in South Africa are generally part of international companies, in which capital investment decisions favour projects and countries offering the highest returns. To the extent that energy efficiency improvements and electricity generation projects (such as cogeneration and renewable energy technologies) in South Africa bear lower return on investment than other potential initiatives in the country and globally, competition for capital constitutes a hindering factor to improving the energy profile of domestic operations.

The South African Government should incentivise investment by establishing an enabling environment, notably by facilitating the allocation of capital to such operations (through for example larger volume of targeted concessional finance), providing a platform for maximising energy-related benefits for companies and the country (both from a financial and non-financial point of view) and implementing a conducive regulatory framework for such investments.

Box 10: The role of context: Carbon tax and public support schemes in Australia

On 1 June 2012, Australia introduced a carbon tax on about 370 companies of AU$ 23 (US$ 24) for every tonne of GHG produced, on the back of increasing electricity prices. Ten industries accounted for over 90% of the revenue from the carbon tax in 2012/2013. Electricity generation, relying for three-quarter on coal, accounted for just over half the value of carbon permits, followed by non-ferrous metals (including aluminium and coal mining), iron ore mining and steel production, and oil and gas extraction. According to the Australian Industry Group, the carbon tax resulted in an average 18% increase in electricity prices on input costs. The tax was repealed on 1 July 2014. Electricity prices are however not expected to fall by the same margin, due to rising network charges and gas prices.

All impacted sectors received process-specific support, due to their constrained ability to pass through costs in global markets. Through the Jobs and Competitiveness Programme, emission-intensive and trade-exposed activities received assistance to cover 94.5% of average industry carbon costs in the first year of the carbon price, while less emission-intensive and trade-exposed activities received assistance to cover 66%. Similarly, the Coal-Fired Generation Assistance provided free carbon units to eligible coal-fired electricity generators and the Steel Transformation Plan provided competitive grants to steel companies to encourage investment and innovation. Additionally, the steel industry was meant to receive a 10% increase in direct emissions and electricity baselines from 2016/2017.

These public support schemes have however been criticised for not differentiating the impact of the carbon price depending on macro-economic conditions. For example, the competitiveness of the coal sector has not been threatened by the carbon tax, due to increasing coal prices and Australia's strategic position to service the growing demand in Asia, while the carbon legislation has, to some extent, amplified pre-existing difficulties and the decline in profitability in the steel sector. These two examples raise the need to consider macro-economic trends in order to better target public assistance schemes and support the transition to a green economy, and not structural inefficiencies. Rather, the tax differentiates support based on the emission intensity of industrial processes.

The Grattan Institute recommends that public support schemes be guided by three conditions: the carbon price must represent such a proportion of an industry's costs that it might lead to a marked decline in competitiveness; and the industry's facilities must be unable to easily reduce their emissions; the industry must be exposed to international competition from countries with equivalent or higher emissions intensity that carries little penalty in the competing country; and the industry must lack access to unique assets or other restrictions to competition that may otherwise enable it to maintain viable margins in spite of a substantial increase in costs not faced by international competitors.

Sources: TIPS, based on AECOM, 2011; Wood & Edis, 2011; Australia Industry Group, 2013

An increased use of the CDM of the Kyoto Protocol also represents a potential opportunity to improve the profitability of energy-related projects in South Africa. Some companies, such as Exxaro, have accordingly explored this avenue. While the use of the mechanism has been limited in the country (and the mining industry in particular), its benefits should be investigated further at national and sectoral levels.

This should be combined with further support for research, development, deployment, diffusion and transfer of new, innovative mine and plant designs, technologies and processes. While some efforts exist in the country to develop and promote pioneering products and services for the mining industry, through notably national mineral research organisation Mintek, more attention is required to build the business case for the implementation of new inventions and innovations, particularly capital-intensive and game-changing initiatives. While it is recognised that the development of specific technologies by mining companies are often protected by intellectual property rights, this may present a lost opportunity for broader and cross-sector use of energy efficient technologies. Collaborative channels at industry level for research and development should be pursued and facilitated at the onset by Government.

Collaborative activities within and across the mining sector may constitute a springboard for enhanced implementation (IPCC, 2014). A system-wide approach and collaboration can help address common barriers while contributing to reducing energy and materials consumption as well as GHG emissions. The clustering of companies, for example in the form of industrial parks, can at the same time facilitate growth and competitiveness, and the implementation of mitigation solutions. Companies can benefit from by-product exchanges (such as waste heat), infrastructure sharing (such as solar parks and waste/wastewater management systems) and joint purchase (of energy efficient technologies for example). By facilitating the provision of technical and non-technical infrastructure, industrial parks and clusters provide the appropriate platform to stimulate symbiosis between firms. Government has a strong role to play in promoting the development of such clusters, by setting up proper frameworks and infrastructures.

Cooperation can also take place between different kind of institutions situated in a similar geographical area, such as industrial and municipal structures. Waste materials and by-products from one sector or operation can be re-used or recycled by another activity. For example, exhaust heat from industries and heat generated from burning municipal waste can fuel local users' heating systems. The reuse of materials recovered from infrastructure and industrial activities (such as steel) carry significant opportunities.

Complementing intra- and inter-industry cooperation, the establishment of a 'one-stop shop' for the industry to gain neutral, up-to-date information on available technologies and techniques, their associated costs, benefits and skills requirements as well as existing financial solutions, schemes and support mechanisms could go a great deal in advancing the transformational agenda.

4.3. Incentivising resource efficiency improvements: more compulsory requirements

As illustrated in Section 3, implementing efficiency improvements in electricity consumption arises as one of the leading options for companies to mitigate the impact of price (and volume) increases on their competitiveness and the risk associated with supply interruptions. In addition, investments in resource efficiency bring environmental and social advantages, as well as generate considerable economic benefits. However, despite the availability of proven flagship technologies to improve resource efficiency and the existing cost-saving opportunities, mining companies have essentially focused on improvements in non-core business areas, limiting the positive impact on resource consumption. Indeed, "despite long-standing attention to energy efficiency in industry, many options for improved energy efficiency remain", according to the International Panel on Climate Change's Fifth Assessment Report (2014).

The South African Government must thus support the development of a culture of resource efficiency throughout the country. Energy management must become inherently part of companies' (and thus employees') objectives and annual targets, replicating Exxaro's initiative to incorporate energy management targets in performance measurement, particularly at senior level. Such initiatives must be promoted and showcased to encourage broader participation. Government entities, particularly state-owned and publicly-owned (even partly) enterprises should set the example and drive the efforts towards greater accountability and responsibility. Practically, energy management should form part of the key performance areas of companies' senior management and executives.

At the firm and sectorial levels, many mechanisms exist to promote energy efficiency gains. Internationally, the use of energy audits stands as a key prerequisite for meaningful energy savings. Such audits are then complemented by a set of policy instruments, primarily information programmes. Economic instruments (such as taxes, trading schemes, etc.), regulatory approaches (such as standards and binding targets) and voluntary programmes are also commonly used by Governments to incentive companies to invest in energy efficiency initiatives. For example, while not the preferred and most efficient option, voluntary programmes can be effective if complemented by subsidised energy audits, mandatory energy management plans, and technical assistance, information and financing for implementation. In addition, a strong institutional framework, robust monitoring and evaluation and a credible mechanism for dealing with non-compliance are critical success factors of any policy (Rezessy & Bertoldi, 2011).

Ultimately, international experience vouches that maximising energy efficiency gains in the mining sector (and optimising the opportunities for more sustainable mining) is not the sole responsibility of mining and linked manufacturing companies but requires an appropriate mix of policies tailor-made to the domestic context.

At the South African level, energy efficiency targets set as part of the National Energy Efficiency Strategy must be strictly monitored and enforced. On the one hand, meeting the target could provide companies with some additional incentives (such as tax breaks and concessional finance) or unlock some partial or total exemptions (from instruments such a carbon tax). On the other hand, failure to reach the agreed objective could trigger penalties or taxes.

Going further, the South African Government should move towards enforcing compulsory energy audits for companies, stringent energy efficiency standards (such as ISO 14 001 and 50 001) for new investments and encouraging retrofitting and improvements for existing infrastructure. This would appropriately complement the existing tax incentive for energy savings, by improving the understanding of potential gains and incentivising companies to maximise energy efficiency improvements beyond low-hanging fruits.

Large investments related to core processes, in addition to smaller, side ameliorations implemented by mining companies, should be promoted. Most mines and manufacturing facilities in South Africa are old and were built at a time where energy was not a concern. While new operations benefit from new designs and the most efficient technologies, opportunities to improve energy efficiency in older mines and facilities remain limited (due to their design and the already sunk capital costs) without significant capital investment. The South African Government should provide the appropriate levers for firms in mining value chains to retrofit their operations and introduce new technologies, designs and processes.

4.4. Increasing the role of renewable energy and cogeneration: Establishing an enabling environment

Going beyond resource efficiency, mining and linked manufacturing companies have been increasingly investigating the role that cogeneration and renewable energy could play in their energy supply. As explained in Section 3, while three different *modus operandi* currently exist for companies to invest in renewable energy in South Africa, options for own-use remain limited to off-grid solutions and a small voluntary market relying on municipal structures, essentially owing to a problematic regulatory framework. Despite the significant potential in the country, avenues to invest in cogeneration are even more limited at this stage.

Based on the success of the REIPP procurement programme, the South African Government should finalise the design of the Medium Term Risk Mitigation Project IPP Procurement Programme 2012 released on 19 December 2012 which includes the procurement of 800 MW of electricity generation capacity from co-generation. Following this initial phase, the South African Government should consider upscaling the programme (on the back of the REIPP procurement programme) to tap into the massive cogeneration potential resulting from the energy-intensive nature of mining value chains. In addition, the potential for own-use cogeneration (on an off-grid and grid-connected basis) is considerable in South Africa and should be supported more aggressively. While some companies, such as Evraz Highveld Steel and Vanadium, are already entering this market, more efforts are required to widespread the use of cogeneration.

Furthermore, the other bottleneck to the development and participation of the private sector in the electricity market extends beyond the successful REIPP procurement programme to the delays in finalising the ISMO Bill. As mentioned in Section 3, the passing of the ISMO Bill would create an enabling environment for a ‘willing buyer, willing seller’ market to be created in the country, positioning IPPs and cogenerators to play a much greater role in the country’s electricity system.

Coupled with the increasing competitiveness of renewable energy technologies (driven by both global and national dynamics), the streamlining of the regulatory and institutional framework with regards to IPPs would open new opportunities for mining and linked manufacturing companies to ensure their energy security, reduce their exposure to carbon taxation, source clean, affordable electricity, and ultimately improve their competitiveness. This would pave the way for the mining and linked manufacturing industry to embark on a more sustainable path and enhance the contribution of the sector to South Africa's transition to a green economy.

4.5. Importing electricity from clean, renewable sources: Considering the regional possibilities

Complementing a more central role of renewable energy and cogeneration, the possibility of importing renewable energy from neighbouring countries into South Africa, such as hydroelectricity from Zambia, should be investigated further, as mentioned in Section 3.5. While there are already cross border trades in electricity between countries through the Southern African Power Pool, it may be useful to consider whether South African mines and large industrial complexes can contract directly with electricity utilities, such as ZESCO in Zambia to procure electricity.

Large-scale hydroelectric projects, which provide clean, renewable, uninterrupted and vast amount of electricity, are particularly suited for the need of mining value chains. Technicalities, such as the appropriate wheeling charge with Eskom (or through the ISMO when operational) and foreign utilities, back-up solutions in case of interruption, would however need to be considered. Zambia's ZESCO currently has surplus capacity, following a large scale expansion investment in generation and transmission capacity and is aiming to export between 200 to 300 MW. Similarly, Namibia and the Democratic Republic of the Congo, though the proposed Grand Inga hydroelectric dam, could also potentially export surplus electricity in the longer term (SAnews.gov.za, 2013; Odendaal, 2014).

4.6. Securing affordable supply of natural gas: A worthwhile, interim solution

Acknowledging that the upscaling of renewable energy and cogeneration sources in the mining industries is a medium- to long-term transition, natural gas emerges as an alternative energy source in the short to medium term. Although not renewable, natural gas is a cleaner fuel option (in terms of GHG emissions) than coal and diesel and, provided it is easily and consistently accessible and competitively priced, constitutes a viable source of energy (notably baseload electricity). As showed in Section 3, several companies in South Africa's mining value chains, such as ArcelorMittal South Africa, Rand Refinery and Sibanye Gold, are investigating a greater use of natural gas. In the platinum value chain, the catalytic converter industry has also highlighted that the cost of liquid petroleum gas in South Africa[49] is up to five times the cost in other countries (such as Brazil), and has proposed switching from liquid petroleum gas to natural gas in production processes to reduce costs.

Competitively priced natural gas that is readily accessible can therefore potentially play a stronger role in the energy mix of mining and linked manufacturing companies. However, serious concerns about natural gas pricing exist in South Africa, particularly from April 2014 onwards given the recent changes in

[49] The maximum liquid petroleum gas price is regulated by the DoE.

regulation (Roberts & Mondliwa, 2014). Current regulation, which granted Sasol a 'Special Regulatory Dispensation' (i.e. exclusive rights to the Mozambique-South Africa gas pipeline for a period of ten years) through specially created regulation known as the RSA Regulatory Agreement, expired on 25 March 2014. From this date, the Gas Act No. 48 of 2001 came into effect, mandating the National Energy Regulator of South Africa to regulate the gas value chain.

This essentially means a change in the pricing mechanism from a 'Market Value Pricing'[50] mechanism, which applied under the Special Regulatory Dispensation period, to a maximum price against a weighted basket of alternative fuels in South Africa (i.e. coal for 36.2%; diesel for 24.8%; electricity for 37.1%; and heavy fuel oil and liquid petroleum gas for 3% collectively).

According to Mondliwa and Roberts (2014), the impact of this change is a significant increase in the price of natural gas from an already high level.[51] This is the result of the variables included in the formula (such as overvalued prices of coal and electricity, and overweighting of the diesel component).

Large industrial users have already challenged the National Energy Regulator of South Africa on the matter, stating that natural gas accounts for up to 20% of their costs and that the new method would put pressure on their margins. In addition, Sasol Gas has been operating at a significant operating margin (between 38 and 52%) under the Special Regulatory Dispensation. Therefore, the price increase under the new formula directly translates to even higher revenues for Sasol Gas, at the expense of other downstream industries.

In order to enable natural gas to play a more prominent role in the energy mix of mining value chains, pricing issues must be resolve as soon as possible. Relevant mining and manufacturing companies, as well as the Economic Development Department and **the dti** should actively participate in the hearings resulting from the complaints lodged with the National Energy Regulator of South Africa and provide submissions on potential impacts. This should contribute to an adequate revision of the formula to the benefit of the country's industry and economic stakeholders.

While the facilitation of the use of natural gas would contribute in the short term to improve the competitiveness of the country's mining and industrial sectors as well as their energy and carbon profiles (thus mitigating some of their negative environmental impacts), such policy should remain a transitory mitigation option to the upscale of energy efficiency, renewable energy and cogeneration solutions. It should be pursued in complement to ambitious policies aimed at meaningfully setting the industry on a green growth path through maximised resource efficiency and the use of renewable, clean, efficient sources of energy.

[50] The Market Value Pricing was made up of: the cost of the alternative fuel delivered to the customer's premises or anticipated place of use (in the case of greenfields customers); the difference between all the operating costs of the customer's use of the alternative fuel and all the operating costs of using natural gas; and the difference between the NPV of the capital costs of the customer's continued use of the alternative fuel and the NPV of the capital costs involved in switching to natural gas, as would be reflected in the customer's accounts. There is also a price cap to the formula, capping Sasol's revenues from gas sales compared to a set of European countries. The volume-weighted average gas price may not exceed this cap, although in practice, it has hardly exceeded the cap.

[51] Even under the Special Regulatory Dispensation regime, South African natural gas prices (for 2012 for instance) were significantly higher than most European and North American countries, except for Sweden (Mondliwa & Roberts, 2014).

5. Conclusion

In conclusion, the road of South Africa's mining value chains to a sustainable energy profile is at a turning point. The industry constitutes a critical pillar of the South African economy and society, and will continue to be so in the foreseeable future. However, with the current coal-based electricity supply, it remains a constraint to the country's transition to a green economy. South Africa's mining and linked manufacturing companies are heavily energy- and carbon-intensive, and existing efforts to positively alter this situation have been limited despite rising electricity price increases and supply interruptions concerns.

As analysed in Section 2, electricity price increases have had a varying impact on mining value chains in the country. On the one hand, surface mining activities, which rely more on diesel than electricity, have been marginally affected. The coal sector has only been marginally impacted, thanks to the small share of electricity in operating costs and strong market conditions, and iron ore companies have not been jeopardised by the moderate effect on the sector due to a booming market environment. On the other hand, electricity represents a much larger share of the energy mix of underground operations, exposing companies to more drastic consequences. While some ability to pass on costs and good overall performance levels have enabled PGMs companies to absorb the impact of electricity price increases, gold mining houses, which already face difficult conditions, have been strongly affected. At the beneficiation level, such as steel production, price increases have had severe negative consequences on firms' competitiveness (with the exception of Rand Refinery owing to its monopolistic position or industries relying essentially on gas, such as catalytic converter producers).

Overall, the impact of electricity price increases has not been sufficient to trigger substantial changes in behaviour and processes. Cost savings and security of supply concerns have actually driven investments in energy efficiency and alternative sources of energy. As described in Section 3, companies across value chains have primarily adopted traditional solutions, such load shifting and diesel-run back-up generators, as well as low-cost, low-hanging fruits in terms of energy efficiency (i.e. the optimisation of non-core activities and processes). While some pioneering mining-related companies are investigating deeper, game-changing innovations around the implementation of new energy-efficient technologies and designs, and the use of cogeneration and renewable energy, these efforts remain limited at this stage. Much of the potential is still untapped. As such, companies in South Africa's mining value chains, supported by Government through the appropriate mix of instruments (encompassing both 'carrot' and 'stick' types of measures), have the opportunity to meaningfully engage with the issues around their energy mix. As mining and linked manufacturing companies face the same challenges globally, the South African industry has a unique occasion to be at the forefront of transformation and reap the long-term benefits of turning to a sustainable energy path (such as increasing competitiveness, reduced energy costs, diminished exposure to price volatility and supply interruptions, increased governmental support, etc.).

Mining and linked manufacturing companies, while unsustainable in their nature, have an instrumental role to play in the transition to a green economy. Beyond their impact on energy structures, mining value chains are the heart of economic, social and environmental considerations in South Africa. The contribution of the mining sector is primordial and an indispensable prerequisite to a successful shift to a green growth path. In addition to contributing heavily to the country's economic performance, mining and linked manufacturing companies are intertwined with the sustainable management of South Africa's natural capital and the achievement of social development objectives.

Moreover, substantial business opportunities for South African mining value chains will follow in the near future from the global move towards a green development path. The mining sector in South Africa is set to benefit from the global transition towards renewable energy (which is estimated to rise by 40% over the next five years according to the International Energy Agency), given that renewable energy and low-carbon technologies (such as fuel cells) are built from minerals, of which South Africa is a major producer. The drive for energy efficiency throughout the economy, particularly in buildings and transport, is also likely to generate new opportunities for mining value chains in South Africa. Minerals and metals are for example crucial in the infrastructure of buildings and their energy profile. Last but not least, South Africa's largest green industry by value remains the manufacturing of catalytic converters for automobiles. Catalytic converters drive 40% of the global demand for platinum, a mineral of which South Africa holds 75% of the global reserves, and the industry accounted for exports of ZAR 16 billion in 2012 (Chamber of Mines, 2012). As car sales keep increasing worldwide and environmental regulations for automobile CO_2 emissions are being progressively strengthened, further opportunities exist to manufacture catalytic converters domestically, providing the right incentives and support mechanisms are implemented by Government.

Ultimately, given their scope and essential role, the transition to a green economy will not fundamentally challenge the central position of mining value chains in South Africa's (and the world's) development path. Nevertheless, the shift to a green economy will structurally affect both the demand for mineral-based products (in divergent trends depending on the ore), i.e. *what to produce*, and the means to providing them, i.e. *how to produce*, and will require proactive responses from the industry and Government. In other words, acknowledging the intertwined but conflictual relationship between mining and sustainable development (particularly in terms of energy) requires the adoption of a prism of analysis investigating the net long-term contribution of the industry to a green economy, considering both the contradictions and challenges, and the potential benefits and opportunities.

In the end, the response of mining value chains to the shift to a green economy cannot be business-as-usual. Successful management of the global green transition will require short-term pragmatism and longer-term planning in the South African mining industry, linking business, Government, labour, non-governmental organisations and the research community in support of sustainable development.

While many companies are already vigorously investing in the green economy, most prospects remain underexploited or untapped. Both the private and public sectors must act proactively to seize these emerging opportunities. Most notably, the role and shape of mining value chains in a greener South Africa, along with the required skills and investments, must be further investigated and understood; only then will South African mining value chains be able to harness the opportunities created by these new markets and position South Africa as a green frontrunner.

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