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Perceived and reported economic and environmental value-add of a methane project in a South African Gold mine

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2017
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Perceived and reported economic and environmental value-add of a methane project in a South African Gold mine.

A research proposal submitted by

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February 2017

ABSTRACT

It has become imperative for business to shift their focus from a strict capitalist paradigm and transition to a philosophy whereby they adopt a broader concept of value to encompass social and environmental capital and thus adopt the principle of sustainable development. Business has the opportunity to reduce their carbon footprint by reducing greenhouse gas emissions through the adoption of clean technology in production processes.

The research aimed to articulate the possible differences between the perceived and reported economic and environmental value of clean technology projects, because perceptions of senior managers may impede to adoption of clean technologies.

10 semi structured interviews were conducted involving senior managers at a South African Gold mine to gain insight into their perceptions of the economic and environmental value added by a clean technology project. The transcribed interviews were coded using thematic analysis and thereafter themes were identified. Data from reports concerning the project was obtained and extrapolated in order to articulate whether the potential differences between the interview data, perceptions, and the reported data could prove to be an inhibiting factor to clean technology adoption.

The research finds that senior managers' perceptions, and the reported environmental and economic value added by the clean technology project, to be mostly aligned and thus these perceptions are not likely to prove to be an inhibiting factor to clean technology adoption. The findings however reveal factors that could affect the adoption of clean technology projects such as capital cost, operational inefficiency and the lack of skills, technology and knowledge required to implement and operate clean technology projects.

The key message from the research is that organisations can increase knowledge and technology sharing and ensure skill transference with regard to clean technology, whilst engaging consistently with organisations promoting clean technology, thereby increasing the adoption rate of clean technology projects and drive sustainable development.

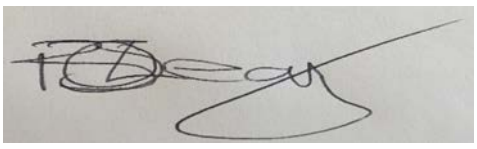
DECLARATION

I, Brett John O'Leary, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Brett John O'Leary

Signed at Wirtschaft Universiteit (WU), Vienna, Austria

On the 2nd day of February 2017



DEDICATION

This research report is dedicated to my friends and family whom have supported me throughout this process.

A special thanks to my supervisor, Julie Courtnage. Your guidance and wisdom has been invaluable, and I appreciate the all the time you sacrificed for the benefit of this report.

To my family -- you have always been the psychological safety net I fall back on when times are tough. Your unwavering moral and emotional support and continued encouragement were the driving force behind this report - thank you.

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CHAPTER 1. INTRODUCTION

1.1 PURPOSE OF THE STUDY

Sustainable development has become an imperative for business to implement in order to ensure future generations are able to meet their needs (Elkington, 1994; WCED, 1987). One of the ways in which they account for it is through triple bottom line reporting (Gimenez, Sierra, & Rodon, 2012). In this context, through a risk management lens, methane has been identified as a risk due to its contribution to climate change (Anifowose & Odubela, 2015).

Through clean technology a business is able to convert this risk of methane being released into a resource by using it to produce energy and thus add potential value to the triple bottom line which is the balance of environmental, financial and social capitals (Gimenez et al., 2012). The purpose of the research is to investigate the possible differences between senior managers' perceptions of the economic and environmental value added by a clean technology methane project at a South African Gold mine, and the actual reported value added to determine whether these perceptions of value could act as a barrier to clean technology adoption.

1.2 CONTEXT OF THE STUDY

"Clean production is one of a number of ways in which an organization can move toward sustainable development" (Guerin, 2006, p. 13).

South Africa has been at the forefront of the global gold mining industry since the discovery of the Witwatersrand goldfields in 1886 (Chamber of Mines of South Africa, n.d.; Handley, 2005). From the crude inefficient gold mining methods of the past, to operating the deepest mine in the world, local mining companies have lead the development and adoption of new technologies globally (Handley, 2005).

Due to the extractive nature of mining activities, environmental impacts are virtually impossible to avoid (Azapagic, 2004). Mining companies face considerable sustainable development challenges in ensuring they are economically viable while also ensuring they are environmentally responsible. The need for engagement with

various stakeholders adds further complexity when conflict of interests arise (Sethi, 2005).

Mining production is energy intensive, and in South Africa, where the majority of the energy is produced by coal fired power plants, this means mining contributes significantly to carbon dioxide emissions (du Plessis & van Greuning, 2011; Levesque, Millar, & Paraszczak, 2014).

Methane, together with carbon dioxide, contribute significantly to climate change through the greenhouse gas effect (du Plessis & van Greuning, 2011; IPCC, 1990). Methane is an explosive gas and is thus dangerous if leaked into underground mining areas and the environment (du Plessis & van Greuning, 2011; Karacan, Ruiz, Cote, & Phipps, 2011). Mining companies, through enterprise risk management, have identified methane not only as an environmental and safety risk but also as a useful resource to produce energy (du Plessis & van Greuning, 2011).

Sustainable development is a process of change from encouraging a business to shift from adopting a strict capitalist paradigm, to taking in a broader concept of value and more specifically social and environmental value (Brundtland, 1987). Through the adoption of clean technology to achieve a state of clean production, a business is able to mitigate the risk of methane (thereby enhancing environmental value), and take advantage of converting methane into energy, which creates economic value through revenue generated by the sale of the energy (Gonzalez, 2005).

Clean technology allows an organisation to reduce their greenhouse gas emissions through maximising waste management efficiency and, at the same time, these technologies can reduce energy and resource usage. With clean technology adoption, a business can contribute to sustainable development due to the ecological and economic effectiveness of the technology (Levesque et al., 2014).

Sustainability reporting has become a requirement as a means of measuring the progress of a business towards sustainable development with regards to, amongst many other factors, carbon dioxide and methane emissions, and is thus an effective tool to measure the benefits of clean technology (du Plessis & van Greuning, 2011; Global Reporting Initiative, 2011).

Through these reporting tools, a business is able to voluntarily report on their contribution to sustainable development through reduction of greenhouse gas emissions. These reports can have a positive reputational effect for the business, but more importantly they could allow a business to gauge the effectiveness of their clean technology in reducing greenhouse gas emissions (WBCSD & WRI, 2004).

The diffusion and adoption of this clean technology has been met with barriers, both external and internal (Narayanamurti, Anadon, & Breetz, 2011; Oliveira, et al., 2016; Suzuki, 2015).

However, through certain risk management tools, opportunities associated with adopting clean technology can be uncovered. Within this context, a business can make use of an enterprise risk management (ERM) system in order to evaluate the upside and downside risks associated with implementing clean technology, thus adding economic and environmental value to the business, thereby driving sustainable development.

In the context of this research, Sibanye has used ERM in order to identify the opportunity in the risk that the release of methane poses, and has used clean technology to take advantage of this opportunity at their Beatrix mine in South Africa.

1.3 PROBLEM STATEMENT

1.3.1 Main problem

The main problem of the research is to articulate the possible differences between the perceived and reported economic and environmental value of clean technology projects, because the perceptions of senior managers may impede the adoption of clean technology.

1.3.2 Sub-problems

The following sub-problems have been identified:

1. The first sub-problem is to evaluate senior managers' perceptions of the economic and environmental value of a clean technology project.

2. The second sub-problem is to evaluate the relative influence of perceived added value in decisions to adopt clean technologies.

3. The third sub-problem is to articulate the potential differences between the perceived and reported economic and environmental value of a clean technology project.

Thus, through the above sub-problems, the following questions are identified:

- What perceptions do senior managers at a South African gold mine have of the environmental value added by the methane project?
- What perceptions do senior managers at the South African gold mine have of the economic value added by the methane project?
- What is the relationship between perceptions and the actual reported environmental value added by the methane project?
- What is the relationship between perceptions and the actual reported economic value added by the methane project?

1.4 SIGNIFICANCE OF THE RESEARCH

The research aims to contribute to research into managers' perception of the economic and environmental value added by clean technology adoption. Research into the environmental, economic and social benefits of clean technology implementation is abundant; however very few of these take into account the perceptions of the employees managing these projects (Lopez-Gamero, Claver-Cortes, & Molina-Azorin, 2011).

Gonzalez (2005) surmises that most factors studied are limited to external forces such as regulation. This research will aim to ascertain whether there are internal forces in the organisation, particularly regarding the perception of economic and environmental value added, that act as barriers to clean technology adoption and diffusion.

This research could provide guidance to organisations looking to adopt clean technology in understanding how perceptions of clean technology could affect their

adoption, and provide reasons for the internal barriers that could affect the adoption and diffusion of this clean technology.

1.5 DELIMITATIONS OF THE STUDY

This research has identified the following delimitations:

- The research will only take place at the Beatrix gold mine but may be applicable to other mines in South Africa.
- Although perceived and reported economic and environmental value-added to the triple bottom line will be explored, social capital will not be included in the research.
- The research will only focus on the perception of senior managers and not all levels of employees.
- The documents analysed are limited to those available with regards to the methane project at the Beatrix gold mine.

1.6 DEFINITION OF TERMS

- **Perceptions:** The manner in which an individual interprets, and develops meaning from, interactions with stimuli and situations. However, the interpretations and meanings derived from the interactions may differ from reality (Pickens, 2005).
- **Sustainable development:** A framework for development that takes into account the finite resources used to create economic growth and to ensure that this growth is prolonged well into the future, while ensuring environmental and social integrity (Bonevac, 2010; Gimenez et al., 2012)
- **Clean technology:** Clean technology can alter the production process in a manner that reduces the amount of pollutants and waste emitted. Erzurumlu and Erzurumlu (2013) regard clean technology as a new and innovative technique, system or product that avoids or reduces environmental harm. Clean technology could increase production efficiency through reduced consumption of inputs as well as energy, and this could have a net positive effect on the triple bottom line (Gonzalez, 2005).

- **Triple bottom line:** A term invented by Elkington in his book, *Cannibals with forks,* refers to an accounting framework that takes financial, environmental and social capitals into consideration when analysing how a business can create value (Elkington, 1997).
- **Sustainability reporting:** refers to the reports compiled by a business indicating their social, financial and environmental impact of conducting business (Lowe et al., 2007).
- **Risk management:** any variable that could affect the possibility of an outcome occurring or not (Miller, 1992). Thus business risks can refer to anything that affects the ability of the business to meet its objectives. Therefore, enterprise risk management is the process through which a business identifies, measures, and manages these risks (Gordon, Loeb, & Tseng, 2009).

1.7 ASSUMPTIONS

- Research respondents are assumed to have knowledge of the methane project at the gold mine.
- Research respondents are assumed to have an understanding of the gold mine as a business.
- Research respondents are assumed to have an opinion and understanding about the economic and environmental value added by the methane project to the business at the gold mine. Should these assumptions be incorrect, the respondent cannot contribute to the research.
- By agreeing to participate in the research, respondents are assumed to be interested and willing to participate in the interview process.
- The researcher remains consistent throughout the interview process in order to ensure that the data retrieved is credible and dependable.

CHAPTER 2. LITERATURE REVIEW

2.1 INTRODUCTION

The objective of the literature review is to provide insight into the literature used in determining the research questions.

The section begins with an explanation and review of sustainable development and climate change, as the research is based within this overarching concept. Further to this, sustainable development with specific focus on greenhouse gas emission reporting is discussed. What follows is an introduction to clean production and the clean technologies that drive this clean production. This will enable a business to develop in a sustainable manner by reducing greenhouse gas emissions, while at the same time creating economic value.

2.2 SUSTAINABLE DEVELOPMENT

The Brundtland Report defined development as sustainable if it “meets the needs of current generations without compromising the ability of future generations to meet their own needs.” (Brundtland, 1987, p. 54). Sustainable development required natural resources as inputs to produce the outputs which lead to economic growth, while maintaining environmental and social integrity (Bonevac, 2010).

Sustainable development is inextricably linked to natural resources, and therefore the immediate environment, as life is completely dependent on these resources.

Sustainable development is used as a framework that takes into account the finite resources used to create economic growth, and to ensure that this growth is prolonged well into the future while ensuring environmental integrity (Bonevac, 2010). Further to this, there is a clear indication of a time frame consideration as future generations are taken into account.

The World Commission on Environment and Development (WCED) recognises the link between the environmental, social and economic issues and therefore has

integrated these issues under the theme of sustainable development (Gimenez et al., 2012).

The call for action to progress towards sustainable development was fostered through a need to address the inequalities that exist in the world by focusing on the alleviation of poverty and reducing the degradation of the environment.

The Brundtland Report (Brundtland, 1987) referred to these issues as mutually inclusive as one issue could not be solved without addressing the other. Without the environment, there would be no resources to use for economic growth, and without society, there would be no skills to convert the resources into products required for economic growth.

According to Robinson (2004), governments and business preferred to use the term sustainable development due to its less radical incremental framework for development. However some non-governmental organisations and academics preferred the term sustainability due to the inseparable link between development and growth, and thus contended that the notion of sustainable development did not address the issue of living within the means of the environment (Robinson, 2004). This research focused on the first framework adopted by governments and business.

Sustainable development could become necessary due an ever-increasing need for the resources required to feed, house, and ensure that basic human needs are met, and therefore ensuring the population is living within the means of the environment. One must also consider the reliance on resources that have a finite capacity, especially fossil fuels such as coal and oil, as well as the by-products of producing energy from these fuels (EPA, 2012).

As increased energy demands are being met through burning more fossil fuels, so increased waste, in the form of carbon dioxide, is emitted into the atmosphere. The increase in carbon dioxide and other greenhouse gases, such as methane, leads to the greenhouse gas effect, which has been identified as a cause of climate change (IPCC, 1990). Karacan et al. (2011) stated that methane is 21 times more potent than carbon dioxide as a greenhouse gas.

Guerin (2006, p. 11) discussed sustainable development in the minerals sector as any investment by a business that was “profitable, technically appropriate,

environmentally sound and socially responsible." In referring back to the triple bottom line, Guerin (2006) highlighted the interrelatedness of these issues.

"... [M]ore output requires more inputs and so the earth's 'sources' (of natural resources) inevitably will be depleted by continued growth of production and consumption" (Grossman & Krueger, 1995, p. 86). They also reiterated the need for sustainable development, as continued economic growth would lead to an increase in resource consumption, and thus place added pressure on the ability of the environment to absorb the extra waste.

Hence, considering the business processes of using resources as inputs in order to produce outputs while producing waste, it becomes pivotal to view sustainable development through a business risk lens. This would allow an organisation to identify financial, environmental and social risks for that organisation and possibly convert those risks into opportunities through the use of clean technology.

2.3 RISK MANAGEMENT

Risk is defined as any variable that could affect the possibility of an outcome occurring or not (Miller, 1992). Thus business risks refer to anything that affect the ability of the business to meet its objectives and, in the context of this research, the risk refers to the release of methane gas and its explosive potential, as well as its threat to the environment.

Identification of a risk allows an organisation the possibility to convert this risk into an opportunity, such as the possibility of converting methane into energy to power a mine (du Plessis & van Greuning, 2011).

Gray and Wiedemann (1999) stated that sustainable development was concerned with an aspect of loss therefore a business needed to consider all elements thereof from a risk perspective.

According to COSO (2004), an enterprise risk management (ERM) system has certain goals to be reached that will make it an effective system. In terms of sustainable development an organisation's strategy needed to be aligned with its sustainability goals and thereby its mission (Gordon, et al. 2009).

Methane poses an environmental and safety risk that could be managed by implementing technology, such as clean technology that is able to covert the risk into a resource and thus creates an economic benefit whilst being environmentally conscious. (du Plessis & van Greuning, 2011). Operational efficiency through optimal use of resources is core to ERM and furthermore ensures economic value is created (COSO, 2004). The use of clean technology is seen as a solution to certain efficiency risks.

In terms of stakeholder engagement, the reporting system needs to be reliable in order to be measurable. Lastly, organisations should adhere to and comply with laws and regulations set out by the relevant bodies, which in this case would be the reporting bodies discussed below (COSO, 2004).

“By reducing non-core exposures, ERM effectively enables companies to take more strategic business risk – and greater advantage of the opportunities in their core business.” (Nocco & Stulz, 2006, p. 9). They also contended that, with an effective ERM system in place, an organisation would be able to measure and manage risks throughout all business units in such a manner that will allow it to achieve its strategic goals.

An ERM system ensured risks were managed consistently across the organisation as opposed to having dealt with them separately in silos, thereby achieving strategic alignment and an increase in the value of a firm would be achieved (Gordon, et al., 2009).

According to the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WBCSD & WRI, 2004), organisations need to consider and manage the business risks associated with greenhouse gas emissions in order to remain competitive and effectively compete in various regions where different policies may apply, thus further emphasising the role of ERM. Regional policies may differ in terms of voluntary protocols, carbon taxes as well as regulations on emissions set out by local governments which needs to be considered when developing an ERM system (WBCSD & WRI, 2004).

Riddell and Welsh (2008) maintained that viewing the strategic importance of climate change from a risk management perspective would allow a business to identify operational risks and opportunities.

In the context of risk management, Sharma (2000) proposed that the manner in which managers interpret environmental issues, in terms of threats or opportunities, could influence the business adoption of clean technology. Further to this, a manager that identified an environmental issue as an opportunity was more likely to take a proactive approach to finding solutions to take advantage of the potential opportunity (Lopez-Gamero, et al., 2011). Thus, managers who saw the release of methane as an opportunity would possibly have been more likely to adopt clean technology as a perceived solution to take advantage of methane as a resource.

Narayanamurti et al., (2011) stated that through advanced energy technologies, a business would remain economically competitive while using energy more efficiently, reducing greenhouse gas emissions, and ensuring a consistent supply of energy. By implementing clean technology as a recognised solution to mitigate the effects of greenhouse gas emissions and ensure a safe working environment, a business would be able to create economic value while being environmentally sustainable.

In order to determine what effect ERM solutions had on sustainable development, and further, the effect they had on an organisations' bottom line, the risks needed to be measured and managed (Nocco & Stulz, 2006). The use of reporting tools can be used to evaluate the effectiveness of the risk management solution, one being clean technology, in increasing economic sustainability by living within the means the environment offers.

2.4 SUSTAINABLE DEVELOPMENT REPORTING

Elkington's (1997) discussion of the triple bottom line identified the need for business to consider profit, people, and the environment in order to develop in a sustainable manner, and he asserted that the triple bottom line should be used as a reporting tool as a means to gauge an organisations progress.

In order to determine the progress towards sustainable development, a plethora of indicators (e.g. the Environmental Sustainability Index, the Environmental Performance Indicator & the Genuine Progress Index) have been developed (Hammond, Adriaanse, Rodenburg, Bryant, & Woodward, 1995; National & Stewardship, 2005; YCELP et al., 2016).

These indicators measured and compared countries through various methodologies, and considered a huge variety of individual factors, thus proving difficult to gain a clear indication of progression due to a confusion in terminology as well as the very ambiguity of sustainable development (Parris & Kates, 2003).

Another example was the Kyoto Protocol, which related specifically to energy use in terms of relevant carbon emission reporting tools, and was an international treaty that encouraged the 84 countries that were member signatories to meet the agreed emission targets in order to mitigate the effects of climate change. Members were required to report on their greenhouse gas emissions (United Nations, 1998).

According to Freedman and Jaggi, (2005) larger organisations from countries that ratified the protocol tended to have higher disclosure indexes. However, multinational organisations that operated in countries that ratified the protocol, but had their home base in countries that did not, tended to show lower disclosure indexes. Thus, in terms of the success of the Kyoto protocol, there were inconsistencies.

In terms of reporting on sustainable development in the environmental sphere, and more specifically greenhouse gas emissions, various bodies developed accounting and reporting tools that allowed businesses to track their contributions to mitigating climate change (Global Reporting Initiative, 2011).

There are a variety of reporting standards and authorities thereby allowing the organisation the freedom of choice. Further to this, Gray and Milne (2002) argued that even though business agreed to produce sustainability reports, they often promoted certain information while omitting other relevant details. Thus reports could be misleading in that they did not project the full scope of the business attempt at sustainability, and, more specifically, their failures. This could have an effect on this research due to information not being available, and could potentially change the results through misinformation.

The Carbon Disclosure Project (CDP) is an organisation that works with business all over the world with regard to reporting on greenhouse gas emissions. The CDP also provides a platform where solutions to climate change, such as clean technology, can be communicated (Riddell & Welsh, 2008).

Bosetti, Carraro, Duval, Sgobbi, and Tavoni, (2009) as well as Naidoo, (2014) proposed that knowledge transfer and the actual transfer of clean technology could decrease the cost of clean technology through a reduction in the 'learning effect'.

Thus, through the CDP providing a platform to exchange solutions to counteract climate change, and in the context of this research, clean technology could become cheaper and thus more widely adopted as one of these solutions.

The United Nations Global Compact is a voluntary initiative that encourages business to incorporate sustainable development strategies and objectives that reduce greenhouse gas emissions where the progress can be monitored through comprehensive reporting (WBCSD, UNGC, & UNEP, 2007).

The notable objectives are:

- Pursuing energy and process efficiency across their operations
- Benchmarking the greenhouse gas impacts of their products and services
- Promoting awareness and understanding among their stakeholders and customers, of energy issues and greenhouse gas emissions through their product and supply chains (WBCSD et al., 2007).

The International Council on Mining and Metals (ICMM) is a voluntary organisation consisting of, and led by, mining companies that set out to advance the concept of sustainable development. With regard to greenhouse gas emissions, the ICMM has developed a climate change program to ensure their members take proactive measures to reduce their emissions (ICMM, 2011).

The objectives as set out by the ICMM are:

- Developing greenhouse gas emission reduction strategies and implement economic emissions reductions opportunities
- Ensuring efficient use of natural resources
- Supporting research and development of low greenhouse gas emission technologies that are appropriate to the industry
- Measuring progress and report results (ICMM, 2011).

The ICMM has been criticised as the governance and leadership structure is made up of mining company executives and there is minimal influence from non-industry stakeholders. Therefore the potential for outside influence is mitigated and information could be controlled (Sethi, 2005). Thus there is potential for information to be withheld which could lead to a slower adoption of certain technologies due to lack of credible evaluative analysis of the effect of these technologies.

The Global Reporting Initiative (GRI) is an independent international organisation providing sustainable development reporting support to business and governments (Global Reporting Initiative, 2011). Through sustainable development reporting support from an organisation such as the GRI, business may be able to evaluate the impact of adopting new technologies on the triple bottom line, and, in the context of this research, the effect of clean technology.

According to Sutter and Parreño, (2007) the clean development mechanism (CDM) was established in order to drive sustainable development in developing countries and assist countries in achieving their greenhouse gas (GHG) emission reductions goals. A project registered with the CDM has the opportunity to trade carbon emission reduction (CER) units, which equate to 1 ton of emission reductions, earned through the measures that reduced GHG emissions (UNFCCC, 2014).

In conjunction with the CDM, an organisation may register a clean technology project with the verified carbon standard (VCS), which is a voluntary GHG emission reductions programme that allows an organisation to trade verified carbon units (VCU). In the context of this research, a clean technology project, such as the methane project, can be registered with the CDM and the VCS and thus has the ability to trade CER's and VCU's generated. This has the potential to add economic value through revenue generation.

Therefore, through sustainable development reporting, an organisation is able to gauge their progress with regards to reduction in emissions that contribute the global warming, as well as evaluate the economic value a clean technology project can contribute. (WBCSD, UNGC, & UNEP, 2007).

2.5 CLEAN TECHNOLOGY AND CLEAN PRODUCTION

Guerin, (2006, p. 15) defined clean production as a “preventive environmental strategy to increase eco-efficiency, involving the efficiency assessment of products, systems and processes.”

Through the integration of clean technology in systems and processes, a state of clean production may be achieved by an organisation. Technology is one of the many solutions that will allow a business to drive sustainable development through the reduction in its greenhouse gas emissions.

Dovi, Friedler, Huisingh and Kleme (2009) noted that rising energy prices and climate change related to greenhouse gas emissions had led to an increase in demand for energy efficiency.

Energy and climate change were business risks that could be managed through adopting certain technologies that offer benefits, including reduced greenhouse gas emissions, and reducing the usage of energy and resources during production (Dovi, et al., 2009).

The terminology with regard to clean technology was inconsistent in the literature. According to Gonzalez (2005), innovative environmental technologies were categorised into two distinct approaches: clean technologies and end of pipe technologies. Gonzalez (2005) described technologies that aimed to transform emissions from the production process into materials easier to manage as end of pipe technologies (EOP). Frondel, Horbach, and Rennings, (2007) noted that end of pipe technologies are generally those technologies that attempt to reduce the harmful substances that occur due to certain production processes without having an effect on the process itself.

In the context of this research, the release of methane is not seen as being part of the production process as it is emitted from natural sources deep in the earth (du Plessis & van Greuning, 2011).

Whereas clean technology altered the production process in a manner that reduced the amount of pollutants and waste emitted, Erzurumlu and Erzurumlu (2013)

regarded clean technology as new and innovative techniques, systems or products that avoided or reduced environmental harm.

Clean technology could increase production efficiency through reduced consumption of inputs as well as energy and this could have a net positive effect on the triple bottom line (Gonzalez, 2005).

Adopting clean technology at an early stage in infrastructure development could result in more efficient and resilient infrastructure, which will negate the future need to decommission or retrofit technologies to make them more environmentally friendly (IEA - International Energy Agency, 2013). This research will focus on clean technology, that prevents or reduces emissions, and the effect they have on the triple bottom line.

In the context of this research, at the 17th meeting of the Conference of Parties (COP), South Africa announced their goal of reducing emissions by 34% by 2020 to the United Nations Framework Convention on Climate Change (UNFCCC). The agreement was subject to the support required from developed countries with regards to financial aid and the provision of technical advice to developing countries (UNFCCC, 2010). Thus, clean technology could play a major role in South Africa in order to reduce emissions to the stated goal by 2020.

Clean technology can be viewed as those technologies that allow an organisation to take advantage of cost savings through the reduction in energy and resource usage, while optimising recycling and maximising waste management efficiency. Further to this, these technologies are sustainable due to their ecological and economical effectiveness for present and future generations (Levesque et al., 2014).

Frondel et al., (2007) noted that clean technology often led to both decreases in harmful by-products, and reduced energy and resource inputs due to increased efficiency.

There are a variety of technologies available for enabling clean production in the mining sector. Guerin (2006) presented 13 cases that showcased a mining company’s commitment to improving their triple bottom line. Within the context of the research, three of the case studies demonstrated the use of innovative technologies in energy efficiency and reduction of greenhouse gas emissions.

Guerin (2006) discussed a case in which a mine made the decision to replace ‘wet scrubbing’ technology with the newer ‘dry scrubbing’ technology. This allowed them to produce energy from waste gas, thereby reducing the amount of energy purchased and waste gas emitted into the atmosphere. This illustrated, through sustainable development reporting, the potential of clean technology to add economic and environmental value for an organisation.

In another successful implementation of clean technology, Guerin (2006) described a case in which the exhaust gas from a turbine was used to generate superheated steam for another process. This had the effect of reducing greenhouse gas emissions and reducing the demand for energy required to generate the superheated steam (Guerin, 2006).

A third case that was more relevant to this research involved the use of methane emitted during mining activities to produce energy. Methane was released into the underground mine and had to be collected and drained, at a cost, in order for mining to continue in a safe manner, as methane has the potential to ignite and explode (Karacan et al., 2011). Thus, through risk management, methane was recognised not only as a risk but also as a wasted resource due its potential to produce energy. The business turned to the technologies associated with clean production in order to take advantage of this risk by installing a generation plant at the mine which used the methane as an input to generate energy (Guerin, 2006).

In addition to the energy requirements of the mine, the generation plant produced additional energy which was then sold off to the grid. The technology was therefore able to reduce greenhouse gases emissions through using the waste methane as a resource and thus contributed to sustainable development. Further to the environmental benefit, the mine was able to sell electricity to the grid thereby providing economic benefit through the revenue generated (Guerin, 2006).

In the South African context this could be difficult to achieve due to the regulatory framework adopted by Eskom and the National Energy Regulator of South Africa (NERSA). Eskom can only purchase energy through a procurement programme, of which there is only one: the renewable energy feed-in tariff (REFIT) (Eskom, 2015). The following steps have to be followed in order to be eligible to be part of the procurement process:

- Grid connection application with the local authority
- License application through NERSA
- Procurement process through the department of energy (Eskom, 2015)

In terms of the methane project, electricity generated is not sold to the grid as yet and is only consumed by the Beatrix gold mine.

The research aimed to determine whether the generation plants using the waste methane at the Beatrix mine had an effect with regard to the contribution to the triple bottom line; and whether this effect differed from the perceptions of senior managers of the project's added value, and whether these perceptions could act as barriers to clean technology adoption.

2.6 BARRIERS TO CLEAN TECHNOLOGY ADOPTION

The implementation of these innovative technologies, such as clean technology, had been met with barriers and thus affected the rate at which business adopted and made use of the clean energy technologies (Narayanamurti et al., 2011). These barriers in developing nations were summarised as financial, technological and institutional by Suzuki (2015).

Financial barriers refer to the high costs associated with the manufacture of clean technology in an environment where financial capital is under strain. The lack of support from major financial institutions inhibits developing nations in acquiring the clean technology from abroad, due to high initial purchasing costs (Naidoo, 2014).

Technological barriers in developing nations include limited access to clean technology as well as the skills and knowledge required to develop, adapt, operate, and manage these technologies (Luken & Van Rompaey, 2008; Naidoo, 2014).

Institutional barriers refer to regulation and policy that could make it difficult to adopt clean technology. Added to this is the lack of information dissemination and support from regulatory bodies due to a lack of skills needed to assimilate clean technology (Suzuki, 2015).

Oliveira et al. (2016) cited the three main barriers that inhibit the transformation to these advanced technologies:

- Technology risk, which refers to the uncertainty by a company about the effectiveness of the technology.
- Access to capital, the lack of which could prohibit a business from having the ability to purchase the technology.
- Policy and regulation with regard to energy technologies, which could make it difficult for a business to implement.

In a South African context, Naidoo, (2014) found that implementing clean technology projects using international finance was difficult due to high transaction costs, and the regulation requiring stringent monitoring and reporting of such projects. This administrative burden revealed yet another barrier to clean technology adoption.

A crucial factor to consider in clean technology finance was the lack of information with regard to financial feasibility, and effectiveness in the market place, which made assessing the project extremely difficult (Goldman, Mckenna, & Murphy, 2005; Suzuki, 2015).

A financier, under normal circumstances, would complete a due diligence on a project prior to approving finance. However this becomes difficult without a track record to work from as in the case of clean technology. This adds a formidable amount of risk to the project.

Added to this, the relatively young nature of organisations producing the technology, proved to be a barrier to clean technology adoption through the higher cost associated with innovative design (Goldman et al., 2005; Suzuki, 2015). The relatively small scale of clean technology projects made it difficult for them to absorb the high costs related to financing a project and thus made them less attractive, proving to act as a barrier to adoption (Goldman et al., 2005).

Goldman et al (2005) purported that the capital-intensive nature of clean technology projects, along with their extended payback period, increased the risk associated with revenue. Due to the protracted payback periods, financiers entered lengthy debt agreements, and thus wanted a modicum of revenue security in order to make the

investment worth their while (Goldman et al., 2005). The length of the agreement was not favoured among some investors due to their capital being essentially unavailable for other projects whilst they were invested in the clean technology projects.

As Goldman at al. (2005) pointed out, clean technologies projects generally had higher capital costs than traditional fossil fuel technologies and, further to this, due to the intermittent nature of certain renewable energy sources, clean technology projects tended to have lower margins. This made these projects difficult to finance as they were compared to cheaper fossil fuel based projects, and this therefore proved to be another barrier to clean technology adoption.

Further to this Shi, Peng, Liu and Zhong, (2008) proposed the following as the four main barriers to clean technology adoption:

- Policy and market barriers
- Financial and economic barriers
- Technical and information barriers
- Managerial and organizational barrier

Considering the context of this research, managerial and organizational barriers are important factors to be considered, as these refer directly to the manager's role in clean technology adoption.

Shi, et al., (2008) proposed that managers tended to focus on increasing production and market share at the expense of taking clean technology into account. Thus, when the possibility of implementing clean technology into the production process arose, a manager might overlook the clean technology due the additional substantive initial investment cost involved, as well as the risk of changing the current production process, thus causing a decrease in production hours (Shi et al., 2008). In addition they stated that managers may not be aware of the economic and environmental benefits clean technology might have for the organization, and could also lack the skills needed to implement it.

This again can lead to a misconception about clean technology from a managers' perspective as they are uninformed about the potential benefits clean technology may provide.

Moors, Mulder and Vergragt, (2005) referred to the organisation and culture of the firm acting as barriers to clean technology adoption, in that an organisational culture that did not favour innovation and investment in new technologies would have more than likely influenced the managers to behave in a similar manner. This would lead to the status quo in production practices remaining in place, while clean technology and the potential benefits were ignored, due an organisational culture which was fostered from the top down, proving organisational support is necessary (Frondel et al., 2007; Moors et al., 2005).

Within this context a business could make use of ERM in order to evaluate the upside and downside risks associated with implementing these strategies and clean technology in order to create sustainable value.

Gonzalez (2005) reiterated that there were barriers affecting clean technology production. However he also took into consideration the importance of these internal forces in the business.

Thus this research will aim to evaluate the perceptions of managers of the environmental and economic value added by clean technologies, in terms of inhibiting the adoption of clean technology.

2.7 ENABLERS OF CLEAN TECHNOLOGY

Much like the barriers to entry of clean technology, the enablers of clean technology tend to centre round financial, technical and institutional factors.

Veugelers, (2012) proposed that certain factors needed to be addressed whilst interventions were put into place in order for clean technology to be adopted faster, and on a greater scale.

In the context of South Africa, the financial burden is too great for the domestic resources to handle, due to the scale required for these clean technology

investments, and thus developed countries are encouraged to provide financial and technical assistance to ensure these projects are successful (Naidoo, 2014). Therefore, a key enabler for the adoption of clean technologies, specifically in the South African context is financial support from developed countries and bodies such as the UNFCCC.

Bosetti et al., (2009) purported that increasing financial resources available to clean technology research and development (R&D) could increase the adoption and diffusion rate of clean technology, thus again proving financial assistance was a key enabler. This was specifically true when observing the adoption of new and developing technologies to counteract the price advantage traditional technologies held (Veugelers, 2012). The World Economic Forum, (2015) noted that technological innovation had the possibility to ensure that the price of technology dropped and that the quality increased.

This technological advancement could ensure that clean technology becomes cheaper and more efficient over time, which would make it a more attractive solution to implement.

One cannot discuss financial enablers without taking carbon prices into consideration. Carbon pricing refers to the price placed on GHG emissions that must paid by companies producing these emissions (Nicholson, Biegler, & Brook, 2011). Carbon pricing consists of 2 main market-based mechanisms: emission trading systems (ETS) and carbon taxes. (Dellink, Jamet, Chateau, & Duval, 2014).

Veugelers, (2012) proposed that these mechanisms not only were able to induce the increased uptake of existing clean technology, but also reduced the production and use of so called ‘dirty technologies’ due to the financial benefit gained through carbon taxes and ETS.

Further to this was the expected future values of carbon pricing, as this would entice organisations to adopt clean technologies sooner should the market determine that the carbon price could potentially increase (Veugelers, 2012).

That being said, it has also been noted that private incentives provided a degree of stimulus to invest in clean technology (Daron Acemoglu, Aghion, Bursztyn, & Author, 2015; Maynard, Shortle, 2016).

Carbon pricing alone cannot act as a key enabler, as enforcing stringent carbon pricing could lead to reduced economic activity through decreased feasibility, as a result of the increased cost. Hence the need for government policy, as well as specific regulations, to encourage a wider adoption of clean technology, alongside that of carbon pricing. (Maynard et al., 2016; Veugelers, 2012).

Taking carbon taxes and clean technology subsidies into consideration, government policy will need to ensure the subsidies and taxes are not so exorbitant as to lead to the green paradox. The green paradox alludes to a situation where future carbon taxes are announced, thus causing the future profit margin of fossil fuel resource owners to decrease. This would lead to profit maximisation prior to the tax being enforced, which would mean the fossil fuel resource owner would increase extraction in order to capitalise on the current profit margin. This would lead to increased emissions and thus have the opposite effect on global warming. (Jensen, Mohliny, Pittelz, & Sterner, 2015)

In terms of technological enablers, assistance and knowledge transfer could ensure an increased adoption of clean technology (Naidoo, 2014). The transfer of knowledge includes the transfer of the actual clean technology, as this could decrease the ‘learning effect’ thereby decreasing the cost of the clean technology (Bosetti et al., 2009). The transfer of technology and assistance from experienced clean technology producers could act as key enablers, by reducing the time required to research and develop the actual technology, whilst at the same time, decreasing the learning curve required to implement and operate such technologies. This, in turn, will increase the potential market for these technologies and thereby increase the rate of adoption and diffusion (Bosetti et al., 2009).

Institutional enablers refer to the role of government and relevant organisations in formulating policies and procedures that promote increased adoption of clean technology whilst ensuring economic and energy security. Government policies to encourage the adoption of clean technology should be formulated to ensure lower emissions are achieved at the lowest possible cost thereby sustaining economic growth (Veugelers, 2012). Government policy can also alleviate the issue of the downside risk of clean technology, by reducing the time taken for an organisation to adopt clean technology, though increased assistance and incentives (Maynard et al.,

2016). Information dissemination is another crucial factor that leads to enable clean technology to be more widely adopted, as it allows the private and public sector, the opportunity to understand the benefits the technology has to offer (Maynard et al., 2016).

2.8 PERCEPTIONS OF CLEAN TECHNOLOGY

A perception is defined as how a person interprets stimuli based on prior experiences (Pickens, 2005). Therefore the perception of a positive outcome, through a past experience, could lead to the formation of a positive attitude and thus a decision to act in favour of the project leading to the positive outcome. (Montalvo & Kemp, 2008)

Therefore, managers' perceptions of clean technology can directly affect the decision to adopt such technology and, further to this, these perceptions could ultimately prove to be barrier, or enabler to adoption through this decision-making process. Managers' perceptions of clean technology could be shaped simply by the perceived increase in risk associated with the implementation of such projects (Shi et al., 2008). The perceived risk is said to be determined through information and evidence generated from similar past and present clean technology projects (Kemp & Volpi, 2008).

Therefore, managers' perceptions could be directly influenced positively or negatively toward clean technology depending on the information disseminated regarding such projects. This does not imply that information about failed clean technology projects should be withheld or falsified, but accurate information about the positives and negatives should be shared with all sectors in order to gain a better perspective regarding clean technology.

Managers' motivation to adopt clean technology was further influenced, although not significantly, by their perception of regulatory pressure applied by governments through environmental and economic policies which included financial incentives, current regulation as well as expected future regulations (Luken & Van Rompaey, 2008). There was evidence which showed that, even if a manger perceived government regulation to be relatively weak, they were still more likely to adopt clean technology than if there were no regulations in place (Luken & Van Rompaey, 2008).

Senior managers' perceptions were also influenced by the term of certain projects, and generally influenced companies to take on short term projects that spanned 5 to 10 years as they might not be entirely focused on the long term environmental effects associated with such projects (Moors et al., 2005).

It was common for clean technology projects to span 20 to 50 years and, with their capital-intensive nature, the payback period was rather lengthy. The perception by managers could be affected as they were tasked with increasing financial performance, the project's returns, in the short term (Moors et al., 2005; Schaefer & Harvey, 1998).

A managers' perception might also have been influenced by the organisations history and how this history affected the organisational processes (Cooremans, 2007).

A decision to adopt or invest in clean technology may be influenced by where the initial idea to invest originated. This could be either from within the organisation or outside of it, as well as the role-players involved in the decision-making process. A manager's perception could therefore have been influenced by the manner in which a similar decision within the organisation was dealt with in the past (Cooremans, 2007). He also noted that some organisations perceived energy purely as a commodity, in this case something that could be traded, as opposed to a resource, a required input into the production process (Cooremans, 2007).

Thus, when there is a significant cost involved in an energy efficiency project, it could be rejected, as energy is not seen a strategic resource deserving of additional investment. This organisational perception could filter down to managers and further change their perceptions of clean technology.

2.9 CONCLUSION

Clean production is a preventive strategy, and to improve its success in contributing to a business's sustainability, it should be linked to the core activities of the business. It includes working efficiently and efficiency is the cornerstone of a successful business. Inefficiencies generate increased waste

> but continued technological development can reduce this waste and potentially convert it into a commercially valuable resource. (Guerin, 2006, p. 12).

Thus, by implementing innovative technologies, such as clean technology, that lead to clean production, economic and environmental value could be generated for the business. The environmental and economic risks could be identified through ERM and thereafter the optimal technological solution implemented in order to take advantage of the upside possibility of the risk.

However, in order to increase the adoption rate of clean technology, certain amendments are required in terms of regulation in the form of policies and taxes, as well as solutions to technological and financial barriers (Gonzalez, 2005).

The promotion of clean technology would be made easier by segregating economic growth from environmental protection through introducing economic incentives; ensuring information was shared; and increasing international support and knowledge transfer (Gonzalez, 2005; Naidoo, 2014). All of the above could influence the senior managers' perceptions with regard to clean technology.

Sibanye Gold, the owners of Beatrix Mine, identified the release of methane as a risk as well as an opportunity at the Beatrix gold mine, and thereafter installed generators which converted this methane to energy for consumption on site. Using this waste methane as a resource to produce energy had the effect of reducing the need for energy from the national grid, and therefore decreased the amount of money spent on purchasing energy. This has effectively decreased fixed costs thereby increasing the profit margin and, in addition, contributed to sustainable development through the reduction in greenhouse gas emissions.

Hence the research related to the generation plants at the Beatrix mine, that provided a solution to mitigate the environmental and health risks associated with methane emissions, whilst ensuring a safe working environment, thereby contributing to the triple bottom line though environmental and economic benefits. The research focused on managers' perceptions of the methane project in order to determine whether there was a discrepancy between the reported value and their perceptions of the environmental and economic value added.

CHAPTER 3. RESEARCH METHODOLOGY AND DESIGN

3.1 INTRODUCTION

The research objective was to determine the reported economic and environmental value generated by the methane project. Further to this, the research aimed to determine managers' perceptions of the economic and environmental value created by the methane project and, through a dualistic approach, whether this acted as a hurdle to clean technology adoption and diffusion.

3.2 RESEARCH METHODOLOGY

The research methodology chosen for the research was qualitative as this allowed for analysing data to gain in depth information from a smaller group of participants (Ambert,, Adler, Adler, & Detzner, 1995). Qualitative research is exploratory by nature and was therefore ideal for the proposed research in determining perceptions of individuals (Creswell, 2003).

Qualitative research has been criticised in the literature for allowing the researchers bias to influence the results, along with a lack of numeric data, clearly defined guidelines and no clear data analysis conventions (Yin, 1994).

Bowen (2009) defined document analysis as a research methodology, as opposed to an instrument; therefore this research has used document analysis as defined by Bowen. The researcher conducted document analysis in order to determine the actual economic value added to the business by the methane project.

According to Bowen (2009), document analysis is a systematic procedure for analysing electronic and printed documents that can provide corroboration through the use of different data sources. Documents are generally easily available and they display a high degree of exactness (Yin, 1994). Documents provided a tool for tracking changes and developments and thus the means to identify the value added to the business over time through the implementation of the methane project (Bowen, 2009).

Document analysis does suffer from certain shortfalls in that it might not provide sufficient detail and a researcher could display bias by only selecting certain documentation (Bowen, 2009; Yin, 1994).

The following was taken into account with regards to the documents being analysed: the reason the document was produced, the target audience, the original source of information from which the document was produced, the document's author and lastly whether the document had been edited (Bowen, 2009).

The Sibanye company secretary gave permission to analyse the documents relating to the methane project. The documents included financial reports, operational reports, sustainability reports, as well as any other reports related to the methane project compiled by Sibanye Gold. An effort was made to compile reports or research from independent organisations relating to the methane project. Endeavours were made to compile all documentation available from Sibanye Gold related to the Beatrix methane project in order to mitigate the effect of bias and ensure the objective of determining the value added by the project was met.

3.3 RESEARCH DESIGN

The research consisted of a single case study as it allowed the researcher to gain in-depth knowledge of the Beatrix methane project. According to Noor (2008) a case study focuses on a specific project or situation as opposed to a broader view of the entire organisation. This was applicable to this research as it focused only on the methane project at Sibanye Gold's Beatrix gold mine.

According to Soy (2015) case studies have been criticised for not being able to offer generalisation of the findings due to the small scope of a case study, and he further insinuated that the researchers' exposure could lead to bias in the findings.

Stake (1995) described a variety of case studies that were dependent on the purpose of the research.

An intrinsic case study provides insight into the research; an instrumental study allows the researcher to gain an in-depth understanding of the project and a collective case study uses more than one case to understand an issue.

An instrumental case study was used in this research as it further contributed to the need to gain a deeper understanding of the Beatrix methane project.

Both Stake (1995) and Yin (1994) developed a protocol for a researcher to conduct case study research. These protocols provided a framework to follow in order to guide the research methodology. In designing the research Zucker (2009) provided the following summary of these protocols to be adopted by the researcher:

Research questions

- Design based on the unit of analysis and research purpose

Data collection and management techniques

- Field methods
- Transcribed notes and interviews
- Mapping of major concepts

Describe the full case

Focus the analysis built on themes linked to purpose and unit of analysis

Analyse findings based on the purpose, rationale, and research questions

- Case perspective
- Disciplinary perspective
- Biography, autobiography, narratives

Establishing rigor

- Credibility
- Transferability
- Dependability
- Conformability

Narrowing and defining the scope of the research ensured the researcher did not use a topic that had too many questions and also that it was not too extensive for one case study (Stake, 1995; Yin, 1994).

Thus the researcher defined the case as the methane project at the Beatrix mine, and the relationship between ten senior managers' perceptions of the economic and environmental value added to the business by methane project, and the actual reported environmental and economic value.

In order to determine the senior managers' perceptions of the environmental and economic value added by the methane project, semi structured interviews were adopted as a data gathering approach.

10 semi structured interviews were conducted with senior managers at the Beatrix gold mine. The interviews were recorded and the results transcribed for inspection and coding according the thematic analysis framework.

The purpose of the semi structured interview was to allow the participants to describe their perceptions and views regarding the methane project and openly share their opinion as to whether the project added economic and environmental value to the business. In order to alleviate the concerns of potential data corruption through researcher bias, a deliberate attempt was made not to ask leading questions during the interviews. Thus open ended questions, as per the interview guideline, were asked of the managers at the Beatrix mine.

Due to the nature of the interviews, the respondents were allowed a fair amount of flexibility in order to discuss the methane project at length (Creswell, 2003). Therefore, the managers at Beatrix gold mine, through open ended questions, were allowed to discuss their perceptions of the economic and environmental value added by the methane project.

Interviews do have shortfalls and Alshenqeeti (2014) pointed out the following as the major disadvantages: they are time consuming; they have a small scale study and there was a potential for subconscious bias and inconsistencies.

3.4 POPULATION AND SAMPLE

3.4.1 Population

The population for this research was limited to senior managers at the Beatrix gold mine. There were no restrictions on age, gender, race, and previous work

background. The main criterion was that the managers needed to have first-hand knowledge of the methane project and preferably have been employed at the Beatrix mine since the inception of the project.

3.4.2 Sample and sampling method

A sample of 10 senior managers from the population was drawn. The managers included in the sample were all based at the Beatrix gold mine due to the need for first-hand knowledge of the methane project. Despite the ideal situation ensuring the selected sample was diverse and symbolic in representation (Ritchie & Lewis, 2014), the reality of the demographics of the mining sector in South Africa did not allow this.

Purposeful sampling was used as the sampling method, (Marshall, 1996) as opposed to random sampling and thus senior managers were selected, as the research required the following of the respondents:

- The managers needed to have knowledge of the methane project
- The managers needed to have knowledge of the overall business, and the potential economic, and environmental value the methane project was able to add to the business

Therefore, despite the advantage of using a diverse sample, this research sample consisted mainly of white males (Marshall, 1996; Ritchie & Lewis, 2014).

3.5 THE RESEARCH INSTRUMENT

3.5.1 Semi-structured interview

A semi-structured interview process was used.

The semi-structured interview was conducted using an interview schedule, containing the interview questions, which were provided to the respondents. This allowed sufficient flexibility to the interviewees in order to cover the topic adequately (Ritchie & Lewis, 2014).

As per Ritchie and Lewis (2014), the following schedule was used when conducting the interview at the Beatrix gold mine:

Stage 1: Arrival

The researcher introduced himself and, by engaging in general conversation, attempted to build a rapport with the respondent in order to place them at ease.

Stage 2: Introducing the research

The research topic was introduced to the respondent through describing the nature and the purpose of the research. The respondent was asked for permission to record the interview and an agreement of confidentiality was reached.

Stage 3: Beginning the interview

The respondent was asked about their background at the Beatrix mine and more specifically their dealings with, or knowledge of, the methane project.

Stage 4: During the interview

The respondent was allowed to discuss the methane project freely. The discussion was guided in order to gain the in-depth understanding required of the methane project. Depending on the direction of the discussion, a few probing questions were asked in order to determine the respondents' perception of the methane project.

Stage 5: Ending the interview

The researcher asked the respondent to provide final comments and whether there was anything further they would like to discuss with regard to the methane project.

3.6 PROCEDURE FOR DATA COLLECTION

The researcher contacted Sibanye Gold's company secretary electronically and explained the research to her. The research was described in detail by stating the purpose, objective and process to be followed. Permission was requested to conduct the case study research and the company secretary provided the name and contact details of the senior environmental engineer. A meeting was scheduled in order to discuss the specifics of the research with the engineer. Further to this, and after the

meeting with the senior engineer, the contact details of senior managers familiar with the methane project was requested. The company secretary sent an email containing a list of senior managers that had first-hand knowledge of the methane project that the researcher was allowed to interview. These individuals were then contacted electronically in order to describe the research and ask for their participation.

10 of the individuals accepted the invitation to participate in the research, and they were then contacted electronically in order to thank them for their acceptance. At this point the researcher contacted the respondents telephonically to discuss the issue of anonymity with regard to their responses in the interview process. A date, time and place where the interviews were to be conducted was then agreed upon.

In order to ensure the respondent was at ease during the interview, the interviews were conducted at the respondents' offices or any place chosen by them (Ritchie & Lewis, 2014). The interviews were expected to be conducted at the Beatrix gold mine or any office that the senior managers preferred. This allowed for a greater degree of convenience to the respondent. Upon agreement with the respondents, the interviews were recorded while the researcher endeavoured to take handwritten notes highlighting certain key points made through body language or tonality.

It was endeavoured not to ask leading questions and instead open-ended questions were asked (Ritchie & Lewis, 2014).

Through a request sent to the senior manager in charge of the methane project, three reports pertaining to the methane project were received which contained financial, technical and environmental related data:

- The Capture and Utilisation of Methane at the Sibanye Gold Owned Beatrix Mine in South Africa (Van der Bank, 2016)
- Methane value released at Beatrix (Sibanye Gold, 2013)
- The Capture and Extraction of Underground Methane at Beatrix Gold Mine for the Generation of Electrical Power (du Plessis & van Greuning, 2011)
- Integrated Annual Report 2015 (Sibanye Gold, 2015)

3.7 DATA ANALYSIS AND INTERPRETATION

The researcher applied a thematic analysis as the data analysis technique. Thematic analysis and content analysis are closely linked in that they both attempt to code and categorise textual data in order to determine trends and relationships within the text (Vaismoradi, Turunen, & Bondas, 2013). Braun and Clarke (2006) described thematic analysis as being able to provide an in depth, detailed and complex account of the data.

Thus from the interview recordings, the interviews were transcribed in order to analyse them using the thematic analysis technique. Based on Braun and Clarke's (2006) suggested process, the researcher applied the following when using thematic analysis:

- familiarising himself with the data, generating initial codes,
- searching for themes,
- reviewing the themes,
- defining and naming the themes,
- and finally producing the report.

Due to the specific nature of the interviewee's answers and the objectiveness of the reports, it was decided that only initial coding was necessary in order to determine the themes (Braun & Clarke, 2006).

Prior to selecting the necessary documents for research, the researcher determined the relevance, authenticity, credibility, accuracy, and representativeness of the documents. The selected documents were read and the meaningful and relevant data was identified. The key data points relating to the economic and environmental value the methane project added to the organisation were extrapolated.

This process was followed when analysing and interpreting both the semi-structured interviews and documents.

3.8 THEMATIC ANALYSIS PROCESS

The research followed the thematic analysis framework as set out by (Braun & Clarke, 2006).

3.8.1 Data familiarisation process

During the interview process notes were taken on any specific topics or facts that stood out. After every interview, the researcher listened to the recording again to further familiarise himself with the data. Clarke and Braun, (2013) pointed out that familiarisation with the data was important as it allowed a complex understanding of the data to develop and thereby extract meanings beyond the obvious.

3.8.2 Transcription of the data

Once all the interviews had been recorded and reviewed, the interviews were transcribed, and, as far as possible, much of the relevant verbal and non-verbal information was retained. Transcribing the data also allowed the researcher to become even more familiar with it and thereby developed a rich and deep understanding of this data (Clarke & Braun, 2013). The interview was listened to whilst reading the transcription to ensure that as little information was left out as possible.

3.8.3 Generating initial codes

Once the researcher was familiar with the research and had developed ideas, along with the interesting facts noted during the interviews, the initial codes were developed. These codes highlighted the interesting features of the data, and thus the data was coded on the basis of salient issues (Attride-Stirling, 2003). Due to the specificity of the interviews only initial codes were generated and no secondary coding was completed.

3.8.4 Searching for themes

After the coding process was completed and a list of codes generated, the researcher analysed the codes to work out broader themes. This was done by analysing the codes to understand how they related to each other and thus form an overarching theme by grouping similar codes together. A prototype thematic map containing the themes and codes was generated to better understand the relationships between them and the data.

3.8.5 Reviewing themes

These themes were then reviewed to determine whether the collated data formed a coherent pattern. Once completed the themes were again reviewed in terms of the entire data set to determine whether the collated data was also coherent with the entire data set. These themes were then refined by grouping the themes into those that were very specific, and those that captured broader ideas contained in many of the transcribed interviews (Attride-Stirling, 2003). The prototype thematic map was then revised and adjusted as required.

3.8.6 Defining and naming the themes

The researcher defined each theme ensuring the definition was coherent with what the theme was about and what significance the theme captured. A detailed analysis of each theme was written explaining its importance and its relation and importance to the research and it was ensured that there was minimal overlap between the themes.

3.8.7 Producing the report

The final analysis of the data was compiled by taking the themes into account. The analysis was coherent, concise and logical for the reader to understand the story the data told. Evidence of the themes was provided from the transcribed interviews.

3.9 LIMITATIONS OF THE RESEARCH

The following limitations were identified:

- The research was subject to single researcher bias and thus an open-ended semi structured interview format was used to mitigate this bias as much as possible.
- The research was limited by the number of potential respondents that had knowledge and understanding of the methane project which led to a narrow scope of perceptions to analyse which may have affected the findings.
- The research was limited to 10 respondents.

- The research was limited to the methane project at the Beatrix gold mine and thus generalisability may be difficult.

3.10 VALIDITY AND RELIABILITY VS. CREDIBILITY, TRANSFERABILITY AND DEPENDABILITY

Reliability is concerned with whether the research procedure would yield the same answer if it was repeated (Stiles, 1993). Validity refers to the precision of the research method in measuring the intended phenomenon (Ritchie & Lewis, 2014).

Reliability and validity help define the strength of the data and are thus important in terms of transferring the research findings to another context (Ritchie & Lewis, 2014).

The literature regarded these measures as more suited to quantitative research, and therefore Guba (1981) proposed alternative measures for naturalistic or qualitative research.

Credibility was proposed instead of internal validity as it dealt with the aspect of truth value. Transferability was proposed in place of external validity as it dealt with the aspect of applicability and generalisation. Lastly dependability was proposed in place of reliability as it dealt with aspects of consistency (Guba, 1981).

3.10.1 Credibility

Credibility refers to the confidence or truth of the findings of the research (Guba, 1981). In order to enhance the research's credibility, Guba (1981) contended that certain processes should be followed. This research made use of 'peer debriefing' in the research. After every interview with a senior manager at the Beatrix gold mine, the researcher attempted to discuss the interview with the research supervisor as a way of debriefing (Guba, 1981).

In order to enhance credibility further, Guba (1981) recommended using triangulation, which is the use of different sources or methods to check the integrity of the data. Thus semi-structured interviews were combined with document analysis to provide a triangulation of the data at the Beatrix gold mine.

3.10.2 Transferability

Transferability requires that the research be conducted in such a manner that time and situational variations do not affect the research findings. The research is not applicable across all times and places but rather from one context to another (Guba, 1981).

In order to enhance transferability, Guba (1981) recommended making use of purposeful sampling as it increased the range of information uncovered. In this regard, purposeful sampling was used by selecting only senior managers who had knowledge of the methane project, as well as a better understanding of the business at the Beatrix gold mine.

Due to the nature of the research, specifically the sampling method, the ability to generalise the findings was limited to a clean technology context unless further research is conducted at the Beatrix gold mine focusing on the methane project in a different context.

3.10.3 Dependability

Dependability refers to the stability of the data (Guba, 1981). In order to enhance dependability, Guba (1981) recommended establishing an audit trail. The researcher therefore has ensured that all the recordings, hand written notes made during the interview, as well as the documents analysed are available to be audited.

CHAPTER 4. PRESENTATION OF RESULTS

4.1 INTRODUCTION

This chapter presents, identifies and discusses the key themes derived from coding the interviews conducted and reports collected using thematic analysis. The researcher sought to gather data through the interview process and document analysis in order to analyse it and determine qualitative differences between perceived and reported economic and environmental value added by the methane project. The criteria used to determine the qualitative difference was whether the reported and perceived value supported positive or negative judgments with regard to the project, as the perceptions of senior managers may impede the adoption of clean technologies. The responses of those interviewed were not prioritised as a factor of importance as this was not the main goal of the research.

The semi structured interviews contained a series of open ended questions pertaining to the senior managers' perceptions of the economic and environmental value of the methane project. Further to this, the interviewees were asked questions relating to their perception of the possible inhibiting and enabling factors contributing to the adoption of clean technology.

In this manner, the researcher was able to obtain and analyse the data pertaining to senior managers' perceptions with regard to clean technology through thematic analysis coding and compare these to the data from the reports collected. Through the process of coding the interview transcripts, themes were derived allowing the researcher to understand the linkage between these themes and the sub-problems identified in chapter 1. The results are presented under the headings of each theme as shown below, and then discussed in the context of the research in the following chapter.

- Economic benefit
- Environmental benefit
- Safety
- Energy generation
- Skills, technology and knowledge as barriers or enablers
- Capital cost

- Clean technology now and in the future

4.2 THEME 1: ECONOMIC BENEFIT

One of the themes derived from the interviews through coding was that of 'economic benefit' and refers to any word, statement or reference referring to the methane project as an economic benefit to the organisation.

The following words and phrases lead the researcher to name the theme: Economic Benefit:

- Economic benefit, cost saving, benefit financially, economically, economical, save money, financial benefit, invaluable, financial gain, cheaper, free resource, economic effect, saving, economic value, potential income, cost beneficial, economic sense, energy benefit, labour cost

Out of the 10 interviewees, nine respondent's interview transcripts contained at least one of the words or phrases listed above concerning the methane project offering economic value to the organisation.

The data from three of the reports also showed that there was a form of economic benefit:

Economic benefit	**Report**
• Accrued 34,591 certified emission reductions (CERs) in 2015	(Sibanye Gold, 2015)
• The income generated from the 9,643 VCUs amounted to R323,084	(Sibanye Gold, 2013)
• To earn carbon credits from methane destruction	(Van der Bank, 2016)
• 2014 - 30,051 CERS	(Sibanye Gold, 2015)

• The project generated 28,000 CERs in Q3 2013	(Sibanye Gold, 2013)
• Contributes to foreign-reserve earnings for South Africa via the carbon-credit sales revenue	(Sibanye Gold, 2013)

4.3 THEME 2: ENVIRONMENTAL BENEFIT

The 'environmental benefit' theme referred to any statement or reference to the methane project adding environmental value to the organisation, or any statement and reference to the methane project having a positive effect on the environment. This theme contained the environmental benefit to the underground and the outside environment.

The following words and phrases led to the theme being named: Environmental Benefit:

- Environmental benefit, environment, underground, general atmosphere, greenhouse gas, burning, flaring, impact, potent, $C0_2$, methane, excess, gas, carbon footprint, harmful, ozone layer, destroys environment, capture, release, harmful, global warming, protect, emit, sustainability, impact, renewable energy, reduce, carbon credits, natural gas.

The thematic analysis coding revealed that all of the interviewees perceived the methane project to add environmental value or have positive effect on the environment.

Similar to the interview findings, the data extrapolated from reports revealed that every report had a reference or statement pertaining to the methane project adding environmental value as per the following:

Environmental benefit	**Report**
• It has also had a positive impact on the environment in that it contributed to clean power	(Sibanye Gold, 2013)

generation, reducing reliance on coal-based electricity and harmful GHGs	
• This project has major benefits in terms of reducing the carbon emissions created as a result of the release of methane gas into the atmosphere. The carbon footprint of the mine will be reduced by approximately 28% which is important in terms of the mine's contribution towards reducing global carbon emissions	(du Plessis & van Greuning, 2011)
• Carbon footprint reduced by 25%	(Van der Bank, 2016)

4.4 THEME 3: SAFETY

This theme derived from the interviews and reports. 'Safety' referred to any statement or reference to the methane project with regard to the safety of the underground environment through the process of methane capture and extraction to the surface.

The following words and phrases led to the theme being named: Safety:

- Safety, safety risk, mine safe, mine safety, process safely, safety systems, safer, explosions, excess gas, extraction, extracted, methane, risk, risk underground, safety factor, reduces risk, risk point, increased safety, explosive gas, unsafe, detection, risk to operate, remove, dangerous, safety technology, trapping, control, improve safety, considerations, static electricity, combustibles, earthed, insulated, gas concentration, reduction in gas, harm, risk, exposed, contain methane, fatal, safety benefit, securely

The research revealed that only one of the interviewees did not allude to the methane project improving safety in the underground environment.

Statements and references to safety in the reports were identified in order to present the results. Every one of the documents showed multiple statements and references of the methane project leading to a safer working environment as indicated by the following statements:

Safety	**Report**
Effective Safety systems critical to the operation of the gas extraction network	(Van der Bank, 2016)
The mine has a well executed methane management system to control this risk and to protect its employees against its inherent dangers	(du Plessis & van Greuning, 2011)
Methane is released underground during mining. This project will reduce the safety and health risks associated with the gas	(Sibanye Gold, 2013)

4.5 THEME 4: ENERGY GENERATION

Through the coding one of the themes that emerged was that of ‘energy generation’ which referred to any statement or reference from the interviews that referred to the energy generation capacity of the methane project.

The following words and phrases led to the naming of this theme: Energy Generation:

- Power generation, Megawatt, producing, energy, electricity, generate, energy, power, Eskom, plants, generators, generated, generating, electricity price, energy production, convert, peak hours, efficient generators, efficient conversion, consumption, power benefit, power technology, power usage,

kilowatt hour, emergency power supply, renewable energy source, concentrated energy source, energy projects.

The coding showed all of the interviewees referred to or made statements about the energy generation of the methane project.

The data extrapolated from the reports show the following facts and figures with regard to the energy generation of the methane project:

Energy generation	**Report**
Currently system is operational at 1.1-1.2MW	(Van der Bank, 2016)
The methane gas will be flared on surface as phase one of the project after which it will be used to generate approximately 5MW of electrical power as phase two	(du Plessis & van Greuning, 2011)
Although only 1MW of the 82MW of electricity consumed by the operation is generated at this stage	(Sibanye Gold, 2013)

4.6 THEME 5: SKILLS, TECHNOLOGY, AND KNOWLEDGE

This theme contained any codes that referred to technology, skills or knowledge with regards to the methane project and furthermore to clean technology in general.

The following words and phrases led the theme to be named Skills, Technology and Knowledge:

- Feasible, source outside the country, assist, homework, research, explore, carbon advisors, experts, skills, help, design, implement, overseas,

technology, availability, operate, new machine, skills training, no idea, knowing, solutions, learn skills, specific engineering skills, know how, consultants, locally, required, tested, possess skills, experience, understand, major issue, skills necessary, new equipment, new technology.

Nine out of 10 of the interviewees mentioned words or phrases relating to skills, technology or knowledge.

Words or phrases from the reports were used as indicators of this theme which was only evident in one report:

Skills, technology and knowledge	**Report**
In addition, the project created jobs during the construction and operation phases, and facilitated skills development	(Sibanye Gold, 2013)

4.7 THEME 6: CAPITAL COST

The theme ‘capital cost’ referred to any statement or reference in the interviews pertaining to the capital investment or financing of the methane project as well as the cost of the capital required to fund the methane project.

The following words and phrases led to the naming of the theme: Capital Cost:

- Fund, capital cost, payback period, initial cost, worth it, financial, capital required, spend money, cost reduced, financial point, capital outlay, expensive, initial capital cost, capital expenditure, net present value (NPV), massive cost, infrastructure cost, capital investment, implementation cost, sound investment, buying, rent, purchase, capital available, actual value, requires capital, capital applications, internal rate of return (IRR), longer payback period.

The coding indicated that seven of the interview transcripts contained words or phrases linking them to the capital cost theme.

Two of the reports contained data referring directly to the capital cost or financing of the methane project as indicated by the following statements:

Capital cost	**Report**
Financing of the project - R54 million	(Van der Bank, 2016)
At a cost of R54 million, the Beatrix methane capture and destruction project	(Sibanye Gold, 2013)

4.8 CLEAN TECHNOLOGY NOW AND IN THE FUTURE

This theme referred to any statement or reference made about any type of clean technology now and in the future in the interviews and did not specifically pertain to the methane project.

The following words and phrases led to the naming of the theme: Clean Technology now and in the future:

- Opportunity, clean technology, leaders, projects possible, feasible, solutions, clean technology ideas, technology evolves, cheaper, developed, researched, technologies, essential, core strategy, regulatory and social pressure, technologies develop, type of technology, future, legislation, exemptions.

This theme was evident in six of the interviewees as they made references or statements with regard to clean technology at present or in the future.

Through analysing the data an indication to this theme was noted in one of the reports:

Clean technology now and in the future	Report
Furthermore, Sibanye will continue to design, develop and implement new innovative strategies and technologies in an attempt to reduce energy consumption at the operations through the use of energy- efficient technologies and, where feasible, reduce carbon footprint. These strategies include the use of renewable energy, such as solar power, methane gas and climate change-mitigation initiatives	(Sibanye Gold, 2015)

4.9 SUMMARY OF THE RESULTS

According to the interviews, the following themes were extrapolated using thematic analysis coding:

- Economic benefit
- Environmental benefit
- Safety
- Energy generation
- Skills, technology and knowledge as barriers or enablers
- Capital cost
- Clean technology now and in the future

As per the above presented results of the data extrapolated from the methane project reports, it was clear there was data to support these themes.

CHAPTER 5. DISCUSSION OF RESULTS

5.1 INTRODUCTION

In this chapter the researcher presents and discusses the results obtained after using thematic analysis coding on the interviews and the reports received. The researcher sought to articulate the differences between the perceived and reported economic and environmental value of clean technology projects, and more specifically the methane project at a gold mine, in order to determine whether perceptions of senior managers may impede to adoption of clean technologies.

Interviews were conducted with 10 senior managers at the gold mine pertaining to their perceptions of the economic and environmental value added by the methane project, and their concepts of clean technology as a whole. A variety of reports relating to the methane project were also collected in order to determine the reported value added.

The data was then coded using thematic analysis and thus the emergence of themes within the interviews and reports that were discussed further relating to the literature review and the research question.

5.2 DEMOGRAPHIC PROFILE OF RESPONDENTS

A total of 10 interviews were conducted using the list of senior managers provided by the company secretary. The initial research goal was to interview a demographically representative sample of senior managers at the gold mine. However, due to circumstances relating to the demographic profile of senior managers in the mining industry, the interviewees were made up of the following demographic profiles:

White male	8
Black male	1
Indian male	1

Eight of the interviews were conducted at the respondents' offices or at a place of their choosing. Two of the interviews were conducted telephonically due to the respondents' schedules and the researcher's schedules not allowing for a face to

face interview. The telephonic interviews were recorded with the respondents consent. Prior to recording the interviews the respondents expressed their willingness for the interviews to be recorded. However certain individuals requested to remain anonymous therefore the entire interview panel remained anonymous. The researcher assigned each interviewee a number and these refer to the interviewees when quoting statements from them.

The findings derived from the interviews and reports were discussed under the headings according to the sub-problems they relate to in order to place the findings in context with the research.

5.3 EVALUATE SENIOR MANAGERS' PERCEPTIONS OF THE ECONOMIC VALUE OF THE METHANE PROJECT

5.3.1 Economic benefit

Adopting a new technology, such as clean technology, can be considered to be a risk as it can have the potential to change the production process and thus have an effect on production hours (Shi et al., 2008). The respondents perceived that adopting the methane project did have such an effect on the production process and more specifically production hours underground as was clear in the following respondents' statement:

"Yes the production hours would be the economic benefit because the mine is producing more gold" – 1

A similar perception of how the methane project, and thus clean technology, transformed the production process in terms of allowing a previously abandoned mining area to be accessed, once more illustrates the economic benefit of the project. Further to this, respondent 1 perceived the methane project to have unlocked economic value in the sense that the ore that was unreachable due to the presence of methane gas can now be accessed.

"I feel the economic effect is the extra production hours my teams have underground. Due to the methane extraction, all the areas that were previously unsafe to work in are now safe. So we can send teams into these areas to mine the gold." – 1

According to the perceptions of respondents 2 and 3, the methane project, and thus clean technology, was able to deliver economic value through a cost saving as the mine could use electricity produced by the methane project from a free resource, methane, as opposed to purchasing the electricity from Eskom.

“... and we would save the mine some money in terms of not having to buy that power from Eskom.” – 2

“We could generate electricity with this gas so we could offset some of our Eskom costs by having our own system that generated electricity. So it would be cost beneficial for us to have the project.” – 3

Respondent 2 went on to discuss the cost differential between the electricity produced by the methane project and the electricity purchased from Eskom. According this respondent, the electricity produced by the methane project, taking capital cost and running costs of the project into account, is cheaper than the price at which the mine purchases electricity from Eskom.

”... and as far as the financial gain, electricity is extremely expensive and it is really hurting the mines. The methane project provides a cheaper form of electricity.” – 2

“I think the main economic benefit is the fact that we are taking a free resource and converting it into energy to power the mine and because of this we do not have to purchase that power from Eskom – which is expensive” -2

The above statement echoed the notion of Frondel et al., (2007) that clean technology can lead to both decreases in harmful by-products as well as reduced energy and resource inputs due to increased efficiency and was therefore an economic value addition. This reflected the finding that certain senior managers perceived the methane project as an economic benefit and thus this perception could increase the adoption rate of clean technology in the future.

In terms of the research sub-problem 1: evaluate senior managers’ perceptions of the economic value added by the methane project: the above findings showed that senior managers perceived the project to have added economic value and thus this might not prove to be an inhibiting factor to clean technology adoption.

5.3.2 Safety and Production

Methane gas poses a serious safety risk in an underground environment, therefore a risk to employees underground, due to its explosive potential (du Plessis & van Greuning, 2011; Karacan et al., 2011).

In the context of this research, methane is released into the underground environment through fissures or faults during the normal mining processes and, if allowed to build up, can cause a fatal explosion (du Plessis & van Greuning, 2011).

Respondent 4 described safety as the most important factor in mining underground and determined that the safety of the employees was always the number one priority. The findings are contrary to those mentioned by Shi, et al. (2008) when they proposed that managers tend to focus on increasing production at the expense of taking clean technology into account. Respondent 4 made this abundantly clear in the following statement:

“Well, a hundred percent of our job is learning about safety first and then production.” – 4

Thus, there was a safety benefit that the methane project, which is a clean technology, was able to add to the underground environment and therefore to the employees operating in this environment. The extent of the risk methane posed and the manner in which the methane project provided safety is described clearly by respondent 5:

“I mean methane is a huge risk in the underground environment so you now contain methane in the pipe underground and it is no longer exposed in the underground environment.” – 5

The importance of this safety aspect was further reiterated by respondents 2 and 1 as they described the reason for initiating the project was to improve safety underground and then only to produce energy. Not surprisingly, the occurrence of environmental incidents, such as the explosions at Beatrix gold mine in 2001, spurred the introduction of innovative technologies like clean technology (Frondel et al., 2007). The respondents provided an interesting viewpoint, in line with the literature, in that they considered the safety aspect of the methane project to be the

reasoning behind the decision to implement the project as opposed to the environmental and economic benefit.

“As far as I know safety was the main reason for the methane project, I think everything else came after.” – 1

Taking the safety aspect one step further, respondents 3, 4 and 6 linked the safer working environment to an economic value add and thus did not consider the safety benefit and the economic benefit as mutually exclusive. Instead they explained how the methane project, by providing a safer working environment, had led to an economic value add due to increased production hours and the possibility to mine areas that were previously too hazardous to operate in.

“...huge benefit financially as well because we could now change the areas that were hazardous into normal mining areas again.” – 6

“I feel the economic effect is the extra production hours my teams have underground. Due to the methane extraction, all the areas that were previously unsafe to work in are now safe. So we can send teams into these areas to mine the gold.” – 1

Through the literature review it was determined that a manager who identified an environmental issue as an opportunity was more likely to take a proactive approach to finding solutions to take advantage of the potential opportunity (Lopez-Gamero et al., 2011).

In this case, through using clean technology as a solution to mitigate the risk of methane being released, certain senior managers were able to see the release of methane as an opportunity.

Capitalising on this opportunity, the methane project led to the added economic benefit of energy production from a free resource providing a cheaper form of electricity, as well as the benefit of safer working conditions that, at the same time, became an economic benefit due to the increased production hours.

5.4 EVALUATE SENIOR MANAGERS' PERCEPTIONS OF THE ENVIRONMENTAL VALUE ADDED BY THE METHANE PROJECT

5.4.1 Environmental benefit

According to Levesque et al., (2014) technologies like clean technology are sustainable due to their ecological and economical effectiveness for present and future generations. In the context of this research, implementing the methane project was been perceived by the respondents to have added environmental value due to its current ecological effectiveness as is evident through the following excerpt:

"Well I mean the environmental impact is perfect because there is no impact." – 5

The importance of the methane project delivering environmental value and the effect this environmental value add has was emphasized by respondents 7, 6 and 9. The respondents identified methane as a potent green house that was harmful to the environment and contributed to global warming.

"Methane is a greenhouse gas which means it is harmful to the environment, or more specifically it contributes to global warming. By using the methane for energy production and flaring the excess, we are ensuring that Sibanye is not contributing further to global warming." – 7

Through the literature review it was noted that methane is 21 more times potent than $C0_2$ as a greenhouse gas, (Karacan et al., 2011), which is a major factor when considering the effect greenhouses gasses have on global warming (IPCC, 1990). Interestingly respondents 6 and 9 shared this view in their interviews and perceived that the methane project added environmental value through the removal and destruction of the methane gas.

"Remember methane is 21 times more potent so it's a gas that destroys the atmosphere 21 times faster. So from the environmental side, to capture….which makes a massive difference to the environment itself and the impact." – 6

"From my understanding, methane destroys the ozone layer faster than C02 so if we are capturing and extracting the gas then we are saving the ozone layer (sic)." – 9

As per the literature, energy and climate change are business risks that could be managed through adopting certain technologies, such as clean technology like the methane project, which offer environmental benefits including reduced greenhouse gas emissions (Dovi, et al., 2009). Erzurumlu and Erzurumlu (2013) regarded clean technology as new and innovative techniques, systems or products that avoided or reduced environmental harm and, in the context of this case, reduced environmental harm through reduced methane emissions.

Furthermore, according to IPCC (1990), the increase in greenhouse gas emissions lead to the greenhouse gas effect which have been identified as a cause of climate change. As was evident through the above respondents' comments, the findings were closely linked to the literature in terms of the environmental value added by clean technology such as the methane project. By ensuring that methane released during the mining process was not released into the general atmosphere has ensured that the mine has not contributed to global warming.

Data extrapolated from the reports, showed the methane project adding environmental value through methane flaring, and in the energy generation processes of the methane project as was evident in the findings section.

Through the findings, the researcher came across an interesting point regarding how the respondents answered when asked about the environmental benefit of the methane project. Respondents 4 and 5 referred to the environment as their immediate working environment which happened to be underground. Thus, these respondents' perception of the environmental benefit of the methane project was the benefit the project added underground. The literature review did not allude to a distinction between the underground environment and the general atmosphere. This was an interesting finding as the respondents were not asked what they considered as 'the environment' prior to the interview process.

5.5 EVALUATE THE RELATIVE INFLUENCE OF PERCEIVED ADDED VALUE IN DECISIONS TO ADOPT CLEAN TECHNOLOGY

A senior manager's perception of a positive outcome could lead to the formation of a positive attitude and thus a decision to act in favour of the project leading to the

positive outcome. (Montalvo & Kemp, 2008). Should a manager have perceived the methane project to add value, it is possible they will adopt a similar type of clean technology in the future. In the context of this research, the findings regarding perception of economic and environmental value added were discussed above. However there are other factors of the methane project which needed to be accounted for in determining future decisions to adopt clean technology.

5.5.1 Generation capacity

The generation capacity of the methane plant was found to be a perceived as an economic value add, however the extent of the value add differed among many of the respondents. It was found that certain respondents perceived the generation capacity as minor if compared to the overall usage of the mine, while others just stated the generation capacity as an economical benefit regardless of the magnitude.

Respondent 9 alluded to the methane project generation capacity being relatively negligent in terms of the overall energy usage of the entire Beatrix gold mine. However he did go on to point out that there was a possibility of scaling the project up and was thus satisfied with the status quo.

“I think it is about 1-2 megawatts and the mine runs on about 70 megawatts, so we have a long way to go.” – 9

Respondent 7 reiterated the scale of the methane project and referred to the marginal economic benefit the mine received due to the limited generation capacity of the project. However the respondent did state that even a marginal benefit was of value especially as Eskom tariffs were continuously increasing, thus placing the mine under financial strain.

“The current generation of 1.4 megawatts is not significant enough to make a massive difference but that being said, with electricity prices being what they are, there is certainly a financial gain for the mine.” – 7

The relatively small scale of clean technology projects made it difficult for them to absorb the high costs related to financing a project and thus made them less attractive proving to act as a barrier to adoption (Goldman et al., 2005). The literature

referred to the small-scale nature of clean technology projects as well as the high capital costs associated with them as proving to be a negative factor when considering implementation. Interestingly only two of the respondents shared this opinion as they perceived the limited generation capacity as too minimal to compensate for the high capital cost of the project.

“Look the problem is that this project has a small power benefit in terms of the rest of the mines power usage so you are spending a lot of money for a small benefit.” – 4

“The current generation of 1.2 megawatts is not significant enough to make a massive difference.” – 9

The findings clearly pointed out that the scale of the clean technology project proved to be a possible inhibiting factor when considering other technology options. The respondents views that, although the methane project did provide generation capacity, the capacity might not be substantial enough to compensate for the initial cost of the project.

The following three themes were directly related to factors that had affected the adoption of clean technology. These themes do not refer directly to value added by the methane project, but point more towards the factors that might have affected and could possibly affect future decisions to adopt clean technology.

5.5.2 Skills, knowledge and technology

As a consequence of certain respondents immersing themselves in the field of sustainable development, they were able to draw on their extensive knowledge about clean technology to determine the feasibility of a project, as per respondent 6: “We have the experts…make these projects possible and feasible.” In direct contrast to this statement, respondent 1 acknowledged his complete lack of knowledge of other such clean technology projects and the problems that these projects can offer solutions to.

“For me it would be about knowing the projects were out there, then we would know that maybe there are solutions for some of the problems we have and we could learn the skills to use the technology.” – 1

Thus, according to Bosetti et al., (2009), knowledge could prove to be an enabler of clean technology as it allows an organisation, and thus senior managers, to evaluate the actual benefits of the technology and therefore increase the rate of adoption. Adding to this is that the lack of information dissemination can lead to difficulties in attempting to assimilate clean technology (Suzuki, 2015).

The findings revealed that certain respondents admitted to a lack of previous knowledge regarding clean technology projects such as the methane project, and were still unaware of other types of clean technology projects elsewhere. However they displayed a willingness to gain further knowledge.

This is directly aligned to principles of the CDP in attempting to provide a platform for knowledge and technology sharing where organisations are able to interact in order to foster this information dissemination allowing clean technology solutions to be more widely adopted. The findings correlate to those of Naidoo (2014), who proposed that knowledge transfer could ensure an increased adoption of clean technology. Respondent 1 discussed the fact that having knowledge of clean technology projects like the methane project, would allow other organisations to provide solutions to problems they are facing.

The skills required to implement and operate new innovative technologies like clean technology are also paramount to an organisation should they wish to adopt these technologies. The importance of possessing the required skills related to clean technology was described by respondent 1 when he stated that acquiring clean technology would amount to almost nothing if the organisation did not possess the skills required to implement and operate the technology. Furthermore, respondent 9 elaborated on this point with specific reference to the possibility that the mine did not possess the correct skills needed to implement the project and thus the need to acquire assistance from a source external to the organisation. This notion of lack of skills was once again expressed by respondent 7 when he mentioned the need to acquire engineers with the skills able to install the methane extraction infrastructure in a hard rock mine as opposed to a coal mine.

Lastly respondent 6 emphasised the point of skill transference during the design and implementation process of the methane project. Notably, in his statement, respondent 6 attributed the rapid pace at which the second phase of the project was

completed, to the skills learnt during phase one and the transference of these skills to the employees working on phase two.

The transfer of technology and assistance from experienced clean technology producers could decrease the learning curve required to implement and operate such technologies which in turn will increase the potential market for these technologies thereby increasing the rate of adoption and diffusion (Bosetti et al., 2009).

These findings were closely linked to the literature in that it was clear to the respondents that the lack of skills required, and the technology available to implement and operate clean technology projects could prove to be a barrier to adoption of such projects. Furthermore, respondent 1 noted that, due to the safety technology not being available locally, the methane project implementation process had lasted longer than expected Evidence linking the findings with skills, knowledge and technology transference is clearly correlated to the literature in the sense that transference can increase the rate of adoption of clean technology.

5.5.3 Capital cost

Not surprisingly, the capital cost of the methane project proved to be a concern amongst many of the respondents when evaluating the project. The report analyses provided a purely objective view of the capital cost of the methane project and, as per Sibanye Gold, (2013), the total capital expenditure on the methane project was R54 million. In contrast to the reports, were the subjective views of the respondents with regard to the cost of the methane project.

The high initial cost of the methane project was alluded to by respondents when they were asked to consider factors that could influence the implementation of future clean technology projects.

Respondent 8 referred to the initial cost of the methane project as slightly too high and made specific reference to the long payback periods associated with clean technology as a factor that could negatively influence the adoption of the technology.

“Firstly it must be the high implementation cost of these clean technology projects and the payback or investment term associated with them.” – 8

Respondent 7 expressed a similar perception in that the capital cost of the project was rather high but offered an interesting view with regard to the payback period within the mining industry. The respondent considered the lengthy period the project will take to pay for itself, mainly due to its marginal benefit, as too long for mining standards. Thus it is clear through this comment that the payback period of a clean technology project could act as a barrier to adoption of future projects due to the negative perception compared to other mining projects.

Contrary to respondent 7's perceptions, respondent's 6 and 5 perceived the value the methane project added as a justification for the high capital cost. Therefore findings show that, even though the cost of capital was high, the methane project was still implemented. However the literature stated that adoption of a project was not likely due to the capital cost, and especially without financing (Goldman et al., 2005).

Goldman et al (2005) indicated that the capital-intensive nature of clean technology projects, in conjunction with their extended payback periods, and often lower margins, increased the risk of revenue generation and this could act as a barrier to adoption as it would be cheaper and easier to acquire financing for a fossil fuel based project due to the direct cost comparison.

In opposition to the literature, respondent 5 described the cost of the methane project as justified due to the energy generation benefit the project provided and further described the 'relaxed' view of the protracted payback period for any project related to energy generation. This was mainly due to the current market conditions where Eskom was escalating tariffs rapidly; leading to a scenario where the marginal benefit outweighed the capital cost.

> Your NPV and IRR has got a big influence on your project viability, I do think in terms of energy we are more relaxed when we get to capital applications that for normal business capital you have certain hurdles that you need to overcome in term so of NPV and IRR. But when we get to energy, because the escalation of your Eskom increases is not given or known, it is really an unknown factor. We do treat energy projects with a slightly longer view than we would normally use. So you might be more relaxed when you see it on

clean technology project like solar, where NPV's and IRR with longer payback periods are considered in capital expenditure due to the energy benefits. – 5

According to Cooremans, (2007), certain organisations perceived energy purely as a commodity as opposed to a resource. Thus, when there is a significant cost involved in an energy efficiency project, it might not be adopted as energy is not seen a strategic resource deserving of additional investment. Again, the findings directly contradict this literature as per the above statement by respondent 5 when he noted that energy was perceived as a key strategic resource for the organisation mainly due to the cost pressure Eskom was placing on the organisation through increased electricity tariffs.

Therefore, according to the findings, capital cost could prove to be an inhibiting factor to clean technology adoption depending on the perceived economic and environmental value added by the technology.

5.6 CLEAN TECHNOLOGY NOW AND IN THE FUTURE

Clean technology in the past had often been associated with certain negative factors such as high capital cost, extended pay back periods and possible inefficiencies (Narayanamurti et al., 2011). The research findings supported these views to some extent with specific reference to high capital cost of the methane project, and the minimal generation capacity of the methane project as being inefficient.

However, through the literature review, it was noted that technological innovation can lead to a price decrease of technology as well is an increase in efficiency (World Economic Forum, 2015). Following this principle, clean technology could become cheaper overtime whilst becoming more efficient due to technological advancements, a sentiment shared by respondent 7 when he mentioned clean technology in the future being more attractive due to it becoming cheaper as the technology develops through increased research.

This point was further emphasised by respondent 8 when he provided the following statement regarding the methane project, as to how technology prices and efficiencies change over time as they become more developed:

> I think due to the early nature of the implementation of the methane project, it was expensive. By early nature I am referring to these clean technology projects as nothing like this had been done before and this obviously adds massive cost to the project. If the project were to be implemented today it would definitely be cheaper as technology is becoming cheaper everyday and there would also be more efficient generators allowing a more efficient conversion of the methane to energy. – 8

Government policy and specific regulations in conjunction with carbon pricing can lead to organisations adopting clean technology more willingly (Maynard et al., 2016; Veugelers, 2012). The comment by respondent 3 with regard to new clean technology projects illustrates the importance of regulation and legislation in terms of new technology implementation in the following statement:

"When you start using these technologies there is legislation that you need to apply to get past it or exemptions so that the clean technology can be used." – 3

This point further reiterated the influence that government policy and regulations have on the adoption and diffusion of clean technology in terms of the processes required to be followed in allowing the technology to be utilised. This regulatory issue became evident when Respondent 3 mentioned a clean technology project that had been developed specifically for underground usage. However the technology could not be implemented due to specific regulations relating to the underground environment.

With regard to clean technology in the future, a recurring theme that emerged was that of the carbon price of the past, present and future and how it could affect the adoption of clean technology. Prior to implementing the methane project, the carbon price or CER's were at a level that would allow Sibanye to earn sufficient revenue through these credits so as to justify the capital expenditure. This was clear through in the report as per the following statement issued by Gold Fields prior to them listing Sibanye Gold as a separate and independent company in February 2013:

> "Towards the end of 2006, Gold Fields noted an opportunity in terms of the Kyoto Protocol to earn carbon credits from methane destruction." (Van der Bank, 2016)

Interestingly, a separate report supported the statements when analysing the CER's earned during the third quarter of 2013 as seen in the following excerpt:

- "The project generated 28,000 CERs in Q3 2013." (Sibanye Gold, 2013)

Thus it was clear in the past that earning CER's could mitigate the high capital cost through revenue generated in trading CER's. The respondents felt that this was no longer the case in the current economic environment as per respondent 8's comment:

"When the carbon price was a lot higher this project could have added serious economic value through exchange and sales of carbon credits." – 8

Respondent 10 reiterated this fact when he described the economic benefit prior to a certain climate change meeting that caused the carbon price to drop drastically, leading to a reduction in revenue earned through trading these credits.

Therefore the finding indicated that the carbon price, and the revenue generated through trading these credits, could prove to be factor influencing the adoption of clean technology.

5.7 ARTICULATE THE POTENTIAL DIFFERENCES BETWEEN THE PERCEIVED AND REPORTED ECONOMIC AND ENVIRONMENTAL VALUE OF A CLEAN TECHNOLOGY PROJECT.

5.7.1 Perceived value added compared to reported value added

In terms of articulating the potential differences between the perceived value and the reported value, it was clear in the economic case that there appeared to be no conflicting data as both interviews and reports showed a form of added economic benefit.

In terms of comparing the interview data to the reports, one cannot attribute the increase in production of the entire mine (the only figures available) to a single factor thus it is near impossible to prove there is a link. However, through analysing the reports, it was clearly indicated that a financial benefit was accrued in the form of

revenue generated through the trading of CER's and VCU's and there was no data indicating a financial or economic loss:

"The project generated 28,000 CERs in Q3 2013."(Sibanye Gold, 2013)

"The income generated from the 9,643 VCUs amounted to R323,084." (Sibanye Gold, 2013)

"To earn carbon credits from methane destruction." (Van der Bank, 2016)

With regard to the senior managers' perceptions of the economic value added by the methane project, the findings showed these perceptions to support the fact that the project added economic value, and furthermore there was no data from the interviews that showed that the project caused a negative economic effect.

Thus, the research has revealed that there was no clear differences but rather consistency between the perceived economic value add and the reported economic value add of the methane project.

As was discussed in the literature review, the decision to adopt a clean technology project could be determined through information and evidence generated from similar past and present clean technology projects, as these could affect the senior managers' perceptions of such projects (Kemp & Volpi, 2008). Therefore, due to the perceived economic value benefit and the reported economic value benefit of the methane project, there was a possibility of future projects being more readily adopted.

5.7.2 Perceived environmental value added compared to reported value added

The research findings indicated that the perceived environmental value added and the reported value added by the methane project showed no conflicting data. The data gathered from the reports highlighted the environmental benefits and value added by the methane project on numerous occasions as per the following excerpts:

"It has also had a positive impact on the environment in that it contributed to clean power generation, reducing reliance on coal-based electricity and harmful GHGs." (Sibanye Gold, 2015)

“To mitigate its global warming impact, a carbon credit project under the Clean Development Mechanism (CDM) of the Kyoto Protocol has been registered to capture and destroy the mine methane of the Beatrix Gold Mine.” (du Plessis & van Greuning, 2011)

“Carbon footprint reduced by 25%” (Van der Bank, 2016)

Through analysing the interviews transcripts, the researcher was able to note that the senior managers perceived the methane project to have added environmental value. Therefore it can be concluded that there are no notable findings in the data to suggest there is a difference between the perceived environmental value added and the reported environmental value added by the methane project and thus there is consistency between reported and perceived value added.

5.8 CONCLUSION

The research problem for this study was as follows:

- to articulate the possible differences between the perceived and reported economic and environmental value of clean technology projects, because perceptions of senior managers may impede to adoption of clean technologies

The findings showed that the data from the document analysis and the data from the interviews regarding senior managers’ perceptions of the economic and environmental value added and the reported economic and environmental value added by the methane project were consistent. There was no evidence to indicate that the difference in the perceived value added and the reported value added by the project could prove to be an inhibiting factor to clean technology adoption. The factors influencing the adoption of clean technology, per the findings, were more related to the initial capital cost of the projects as well the potential fringe benefits, such as safety, that they offered. Furthermore, in terms of clean technology adoption, the carbon price could play a significant role due to the perceived economic benefit clean technology projects would be able to offer an organisation through CER and VCU trading.

CHAPTER 6. CONCLUSION

6.1 INTRODUCTION

The aim of the research is to contribute to articulating possible differences between the perceived and reported economic and environmental value of clean technology projects, and whether the inaccurate perceptions of senior managers could impede the adoption of clean technologies.

The researcher conducted 10 interviews with respondents that had first-hand knowledge of the methane project at the Beatrix gold mine. The respondents interviewed were asked to provide their perceptions of the economic and environmental value added by the methane project. These views were then compared to the reported economic and environmental value added, in order to determine whether differences could prove to be an inhibiting factor to clean technology adoption. The respondents were asked open ended questions in a semi structured interview format to elicit their perceptions and opinions with regard to the methane project and clean technology in general. The interviews were then coded using thematic analysis and the reports were analysed to extrapolate the necessary data in order to ascertain whether there was a difference.

6.2 CONCLUSIONS OF THE RESEARCH

As per the thematic analysis and data from the reports, it is clear that there was consistency between senior manger's perception of the economic and environmental value added by the methane project, and the reported economic and environmental value added.

The results indicate that the senior managers viewed the methane project at the Beatrix Gold mine to add economic value, although some perceive the amount of value as more than others. The managers saw the economic value add to be in three formats:

- Cost saving through reduced consumption via Eskom due the electricity generation by the methane project
- Carbon taxes and trading of CER's and VCU's adding to revenue generation

- Safety and increased production. The removal of highly dangerous methane gasses improves the safety conditions underground at the mine, and also allows abandoned mining areas to be mined therefore increasing production

The above forms of economic value added by the methane project are alluded to in the data from the reports confirming that senior managers' perceptions of value added are not in conflict with the reported value added. Thus, there is no evidence to link the difference in senior managers' perceptions of economic value added by the methane project and the reported economic value to these perceptions being inhibiting factors to clean technology adoption.

Similarly, the results indicate that senior manager's perceptions of the environmental value added by the methane project are not in conflict with the reported environmental value. The managers regard the environmental value add to be in three formats:

- Methane capture and thus it not being released into the general atmosphere
- Methane destruction through flaring and energy generation and therefore not being released into the atmosphere
- Reducing the mines' carbon footprint

The environmental value added thus centres on the methane project, ensuring that the Beatrix gold mine is not contributing to global warming through the release of methane into the general atmosphere. This is achieved by capturing the methane at source, transporting it to the surface and then destroying the methane either through flaring or using it to generate electricity through the methane generators.

The results indicate that there is no indication of a difference between senior managers' perceptions of environmental value added and the reported value added by the methane project. This leads to the conclusion that there is low probability that senior managers' views of the environmental value added by the methane project could prove to be an inhibiting factor to clean technology adoption.

The research, however, uncovers factors, according to the respondents, that could prove to be inhibiting factors to clean technology adoption. The relatively high initial capital cost and the extended payback period of the methane project is alluded to by

majority of the respondents as a potential draw-back of the project, and thus could prove to be an inhibiting factor for future considerations of clean technology should the technology remain expensive in comparison to cheaper fossil fuel substitutes.

The generation capacity of the methane project is denoted as another potential draw-back of the methane project. The respondents appreciate that while this is an alternative means to generate power, they point out the low generation capacity as compared to the entire Beatrix mine usage as an issue. This could be seen as inefficiency in the technology itself which might prove to be an inhibiting factor for adoption of clean technology projects in the future.

Another potential inhibiting factor discovered through the research is that of the carbon price which, in the context of this research, refers to CER's and VCU's generated through the methane project at Beatrix gold mine. The respondents note that the decline in the carbon price could affect the future adoption of clean technology projects such as the methane project, due to reduced potential for revenue generation, therefore negatively affecting the feasibility of such projects.

Lastly, the skills, technology, and knowledge required to implement and operate the methane project is alluded to as another potential inhibiting factor. The respondents indicate that the lack of skills and knowledge required in implementing the methane project as an issue that needed to be addressed before the implementation begun. Coinciding with this was the lack of technology required, within South Africa, to implement the project and thus the protracted period between the idea conception and completion.

6.3 RECOMMENDATIONS

The research indicates that there are no dualistic differences between senior mangers' perceptions of the economic and environmental value added and the reported economic and environmental value added by methane project; thus these perceptions may not prove to be inhibiting factors to the adoption of clean technology. The research was conducted whilst the project was in operation and thus there was data to analyse regarding to the methane project. However the findings might have been different should the research have taken place prior to any data being available.

The research uncovers other factors that may influence the adoption of clean technology such as the high initial capital cost, clean technology efficiency, carbon credits and skills, technology, and knowledge. The research indicates that the majority of the respondents are aware that the methane project delivers economic value; however they are not aware of the extent of the value added. Thus there is an opportunity for knowledge and information sharing, as per the literature review, which would allow the respondents to understand the justification for the high capital cost. Coinciding with this fact is that the skills and technology needed were not available locally; however they were available internationally and thus the importance of skill and technology transfer in the clean technology industry becomes apparent.

The researcher recommends that senior management at all levels be made aware of the current economic value and environmental value added by the methane project in order to understand the potential that clean technology projects currently offer. Furthermore, increased association with clean technology organisations around the world is recommended in order to foster knowledge, increase skills transference, and gain technological insight with regard to clean technology projects.

6.4 SUGGESTIONS FOR FURTHER RESEARCH

The research aims to articulate whether perceptions could act as barriers to clean technology adoption. However the research indicates that other factors prove to have greater potential to be inhibiting factors. Therefore, the researcher suggests research into the following aspects:

- Capital cost and economic value of clean technology projects

The research did not go into to financial detail regarding the capital cost of the methane project and the exact economic benefit thereof. Therein lies an opportunity to research the capital cost of various clean technology projects as well as the economic value added by them. The goal of the study would be to determine whether clean technology projects are economically viable in terms of their return on investment (ROI).

- Cost of clean technology over time

The respondents and the literature note that technology may become cheaper and more efficient over time. A research study into the implementation costs of clean technology projects as well as their operational efficiencies could be undertaken. The objective would be to ascertain whether clean technology is in fact becoming cheaper and more efficient over time.

- Female senior managers

The research did not include any respondents that were female and thus would have benefitted from a bigger pool of candidates. A new research study to determine the whether the perceptions of female senior managers of the value added by clean technology projects differs from their male counterparts. The goal would be to better understand how female senior managers perceive clean technology projects and what they would view as inhibiting factors to clean technology adoption.

- Alternative clean technology in other industries

The research focuses on a single mine in South Africa and on one specific project. New research into clean technology in the energy sector is needed, and whether clean technology like the virtual power plants, waste to energy plants, and micro-grids could be utilised. The objective would be to determine the feasibility of such projects and their potential effect on global warming.

- Skills and knowledge as barriers

The respondents in the research indicate that there exists in South Africa a lack of skills and knowledge required to implement and operate clean technology projects. Further research into this aspect in all areas of industry employing clean technology can be completed. The objective would be to ascertain whether a lack of skills and knowledge still exists and thus provide recommendations on solutions to solve these problems.

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Appendix A

First contact letter

Good day Mr/Mrs ……

I am conducting a study into clean technology and would like to focus on the methane project at Sibanye's Beatrix gold mine.

In order to commence, I require consent to use Sibanye's name in the proposal. The proposal is an internal document at Wits and will not be seen by anyone outside the 4 people who review it.

Would you be able to provide me with consent to go ahead with the research?

Please let me know if you require any information with regards to the research.

Brett O'Leary

Request for interview letter

Good day Anton

I am contacting you as per Jane's email with regards to research related to my thesis.

The thesis will be exploring perceived economic and environmental value added by the methane project as well as the actual reported value.

Would it possible to set up a meeting next week, or the following week, to conduct an interview with you at any place of your convenience? The interview process should last approximately 30-40 min.

The interviews will remain confidential and names will not be used in the research report.

Thank you

Regards

Brett O'Leary

0823716988

brett@rudmanhydraulics.co.za

Interview questions

Question1:

What is your perception of the economic effect of the methane project? Please explain.

Question 2:

What is your perception of the environmental effect of the methane project? Please explain.

Question 3:

What factors did affect the implementation of the methane project?

Question 4:

What do you perceive to be other factors that affected the implementation?

Question 5:

Can you describe the benefits of the methane project at inception?

Question 6:

What would you consider the barriers inhibiting clean technology from being more widely adopted?

Consistency matrix

Research problem: To determine whether senior managers' perceptions of the economic and environmental value, added by the methane project at the Beatrix gold mine, could prove to be a hurdle in implementing clean technology.					
Main problem	**Literature review**	**Research question**	**Source of data**	**Type of data**	**Analysis**
To identify whether senior managers' perceptions of the economic and environmental value added by the methane project differ from the actual reported value.	(Bonevac, 2010; Brundtland, 1987; COSO, 2004; Gonzalez, 2005; Guerin, 2006; Levesque et al., 2014; Nocco & Stulz, 2006; Robinson, 2004; Suzuki, 2015; WCED, 1987)	What are senior managers' perceptions of the economic and environmental value added to the triple bottom line through clean technology as compared to the actual reported value?	Interview data – Refer draft interview outline for respondents (Appendix A). Documents relating to the methane project (Financial reports, production reports and sustainability reports).	Qualitative opinions and commentary.	Thematic analysis

Research problem stated here					
Sub-problem	**Literature Review**	**Research question**	**Source of data**	**Type of data**	**Analysis**
What are the perceptions of senior managers at the Beatrix gold mine of the environmental value added by the methane project?	(Hammond, Adriaanse, Rodenburg, Bryant, & Woodward, 1995; National & Stewardship, 2005; YCELP et al., 2016 ;Gray & Milne, 2002)	What are senior managers' perceptions of the economic and environmental value added to the triple bottom line through clean technology as compared to the actual reported value?	Actual interview	Qualitative opinions and commentary.	Thematic analysis
What are the perceptions of senior managers at the Beatrix gold mine of the economic value added by the methane project?	(Miller, 1992; Levesque et al., 2014; Dovi, et al. 2009; (Lopez-Gamero, Claver-Cortes, & Molina-Azorin, 2011; Guerin, 2006)	What are senior managers' perceptions of the economic and environmental value added to the triple bottom line through clean technology as compared to the actual reported value?	Actual interview	Qualitative opinions and commentary	Thematic analysis

Research problem stated here					
Sub-problem	**Literature Review**	**Research question**	**Source of data**	**Type of data**	**Analysis**
How do the perceptions relate to the actual reported economic value added by the methane project?	(Hammond, Adriaanse, Rodenburg, Bryant, & Woodward, 1995; National & Stewardship, 2005; YCELP et al., 2016; Gray & Milne, 2002)	What are senior managers' perceptions of the economic and environmental value added to the triple bottom line through clean technology as compared to the actual reported value?	Financial reports, production reports and sustainability report	Text or word documents; tables.	Thematic analysis
How do the perceptions relate to the actual reported environmental value added by the methane project?	(Miller, 1992; Levesque et al., 2014; Dovi, et al. 2009; (Lopez-Gamero, Claver-Cortes, & Molina-Azorin, 2011; Guerin, 2006)	What are senior managers' perceptions of the economic and environmental value added to the triple bottom line through clean technology as compared to the actual reported value?	Financial reports, production reports and sustainability report	Text or word documents; tables.	Thematic analysis