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Energy management by platinum companies in South Africa: exploring mitigation strategies for reducing the impact of electricity price increases

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Introduction

The platinum industry remains a vital and strategic mining sector for the South African economy, owing to its contribution in terms of GDP (4.1%), export earnings (9% of merchandized exports), and employment (197 487employees and R34.4 billion in annual salaries and wages). The industry is the global leader in platinum production and boasts 80% of the world's known resources and reserves. (Baxter, 2014) Challenges facing the industry include the impact and consequences related to protracted industrial action and significant cost increases squeezing profit margins. This paper assesses how companies have dealt with rising electricity costs. Have these strategies been effective, and has the issue been given the attention it deserves? The paper also considers the way forward in view of the findings related to the mitigation strategies currently employed and other options available.

Energy issues (related to supply and costs) have featured among the top ten business risks in the South African mining sector over the last decade (PWC, 2013). Sustainable energy management is a cornerstone to risk and business management in the sector. In mining, electricity price increases have been the primary input price increase between 2007-2012 (Chamber of Mines, 2014) and mitigation strategies to cushion the impact of rising electricity prices are fast becoming a vital strategic consideration for businesses. The platinum sector in particular faces risks associated with electricity price, which has risen by 238% from R0.18 per kilowatt-hour in 2007 to R0.61 per kilowatt-hour in 2012 (Baxter, 2014). The platinum sector is heavily dependent on electricity as a source of energy, with many of the major producers using more than 70% electricity in their energy mix (based on annual company sustainability reports). This paper examines the energy management approaches taken by the major platinum producers in South African to mitigate the impact of electricity price increases, and argues that sustainable energy management is underpinned by both an economic rationale for cost saving as well as a long-term strategic focus on diversification of energy sources and reducing greenhouse gas emissions.

Energy issues for platinum companies are often framed in the short term, and identified as business risks in terms of energy cost and security of supply. This paper demonstrates the approach companies typically take, dominated by targeting the low-hanging fruit. Instead, energy management should be a longer term consideration that takes into account the ways in which companies can reduce their energy consumption and change their energy profiles. The business case for energy management is often dominated by, and reduced to, a cost-benefit approach. However, effective and sustainable energy management involves more than just using less energy and reducing costs. This paper explores three types of mitigation options in the platinum sector, namely energy efficiency, technology innovation, and investments in alternative energy.

Some of the key challenges facing the platinum sector are reviewed. Different approaches to energy management within the sector are highlighted, with a focus on energy efficiency. The paper then explores the energy savings potential of technology innovations in platinum production, through the Kell Process and ConRoast smelting. Alternative energy investment options in the sector, in the form of cogeneration and renewable energy, are examined. Finally, the opportunities and challenges arising from the mitigation strategies are summarized some of the implications for sustainable energy management in the sector highlighted. The future of South Africa's platinum sector is not only a practical matter of cost management, but also a case of diversifying demand. Platinum is a metal of the future, particularly for the development of clean energy sources such as fuel cell technologies, and energy management will play an important role in shaping the future of the platinum industry.

Energy management challenges to platinum mining in South Africa

Electricity price increases have economy-wide implications for South Africa, impacting upon economic growth, adding to inflationary cost pressures, and squeezing the margins of industries across various sectors of the economy (Altman *et al*., 2010). As an energy-intensive industry, mining is responsible for 6% of South Africa's electricity consumption, with thhe platinum sector accounting for 33% of the electricity sold to mines by state-owned utility company Eskom.

Increasing competitiveness, profitability, and productivity constitute the three main drivers for the implementation of energy management by mining companies. Factors fuelling the need for sustainable energy management are rising energy costs, particularly electricity prices, and potential energy shortages in the future, as well as climate change risk and greenhouse gas emission targets. As such, the four main challenges impacting energy management in the sector are physical limitations on mining operation, socio-economic factors (in terms of local economic development and labour concerns), industrial and energy policy development, and the sustainability dimensions of mining.

Energy risk amongst other challenging including rising production costs

The two main challenges faced by the platinum sector in South Africa in terms of energy management include the price increases of electricity and the energy requirements at mining and processing level (exacerbated by the age and depth of mines and ore grade). Compared to other mining sectors, gold and platinum mining face particular challenges associated with deep-level mining. The age of a mine impacts on its energy requirement, as does the depth of mining activities. Another factor impacting electricity requirements is the ore grade, with lower grades requiring more energy for crushing and milling. Due to the high geothermal gradient in the platinum mining areas (Karsten and MacKay, 2012) and high mean rock temperatures, platinum mines require refrigeration and ventilation at early stages in their development. High chrome content of the ore is another challenge, as these ores require more energy for effective smelting.

Above-ground challenges: labour unrest and socio-economic development

The underground challenges to the sector are compounded by business risks and challenges above ground, including labour unrest and the market fundamentals of the platinum industry – the supply and demand of platinum impacting on price and production costs and profits. The strike action in 2014 and protracted five-month labour dispute in the sector has had a significant impact on the industry, with production losses amounting to R22 billion. Labour and energy issues have resulted in credit rating downgrades for South Africa and a decline in investor confidence which has economy-wide implications. The socio-economic realities of operating a mine in South Africa also involve maintaining the social license to operate. Many of the current challenges in the sector stem from its historical development, particularly the use of cheap migrant labour and historically abundant and inexpensive electricity.

Industrial development based on cheap and abundant electricity supply: a thing of the past

The development of South Africa's industrial sectors, and mining in particular, was founded on the cheap and ample supply of electricity, in what is known today as the minerals and energy complex (MEC) (Fine and Rustomjee, 1996). The MEC describes the relationship and interdependence of mining and linked manufacturing sectors, and the dependence of South Africa's industrial development upon cheap coal-fired electricity. Due to delays in further capacity expansion to meet electricity demand and a failure to achieve cost-reflective tariffs, the electricity supply industry in post-apartheid South Africa, is characterized by shortages of supply (with load shedding and increased electricity prices. Eskom's large and expensive expansion programme (to build large coal-fired power stations Medupi and Kusile and other investments decisions) has faced significant delays and cost overruns. In recent years, pressure has been placed on platinum and other mining companies to reduce consumption by 10% during periods of electricity supply shortages (as part of Eskom's demand-side management programme), and adherence to this requirement presents operational and cost challenges to the industry. The market structure, policy landscape, and regulation of electricity prices impact on the cost and supply of electricity to mines and on the price path and predictability of electricity prices.

A further challenge to the electricity supply industry is its significant carbon footprint. The South African government has committed to reducing greenhouse gas emissions by 2020 and 2025 by 34% and 42% respectively compared to a business-as-usual trajectory. It is also planning to implement a carbon tax in 2016, which will exacerbate business costs related to electricity use, particularly for mining companies, presenting a sizeable tax risk for the platinum sector.

Sustainability challenges: environmental and climate change risks

In terms of their impact on the environment and sustainability, platinum companies comply with both national legal reporting requirements (particularly the National Environmental Management Act – NEMA) and international guidelines, in some cases also setting their own targets for emissions reduction and energy consumption and efficiency. Environmental challenges associated with climate change will need to be considered in terms of the future sustainability of the platinum sector. This suggests impacts on infrastructure and operations, changes in the supply chain, workers' health and safety conditions, environmental management and mitigation, community relations, and exploration and future growth. Examples of the climate change risks facing the platinum sector are presented in Appendix 1. Effective energy management is related to the broader issue of climate change mitigation and thus features as an issue of sustainability related to the future impact of climate change on mining.

Platinum energy management is dominated by energy efficiency

Energy management is a subcomponent of the broader environmental management dimension of the sustainability reporting by mining companies, but appears more broadly at a strategic level in considerations around business risk and climate change. Energy efficiency is a key component of energy management, providing many cost saving benefits to companies, but energy management is not limited to energy efficiency alone. Table I provides an overview of energy efficiency initiatives implemented by major platinum producers in South Africa, and the resulting savings.

The examples of the energy efficiency initiatives implemented by major platinum producers between 2008-2014 show that many of the energy savings gains are made predominantly at mine level. Ease of implementation and cost benefits are the key drivers of the decision to implement such changes and, in many cases, these were done in partnership with Eskom's energy efficiency programmes. Eskom published an energy efficiency guide for the mining sector which stated that energy efficiency gains could be achieved in: materials handling (23%), processing (19%), compressed air (17%), pumping (14%), fans (7%), industrial cooling (5%), lighting (5%) and other sources (10%) (Eskom, 2012). In the platinum sector,

Table I
Energy efficiency initiatives by top platinum producers 2007-2012

Total group savings
The Anglo American Group had implemented 223 energy savings projects by 2012, achieving a US$75 million saving. In 2013, R111.7 million was spent in the Group on energy efficiency alone. Amplats' energy efficiency savings are predominantly achieved through the installation of compressors (64%), asset and optimization at smelters (17%). Savings are also achieved in ventilation fans (4%), refrigeration (2%), heat pumps (2%), underground lighting (6%), and other initiatives (5%).
Implats has not reported a total investment amount and energy saving from energy efficiency projects, but initiatives reported include the installation of power factor equipment (to achieve a 2.5% saving) and the trial of fibreglass-reinforced plastic fan blades. As there is limited opportunity to reduce electrical energy usage at its smelters and refineries, Implats' strategic focus is primarily on promoting energy efficiency. New shafts have been designed with high-level specifications for energy efficiency and power management in the main shaft station, refrigeration systems, underground lighting, and air compression and reticulations systems.
Lonmin has invested in energy efficiency in partnership with Eskom, on projects to the value of R150 million since 2007, achieving a 0.8 MWh/PGM and 1.06 GWh saving. These have been in compressed air optimization (39%), ventilation optimization (46%), hot water generation (6.3%), renewable and green technologies (4.4%), and other initiatives (4.3%).
Savings from changes in light fittings: 0.08-9.55 MW
Amplats installed energy-efficient lighting between 2006-2009, replacing incandescent lamps with compact fluorescent lamps, resulting in an audited saving of 9.55 MW.
Implats quoted a potential energy savings of 7 000 MWh at a cost of R500 000 for a compact fluorescent lighting project in 2009.
Lonmin's above-ground installation of energy-efficient fluorescent and LED (light emitting diode) lighting technology amounted to load reduction and associated cost reductions of 0.33 MW and R0.21 million, calculated at 2013 tariff rates. Underground LED lamps added a further 0.08 MW reduction.
Compressed air optimization: savings of between 7.18 MW- 68.133 MW
Amplats optimized the air compressors in 2006/2007 with savings of 10.86 MW and 68.13 MW per annum, extending air optimization projects to other mines from 2010.
Lonmin's optimized air network (OAN) installations reduced electricity load by 7.18 MW, which equates to cost reduction of R27.9 million, calculated at 2013 tariff rates.
Ventilation fan settings: 0.9-5.414 MW
Amplats invested in internally funded projects for ventilation fan optimization between 2009 and 2010, saving 5.41 MW for electricity used between 18:00-20:00 per day.
Lonmin's aerodynamically-optimized 45 kW fans have been installed, saving 0.9 MW and R0.68 million.
Heat pumps: 1.35 MW
Lonmin installed heat pumps achieving a 1.35 MW load reduction and a R3.08 million cost saving, calculated at 2013 tariff rates.
Equipment changes
In 2008, Amplats began using electric rock drills, which consume less energy than compressed air drills. With compressed air systems, energy has to be applied to compress the air – in an electrical system the losses are inherently lower. Compressed-air drilling costs 7.2 kWh per metre drilled, whereas electrical drilling is 0.1 kWh.
Implats is installing power factor correction equipment at Rustenburg, which is expected to deliver 2.5% in annual savings.

savings are mostly in compressed air and industrial cooling.

In order for companies to better manage their energy use and find opportunities to improve energy efficiency, the monitoring of energy use is becoming a vital business activity. Large investments in group-wide, live monitoring systems (such as ECO2MAN) are likely to follow. However, if energy management is reduced to energy efficiency alone, the gains from cost-cutting measures will be limited to a tweaking at the margin. Energy management and mitigation strategies for reducing electricity use should extend to innovations in platinum production processes and technologies as well.

Technology innovations are costly and difficult to implement

Process innovations provide some of the most revolutionary gains in terms of energy saving. However, research and development is more expensive than efficiency initiatives, the time horizons are longer, and implementation of the results is more complex. Two such energy saving technologies shaping the platinum sector are the Kell Process and the ConRoast smelting technology.

The Kell process

The Kell process is a patented hydrometallurgical process, demonstrated to be effective on UG2 and Platreef concentrates. The process is able to handle the higher chrome content of these concentrates, and removes the need for smelting. Overall benefits include reduced power costs, ease of processing, and environmental benefits, allowing for a saving of 80% of energy costs for smelting (Creamer, 2014). It uses only 14% of the electricity used in conventional smelting methods, i.e. 140 kWh for every ton of concentrate processed compared with 1 000 kWh for every ton of concentrate smelted. In addition, emissions are reduced by around 70% compared to conventional refining and smelting (Liddell *et al*., 2010).

The technology has been proven at the pilot scale and the first commercial implementation of the process, by NewCo Mines, is planned for the end of 2014. The pilot tests showed recoveries 6% higher than conventional processes. The Kell Process will be implemented on a new, shallow and largely mechanized open-pit platinum mine. The Pallinghurst private equity company, the Bakgatla Ba Kgafela community, and the Industrial Development Corporation (IDC have invested R3.24 billion over five years in this project, with a further R1.5 billion invested by foreign investors (Creamer, 2014). The developments and use of the Kell process indicate that it is limited to use in new mines however marketing of the new process is aimed at use across different platinum mines.

ConRoast smelting

Another innovation able to manage chrome-rich ores, still using a smelter, is the ConRoast process, which is commercially licensed until 2020 to Braemore Platinum, a wholly-owned subsidiary of Jubilee Platinum, a smaller JSE-listed platinum producer. The ConRoast process was developed by Mintek and Jubilee has designed a 5 MW arc ConRoast smelter to be used at its Middelburg smelting facility The process involves removing and capturing sulphur from the concentrate prior to smelting in a DC 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 Middelburg brownfield smelting facility will become the first site of its ConRoast furnace build programme. An interesting feature of this site is its independent power source. Power Alt (Pty) Ltd (in which Jubilee has a 70% controlling interest) owns an on-site 11 MW gas-fired electricity generation plant that supplies 5 MW of power to the facility. Surplus is sold to power to Eskom through a power purchasing agreement (Matthews, 2013). Exact statistics on the cost saving of the ConRoast technology are not publically available, although results from trials have been published. Jubilee's report on operational performance to date confirms that since 2012, when the DC furnaces were installed, overall production has improved by 45% (Jubilee Platinum, 2014).

Both of these technology innovations are being implemented by relatively new platinum producers. The use of these technologies is, however, limited by patents and commercialisation licenses. Although the technologies have been proven scientifically, their actual use by platinum producers is still in development. In both cases, energy innovations extend beyond smelting. Energy savings occur at mine level in terms of mine design and include investments in alternative energy sources to reduce dependency upon electricity supply from the national utility.

Investments in alternative energy by platinum producers remain in their infancy

The abovementioned technology innovations not only reduce the use of electricity in some instances but also do away with a need for certain energy intensive-processes entirely. Another mitigation strategy to reduce the impact of electricity costs is not only to reduce electricity use and requirements, but to shift away from a reliance on electricity supplied at Eskom's tariffs through cogeneration and/or renewable energy.

Cogeneration

Cogeneration is the simultaneous production of more than one type of energy (electrical, mechanical, or thermal) from a single fuel source (SANEDI, 2014), usually from industrial processes. Only one major cogeneration project is currently underway in the platinum sector. At its Waterval Smelter in Rustenberg, Amplats has invested in a thermal harvesting project through an independent power producer. This is a pilot initiative with a total investment of R155 million, financed by Investec and including a R30 million infrastructure grant from the Department of Trade and Industry. Eternity Power is the special purpose vehicle in which Investec Corporate and Institutional Banking has an 80% stake, with 20% held by a clean energy developer Vuselela Energy. The cogeneration opportunity being explored uses the Ormat Organic Rankine Cycle (ORC) system, which uses waste heat recovered from hot water received from a smelter to evaporate an organic liquid and drive an expansion turbine. The installed capacity of the plant will be 4.9 MW and is expected to produce 20 GWh per year, providing 10% of the smelter's electricity needs.

The IDC estimates that South Africa's mineral smelters and chemical plants have the potential to generate 2 000 MW (IDC, 2014). Benefits of cogeneration include cost-effectiveness and the diversification of energy supply. However, challenges lie in the cost and complexity in connecting a cogeneration facility to the national grid and to end-users (Prakash, 2009). Furthermore, the lack of policy clarity and successful programmes to promote cogeneration have resulted in missed opportunities for harnessing the potential of cogeneration power.

Renewable energy

Renewable energy makes up a very small part of the energy provisions in the South African platinum value chain. Globally, the use of renewable energy in mining is nevertheless growing. In the broader Anglo American group, 14% of energy is sourced from renewable sources, mainly from hydropower used in South America (Anglo American, 2011). It is forecasted that the global mining industry will invest UD$20 billion in renewable energy by 2020 and that 5-8% of energy in mining will be supplied by renewable energy sources by 2022 (Navigant Research, 2013).

According to sustainability reports in the platinum sector, many feasibility studies on renewable energy options are currently underway. Amplats is investigating a 20 MW solar photovoltaic plant, a 15 MW biomass plant, and wind generation potential. Lonmin has completed a pre-feasibility study on the development of a renewable resource facility on site, assessing the viability of wind, biofuel, and solar projects. Environmental permitting for a solar plant capable of delivering 1 MW of power is currently underway

The renewable energy market in South Africa has undergone significant development since the launch and successful implementation of the large-scale Renewable Energy Independent Power Producer Procurement (REIPPP) Programme in 2011. A total of 17.8 GW is the long-term target for renewable energy generation by 2025 (Department of Energy, 2013), with the REIPP programme bringing on 3725 MW capacity for renewable energy in South Africa. As of July 2014, the REIPPP initiative has resulted in 64 renewable energy projects across three bidding rounds, embracing a range of technologies including wind and solar, with a total investment potential of more than R150 billion. In total, 30% of new generation capacity in South Africa is earmarked for the participation of the private sector, and the successful launch of the REIPPP attests to a healthy and competitive renewable energy market in the country, with prices having dropped significantly over the three rounds. For example, prices have plummeted on average from R2.75 to 88c per kilowatt-hour for solar photovoltaic, and from R1.14 to 66c per kilowatt-hour for wind technologies, as shown in Table II. The success of the procurement programme is attributed to the scale for renewable energy procurement, policy clarity, and adherence to strict rules and guidelines, and most importantly the bankability of the PPA and risk allocation to Eskom as the purchaser of electricity generated with the financial backing of the National Treasury (TIPS, 2014).

Furthermore, renewable energy technologies are fast becoming some of the most cost-effective solution for new

Table II
REIPPP tariffs over bidding rounds (rand per kilowatt-hour)

Technology	Round 1	Round 2	Variation	Round 3	Variation
Onshore wind	1.14	0.89	-22%	0.66	-26%
Concentrated solar power	2.68	2.51	-6%	1.46	-42%
Solar photovoltaic	2.75	1.65	-40%	0.88	-47%
Biomass	NA	NA	NA	1.24	NA
Landfill gas	NA	NA	NA	0.84	NA
Small hydro (≤10 MW)	NA	1.03	NA	NA	NA

Source: Department of Energy 2013

capacity for a country like South Africa (IRENA, 2013). Figure 1 illustrates the levellized cost of specific renewable energy technologies against the most expensive peak electricity and cheapest coal-based generation used by Eskom.

The reluctance of platinum companies to invest in renewable energy may be due to cost, but also to the dominance of the large procurement programme. The reality is that renewable energy is not a core business for mining companies and that the chief means of moving towards renewable energy is through power purchasing agreements, placing the cost of generating electricity upon independent power producers.

Both the cogeneration and renewable energy options discussed above are mitigation strategies to reduce dependence upon Eskom, and in some cases may prove less expensive. Another energy management mitigation strategy related to renewable energy is that of fuel switching. This does not necessarily address the issue of reducing electricity use, but contributes to the broader diversification of energy sources to more sustainable sources, and to reduction in greenhouse gas emissions.

Examples of fuel switching in the platinum sector include a coal-to-biomass fuel-switching project using biomass and bamboo as an energy source at a smelter that Implats is investigating (feasibility studies were conducted in 2012). If this fuel switch is realized, it will also reduce direct greenhouse gas emissions by replacing coal. Amplats, through Anglo Zimele, is looking to supply biodiesel to its operations.

The move to invest in alternative sources of energy is not necessarily driven by cost, as renewable energy alternatives have only recently started becoming a cheaper alternative. A combined factor is the need to reduce carbon emissions in the platinum sector. The dependency upon electricity means that carbon emissions associated with platinum mining are particularly high (at around 70% of energy) compared to other mining sectors. The liability under the proposed carbon tax (planned for 2016) is thus a concern for platinum companies. Companies are therefore looking into ways to offset this tax liability through the Clean Development Mechanism (CDM) of the Kyoto Protocol.

Energy management must be considered in the broader sense in terms of not only a reduction in electricity use and a cost saving to businesses, but also emissions reduction. Carbon credits are granted for reductions achieved through the CDM projects. By 2012, 347 CDM projects had been submitted in South Africa and 12 projects had received certified emissions reductions. CDM projects range from energy efficiency projects to cogeneration and renewable energy initiatives. In the platinum sector, Impala Platinum's fuel switching and biomass power generation projects (submitted in 2012) are currently being investigated. These target a 27 388 tCO_2 and 62 512 tCO_2 annual emissions reduction respectively (Department of Energy, 2014).

The additional cost implications of a carbon tax are linked directly to energy issues and electricity use in particular. This paper does not address the carbon tax issue in particular, except in terms of energy management approaches and mitigation strategies to reduce electricity price increases. Matters related to carbon tax costs will become a more significant issue for platinum companies as carbon tax design and implementation is finalized by the South African government. In the meantime, other opportunities for cleaner energy production lie at the heart of the platinum sector itself, with the potential of fuel cells.

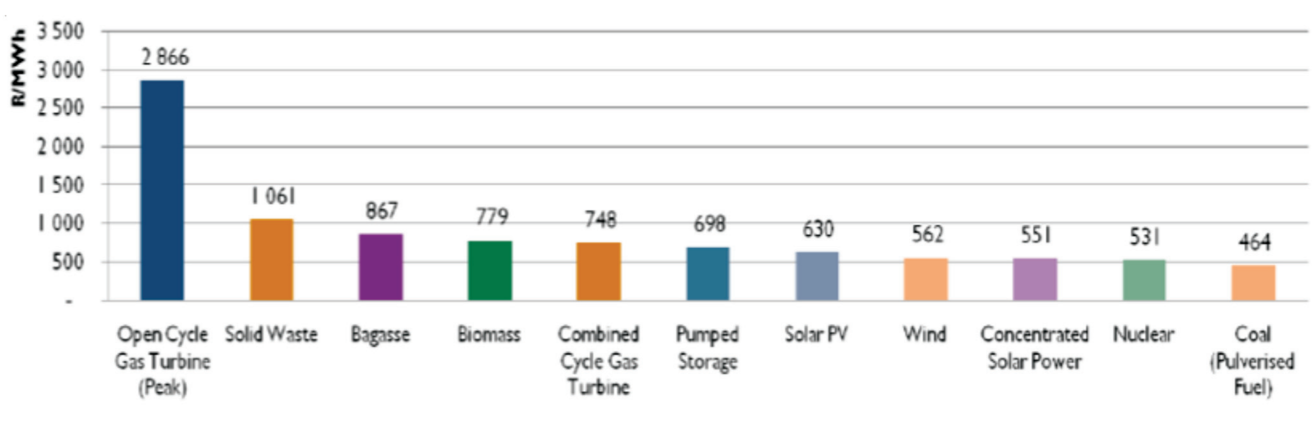

Figure 1. South Africa's IRP projected levellized cost of electricity in 2020 for various utility-scale generation sources (Department of Energy, 2011)

The other alternative lies within platinum products: the future of fuel cells

Platinum is used in fuel cell technology which is at the heart of a clean energy revolution to produce zero emissions electricity for applications ranging from industry to transport. Platinum is a key metal of the future, particularly for emissions-reducing technology. The autocatalyst industry drives platinum demand, and development of the fuel cell market will both diversify the demand for platinum and be a vital part of the cleaner energy revolution. An overview of the sustainability reports of major producers Amplats, Implats, and Lonmin, confirms that sizable investments are being made in the future of fuel cells. Implats, for example, has invested R6 million in the development of fuel cell technology for forklifts used on site.

Table III shows the breakdown of the initial US$20 million invested by Amplats in the PGM Development Fund (a private equity fund established for the development of the platinum sector), with further commitements of over US$100 million until 2018. The investments cover enery storage, and the development of the hydrogen and fuel cell value chains, including specific investments in companies, such as Altergy (designing and manufacuring fuel cell power systems), Ballard (producing fuel cell products), and Primus Power (developing energy storage solutions) (MISTRA, 2013).

The South African government has supported the development of fuel cell technology since 2008, with a 15-year research and development plan, and hopes to target 25% of the global fuel cell market by 2020. Challenges to the development of fuel cell technology include providing a safe and reliable supply of hydrogen (as hydrogen is the energy source in most fuel cell applications to produce electricity). Being a highly reactive gas, hydrogen does not occur naturally and needs to be extracted from oil, natural gas, or by electrolysis of water. Developing a holistic and economically viable system for sourcing hydrogen to be used in fuel cells is is the main challenge (Kemm, 2013). Until fuel cells become commercially viable and economically sustainable, the development and use of fuel cell technology will remain in its infancy.

Amplats, in partnership with Ballard Power Systems (Canadian company), Eskom, and the Department of Energ, has implemented a field trial of a methanol-fuelled home generator system in a rural setting. This prototype demonstration feeds off-grid electricity into 34 homes of the Naledi Trust Village. The off-grid market requirements will be tested by this prototype. The commercialization of fuel cell based products is key and there is great potential for the fuel cell market, particularly in Africa.

The system uses a 5 kW Ballard fuel cell that runs on methanol fuel, and as an off-grid system includes a battery bank and inverter operating with a micro-grid. 'The system is designed to provide a total of 15 kW of fuel cell-generated electric power, and can generate peak power of 70 kW with the support of batteries.' (Hinckly, 2014)

Sustainable energy management extending beyond the impact of electricity price increases

Very few sector studies have been conducted to assess the impact of electricity price increases on the platinum sector in particular. Often, impact assessments provide an economic narrative on energy and mining in general, aggregating the various consequences for varied mining value chains and missing the nuanced and specific details particular to a sector, essentially overlooking the vulnerability of a particular sector to electricity price increases.

The platinum mining value chain will be impacted by electricity price increases to varying degrees based on three key characteristics or dimensions: namely, electricity's contribution to operating costs, the electricity intensity across the value chain, and the ability of the firm to pass on costs further downstream (Deloitte, 2012). Such impacts are linked to the competitiveness (production and profitability) of firms, resulting in different outcomes across companies, which are further shaped by market dynamics and conditions unique to those sectors.

It is estimated that electricity costs as a share of total costs in the platinum sector ranges between 3-7% (with utility costs at 9% on average), which is lower than gold mining and other diversified mining groups, for which electricity costs can be as high as 14% and 21% of total costs respectively (TIPS, 2014) As mentioned earlier, electricity is a major component of the energy mix of platinum companies, and the electricity intensity of these platinum producers is particularly high in the mineral processing and beneficiation stages. The ability of firms to pass on costs remains a contested topic, but reports suggest that many major producers have some ability to pass on costs (TIPS, 2014), perhaps through large contracts held with industrial customers.

In most cases, it is difficult to show a direct link between

Table III
Investment portfolio of the initial US$20 million for PGM development

Focus area	Initiative	Partners	Funding
Research	2 HySA projects with DST	South African universities	US$0.3 million
Technology Development	Underground locomotive; rural electricitfication; dozer development	Ballard vehicle projects	US$12.4 million
Demonstration	DST Cofimvaba Rural Schools Cop17 fuel cell power 200 kw grid-connect fuel cell generation at Lephalale, Limpopo Province	Clean Energy Ballard Dantherm Power	US$2.4 million
Scale up and commercialization	Support of Limpopo local economic development study Clean energy (Telecoms back-up) Rural electricificaiton (pending field trial) Mining applications (pending tests)	Limpopo Province Department of Science and Technology and Altergy Ballard	US$5.1 million

Source: PGM Development Fund, 2012

the impact of electricity price increases and some of the mitigation strategies for electricity use and costs in the platinum sector. However, three areas of energy saving provide insights on elements impacting upon energy management in the sector in general. Table IV summarizes the opportunities and challenges related to these mitigation options.

Further research required

Increasing electricity prices are only one of the factors driving the need for platinum companies to investigate the potential costs and benefits of mitigation strategies in electricity use. Other drivers include environmental management commitments for greenhouse gas emissions. Exploring the mitigation strategies implemented in the platinum sector provides an opportunity to investigate the drivers and rationale for energy management choices made in the sector. This qualitative research, however, does not provide further insights into the economy-wide implications of electricity price increases for the sector and the mining industry in general. Aggregated studies on energy and mining miss the nuanced and varied approaches to energy management particular to mining industries, as is the case for deep shaft mining versus open-pit mechanized approaches. There is a gap in research that looks specifically at the impact of electricity price at the company level.

Table IV
Opportunities and challenges associated with the mitigation strategies in the platinum sector

Energy efficiency	
Opportunities	Challenges
• Energy efficiency gains are the low-hanging fruit for effectively managing electricity use and costs • Initiatives are often based on ease of implementation and the cost-benefit trade-off of making small changes • Energy efficiency constitutes the bulk of initiatives by platinum producers and provides opportunities for partnership with key players such as Eskom • Measuring improvement compared with baseline year is often easiest with energy efficiency initiatives • EE initiatives do not require major process changes.	• Energy efficiency gains will often be dominated by a cost-benefit approach and energy prices • Health and safety standards and practical implementation challenges and complexities are part of energy efficiency considerations and constraints • Limited gains to be made from energy efficiency • Dependency upon electricity in energy use dominates the platinum sector, and substitutes for electricity depend on power requirements and reliability supply, as well as cost • Mine age, depth, and ore grade quality impact upon efficiency gains.
Implications for sustainable energy management in the platinum sector: Energy efficiency gains are some of the earliest initiatives taken by the platinum sector to reduce the impact of electricity price increases and dependency on electricity in the mining value chain. In terms of sustainable energy management, effective monitoring of energy use will drive the identification of further gains. Platinum businesses require a better understanding of energy and electricity use across their value chain through monitoring and evaluation to continue achieving energy efficiency. As the opportunities for energy efficiency gains diminish, the decision to implement initiatives will continue to be governed by ease of implementation and cost benefits.	
Technology innovations	
Opportunities	Challenges
• Technology innovation may provide opportunities to reduce dependency upon electricity through major process changes • Gains from technology innovations provide opportunities at smelter level' where energy efficiency gains could not previously be made • - Technology innovations may have lateral application to other mining value chains.	• Research and development time horizons are longer for technology innovations and require greater cost commitment by platinum companies • Use of technologies is often limited by patent and commercialization licenses, for use by specific companies only (often newer mining companies) • New technologies may require expensive and complicated process changes that do not make sense in terms of cost-benefit analysis and the age of certain mines. Thorough testing of technologies may also cause delays.
Implications for sustainable energy management in the platinum sector: Technology developments in the platinum sector have been pioneered by specialized research and development institutes such as Mintek. For sustainable energy management in the future, partnerships and support for the research and development in technology innovation are vital. Maximizing the potential gains from technology innovations requires developing and proving technologies targeting more energy efficient and environmentally friendly production processes. The use of technology innovations may be limited to newer mines.	
Investments in alternative energy sources	
Opportunities	Challenges
• The benefits of renewable energy use include emissions reductions and environmental sustainability • As the cost of renewable energy becomes more competitive, there are cost benefits to be realized from using renewable energy, particularly in South Africa where electricity price increases are likely to continue • Investments in fuel cell technologies will provide new markets for platinum producers. Fuel cells may also be applied to in platinum mining operations to reduce the use of electricity from coal-fired power sources.	• Reliability of supply and the cost of generation remain two key determining factors of the use of renewable energy in mining • Financial risk for building alternative energy source (cogeneration and renewable energy) is often the responsibility of developers alone • Commercialization remains a challenge to the broader use of fuel cell technology. The main challenge lies in safe supplies of hydrogen fuel in a holistic system that is both technically feasible and economically viable.
Implications for sustainable energy management in the platinum sector: The use of renewable energy sources is driven not only by electricity cost in the sector, but also by the targets companies have set for emissions reductions and energy use (as well as options to reduce a potential carbon tax cost liability). Economic feasibility and reliability are key factors influencing decisions to invest in alternative energy sources. Sustainable energy management for the future of the platinum sector extends beyond the impact of electricity price to environmental, tax, and risk considerations.	

Further research is required to bridge this gap in order to provide government, power producers, and mining companies with a way forward in energy planning and management for a sustainable future. At company level, productivity, energy consumption and energy intensity as well as the market structure and dynamics of the platinum sector impact upon the mitigation strategies companies employ in energy management. The return on investment and potential savings need to be quantified. The socio-economic and environmental dimensions of energy management and mitigation decisions need to be extended to explore the impacts upon labour, mining communities, and the broader environmental aspects of mining operations, including water and air quality management.

Conclusion

Sustainable energy management has become a strategic imperative for platinum businesses, not only for mitigating the cost of electricity price impacts, but also in diversifying energy sources used in platinum production and reducing electricity dependency. The opportunities and challenges associated with the three types of mitigation strategies show that energy management has a broader ambit than energy efficiency, and relates to technology innovation as well as investment in alternative energy and the use of platinum in new products, particularly greener technology products such as fuel cells. Establishing a direct link between rising electricity prices and the need to mitigate this impact requires quantitative assessments of the costs and savings (and the consequent returns on investment) associated with the mitigation strategies, which will either strengthen or reduce the business case for these mitigation options.

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Appendix 1: Climate change risks to the platinum sector

Disturbance to mine infrastructure and operations
More frequent and intense natural disasters may damage mine, transportation, and energy infrastructure and equipment, which in turn will disrupt construction and operations. Heavy rain and increased erosion may affect slope stability near opencast mines, and rising sea levels may make coastal facilities harder to access.
Hotter and drier conditions may increase wildfires and threaten facilities.
Reduced amounts of water may be available for mining, processing, and refining activities. Costs will increase for pre-use and post-use water treatment.
Rising temperatures will increase energy demand for cooling underground mines and surface facilities. Greater demand and rising prices (driven by limited supply of natural gas, the imposition of carbon taxes, and expensive alternative energy sources) will add to costs.
Temperature fluctuations that increase energy demand and strain the capacity of transmission and distribution facilities can disrupt supply to operations. Energy rationing may lead to permanent decreases in production, affecting profits and commodity prices.
Changing access to supply chains and distribution routes
Natural disasters and heavy rainfall are likely to disrupt land transportation routes and degrade roads. Disruption in delivery of input materials such as steel, timber, cement, hydrochloric acid, and cyanide, or consumables such as diesel, tyres, and reagents, will curtail production or limit its efficiency.
Challenges to worker health and safety conditions
Flooding may affect employee safety on-site and on roads.
Flooding, natural disasters, and drought will undermine food security, and rising temperatures will exacerbate water shortages, undermining worker health and productivity.
Higher temperatures are likely to increase the incidence, prevalence, and geographic reach of tropical diseases with consequences for workforce health.
Challenges to environmental management and mitigation
Water scarcity and higher temperatures will make it more difficult to re-establish vegetative cover and will put stress on other environmental mitigation measures in some regions.
Risks of heavier rainfall include tailings dam failure, discharge of contaminated water into surrounding areas, accompanying remediation costs, increases in environmental liability, impacts on community health and safety, and significant potential for reputational damage.
Legacy mine sites rehabilitated under older climate regimes may require supplemental protection measures to ensure stability of waste rock and tailings covers. Environmental liability costs may increase, and monitoring responsibilities may be extended to ensure effectiveness of reclamation measures.
More pressure points with community relations
There may be increased requests for financial and employee support in response to natural disasters in host communities. Damage to livelihoods and property will elevate the need for basic services and restoration of economic activity. If these are also home communities for employee and contractor workforces, such incidences will directly affect worker health, attendance, and productivity.
Flooding and rising temperature will increase the spread of tropical diseases that affect community health.
Exploration and future growth
Future exploration may be restricted by expanded protection for biodiversity threatened by climate change and for forested areas that serve as carbon sinks.
Inadequate energy supply will become a major constraint on the expansion or development of new projects in some locations
Investors, lenders, and insurers will pressure companies to minimize carbon liabilities and develop adaptation plans, as well as incorporate climate change risk into due diligence. Management of climate change impacts will affect share prices and access to capital.

Source: Direct response from platinum companies to the Carbon Disclosure Project (2009)

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