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COAL FLY ASH WASTE MANAGEMENT CHALLENGES IN THE SOUTH AFRICAN POWER GENERATION SECTOR AND POSSIBLE RECYCLING OPPORTUNITIES:

A CASE STUDY OF HENDRINA AND KENDAL POWER STATIONS

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In fulfilment of the requirements for the degree of Master of Science in Geography and Environmental Studies

Supervisor: Dr Melanie Samson

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ABSTRACT

South Africa will be dependent on coal for power generation for many decades to come, before a complete transition is achieved where more energy will be generated from non-fossil fuel sources. Through case studies of Hendrina and Kendal Power Stations, this study explored how the management of fly ash (FA) waste in South Africa can be improved to minimise its impact on the environment and human health and examined the potential recycling applications that can benefit local communities. The study drew insights from an environmental justice framework to examine the pollution impacts that FA is exposing to the local community. The environmental justice theory is based on the principle that all people have a right to live in an environment that enhances their wellbeing. Empirical evidence obtained from local community's in-depth interviews revealed that FA is impacting on the health of communities by exposing them to respiratory and other illnesses and it is also affecting their livelihoods which primarily involves farming.

A just transition theory was employed to examine potential socio economic opportunities that can be derived from FA recycling to fulfil redistributive measures that can reduce inequality and eradicate poverty in local communities. Some of Eskom's power stations like Hendrina are nearing the end of their lifespan since their commissioning in the 1960's and 1970's. To aid a just transition, ash recycling was found to have the potential to address the socio economic situation of the power station's employees and the local communities. The study found that local communities generally lack knowledge about coal ash recycling and need to be empowered and supported to partake in ash recycling ventures. The study argues that a shift in the ash recycling regime is needed in order to benefit local communities and facilitate a just transition to a clean energy production.

DECLARATION

I, Mbavhalelo Justice Ramagoma, hereby declare that this dissertation is my own work except as indicated in the references and acknowledgements. It is submitted in fulfilment of the requirements for the Master of Science in Geography and Environmental Studies. It has not been submitted before for any degree or examination at this or any other university.

.....

Mbavhalelo Justice Ramagoma

31 May 2018

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LIST OF ABBREVIATIONS AND ACRONYMS

ADF:	Ash Disposal Facility
AMD:	Acid Mine Drainage
AQOF:	Air Quality Officer's Forum
ASTM:	American Society for Testing and Materials
BEE:	Black Economic Empowerment
BBEE	Broad based Black economic empowerment
CEDEFOP:	European Centre for the Development of Vocational Training
CCI:	Centre for Community Innovation
CER:	Centre of Environmental Rights
CO2:	Carbon Dioxide
DEA:	Department of Environmental Affairs
EIA:	Environmental Impact Assessment
FA:	Fly Ash
GHG:	Green House Gases
HEJN:	Highveld Environmental Justice Network
HPA:	Highveld Priority Area
MEC:	Minerals Energy Complex
MPRDA:	Mineral and Petroleum Resources Development Act
MSRG:	Multi-Stakeholder Reference Group
NWA:	National Water Act
NEMA:	National Environmental Management Act
NEMAQA:	National Environmental Management: Air Quality Act

NEMWA:	National Environmental Management: Waste Act
NUM:	National Union of Mine Workers
NUMSA:	National Union of Metal Workers of South Africa
NGO's:	Non-Governmental Organisations
PM 10:	Particulate Matter with an aerodynamic diameter of less than 10 µm
PM 2.5:	Particulate Matter with an aerodynamic diameter of less than 2.5 µm
SACAA:	South African Coal Ash Association
UNDP:	United Nations Development Programme
UNEP:	United Nations Environmental Programme
WWCAC:	Worldwide Coal Ash Council

1 CHAPTER ONE - Introduction and the Demarcation of the Study

1.1 Introduction

Coal FA waste management poses a number of environmental pollution challenges to the environment and to human health. Since the beginning of widespread electricity use, coal has fuelled, and continues to fuel, the largest share of worldwide electric power production (Yao et al., 2015). South Africa's economy is highly fossil fuel dependent and it is estimated that coal contributes between 91% - 93% of electricity generation (Baker et al., 2015; Eberhard, 2011; Bench Marks Foundation, 2014). Due to the country's particularly high dependence on coal for power generation, coal fired power generation activities inevitably generate large volumes of ash that is disposed on land in the vicinity of the power station. The combustion of coal for power generation produces a variety of residues; of which FA is the most abundant one and bottom (coarse ash) is the residue with a high specific gravity that remains behind in the bottom of the combustion chamber (Petrik, 2004).

For many years, ash recycling has benefited well established cement manufacturing companies in South Africa. A few start-ups of brick makers struggled to be sustainable mainly because of the lack of access to the market and the classification ash as hazardous waste. There is a need for a shift in the ash recycling regime in South Africa to ensure that ash recycling benefit local communities to the power station stations generating FA. Reynolds-Clausen and Singh (2016: 7) observe that "South Africa has a long history regarding the development of new applications for FA, however, cementitious uses, the inclusion of ash in cement-based bricks and the use of FA in cement itself, are by far the biggest recycling in South Africa".

The usage of coal is under pressure and discredited around the world due to concerns regarding climate change and global warning in favour of the intensification of sourcing energy from green energy sources. The energy mix is being revised in many parts of the world to limit electricity generation from coal. Ash dumping facilities are a source of pollution for neighbouring communities that reside adjacent to coal fired power stations. In many cases, local communities do not protest against the exposure to pollution because they accept and adapt to it as part of their daily lives.

The health impact of coal ash dust from an ash disposal facility is explained by a respondent below:

> "We have been living on this farm for 44 years; the power station has caused health issues for my wife and children. My father and grandfather both had asthmatic problems from ash pollution. Inside the house the furniture is always covered by light FA, depending on the wind direction the FA will blow directly over our house sometimes so bad that we barely see anything. My wife suffers from coughing fits when the wind blows ash over our house. For the past 18 years, we must filter the water before we drink it. We are farmers and we can see the effect of pollution on the ground".
>
> (Resident residing next to Hendrina Ash dump facility # 12. 29 November 2016).

1.2 Fly Ash Waste Generation

Coal combustion mainly generates FA waste. "While coal ash comes in several forms, it is found mainly in FA and bottom ash, it contains powdery particles that rise with smoke and are only partially captured by existing pollution control devices and by contrast, bottom (coarse) ash consists of coarser material that falls to the bottom of the boiler" (Daniels, 2016: 2). This study focused on coal ash waste management and more specifically FA, which is the predominant ash waste generated compared to coarse ash. "FA is a complex heterogeneous substance composed of amorphous and crystalline phases which get their spherical shape as a result of cooling and solidifying from molten droplets of inorganic coal residues" (Petrik, 2004: 26).

1.2.1 Coal ash formation and characterisation

Petrik (2004: 26) indicates that "the mineralogy of FA is a factor of the parent coal type". In South Africa, limited studies have specifically described the characterisation of FA and its recycling thereof. "FA is usually classified by particle size, creating a relatively uniform fine grey powder of which the particles are predominantly spherical in shape. Depending on the source and type of coal being combusted, the composition of FA may differ considerably but its chemical nature remains predominantly glassy or amorphous" (Van der Merwe et al., 2014: 73). Photo 1 below shows the fine texture of FA.

The characteristics of FA naturally vary and the intensity of combustion has an influence on its final chemical characteristics. “In some cases FA surfaces are quite smooth; others are edgy and rough on a micro scale while others may be partly covered with a powder deposit condensed from a vapour phase after solidification” (Petrik, 2004: 26). Zhu (2011: 5) indicates that “the formation of FA in pulverized coal boilers involve a complex series of processes that include coal burn outs, inorganic mineral undergoing fragmentation followed often by coalescence on the char surface”.

According to Daniels (2016: 2) “FA contains high levels of arsenic, mercury, lead, selenium, and other heavy metals that threaten wildlife, aquatic life and human life. Besides certain heavy elements, “FA also contains valuable metals including germanium (Ge), gallium (Ga), vanadium (V), titanium (Ti) and aluminium (Al), which are extractable if a viable process can be developed” (Yao et al. (2015: 114). The potential uses of FA are mainly based on the classification of FA. Petrik (2004: 27) explains the chemistry of FA based on the American Society for Testing and Materials (ASTM, C618) as: “Class F FA is produced from the burning of bituminous or anthracite coal, which is typically pozzalanic (meaning it is a siliceous or alumino-siliceous materia)l. Class C on the other hand may have reported calcium oxide contents as high as 30 to 40 percent”.

Photo1: Coal FA waste



1.3 Statement of the Research Problem

Van der Merwe et al. (2014:70) indicate that “a very small percentage of coal FA produced worldwide is currently being exploited and with the growing concern about pollution and increasing landfill costs, there has been global interest to increase the utilisation of coal FA”. South Africa generates a large volume of coal ash and only a limited amount is recycled. “It is estimated that South African coal-fired power stations produce about 25 million tons of FA per annum, of which only approximately 5% is currently reused” (Van der Merwe et al., 2014: 73). Local communities close to coal fired power stations are impacted daily by the contamination of the environment and degraded ecosystems and the problem is compounded by mining activities and power generation that are often operated in close proximity to each other.

Coal fired power stations burn lower quality coal and while the higher quality is exported to international markets. Hall (2013: 4) argues that “coal exports provide a substantial source of foreign revenue for South Africa and indications are that, even in a low carbon world, there will still be a demand for export coal until 2040 and beyond” Against the above background, the main research problem is formulated as follows: **“The large amounts of FA waste produced daily in coal fired power stations pose significant negative impacts to the environment and human health due to the lack of disposal alternatives and limited recycling opportunities”.**

1.4 Rationale of the study

South Africa’s economic growth is currently fueled largely by coal and it is commonly estimated that the country has sufficient coal reserves to last for at least another 200 years. FA generation and pollution is a daily problem affecting communities, particularly those who live adjacent to mining- power generation areas. Limited academic research work has been conducted in South Africa to address FA’s extensive long-term accumulation on land (in ash dump facilities) and the management of its associated impacts. This study has been conducted to address this gap in academic research. Due to the increase in demand for electricity, FA will be generated daily for the decades to come and it is essential that an investigation is conducted on FA to understand its impact and to explore the intensification of recycling to benefit local communities.

.

1.4.1 Aim of the study

Leedy and Ormrod (2005) indicate that the research problem should address an important question such that the answer can actually "make a difference" in some way and secondly it should advance the frontier of knowledge by leading new ways of thinking. The main aim of this study was to explore how the management of FA waste in South Africa can be improved to minimise its impact on the environment and human health and also to investigate the potential recycling applications that can significantly reduce the high amount of FA disposal on land and benefit local communities. The theoretical contribution of the study is to explore how the above stated aim can be achieved within the context of an environmental justice framework and just transition theories.

1.4.2 Research question and sub questions

The impact of FA is well documented worldwide, but there is limited research work that has involved the views of communities' experiences in South Africa. Yao et al. (2015: 107) argue that "coal contains significant amounts of various trace metals, and after combustion, metal concentrations in FA are sometimes 4–10 times higher than that of the parent coal and trace metals contaminate the water and pose health hazard through emissions if they are not contained". Understanding the physical, chemical and mineralogical properties of FA is important, as these properties influence its subsequent use and the disposal decision.

The primary research question is stated as follows: **"How can the management of FA waste from coal fired power stations be improved to minimise the negative impacts and enhance potential benefits?"** The primary research question is further supported by the sub research questions as presented in Table 1.1.

Table 1.1: Research sub questions

Q_1	What impacts are FA disposal facilities having on the natural environment and neighboring communities?
Q_2	Which interventions can be employed to ensure that FA recycling opportunities benefit local communities in South Africa?
Q_3	What are the prospects of a just transition to clean energy sources and environmental justice through FA recycling?

1.5 The Research Objective and Secondary Objectives

In order to answer the research question and sub questions stated above, the primary and secondary objectives are stipulated by the researcher and addressed accordingly by this research. The objectives were formulated and linked to the primary research question and sub questions by basing them on the specific outcomes that the research questions seek to answer. The heavy dependence on coal poses many risks that can potentially affect the South African economy in sustaining future growth rates without alleviating irreversible environmental consequences that include impacts on water resources and air quality (Eberts, 2011). The South African economy is structured around a carbon intensive environment where industrialisation is energised by coal-based electricity; therefore, any shift towards de-carbonisation of the electricity sector would significantly affect the coal sector and the South African economy more broadly.

"Ash dump sites occupy vast land and they also impact negatively on the aesthetic value of the land" (Haibin and Zhenling, 2010: 1331). The environmental impacts of coal ash waste have a direct impact to human health. **The primary objective of this research is to explore the short, medium and long-term activities and interventions needed to manage FA waste in the coal fired power stations in order reduce its impact and to optimise social and economic benefits to the affected local communities in South Africa.** In support of the primary objective, secondary objectives are identified in Table 1.2 below:

Table 1.2: Secondary research objectives

O_1	To identify the impact of FA on the receiving environment and the wellbeing of local communities.
O_2	To explore the challenges and interventions that can be employed to ensure that FA recycling opportunities benefit local communities in South Africa
O_3	To expose the prospects of a just transition to clean energy sources and environmental justice through FA recycling

1.6 Structure of the Dissertation

- **Chapter 1:** Introduces the study and explains the statement of the research problem which informs the need to conduct this study. The rationale and the aim of the study are tabulated with the research questions, sub questions, main objectives and secondary objectives of the dissertation also stated.

- **Chapter 2:** This chapter provides background information and an overview on the politics of coal mining, the dynamics of coal mining and coal exports. The social impacts, environmental impacts of coal mining are also explained in detail. The processes of combustion of coal for power generation, coal ash disposal and the impact of coal ash waste on the environment and human health are highlighted. The chapter concludes by describing the general global waste management challenges and legal instruments that are applicable to the coal electricity generation sector in South Africa.

- **Chapter 3:** A literature review on the political economy of coal in South Africa, the evolution of the mineral energy complex economy and the role of coal power stations in the mineral energy complex economy is conducted. The constraints of transitioning away from the mineral energy complex economy and the reconfiguration of South Africa's energy mix are discussed. Included is a discussion on the selected theoretical framework for the study that includes environmental justice and a just transition.

- **Chapter 4:** This chapter explains the mixed research methodology adopted for the study. The population studied by the research is described in detail. The chapter also elaborates on the case studies of two selected power stations (Hendrina and Kendal Power Stations). The sample, measuring instruments and methods followed for data analysis are explained and the ethical considerations adopted by the study discussed. The chapter is concluded by stating the limitations of the study.

- **Chapter 5:** This chapter presents the results and the analysis of the study on the effects of FA on local communities and the environment.

The chapter exposes the feedback received from the respondents during in-depth interviews in relation to the impact of FA on the community and on the environment. The chapter also analyses the pollution aspects in relation to FA impacts on the livelihoods of local communities (*i.e.* impacts on farming activities).

- **Chapter 6:** This chapter presents the results and analysis on the potential recycling opportunities to benefit local communities and the barriers which are preventing the attainment of this potential. The results of the survey conducted on different stakeholders that are associated with coal fired power generation are interpreted. The recycling aspects in relation to opportunities and benefits that may promote job creation and enterprise development through ash recycling are also discussed.

- **Chapter 7:** The results and analysis are explained in context and in relation to the environmental justice framework and just transitions theory by focusing on the implications of FA pollution on the local communities. The analysis also focuses on the implications of recycling FA to facilitate a just transition to clean energy production.

- **Chapter 8:** This chapter presents the concluding remarks and recommendations derived from the study. Recommendations of the study in relation to the impact of ash on the community and ash recycling initiatives to benefit local communities are provided. The chapter concludes by presenting the implications of the study to policy makers.

2 CHAPTER TWO - Background: Understanding the South African Coal Industry and Coal Combustion for Power Generation

Coal is a highly combustible fossil fuel that originates from plants and a major source of energy in electricity generation in South Africa. “Coal type is defined by the kind of plant material and coal rank refers to the degree of metamorphism and grade defines the range of impurities contained within the deposit” (Petrik, 2004: 22). The abundance of bituminous coal reserves have contributed significantly to a successful establishment of a value chain of industries that is energised by coal. “South Africa’s economically recoverable coal reserves are estimated at between 15 and 55 billion tonnes, 96% of reserves are bituminous coal; metallurgical coal accounts for approximately 2% and anthracite another 2% and production is mainly steam coal of bituminous quality” (Bench Marks Foundation, 2014: 3). South Africa coal is a major driver of industries in the African continent and the dominance of South Africa in the continent can also be attributed to the abundance of coal reserves. Petrik (2004: 23) indicates “South Africa contains approximately 90% of the known coal resources of Africa”.

2.1 Coal mining overview in South Africa

Coal mining is responsible for the industrialisation status and economic development because of its fundamental role in energising other industries with electricity. Politics has had a major influence in the mining sector for many decades. Munnik, Hochmann and Hlabane (2010: 8) indicate that “as far back as 1903, South Africa has had laws that placed the responsibility for mining impacts on the mine owner, when a closure certificate was obtained, this responsibility ceased”. Since the beginning of the century, mines were one of the avenues were the political control was fought for, in 1948 during the inception of apartheid; coal mining provided an avenue for advancing Afrikaner capital and control (Greenpeace, 2012). The success of mining in South Africa was boosted by low wage and unskilled labour force. “Cheap black labour, achieved via the migrant labour system (in which mineworkers left their families behind and lived in all male, strictly controlled compounds), required political control” (Munnik, Hochmann and Hlabane, 2010: 4).

2.1.1 The dynamics of coal mining in Mpumalanga Highveld

South African coal mines are largely located in Mpumalanga because the majority of South Africa's coal reserves and mines are in the Central Basin in the Mpumalanga Highveld. South Africa's coalfields have a complicated coal dynamic in the area which has resulted in extensive environmental and social externalities (Bench Marks Foundation, 2014; Greenpeace, 2012). "About 51 percent of South African coal is mined underground and about 49 percent is produced by open-cast methods" (Munnik, Hochmann and Hlabane, 2010: 5). The location of one of the power stations in close proximity to coal mines, influenced by the availability of coal, has added to the dynamics of coal mining in Mpumalanga and other heavy industry using coal to produce steel and alloyed products including coal hauling by truck. This complex dynamic has contributed to the concerns that have been and are being raised regarding environmental pollution (Greenpeace, 2012).

2.1.2 Coal exports

The infrastructure specifically developed in the form of a railway line, developed in 1976 allowed South Africa to export high quality beneficiated (washed) coal of better quality to Europe while low-grade run-of-mine domestic coal was used by Eskom (CER, 2016). "Around 28 percent of South Africa's production was exported around the year 2010, mainly through the Richards Bay Coal Terminal, making South Africa the fourth-largest coal exporting country in the world" (Munnik, Hochmann and Hlabane, 2010: 5). Currently there is also demand for lower grade coal in Asia, particularly India although historically the export destination was Europe. More than half of South Africa's coal exports now go to the East (CER, 2016). The future success of coal exports is uncertain and the coal quality in some collieries in Mpumalanga is diminishing, resulting in falling revenues (Munnik, Hochmann and Hlabane, 2010). Hall (2013: 18) observes that "given the distribution of South Africa's remaining resources, any growth in exports above these levels will require mines to be developed in other coalfields, notably in the Waterberg".

2.1.3 Social impact of mining

Mining in the context of South Africa has caused dire social instability due to the migrant labour system and the impact to the wellbeing of local communities. The impact of coal mining on the environment and to the social conditions of local communities is well documented.

Munnik, Hochmann and Hlabane (2010: 3) argue that, “South African coal mining activities have contributed to the serious social consequences on the movement of people, on people’s health and on the environments they live in”. There is conspicuous evidence of mining-affected communities that are exposed to water, soil, noise and dust pollution causing ill health regularly and communities usually experience social disruption ranging from increased crime to forced resettlement (CER, 2016). In many cases, local communities adjacent to mines live in appalling conditions. Cock (2016: 5) indicates that “communities regularly report dust, water pollution, damaged boreholes and cracked housing, especially in vicinities of open cast mining and blasting”. CER (2016: 12) argues than “often the most vulnerable communities suffer the worst of these consequences and some settlements are perilously situated above or close to abandoned mines and collapse when subsidence occurs”.

2.1.4 Environmental impacts of coal mining

Mining activities pollute the environment and years of coal mining has had significant impact on air and water resources. Air pollution through fugitive dust emissions and water contamination due to Acid Mine Drainage (AMD) are challenges South Africa is faced with. “Being largely an arid country, South Africa is fast approaching the limits of its available water supply, threatened in terms of both quantity and quality” (Petrik, 2004: 12). Debates about the looming water crisis are well documented. “The problem of short supply of water and depletion of clean water resources seems inevitable and if no appropriate action is taken there will be a water crisis in future” (Saimy and Yusof, 2013: 374).

“AMD occurs when water decants from mines and flows over pyrite and when pyrite is exposed to water and oxygen, a reaction takes place between the sulphides and sulphuric acid is formed” (CER, 2016: 04). AMD poses pollution challenges to catchments that drain water from the Mpumalanga Highveld region. Mpumalanga contains areas of immense hydrological importance that are strategic for the country’s water supply.

According to Greenpeace (2012: 15) major rivers rise from the Mpumalanga Highveld and they include:

- “The Vaal River, which is the source of Rand Water’s raw water for more than 10 million people and the core economy in Gauteng and neighbouring areas, runs through South Africa’s industrial heartland.

- The Olifants River supplies water to the national electricity supplier, Eskom, to the Kruger National Park and to surrounding private game reserves which are the heart of South Africa's conservation and ecotourism industry. The Olifants River flows through eMalahleni and Middelburg and is described as one of the most polluted rivers in Southern Africa

- The Olifants and the Inkomati rivers are shared with neighbouring Mozambique and Swaziland, where major downstream investments have been made in irrigation".

2.2 Coal Combustion for Power Generation

South Africa is currently largely dependent on the combustion of coal for power generation. Petrik (2004: 8) indicate that "when low grade coal of the kind South Africa is exploiting is burned by coal powered utilities, the approximately 25% inorganic residue, called FA, remains as waste that largely consists of quartz and mullite". Coal combustion in South Africa is dominated by Eskom and Sasol. "Eskom, the major power utility in South Africa and Sasol, one of Africa's major producers of chemicals and liquid fuels, are the biggest consumers of coal in South Africa" (Bada and Potgieter- Vermaak, 2008: 38).

Eskom and Sasol use high ash, low calorific value coal while good quality coal is largely exported to maximise national revenue. "Coal supplied to Eskom's power plants is usually screened and washed before it is supplied, which typically reduces the ash content from 60% down to 35%" (Eberhard, 2011: 11). The extensive amounts of FA that is produced daily in coal fired power stations pose significant impacts to the natural environment and human health due to lack of disposal alternatives and limited recycling opportunities. Ash disposal facilities are conspicuous features next to coal fired power stations and they are a source of air and water pollution which impacts upon local communities.

The country's future energy generation will be largely met by the use of coal. Thopil and Pouris (2015: 2814) observe that "the South African coal power plant fleet consists of 10 baseload power plants and 3 return to service (RTS) power plants. The RTS plants are used to deliver power during peak demand periods". Table 2.1 illustrates the current electricity supply situation in South Africa.

Table 2.1: Eskom's coal power plant fleet

Category	Power Station	Cooling technique	Year of completion	Capacity (MW)
Base load	Arnot	Wet recirculating	1975	2100
	Duvha	Wet recirculating	1984	3600
	Hendrina	Wet recirculating	1970	2000
	Kendal	Direct dry	1993	4100
	Kriel	Wet recirculating	1979	3000
	Lethabo	Wet recirculating	1991	3600
	Majuba	Wet recirculating and dry	2000	4100
	Matimba	Direct dry	1991	3800
	Matla	Wet recirculating	1983	3800
	Tutuka	Wet recirculating	1990	3600
Return-to-service	Camden	Wet recirculating	1967	1600
	Grootvlei	Wet recirculating and dry	1973	1200
	Komati	Wet recirculating	1966	1000
New build	Medupi	Direct dry	On-going	4800
	Kusile	Direct dry	On-going	4800

Thopil and Pouris (2015: 2814)

2.2.1 The impact of coal ash on human health

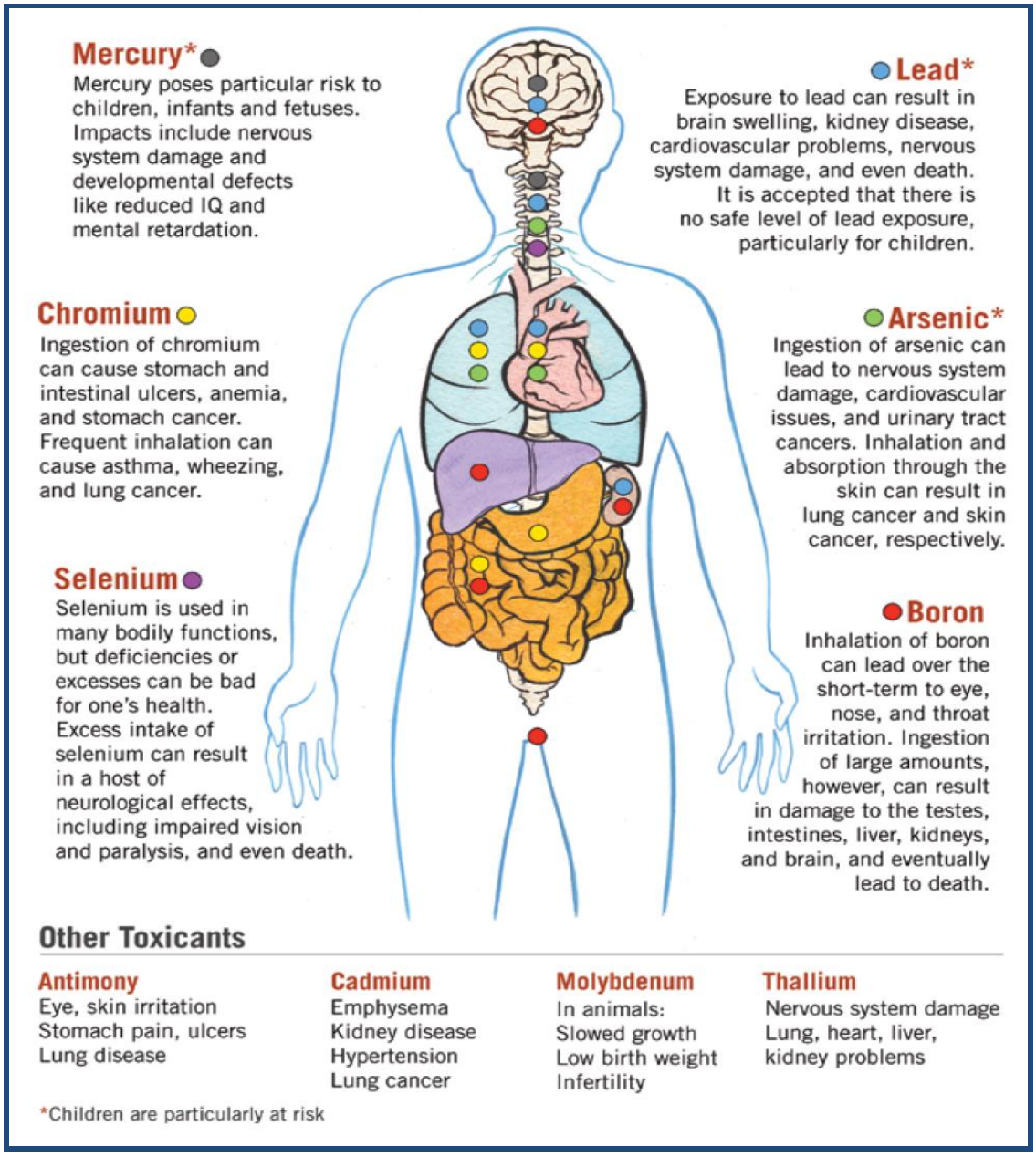
Coal ash is dangerous if inhaled, ash containing water is also dangerous when consumed. “FA is a significant environmental pollutant that presents a respiratory hazard when airborne and can cause chronic respiratory health problems should they become deposited in the lower respiratory tract” (Brown, Jones and BéruBé et al., 2011: 3332). Coal ash contains heavy metals that are harmful to human health. “Typically, coal ash contains arsenic, lead, mercury, cadmium, chromium and selenium, as well as aluminium, antimony, barium, beryllium, boron, chlorine, cobalt, manganese, molybdenum, nickel, thallium, vanadium, and zinc (Gottlieb, Gilbert and Evans, 2010: vii).

These metals can be toxic, especially where there is prolonged exposure; the impact is particularly severe to the most vulnerable members of the society that include children and the elderly. According to Munnik, Hochmann and Hlabane (2010: 11) and Gottlieb, Gilbert and Evans (2010: vii) “these metals can cause several types of illnesses that include:

- Cancer,
- Heart damage,
- Lung disease,
- Respiratory,
- Distress,
- Kidney disease,
- Reproductive problems,
- Gastrointestinal illness,
- Birth defects, impaired bone growth in children,
- Nervous system impacts,
- Cognitive deficits,
- Developmental delays and
- Behavioural problems”.

In short, coal ash toxics have the potential to injure all of the major organ systems of the human body, damage physical health and development, and even contribute to mortality” (Gottlieb, Gilbert and Evans, 2010: vii). Figure 2.1 illustrates potential health impacts of coal ash illustrated in a human body.

Figure 2.1: Potential health impacts of coal ash



Source: Gottlieb, Gilbert and Evans (2010: 5)

2.3 Factors that Influence Coal Ash Handling in Coal Fired Power Stations

Management of coal ash is influenced by a number of factors that influences the management of ash in a coal fired power station environment. Coal FA waste management challenges in the South African power generation sector are mainly experienced in ash disposal facilities. Eskom's disposal facilities are not lined, particularly those disposal facilities of older fleet power stations that were constructed in the 1960's, 1970's and 1980's. This is due to the fact that they were constructed before progressive waste legislation was promulgated and as a result, toxic metals still do leach into the ground from these sites.

When ash in the disposal site dries, the toxic elements that are contained in ash have the potential to be airborne especially in dry disposal facilities where they can cause air pollution or be deposited into nearby surface water bodies (Fatoba, 2007). Leaching of toxic metals, especially heavy metals to the ground is a significant challenge that is experienced in ash disposal facilities and the risk of groundwater contamination remains one of the main challenges of ash disposal facilities (Zhu, 2011; Fatoba, 2007). The factors below were identified from literature and they were found to have significant influence on the management and handling of FA waste.

2.3.1 Coal quality

Hall (2013: 4) observes that "good quality coal is exported to provide an important source of foreign revenue for the country in South Africa". Coal quality has a direct influence in the combustion efficiency during power generation. Good quality coal generates less quantities of ash during combustion. Coal that Eskom uses is of poorer quality and it generates larger quantities of ash, produced as by-products of combustion (Singh et al. (2016: 1). Yao et al., (2015: 106) indicate that "the specific properties of FA depend on the type of coal used, the combustion conditions, and the collector setup, the quality of the coal pulverized coal feed and proper quality control in maintaining the particle size among other factors".

2.3.2 Ash handling

The two methods that are employed to dispose ash at Eskom are dry ashing and wet ashing. In dry ashing, slightly moistened ash is conveyed to the ash dump facility through overland conveyors, ideally, the ash on the conveyor belt contains about 15% moisture (Mokhahlane, 2013). This prevents ash from blowing off the conveyor belt, including from off the ash dump facility where it is disposed. Wet ashing “involves transportation of ash as slurry to a series of holding ponds where the solids are allowed to settle out of suspension” (Petrik, 2004: 27). The handling “has a direct influence in terms of the environmental impact for example: ground water pollution because of an ash dump facility would consequently seep at the foot of the dumping facility when the wetting front spreads to the bottom” (Mokhahlane, 2013: 13).

2.3.3 Ash classification as hazardous waste

At present coal ash is classified as hazardous waste in terms of waste legislation in South Africa. Due to its heavy metal concentrations this classification has a bearing on licensing requirement that direct the management of ash in a disposal facility thereafter (Reynolds-Clausen and Singh, 2016). Ash classification as hazardous waste is directly affecting the intensity of ash recycling in the country. The South African waste legislative framework pertaining to waste management strictly governs ash utilisation and classification. Amendments and unlocking the waste legislation would be a key enabler to market development of ash applications (Van der Merwe et al., 2014; Reynolds-Clausen and Singh, 2016).

“It is for this reason that Eskom has rejuvenated its ash utilisation project by submitting a landmark application to the DEA on behalf of the industry” (Reynolds-Clausen and Singh, 2016: 1). Van der Merwe et al. (2014: 73) observe that “in recent years in South Africa, the classification of coal ash as hazardous waste compounded by a growing concern about pollution and increasing landfill costs is stimulating research into new ways to utilise FA for economically beneficial applications”.

2.3.4 Fly ash recycling opportunities

Coal ash is considered as a resource worldwide and the utilisation of both coarse ash and FA for various applications cannot be neglected (Petrik, 2004). Recycling FA is an alternative to permanent disposal and could achieve significant economic and environmental benefits to local communities. FA recycling research and debates are not new around the world; FA is a heterogeneous solid waste that has been studied extensively on physiochemical properties and potential beneficial applications (Zhu, 2011). FA waste recycling can significantly contribute to the improvement of the socio-economic situation of local communities who are impacted by pollution emanating from coal fired power stations. Reynolds-Clausen and Singh (2016: 1) observe that "ash could play a key role in business development, job creation, skills transfer and localization specifically in the brick making and construction industries".

2.4 The Environmental Impacts of Coal Ash Waste

Due to the toxic metals coal ash contains, its disposal methods contribute to poor air quality and poor water quality. Liu et al. (2016: 1059) argue that "if FA is not properly handled, it can disrupt ecological cycles, pose soil and water hazards and can also cause heavy air pollution such as the haze and smog that has been noticed in recent years".

2.4.1 The impact of fly ash to water resources

Water is a precious natural resource that does not have a replacement. Scarcity of water is a broad issue that is of concern for national governments and policy making bodies the world over. "More than 1 billion people currently lack access to safe drinking water and 2.4 billion people lack access to improved sanitation" (Thopil and Pouris, 2015: 2813). Power stations transport and store waste water containing ash in dams in aqueous form. "Specifically, the interaction between FA and the aqueous phase is the main pathway for the release of toxic constituents from FA to the environment, posing potential harms to human beings and other living organisms" (Zhu, 2011: 1). Usage of water as an ash transportation medium has impact to both quality and quantity of water and it depletes fresh water resources due to the increased usage of raw water.

Eskom is a strategic water user in South Africa and coal fired power generation cannot happen without water (Petrik, 2004). Saimy and Yusof (2013: 371) observe that “water is becoming scarce and many countries are already facing problems of access to safe drinking water”. South Africa is a water scares country. Contamination of water by coal ash needs to be managed; there is a risk that South Africa might face a situation of extensive water scarcity unless current reserves and usage patterns are managed properly (Thopil and Pouris, 2015).

2.4.2 Air pollution emissions

Air pollution is on the agenda the world over and how coal fired power generation harms the environment is well documented, particularly greenhouse gases that are worsening the climate change phenomenon. Fugitive dust particles from ash disposal facilities have not received much attention compared to greenhouse gases. Yao et al. (2015) indicate that FA particles are easily suspended in air and have become a major source of air pollution with repeated exposure to FA causing irritation of the eyes, skin, nose, throat and respiratory tract and can even result in ambient air poisoning. The conglomeration of mines, power stations, steel industries and other related industries on the Mpumalanga Highveld have compromised the air quality in the region. “The Mpumalanga province has been declared as an air quality priority area and currently this province has amongst the worst air quality in the world, largely due to coal mining activities; uncontrollable underground fires and power-stations burning coal” (Munnik, Hochmann and Hlabane, 2010: 11).

Local communities close to power stations are exposed to pollution daily. Coal ash disposal sites like any other landfill sites require land availability. “Most FA disposal methods ultimately lead to the dumping or disposal on open land leading to the accumulation of FA over vast areas of land, which results in the degradation of the soil and danger to both human health and the environment” (Yao et al., 2015). Air emissions caused by fine particles that are directly emitted from coal combustion react in the air and fugitive dust from ash dumps and other forms have a detrimental effect on public health (UNEP, 2011; Giovanis, 2015). FA exposure to local communities can also be attributed to poor or incomplete rehabilitation of ash dumping facilities, and as a result, during windy days communities are covered by a cloud of FA making the outdoor air quality poor.

Pandey and Singh (2014: 40) argue that “the environmental problems of FA can be mitigated by re-vegetation of the ash dumpsites”. Where necessary the challenge of emissions from FA fugitive dust must be managed through communities’ relocation away from ash dumping facilities in order to limit daily exposure to polluted air.

2.5 Global Waste Management Challenges

Industrialisation has brought development in many parts of the world and with it is the inevitable generation of waste. Waste management remain a challenge around the world and its manifestations are more pronounced in developing countries. “Globally, waste has strong linkages to a range of other global challenges such as health, climate change, poverty reduction, food, resource security, sustainable production and consumption” (United Nations Development UNDP, 2015: 7). Waste management challenges are more conspicuous in Africa, particularly in the Sub-Saharan region.

The United Nations (2014: 2) argues that “a key indicator of the challenge to manage some of these waste streams is reflected in the difficulty by most African countries to meet the Millennium Development Goals”. Innovative ways of reusing waste as a resource are getting attention and bringing along economic opportunities (Ghisellini, Cialani and Ulgiati, 2015). South Africa generates tons of both general and hazardous waste daily. Rottgers and Grote (2014) indicate that waste prevention programs must be imbedded in daily operations of the plants by implementing, waste reduction into design, and delivering new and improved products and services through recycled waste.

2.5.1 Waste management in South Africa

South African environmental legislation is anchored by the Constitution of The Republic of South Africa, 1996. It is the backbone upon which all legislation is crafted. South African Environmental legislation is aligned to the principles of the sustainable development (social, economic and environmental) framework. It advances equitable distribution of resources by protecting the environment, mitigating negative impacts while enhancing positive impacts. Environmental protection and pollution prevention is legislated in South Africa.

The Constitution of The Republic of South Africa, 1996 (Section 24) states that "Everyone has the right:

"(a) To an environment that is not harmful to their health or well-being; and
(b) To have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that –
(i) prevent pollution and ecological degradation;
(ii) Promote conservation; and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development".

The National Environmental Management Waste Act (NEMWA), 2008 act No. 59 of 2008 is the legislative measure that governs waste management in the country. According to NEMWA "waste" means:

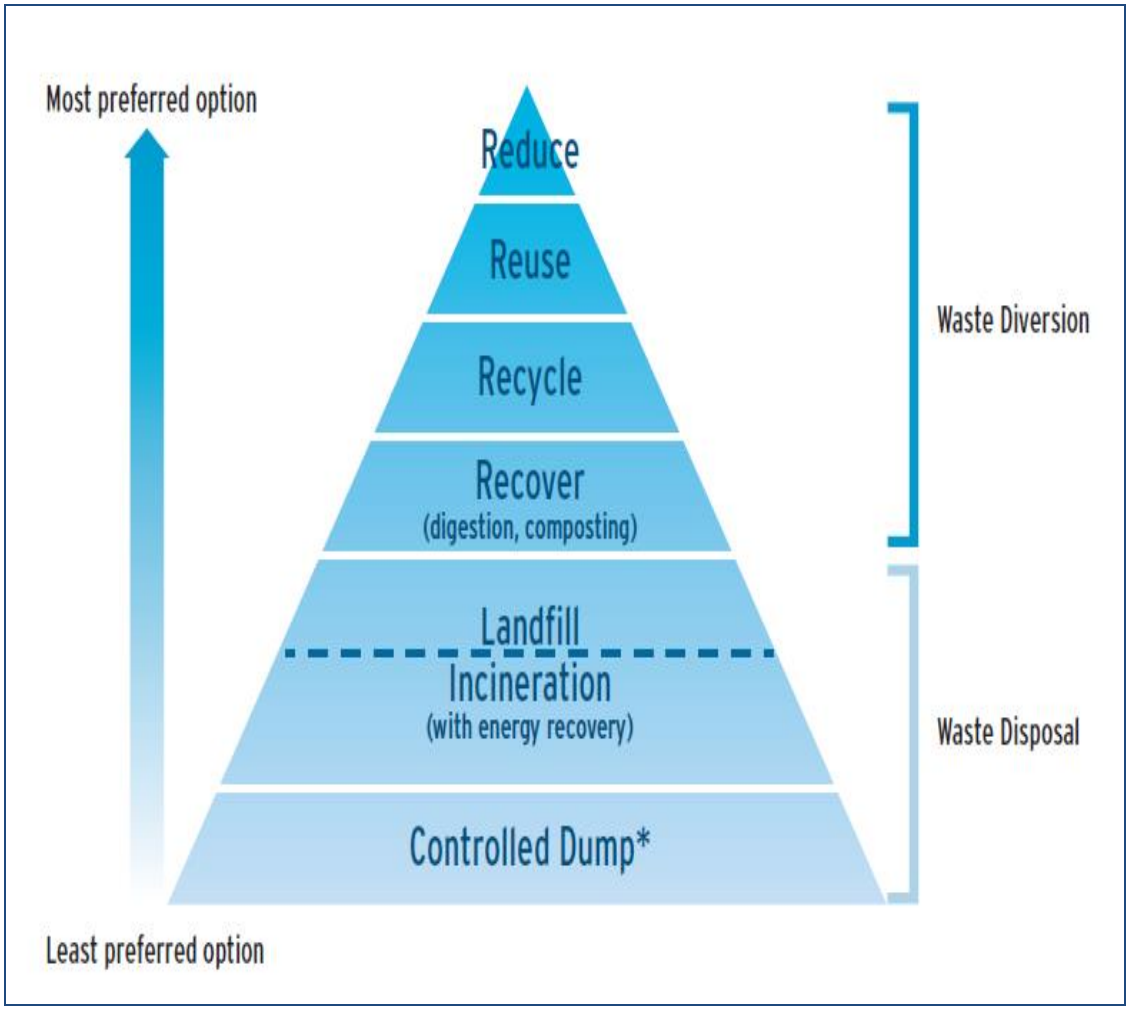
(a) any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of, or that is intended or required to be discarded or disposed of, by the holder of that substance, material or object, whether or not such substance, material or object can be re-used, recycled or recovered and includes all wastes as defined in Schedule 3 to this Act; or

(b) any other substance, material or object that is not included in Schedule 3 that may be defined as a waste by the Minister by notice in the Gazette. The Waste Act aims to protect health, well-being and the environment by providing reasonable measures for: avoiding the generation of waste; reducing, reusing, recycling and recovery of waste; treating and safely disposing of waste as a last resort; preventing pollution; and securing ecologically sustainable development while promoting justifiable economic and social development.

The Department of Environmental Affairs (DEA): National Waste Management Strategy (NWMS), 2011 states that: "The objects of the Waste Act are structured around the steps in the waste management hierarchy, which is the overall approach that informs waste management in South Africa". The waste management hierarchy consists of options for waste management during the lifecycle of waste, arranged in descending order of priority. These first four stages of the waste management hierarchy are the foundation of cradle-to-cradle waste management, which refers to handling of waste from its creation to its ultimate disposal.

As a last resort, waste enters the lowest level of the hierarchy to be treated and / or disposed of, depending on the safest manner for its final disposal. Figure 2.2 illustrates the waste management hierarchy approach adopted by many countries around world.

Figure 2.2: Waste management Hierarchy



Source: World Bank (2012: 27)

2.5.2 Legislation applicable to the energy generation sector in South Africa

These legislation is premised to enhance the quality of life and the wellbeing of all those who are residing in the republic of South Africa while preserving the resources for future generations. The applicable legislations and their purpose are stated below in Table 2.2.

Table 2.2: Environmental legislations in the mining and energy sector.

No	Legislations (as amended)	Purpose of Act
1	**Constitution Of The Republic Of South Africa, 1996 (Section 24)**	Everyone has the right – (a) to an environment that is not harmful to their health or well-being; and (b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that – (i) prevent pollution and ecological degradation; (ii) Promote conservation; and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.
2	**Mineral and Petroleum Resources Development Act (MPRDA),** No. 28 of 2002	To make provision for equitable access to and sustainable development of the nation's mineral and petroleum resources; and to provide for matters connected therewith.
3	**National Environmental Management Act (NEMA) No. 107 of 1998**	To provide for co-operative environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for co-ordinating environmental functions exercised by organs of state; to provide for certain aspects of the administration and enforcement of other environmental management laws; and to provide for matters connected therewith.
4	**National Water Act (NWA), No. 36 of 1998**	To provide for fundamental reform of the law relating to water resources; to repeal certain laws; and to provide formatters connected therewith.
5	**Electricity Regulation Act, No. 4 of 2006**	To establish a national regulatory framework for the electricity supply industry; to make the National Energy Regulator the custodian and enforcer of the national electricity regulatory framework; to provide for licences and registration as the manner in which generation, transmission, distribution, reticulation, trading and the import and export of electricity are regulated; to regulate the reticulation of electricity by municipalities; and to provide for matters connected therewith.
6	**National Environmental Management: Air Quality Act (NEMAQA)** Act, No, 39 of 2004	Provides the regulatory tools for the State to ensure that air quality is of an acceptable standard and not detrimental to people's health
7	**National Environmental Management: Waste Act, No. 59 of 2008**	To reform the law regulating waste management in order to protect health and the environment by providing reasonable measures for the prevention of

		pollution and ecological degradation and for securing ecologically sustainable development; to provide for institutional arrangements and planning matters; to provide for national norms and standards for regulating the management of waste by all spheres of government; to provide for specific waste management measures; to provide for the licensing and control of waste management activities; to provide for the remediation of contaminated land; to provide for the national waste information system; to provide for compliance and enforcement; and to provide for matters connected therewith.
8	**Hazardous Substances Act, No. 15 of 1973**	To provide for the control of substances which may cause injury or ill-health to or death of human beings by reason of their toxic, corrosive, irritant, strongly sensitizing or flammable nature or the generation of pressure thereby in certain circumstances, and for the control· of certain electronic products; to provide for the division of such substances or products into groups in relation to the degree of danger; to provide for the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products; and to provide for matters connected therewith.

Source: Acts - South African Government (www.gov.za/documents/acts South African legislations, 2017)

2.5.3 Applicable legislation to coal ash handling in South Africa

Coal ash is currently classified as hazardous waste under the NEMWA: Category A: Hazardous waste. This requires potential users of ash to apply for waste management licenses, supported by either an EIA or Basic Assessment (BA). Without a waste management license, businesses will not be able to "trade" in ash. This significantly impacts the ability to develop new businesses and jobs. The recycling of coal ash from Eskom Power Stations has been taking place for approximately two decades in South Africa, largely benefiting established cement manufacturing businesses. The provisions of NEMWA (Section 82 and 74) have not assisted in the widespread use of ash particularly to local communities.

“In terms of transitional provision regarding listed waste management activities, Section 82 states that: “A person who conducts a waste management activity listed in Schedule 1 on the date of coming into effect of this Act, and who immediately before that date lawfully conducted that waste management activity under Government Notice No. 91 of 1 February 2002, may continue with the activity until such time that the Minister by notice in the Gazette directs that person to apply for a waste management licence under this Act”.

NEMWA Section 74 (applications for exemption) stipulates that “(1) any person may apply in writing for exemption from the application of a provision of this Act to the Minister or, where the Member of Executive Committee is responsible for administering the provision of the Act from which the person or organ of state requires exemption, to the Member of Executive Committee”. NEMWA: Waste classification and Management Regulation 9 (1) stipulates that “Any person may submit to the minister to list a specific waste management activity that does not require a waste management activity in terms of section 19 of the act, but that is required to adhere to the requirements or standard determined in terms of section 19 (a) of the act for that activity”. The South African legislation is clear; recycling coal ash without the approval of government is an offence that can lead to sentence.

2.6 CONCLUSION

Coal mining impacts the environment, human health and wellbeing. This chapter provided the background information about coal mining in South Africa including the impact of coal to the environment and its associated social impacts to the community. Coal combustion was also discussed with a special focus on FA waste management challenges in the South African power generation sector. The discussion included the impact of FA to the environment and human health. Waste management is a challenge in South Africa and it is well legislated. The chapter explained the general global waste management challenges followed by the waste management regime in South Africa. The chapter also elaborated on specific legislation that is applicable to the energy generation sector with a specific discussion on the coal ash waste legislation and coal ash classification as hazardous waste. The chapter also discussed coal combustion and the characterisation of ash including its properties.

3 CHAPTER THREE - Literature Review and the Theoretical Concepts

This chapter reviews literature relevant to the research problem presented in Chapter 1. Relevant studies pertaining to this study are critically analysed and evaluated in this chapter. Chapter 3 also reviews the literature of published academic articles in journals and books. Reports from organisations that are interested in coal fired power stations and the political economy of coal in South Africa are also reviewed and the discussion includes the political economy of coal in South Africa by focusing on the evolution of Minerals Energy Complex (MEC); the role of coal powered power stations in the MEC; major constraints on transitioning away from coal; the environmental pollution dilemma associated with coal usage and the reconfiguration of the energy mix in South Africa. This chapter also reviews the debates about a transition to clean energy production from fossil fuels with the primary focus on ecological modernization; the green economy; just transition and environmental justice theories.

3.1 The role of coal in South African energy production

South Africa is a middle-income country and one of the most industrialized countries in Africa with highly sophisticated energy production and distribution capabilities, which were developed under circumstances of economic isolation in order to meet the needs of the industrial sector during apartheid era (Ziramba, 2009). The abundance of coal reserves has shaped the South African economy. The South African economy is highly dependent on mineral-extractive and energy-intensive industries. The characterisation of the South African political economy is referred to as the MEC. According to Baker et al. (2015:1) the “South African MEC economy is structured around an evolving system of accumulation for the disproportionate benefit of mining and minerals-based export oriented industry, with approximately 40% of the country’s electricity consumed by its energy-intensive industrial users”.

The MEC has historically been responsible for economic development and economic growth including massive employment opportunities in the country. “Key to understanding the structural elements of the MEC is the role coal plays in South Africa’s energy system, both in the conversion to electricity by Eskom, and to liquid fuels by Sasol” (Baker et al., 2015: 13).

The discovery of coal particularly bituminous coal has been a foundation of the power generation sector and the value chain that depend on it. Coal reserves have influenced many policies and legislation all of which are geared to economic development and environmental protection. The country cannot afford to completely abandon coal that it is so well endowed with in order to meet its energy needs. The country has made significant strides in improving affordable access to electricity to the previously disadvantaged groups in the country. “The move away from coal to low-carbon energy sources may mean higher electricity prices in the short-term, although there would be significant grid parity opportunities in the long-term” (Swilling, Musango and Wakeford, 2015: 40).

South Africa is positioned on the continent as the most industrialised country with well-established infrastructure. “Coal mining and coal-fired power stations, provided the energy for diamond and gold mining and associated industry and infrastructure, including the railways” (Ebehard, 2011: 5). The whole value chain of industrialisation and mining is sustained by coal fired power stations.

3.1.1 The role of coal in the evolution of a minerals-energy complex economy

The discovery of coal has shaped the political economy of South Africa and historically coal was used to advance the elite of the government of the day. The apartheid dispensation based their investment decision particularly foreign exports earnings around coal and other minerals and the same approach is currently being advanced by the government of the day. “Under apartheid, coal mining provided an avenue for advancing Afrikaner capital and currently it is now the focus of a programme for building a black middle class through an inclusive participation in coal mining” (Munnik, Hochmann, and Hlabane, 2010: 6). Coal mining has flourished sustainably particularly in Mpumalanga Highveld region because of the availability of cheap labour and close proximity coal fired power stations.

Power stations were established in close proximities to the mines to ensure that the distance of coal supply was reduced in order to reduce transportation costs. The management of the MEC has always been a challenge because of the stakes and interests from organised labour, public and private sectors. Organised labour is largely interested in the job security, decent wages and safety of their members and they are well established and vocal in the coal sector.

Coal minerals have largely benefited a few dominant mining houses players who amassed wealth from this natural resource. Ownership of mining houses that dominate the coal sector is changing at a snail's pace according to NGO's sentiments. Ownership remains largely the same; in limited cases there have been mergers between big mining houses in terms of shares of ownership and Broad based Black economic empowerment (BBEE) companies to include the previously disadvantaged communities to be players in the coal sector. Currently the government is under tremendous pressure to change the phase of mining ownership. Few BBEE players have entered the industry; some of the mining houses are forging relationships with new BBEE players. Baker et al. (2015: 14) "observe that the stable post-apartheid relationship between major mining houses and Eskom has evolved as major mining houses have internationalised their operations and new players have entered the market".
The main players in coal mining according to Ebehard (2011: 5) remain to be:

- "Anglo-American, coal mining: has been dominating the coal sector for many years as South Africa's largest company, has its origins in gold mining and remains a major coal producer.

- Another multinational company currently involved in the coal sector in South Africa, Xstrata, has its origins not only in Swiss capital (Glencore) but also Lonrho's mining interests in Southern Africa (Duiker Mining).

- The third major current coal company, BHP Billiton, stems in part from General Mining or Gencor (which absorbed Trans Natal collieries and Rand Mines), which became Billiton, which later merged with Australia's BHP.

- After the Afrikaner nationalists came into power in 1948, there was a conscious attempt to bolster Afrikaner capital as a counterweight to English —colonialǁ mining capital. Gencor was one of the products of this initiative".

Mohamed (1999) argues that South Africa requires policies that restructure the economy in a way that shifts the core of the economy away from mining and minerals related activities toward more labour intensive and employment creating, downstream and value-added industrial activities. Future policies could be combined with interventions in electricity supply to provide a mix that provides economic development, social sustainability, and both local and global environmental benefits (Winkler, 2007).

3.1.2 The role of coal powered power stations

Coal has propelled South Africa to be the highest electricity generator on1 the African continent. South Africa's energy needs are expected to be fuelled by coal for the foreseeable future. Future energy mix projection still highlights the dominance of coal usage in future including exporting coal to international markets (Hall, 2013). "South Africa's electricity generation capacity is expected to increase from approximately 44 00MW to 80 000MW between 2012 and 2030 to meet the projected demand growth; the projected electricity consumption rate is estimated to increase by an average of 2.7% per annum over the next nine years" (KPMG, 2014: 31). Coal fire power stations provide a reliable base load that can be depended on during peaking power required to meet the daily (morning and evenings) and seasonal (winter) peaks when most power is required from the grid network. Currently about 85% of installed capacity comes from 13 coal-fired power plants, many located immediately adjacent to privately owned coal mines (Baker et al., 2015: 10).

3.1.3 Major constraints on transitioning away from coal

The coal mining sector and the energy intensive industries contribute to employment and any discussion that seeks to abandon the coal industry receives a hostile response from employees and their representatives in the form of organised labour. The prospects of decarbonisation that can curtail the usage of coal can affect the survival of labour unions and they are not keen to negotiate their own demise. Baker et al. (2015: 10) argue that "while parts of organised labour provide a progressive voice on climate change mitigation policy, environmental justice and a just transition, such statements do not appear to have any real impact given the realities of the carbon-intensity of many important labour union sectors".

South Africa collects a considerable amount of revenue from coal exports, "it is the third largest commodity export earner (after platinum and gold)" Ebehard, 2011: 29). The revenues that are obtained contribute substantially to the Gross Domestic Product (GDP). Transitioning away from coal can have substantial impact on the mining sector as a whole and the country cannot afford to lose the revenues derived from this sector. Coal exports has its own challenges that pertains to infrastructure, Ebehard (2011:1) indicate that "South Africa has substantial coal reserves and there is scope for expanding its coal exports, and reducing the country's negative trade balance and current account deficit, however, increased coal exports face serious barriers and obstacles including:

- Inadequate rail capacity to the coast
- A lack of planning and investment coordination between privately owned mines, state-owned rail infrastructure and
- Inefficient port capacity".

Another constraint regarding a contemplation of a shift from coal includes the increase in electricity prices. Higher electricity prices can affect investment which can have a direct impact on economic growth. Coal is among the minerals that have been a catalyst to the industrialisation of Swilling, Musango and Wakeford, (2015: 40) cautions that "shifting away from coal to other sources of energy has to take into account coal's entire value chain and inter-linkages with other parts of the economy that lie outside of the mining and the electricity sectors". Coal is abundant and it is a cheap source of energy in South Africa.

3.1.4 The climate change crisis and the South African position

South Africa is one of the major greenhouse gases emitter on the continent mainly due to a high dependence on coal to generate electricity. "It is amongst the twenty most carbon-intensive economies in the world, global warming and other environmental concerns are beginning to constrain further local coal-based investment decisions" (Ebehard, 2011: 1). South Africa has been an active participant in global warming debates and there is consensus around the world that the biggest source greenhouse gases is coal burning during coal powered electricity generation. Six gases contribute to global warming according to Marchal et al. (2011: 9) "they are responsible for the bulk of global warming and of these, the three most potent are carbon dioxide (CO2), methane gas (CH4), and nitrous oxide (N2O) currently accounting for 98% of the GHG emissions covered by the Kyoto Protocol.

The other gases are hydro fluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) which account for less than 2%". There are various projections in terms of the impact resulting from global warning. Africa will be one of the hardest hit by global warming according to research on global warming. Marchal et al. (2011:21) "project that in Africa: by the year 2020, between 75 and 250 million people will be exposed to increased water stress; yields from rain-fed agriculture could be reduced by up to 50% in some regions by 2020; agricultural production, including access to food, may be severely compromised".

Evidence of water shortages are currently being observed in many parts of the African continent including parts of South Africa, the current persisting drought in the Western Cape is a typical example. South Africa is under pressure to reconsider its dependence on coal. There are many initiatives that the country is considering in order to integrate other energy sources into the energy mix, particularly with a focus in the renewable energy sector including introduction of technology that captures greenhouse gases in coal fired power stations.

“South Africa’s energy needs are still mostly met by coal and oil with only a small percentage of the energy consumption mix comprising of natural gas, hydroelectric power, biomass and nuclear” (Donev, van Sark, Blok and Dintchev, 2012: 3004). Developing countries like South Africa, has too many other pressing issues to deal with besides the investments in curbing green houses that contribute to climate change, such as chronic poverty, corruption/governance, disease like HIV/AIDS, etc. Abanda, Ng’ombe, Keivani, and Tah (2012) argue that Africa must focus on renewable energy investments to address environmental impacts.

3.1.5 Reconfiguration of the energy mix in South Africa

Pressure from climate change forums has necessitated the need for South Africa to reconsider its options regarding the energy supply sources in the country. The government of South Africa has defined strategies to increase power generation capacity through the Integrated Resource Plan in 2010 and the updated 2013 plan. “The plan also includes changing the country’s electricity generation mix from high coal dominance (85%) to a moderate one (48%), that will include a high level of renewable energy and also nuclear power plants”. (KPMG, 2014: 31). Decarbonisation of the energy sector and introduction of new energy sources will inevitably affect Eskom’s operations as a monopoly electricity supplier in the country. Baker et al. (2015: 14) caution that any shift towards decarbonisation of the electricity sector would significantly affect the coal sector and the South African economy more broadly, these shifts are likely to cause conflict between firms, Eskom and the state” (Baker et al., 2015: 14).

According to Eskom’s integrated results (2017:1) “Eskom currently has a total nominal capacity of 44 134MW; 36 441MW is generated from coal power stations; 1 860MW is nuclear power; 2 409MW from gas fired power stations; 2 724MW from pump storage stations; 600MW from hydro stations and 100MW produced at Sere wind farm”. Coal power stations still generate more electricity in South Africa and also sell some electricity to neighbouring countries.

Policy makers are faced with a dilemma in terms of reconfiguration of the energy mix in South Africa. Ebehard (2011: 29) argues that a number of key policy questions remain unanswered and chief amongst these are the issues that pertains to:

- South Africa's carbon intensive economy and its potential future exposure to international climate change treaty commitments aimed at reducing greenhouse gas emissions.

- South Africa's commodity exports, whose production currently depends on coal-based electricity, may face carbon tariff barriers by its major trading partners. These possible future developments have a direct bearing on investment decisions around additional coal-fired stations.

Decisions pertaining to the future of power stations will have a direct influence on coal FA waste management challenges in the South African power generation sector and possible recycling opportunities. Introduction of energy from green energy sources like the sun and water will reduce the fleet of coal fired power stations leading to a reduction of coal ash generation. Ash handling is particularly a challenge in aging power stations that are more likely to be retired due to the increase in the introduction of megawatt in the grid from renewable energy sources.

3.2 Debates on Transition to a Cleaner Energy Production

Scholars have been debating a transition to cleaner energy production from time in memorial. "The majority of national governments have consistently made it clear that they do not want to sacrifice growth for the environment and in the face of an increasing realisation of the planetary limits to growth, they argue that it is not the amount of growth that matters, but the type of growth" (Bell, 2016: 74). Social justice demands that all households have access to energy; ecological sustainability demands that it should take the form of safe, clean, affordable and non-polluting energy (Holm and Tauning, 2002; Baker et al., 2015). Three main approaches to facilitate a transition have been at the centre of the debate and they are discussed below:

3.2.1 Ecological Modernisation theory

The ecological modernisation theory appreciates the technological changes as inevitable changes that provide solutions to ecological crisis. At the core of ecological modernisation theory is the idea that “modern society has the capability to establish institutions and develop technology that may solve the ecological crisis” (Holm and Tauning, 2002: 2). This theory concedes that ecological or environmental crisis should be addressed by the changes that that modernisation brings to the institutions that are created by modern society (Spaargaren, 1997). Ecological Modernisation theory scholars believe in change that have to be adapted to, in order to address pollution impacts.

“This belief is due to the understanding that a new form of modernisation can unify economic growth and environmental improvements whereby environmental problems become an impetus for improved economic growth and environmental problems are solved by technological and institutional innovation” (Holm and Tauning, 2002: 2). Environmental management plans/ programmes and risk management initiatives support the principles that are being advanced by the Ecological Modernisation Theory. Mol and Sonnenfeld (2000: 1) argue that that “from the initial contributions onwards, the aim of the Ecological Modernisation Theory has been to analyse how contemporary societies industrialised deal with environmental crises”.

3.2.1.1 Historical development of the Ecological Modernisation theory

“Ecological Modernisation Theory has been developed decades ago,initially in the early 1980s primarily in a small group of western European countries, notably Germany, the Netherlands and the United Kingdom (UK). Social scientists such as Martin Janicke, Volker von Prittwitz, Udo Simonis and Klaus Zimmermann (Germany), Gert Spaargaren, Maarten Hajer and Arthur P.J. Mol (the Netherlands) and Albert Weale, Maurie Cohen and Joseph Murphy (UK) made substantial contributions to this scholarship” (Mol and Sonnenfeld, 2000: 4). This theory is particularly relevant to Eskom’s role of electricity production in South Africa because of its emphasis to on the role of institutional actors within the sphere of production in bringing about sustainable development, in a sense. The incorporation of Environmental Management systems (EMS) in the daily management of environmental risks at Eskom’s power stations is an alignment to this theory.

During its development, institutional actors or the so called 'target groups' formed the most central objects of concern, the list of target groups included in the list of target groups, consumers and also small company holders were not among the central concerns of environmental policy-makers at that time (Spaargaren, 1997). “Since the mid-1990s, the frontier of Ecological Modernisation Theory has broadened theoretically and geographically to include studies on the ecological transformation of consumption; ecological modernisation in non-European countries (newly industrialising countries, less developed countries, the transitional economies in Central and Eastern Europe, but also OECD countries such as the USA and Canada); and global processes. Works in the present volume fit squarely in this third phase of Ecological Modernisation Theory” (Mol and Sonnenfeld, 2000: 5).

3.2.1.2 Core themes of the Ecological Modernisation theory

Crowley (1999: 1014) indicate that “the ecological modernisation is an emergent term that appears in the first instance to have served as a means for pursuing socio-political discussions about the institutional changes necessary in Western industrialised countries for overcoming the ecological crisis”. Ecological Modernisation theory has contributed significantly to the development of many disciplines in the natural sciences field, by studying these processes of environmental reform on different levels and in different segments of social life, sociologists have a pivotal contribution to make to the environmental sciences and to environmental politics (Spaargaren, 1997). Mol and Sonnenfeld (2000: 11) argue Ecological Modernisation Theory is useful for social scientific analysis and policy formation, even where all conditions for development of ecologically modern institutions do not yet exist.

In South Africa, the coal electricity generation sector is at a critical juncture that will affect its survival. Government needs to intervene through policies and legislation. “The central feature of the ecological modernization approach as a theory of political modernisation is its focus on new forms of political intervention, the changing role of the state” Holm and Tauning (2002: 2). According to Spaargaren (1997:34) “the ecological modernisation theory’s main achievement was to provide new concepts to think through the relationship between economy and ecology, between society and its sustenance base”.

3.2.1.3 Critical views on the Ecological Modernisation theory

The Ecological Modernisation theory has contributed in the field of environmental management substantially, particularly the management plans and tools that incorporate consumers and other stakeholders in the production environment. Being a relatively new theory, Mol and Sonnenfeld (2000: 12) argue that it should not surprise us that numerous issues remain to be elaborated and addressed by the Ecological Modernisation theory, key outstanding issues include:

- “The nature of requisite political and institutional cultures for successful (and 'reflexive') ecological modernisation;
- The varying role and importance of environmental and other social movements and non-governmental organisations in ecological modernisation, especially in countries with weaker histories and institutions of popular participation;

- Global and domestic inequalities in capacities to establish and maintain ecologically modern institutions, technologies, and practices; and the dialectics of globalisation in its various outlooks and dimensions, and ecological modernisation.

Some problems of this theory according to Pepper (1998: 3) include:

- First, some of the environmental improvement which has been achieved has come at a cost of displacing environmentally harmful activities to newly industrialized and less developed countries, an example is: In the mid-1990s a rising amount of publicity about the steady flow of toxic wastes from Western countries to India, for instance.

- Second, neither the technological adjustment nor policy discourse aspects of Ecological Modernisation necessarily diminish total resource consumption, which is what radical environmentalists demand.

- Third, Ecological Modernisation theory is currently conceived as only ‘weakly ecological’, for it is economically reductionist, attempting to monetize the environment.

- Fourth, it is not truly international and holistic. It does not take into its accounting the kinds of displacement cost, nor the environmental/social costs of so-called 'efficiency gains' through globalisation of the economy and so-called 'comparative advantage' in trade. These often do harm to indigenous economies and cultures".

3.2.2 A just transition theory

A just transition theory is one of the relevant theories that explains the dilemma of transition due to the climate change and global warning imperatives all over the world. Decision makers are faced with the realities of job losses and livelihood destruction because of the continued dependence on fossil fuels. Rosemberg (2017:1) describes the concept of just transitions as a "strategy aimed at protecting those whose jobs, income, and livelihoods are at risk as a consequence of climate policies, or more broadly as the world pursues more sustainable pathways presents the advantage of engaging with those workers and communities most affected, giving them an active role in rethinking their future".

The just transition theory has a strong link with the Ecological Modernisation because both theories are inclusive in their analysis of the institutions and their roles, the role of the state is analysed as just one element among a variety of initiatives and strategies developed in modern society to bring about environmental reform (Spaargaren, 1997). Both theories support cleaner production that enhances the health and wellbeing of society. They advocate for a transition to cleaner production that should not be at the expense of employees and local communities. The opportunity to address the needs of local communities who reside and depend on production plants exist and this can be forged through interventions like policies and legislation. Such efforts should include address not only employment but the socio economic needs like housing, health education, etc (Childs, 2011).

3.2.2.1 Emergence of the concept of just transition

Labour unions have been at the centre of the debate about the fate of employees after organisations ceases or scale down their activities due to climate change commitments and compliance requirements. A just transition concept begin in the 1990's when North American labour unions began developing the concept of just transition.

“Initially, trade unionists understood just transition as a program of support for workers who lost their jobs due to environmental protection policies” (Just Transition Centre, 2017: 2). The true meaning of a just transition was missed when it was advocated initially, for many it was all about job losses. Scholars who embraced the concept faced a difficult task to reconcile loss of employment opportunities with the need to protect the natural environment. “The first references to the concept of just transition appeared in the North American trade union movement” (Rosemberg, 2017:6).

“Global warning and climate change debates around the world was interpreted based on the position and commitment of the persons that were interested in the matter and as understanding of the climate crisis grew, unions began to tie just transition specifically to action on climate change” (Just Transition Centre, 2017: 3). The global climate movement has started to develop its own definitions and approaches to the just transition concept, there are those who only focuses narrowly in the energy generation sector and specifically fossil fuels (Childs, 2011; Rosemberg, 2017; Just Transition Centre, 2017).

In many countries around the world, transition for some means deriving energy from green energy sources, particularly renewable energy (Hamilton, Valova, and Rábago, 2017). The imperatives of addressing climate change and employment opportunities requires that these challenges are not dealt with separately but jointly to ensure that there is harmony between employees and their employers and the environment can receive maximum protection. North and Longhurst (2013) reveal that politicians implementing low carbon initiatives because they have not shown any decisive efforts that can assist to overcome barriers and challenges associated with the envisaged low carbon future. In terms of opportunities and challenges, the International Labour Organisation (2015: 5) indicates that, “in the transition to environmentally sustainable economies and societies, the world of work can benefit from some major opportunities, for example:

(a) Net gains in total employment from realizing the potential to create significant numbers of additional decent jobs through investments into environmentally sustainable production and consumption and management of natural resources;

(b) Improvements in job quality and incomes on a large scale from more productive processes, as well as greener products and services in sectors like agriculture, construction, recycling and tourism;

(c) Social inclusion through improved access to affordable, environmentally sustainable energy and payments for environmental services, for instance, which are of particular relevance to women and residents in rural areas faces some major challenges;

(d) Economic restructuring, resulting in the displacement of workers and possible job losses and job creation attributable to the greening of enterprises and workplaces;

(e) The need for enterprises, workplaces and communities to adapt to climate change to avoid loss of assets and livelihoods and involuntary migration; and

(f) Adverse effects on the incomes of poor households from higher energy and commodity prices".

3.2.3 Green economy theory

Since the inception of the ecological modernisation theory a number of theories were crafted to address its shortcomings, to some extent other theories were crafted as an expansion to Ecological Modernisation theory. Kenis and Lievens, (2016:4) argue that "the green economy is a topic of interest as it has affinities with the ecological modernisation or transition management theories. The green economy theory is positioned as an intervention to appreciate the dynamics of the economy, social and environmental protection sphere". The arguments that are postulated by this theory focused largely on the economy unlike the ecological modernisation and the just transition theories. Bell (2016: 73) indicate that "green economy is not an entirely new approach but, with the multiple crises of recent years, governments, policy-makers, businesses and policy-influencing groups have become particularly interested in the concept of late because of its inherent promise to kick start sluggish economies".

The central theme of the green economy theory is clean energy and the emphasis is on development that hinges on economically, socially and environmentally sustainable impetus (Swilling, Masango and Wakeford, 2016). Definitions of green economy vary, according to the Centre for Community Innovation [CCI], (2008:1) "at its most basic level, the green economy is the clean energy economy, consisting primarily of four sectors: renewable energy (e.g. solar, wind, geothermal); green building and energy efficiency technology; energy-efficient infrastructure and transportation; and waste recycling".

The green economy emphasise the balancing of all needs in order to derive the benefits of economic growth. Heshmati (2014) observes that the green economy was introduced as a model, claiming that sustainable economic growth requires clean energy that is achieved through a balance between the management of environmental impacts and economic growth. Swilling, Masango and Wakeford (2016) expand the scope of the green economy in their definition as not just about the ability to produce clean energy, but also technologies that allow cleaner production processes, as well as the growing market for products which consume less energy and services that reduce environmental impact or improve natural resource use.

The drivers of green economy has been widely debated, at the heart of debates is whether clean energy can drive economies that have largely been built through fossil fuels. Kenis and Lievens, (2016) challenges the proponents of fossil fuels and argues that economy will create new jobs, underlying in the idea that a sustainable society will possibly more strongly rely on labour-intensive activities, instead of replacing human labour by fossil-fuel driven machines. Economic growth must be inclusive in order to be sustainable, the debate amongst green economy scholars have been the question of equitable economic growth that enhances the social cohesion and environmental protection.

The proponents of green economy concur that green economy initiatives must be equitable to all stakeholders, example: workers; communities; authorities and business owners. Teklemariam et al. (2015: 788) assert that “stakeholders must be considered, and their genuine participation is a requirement for inclusive deals including: protection of vulnerable groups, i.e. local economies, social fabric, and cultures, is also a basic need among the biophysical environment, stakeholders, governance, and institutions in the context of competitive land use is essential”. Fossil fuels energise economies in most parts of the word; a transition to cleaner energy is a pipe dream for developing countries.

Access to energy is generally a challenge for developing countries, Jayanti and Gowda (2014) argue that in general, emerging markets lag behind developed economies in environmental stewardship, because they have more pressing issues related to the socio economic situation of their citizens in relation to basic services delivery. Countries that are energised by fossil fuels find themselves in a dilemma and South Africa is no exception.

Swilling, Musango and Wakeford (2016: 39) observes that South Africa's energy and resource-intensive growth path can be summarised to be unsustainable for four major reasons:

- "Economic activities often have large environmental impacts in terms of air, water and land pollution, and threats to ecosystems and biodiversity.
- Non-renewable natural resources are being depleted.
- Our long-term investments in outdate fossil-fuel based infrastructure locks us into unsustainable resource use patterns.
- The current path is not adequately creating jobs and alleviating poverty and inequality".

Factors that influence governance of green economy programmes in developing countries like South Africa have not been researched adequately and specific enabling conditions will be required. These enabling conditions consist of national regulations and policies as pillars of the green economy transition. This will require not only transformation of technologies, modes of production and consumption patterns, but also greater justice and democracy, empowerment of marginalized groups and active collaboration and dialogue in tackling social problems and crises (Musango, Brent and Bassi, 2014).

Green economy initiatives have largely been described in broad terms, Eberts (2011: 6) attempts to identify products and services that meet one of several criteria of a green economy to include: "environmentally friendly and enhancing products and services; renewable energy products and services; clean transportation and fuels; green building; energy efficient manufacturing, distribution, and construction; reduction of energy, materials, and water consumption through high efficiency strategies and switch from carbon to non-carbon components". The discussion about what the green economy entails has been raging for years. A transition to clean energy economy cannot take place without a shift from fossil fuels as a source of energy; therefore, decarbonisation in the electricity sector cannot be achieved without reducing the absolute contribution of coal-fired power at the same time as integrating a range of low-carbon energy supply from green energy sources (Baker et al., 2015).

Musango, Brent and Bassi (2014: 260) outline the policies, strategies and plans linked to green economy in South Africa namely:

- “2009 SA framework for responding to economic crisis
- 2009–2014 Medium Term Strategic Framework and 12 Outcomes
- National Green Economy Summit and Programmes Report
- New Growth Path, Green Economy Accord and Green Jobs Report
- Industrial Policy Action Plan (IPAP-2)
- National Strategy for Sustainable Development and Action Plan (NSSD1)
- National Climate Change Response Policy
- National Development Plan Vision 2030
- Science and Innovation Plan
- Integrated Resource Plan & Integrated Energy Plan
- Environmental Fiscal Instruments (e.g. carbon tax, green fund)
- National Skills Development Strategy
- National Water Resource Strategy
- National Waste Management Strategy”.

Smit and Musango (2015) infer that for the South African green economy to be inclusive and socially just, it would need to engage with the mass of disenfranchised individuals in a way that empowers and reinforces participation and sustainable livelihoods. Furthermore they argue that, a more open and enabling policy environment could greatly assist the transition to an alternative economic model, which may be more conducive to socially equitable and environmentally sustainable development (Smit and Musango (2015). Nhamo (2013) contends that governments and organisations that are found to be green economy ready are those that have invested considerable resources to address the key pillars of sustainable development.

Such governments have environmental and other social aspects engraved in their constitutions, they have environmental management or conservation acts in place, along with sustainable development strategies, skills development policies and acts, biodiversity and air pollution acts, water acts, and many more and such conformity may be considered to constitute first-order green economy readiness. Green jobs are found in many sectors of the economy from energy supply to recycling and from agriculture and construction to transportation, they help to cut energy, raw materials and water consumption through high-efficiency strategies, to decarbonise the economy and reduce greenhouse-gas emissions, to minimise or avoid altogether all forms of waste and pollution, to protect and restore ecosystems and biodiversity (CCI, 2008).

3.3 The Selected Theoretical Framework of the Study

The frameworks adopted for this study are the environmental justice framework and a just transition theory. The environmental justice framework focuses on the health impacts of FA to the community. This involves the investigation of the effects that are affecting the community in the form of air pollution, water contamination and the impact to their livelihoods. Interviews with the local communities; NGO's, Eskom and government's practitioners had questions that elicited responses about the impact of FA to the community. A just transition framework focused on the potential FA recycling opportunities that included analysis of the barriers impeding community's involvement in FA recycling projects. Interviews with ash recyclers; NGO's, Eskom and government practitioners elicited responses about the impact of fly to the community.

3.3.1 Communities environmental justice

Movik (2014) states that South Africa has multiple dimensions of environmental justice, both in terms of the human rights perspective, for example: the right to water as a necessity of life and the right to a healthy environment in terms of distribution of resources. South Africa is one of the countries that have intensive mining activities. Migration, particularly of black people to mining areas has rendered many communities to live in squalor. Coal power generation activities have added to pollution that communities experience in mining areas.

“Black South Africans continue to live on the most damaged land, in the most polluted neighbourhoods often adjoining mine dumps, waste sites or polluting industries, without adequate services of refuse removal, water, electricity and sanitation” (Cock, 2014: 4). Agyeman and Evans (2004: 155) observe that “the environmental justice discourse has matured, it has become increasingly evident that it should play a role in the wider agenda for sustainable development and social inclusion”. It is imperative that the focus for environmental justice is on economic inclusion that ensures that communities are not forced to endure pollution and risk to their health and wellbeing because they are looking for opportunities, they must be located in areas that are socially just and ecologically sustainable (Outka, 2012).

Schlosberg, (2004: 523) strongly argue that “communities must be empowered to challenge a range of cultural, political and structural obstacles constructed by cultural degradation, political oppression, and lack of political access to ensure that the injustices of exposure to pollution is addressed”. The previous chapters have alluded that FA generated from coal-fired power stations can pose environmental and health risks associated with the release of heavy metals and inhalable particulate matter. FA contains heavy metals, which are naturally present in coal and subsequently concentrated through the combustion process (Zhu, 2011). This study is investigating whether the environmental justice of the local communities is compromised.

3.3.2 A just transition

Climate change has worsened the poverty levels for many communities in the world. In this study a just transition is adopted in the context that transition is not only a shift to clean energy to secure employment but also include aspects resources efficiency and redistributive measures that reduce inequality and eradicate poverty (Swilling, Masango and Wake ford, 2016). Pelletier (2010: 20) infers that, “in terms permeating contemporary environmental governance regimes one finds them fundamentally incompatible with the requirements of environmental sustainability, transitions focus largely on the economic situations of communities and neglect the socio economic situations of communities”. “In South Africa, more and more cost effective clean energy resources, such as wind and solar, continue to increase in availability and are poised to maintain grid reliability despite the closure of aging and inefficient infrastructure in the electrical power generating sector” (Hamilton, Valova and Rábago, 2017: 70).

This study examined the potential of a just transition with an overall goal based on local communities wellbeing (income, education and health) within a sustainable environment (decarbonisation, resource efficiency and ecosystem restoration (Swilling, Musango and Wakeford (2016).

3.4 CONCLUSION

The literature review has exposed the contemporary situation regarding evolution of the MEC economy and major constraints affecting a transitioning away from coal. Literature also revealed the fact that, due to the discovery of coal, the South African economy remains a MEC economy in character. The environmental impact of FA to local communities is a challenge that is well documented in literature. The chapter examined the relevance of the environmental justice framework in the context of the study. The chapter also examined the relevance of a just transition theory to clean energy production through FA recycling. The other frameworks that were discussed are the Ecological Modernisation theory and the green economy framework. The chapter is concluded by a selection of two theoretical frameworks that are used to analyse the research results. The selected frameworks are the Environmental justice and a just transition.

4 CHAPTER FOUR- Research Methodology

A research methodology is the general approach that the researcher takes in carrying out the research project, to some extent, this approach dictates the particular tools the researcher selects (Leedy and Ormrod, 2005). This chapter provides information on how the research design is executed. These include data collection methods, population, sampling methods and how the research instrument is designed. The researcher is an employee of Eskom's Hendrina Power Station where the researcher works in the capacity as an Environmental Manager. The researcher is involved in the day to environmental management responsibilities in the power station. It was practically easy to identify the various categories of respondents that include local communities, ash recyclers, NGOs and environmental/ engineering practitioners who are role players in ash management and recycling because of the role of the researcher in the coal power generation sector.

4.1 Case study research

Leedy and Ormrod (2005: 135) states that "in case study research, the researcher collect extensive data on the individual (s) , programs (s), or event (s) on which the investigation is focused and the data often include observations, interviews, documents, past records, audio visual material. The researcher also records the details about the context surrounding the case, including information about physical environment and historical, economic and social factors that have bearing on the situation". The data collection methods that were followed in this study include: observations, interviews, review of documents pertaining to the two power stations (Blumberg, Cooper and Schindler, 2008). Data from the respondents located in the vicinity of the two power stations were categorised and interpreted in terms of common themes and conclusions were drawn regarding the pollution impact of ash disposal facilities in the two power stations (Leedy and Ormrod, 2005).

Blumberg, Cooper and Schindler, 2008 argue, that investigation of an issue in more than one context (i.e case) is better than basing the results on just one case. Two power stations were selected: Hendrina Power Station and Kendal Power Station. Both power stations have recently been involved in Environmental Impact Assessments (EIA) to construct new ash dumping facilities due to the capacity of their current dumping facilities being reached.

The published EIA information and concerns raised during public participation by interested and affected parties were also analysed in the context of establishing the nature of impact that communities are apprehensive about pertaining to the two ash dumping facilities operations. The two power stations were selected because they have distinct differences. Hendrina is part of Eskom's old fleet and at the time of the research, no ash recycling activities were taking place; Kendal is a modern base load power station that sells some of its FA to established cement producers. Hendrina uses a Wet ashing system contrary to Kendal that uses a Dry ash handling system. The researcher analysed the information that pertains to the two methods of handling ash and the associated impacts. Leedy and Ormrod (2005) state that if a researcher studies two or more cases, and often the cases are different in certain key ways, such an approach is called a multiple or collective case study. The two power stations were selected amongst Eskom's 15 coal fired power stations. The location of the two power stations is shown in Map 1 and 2.

4.1.1 Hendrina Power Station

The Eskom website (http://www.eskom.co.za/sites/heritage/Pages/Hendrina-Power-Station.aspx: sourced: 04 January 2018) states that Hendrina Power Station is approximately 40km south of Middelburg in Mpumalanga. It came into operation between June 1970 and December 1976. When it was built, it had the longest turbine hall of any Eskom power station. Hendrina Power Station is located at Pullenshope (near Hendrina town) in the Mpumalanga Province and falls within the Steve Tshwete Local Municipality which falls within the Nkangala District Municipality. Hendrina Power Station currently uses a wet ashing system for the disposal of ash. A wet ashing system entails the hydraulic conveyance of ash where ash is mixed with water and pumped in the form of slurry via steel pipelines. The slurry is allowed to settle in the ash disposal facility, and the water decanted to storage dams for re-use as shown in photo 2 and 3 below.

Photo 2: Hendrina Power Station ash dumping site



Photo 3: Hendrina Power Station ash dumping site (ash dam 1)



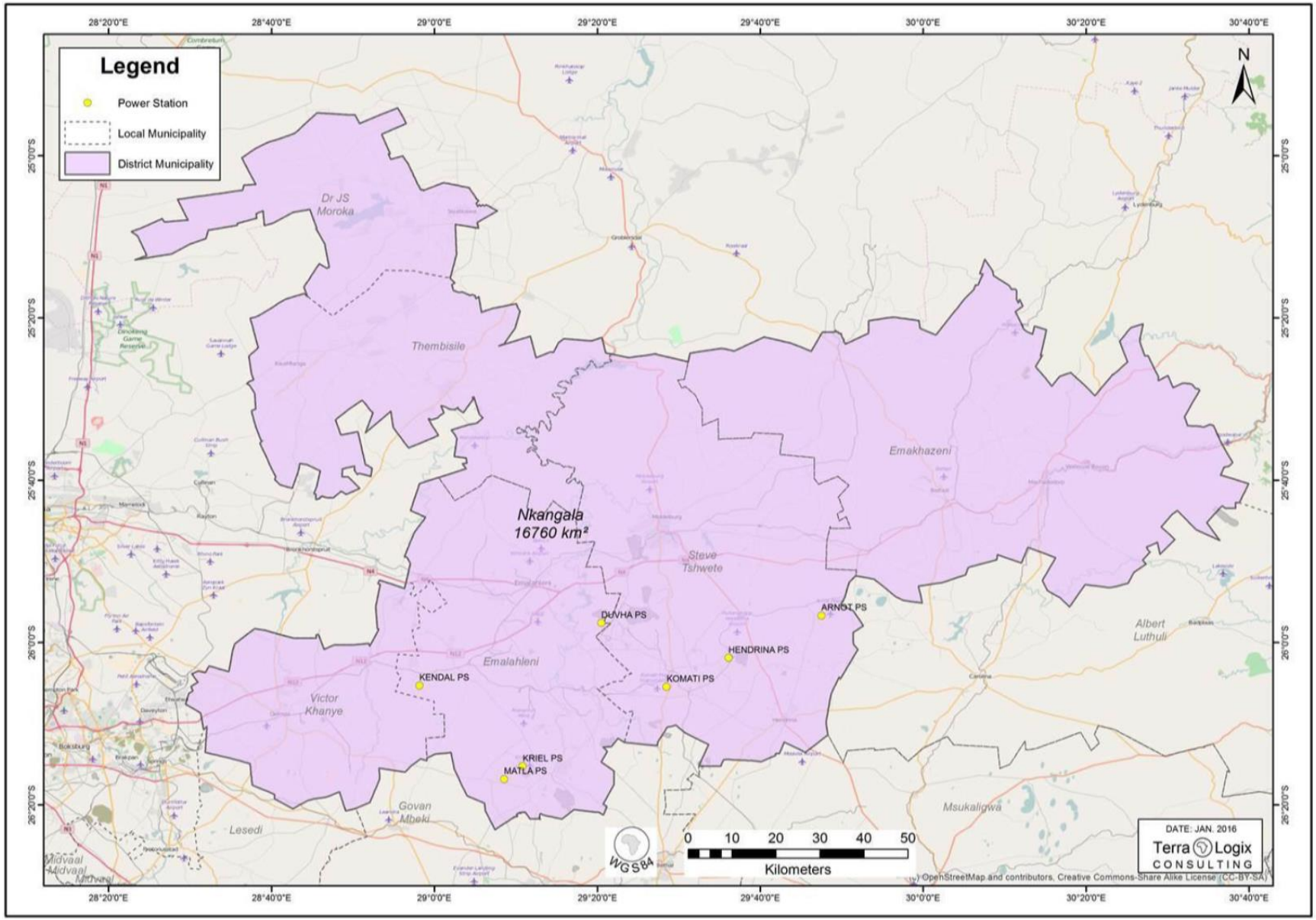
4.1.2 Kendal Power Station

The Eskom website (http://www.eskom.co.za/sites/heritage/Pages/Kendal-Power-Station.aspx: sourced: 05 January 2018) states that “construction started at Kendal Power Station in July 1982. On completion in 1993 it became the world's largest dry- cooled power station. Kendal is designed to generate approximately 4000 MW. Kendal has an indirect dry-cooling system, which means that it uses significantly less water in its cooling processes than the conventional wet cooled power stations. The station's cooling towers are the largest structures of their kind in the world with a height and base diameter of 165m”. Kendal Power Station is located approximately 40km southwest of Witbank in Mpumalanga. It falls within the Emalahleni Local Municipality which falls within the Nkangala District Municipality. Kendal Power Station currently uses a dry ashing system for the disposal of ash, shown in photo 4 below.

Photo 4: Kendal Power Station ash dumping site

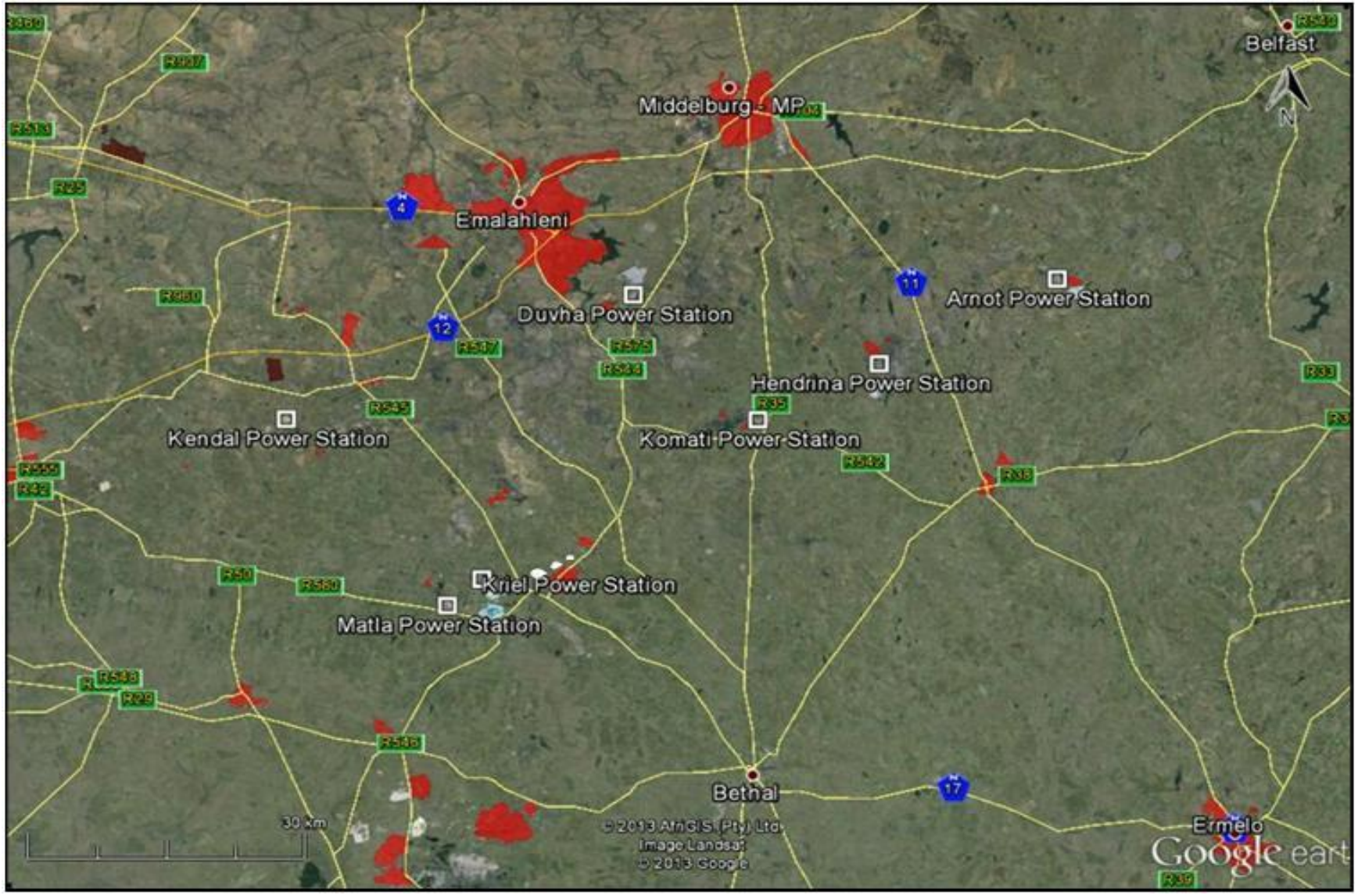


Map 1: Hendrina and Kendal Power Stations and their respective locations in Nkangala district municipality



Source: EkoInfo CC & Associates (2016: 34)

Map 2: Hendrina and Kendal Power Stations relative to other stations in Nkangala district



Source: Google Earth (2017)

4.2 Mixed Methodology Approach

The research followed a mixed methodology design by employing both qualitative and quantitative approaches. By adopting multiple research techniques, the researcher intended to create a set of complementary data gathering activities that compensate for the weaknesses of an individual methodology (Lee, 1999). A qualitative approach was conducted in order to elicit views of all stakeholders including individual community members about their experiences and perceptions regarding the impact of FA to the natural environment and their well-being. It also explored whether the interventions that are currently being employed in the two selected power stations to minimise the impact of FA are yielding positive results. Quantitative research design constituted phase two of the research with the purpose to expand on the feedback that was received from the qualitative phase and to gauge the views of a larger population of respondents.

4.3 Research methods table

This section is aimed at describing the research design stages, providing details about the nature of empirical evidence required to address the main research question and sub questions to achieve the research objectives. A research design constitutes a blue print for the collection, measurement and analysis of data (Blumberg, Cooper and Schindler, 2008). In order to answer the primary research question, sub-questions are tabulated with the research approach to be followed. The primary research is stated as follows: “How can the management of FA waste from coal fired power stations be improved to minimise the negative impacts and enhance potential benefits?” Table 4.1 illustrates the research sub-questions and methods followed by the research to address them.

Table 4.1: Research sub-questions and the methods allocated to them

STEP	RESEARCH QUESTIONS	METHODOLOGY
1	What impacts are FA disposal facilities having on the natural environment and neighboring communities?	Qualitative research: Semi structured interviews. Individuals and focus groups of local communities; environmentalists; engineering practitioners; recyclers and NGO's.
2	Which interventions can be employed to ensure that FA recycling opportunities benefit local communities in South Africa?	Quantitative research: Structured interviews using a survey questionnaire to ash recyclers; environmentalists; government officials and NGO's.
3	What are the prospects of a just transition to clean energy sources and environmental justice through FA recycling	Qualitative research: Semi structured interviews to individuals and focus groups of ash recycler's; environmentalists; engineering practitioners and NGO's.

4.4 Exploratory Studies Approach

This study employed an exploratory research approach because of the limited research work that has been conducted and to include many stakeholders who are either interested or affected by coal ash generated from power generating activities. It was beneficial to adopt an exploratory approach, Blumberg, Cooper and Schindler et al. (2008) indicate that exploratory research help researchers to develop concepts more clearly, establish priorities, develop operational definitions of variables/ factors and describe concepts more objectively. Exploratory studies have several main advantages, which include providing an opportunity to the researcher to explore areas of research that have not been researched extensively and provides a platform to make an easy decision by the researcher to determine if it is important to continue with the research (Leedy and Ormrod, 2005).

4.5 Population to be studied by the Research

The composition of the targeted population proposed for this study included a sample of environmental/ engineering practitioners from coal fired power stations, non-governmental institutions, private companies, researchers, academics and associations aligned to environmental management and ash recycling. Environmental stakeholders are a challenge to identify, “their struggles have no coherent centre and no tidy margins; they constitute an inchoate sum of multiple, diverse, uncoordinated and fragmented struggles and organisations” (Cock, 2014: 23). Guided by literature reviews, the researcher explored the stakeholders that are interested and affected parties of coal ash management and recycling and approached them. Members of the association were sampled for both qualitative and quantitative phases of the study. The identified categories of respondents are listed below.

4.5.1 Eskom engineering and environmental practitioners

Ash handling and management is the responsibility of Engineering and Environmental practitioners at a power station. Practitioners were part of the population that were interviewed during both the qualitative and quantitative phase of the study. Only practitioners that are involved in coal-fired power stations were involved.

4.5.2 South African Coal Ash Association (SACAA)

Respondents were sought from SACAA. According to the SACAA website (2016), the aim of SACAA is to promote and encourage the utilisation of FA where it is technically feasible, sustainable and economically viable. Membership is open to individuals, companies, academia, non-governmental organisations, and regulatory authorities within government. Along with other international ash associations, the SACAA established the Worldwide Coal Ash Council (WWCAC) that provides members access to information.

4.5.3 Local communities

The population of respondents also included affected communities that reside adjacent to ash dump sites. Communities from Hendrina Power Station (farms steads).

Pullenshope village and an informal settlement next to the N11 road) and a community that reside in a settlement called Botha farm next to Kendal Power Station were interviewed to determine the impact of FA to the natural environment and their wellbeing. The focus was on local communities that reside adjacent to ash dumping facilities of the two selected power stations. The communities were only sampled for the qualitative phase of the study because some of them could not read and write and the majority had a limited understanding of the factors that influence ash pollution and the recycling activities associated with ash.

4.5.4 Non Profit and Non-Governmental Organisations (NGOs)

The study also included community based NGO's and Non Profit organisations that are interested and affected by ash management activities in the selected power stations. NGO's and labour unions that operate in the selected power stations were also included, including Solidarity; NUM and NUMSA. One of the prominent communities based environmental NGO in Mpumalanga is the Highveld Environmental Justice Network (HEJN), its members were interviewed. The HJN was established with a vision of promoting awareness and advocating for environmental justice within the Highveld and the country.

Members of the association were sampled for both qualitative and quantitative phases of the study. According to HJN (2014:1), their vision is to:

- "Seek to create unity amongst environmental and social justice, faith, labour, youth and other relevant organisations based in the Highveld in order to have a common voice on environmental justice issues;

- Be a platform of solidarity for local communities against environmental injustices relevant to the Highveld and/ or its people;

- Educate, organise and mobilise with organisations and public on environmental justice issues relevant to the Highveld and/ or its people;

- Respond to grass roots concerns on environmental injustices relevant to the Highveld and/ or its people".

4.5.5 Multi-Stakeholder Reference Group (MSRG)

The MSRG members were sampled as part of the study. The Department of Environmental Affairs (DEA) facilitates the functioning of the forum. According to DEA (2017) since the declaration of the Priority area, a number of steps have been taken to ensure that air quality management in the highveld is focused. The establishment of the Highveld Priority Area Air Quality Officer's Forum (AQOF) takes place regularly. Members on MSRG have meetings lead by the Environmental Department. The Highveld Priority Area Air Quality Management Plan is implemented at a local level, the local authorities (Nkangala) facilitate a forum named Nkangala Implementation Task Team (ITT). The forum implements all decisions that are agreed upon during the MSRG meetings. Both forums are composed of the authority; industry and interested and affected parties. Members of this forum were contacted to elicit their responses for both qualitative and quantitative phases of the research.

4.6 Qualitative Methodology

The qualitative phase constituted the first phase of the research. Secondary research, case study research and in-depth interviews were employed to conduct the qualitative phase of the study. The qualitative phase was particularly helpful in eliciting responses from local communities and NGO's. It is also involved interviews of government officials and environmental/ engineering practitioners. Interviews were conducted in isiZulu, Sesotho, and English but also varied in content and complexity depending on targeted respondent to ensure that the researcher understands the respondents' views and experience. The research is also focusing on the potential recycling opportunities that can benefit the local communities. The study also exposed the barriers that are affecting recycling of FA. The method for data collection was focus groups and unstructured questionnaires.

4.6.1 Secondary research

Relevant literature was reviewed and this included books, journals and articles about the impact of FA generated from power generation plants. The main aim of primary sources literature reviews was to establish the current status of the FA management in the energy sector particularly at Eskom. Relevant research work and studies conducted on the topic were also reviewed.

Non-academic published documents on the topic reviewed included annually published reports about FA, non-governmental bodies involved in the sector and fossil fuels stakeholders published research work. Comprehensive reviews of secondary sources were conducted using international and national data searches through the library of the University of the Witwatersrand. This also included reviewing research projects saved in the University's research data bases and research journals published on line by Science Direct and Google scholar internet search engines. The documents were analysed using a content analysis approach.

4.6.2 Method data collection

Interviews were arranged with different categories of respondents. Personal meetings enabled the researcher to be more flexible and to adapt the questionnaire whenever it becomes apparent that a particular individual wished to share personal experiences of relevance to the study. The sample sizes were small and selected on convenience basis. The questionnaire seeked to elicit the articulation of individual experiences and perceptions. Communities were visited during the day. At Hendrina, some of the respondents work in the vicinity of the power station. At Kendal, the majority of respondents were visited in their working area and their employer was requested to permit the interviews of his employees.

Eskom employees were emailed the questionnaires and some were physically met to complete the questioners in the presence of the researcher. Some members of NGO's were contacted and met at Witbank municipality offices, and the researcher requested some NGO members to handover some of the questionnaires to members who could not be met. ANNEXURE 1; 2; 3; 4; 5 are data collection questionnaires for the qualitative phase of the research.

4.4.2.1 Focus groups

A focus group entails a conversation between 4-10 people where the interviewer facilitates the discussion between the participants (Leedy and Ormrod, 2005). The main advantage of a focus group is that a researcher can engage with the respondents and get an understanding of how issues are debated between certain groups of people. The communities that were selected for this study are located close to ash dumping facilities, and the researcher was able to assemble a group of respondents at the vicinities of both Hendrina and Kendal Power Station

There were 6 respondents in total from Kendal and a group of 4 respondents at Hendrina Power Station. Focus groups from both power stations expressed experiences.

4.4.2.2 Semi-structured Interviews

A semi structured questionnaire was used during the qualitative research phase and it constituted phase one of the research. The researcher visited the community's sites particularly during windy days. At Hendrina power station, the researcher noticed that during windy days ash dust was lifted and dispersed on residential area particularly the community location (Southern side) adjacent to the ash dam. The wind direction did not seem to divert the ash away from the families. At Kendal Power station the extent of exposure to ash dust was influenced by the wind direction, the closest communities are located in the southern and eastern side of the ash dump facility.

The information obtained from phase 1 served as an input for a survey questionnaire that was used to conduct the quantitative phase of the research. Semi-structured interviews follow the general feel of an unstructured interview with an interview guide being the only crucial difference between the two (Leedy and Ormrod, 2005). The questionnaires listed all aspects of the research problem and the questions were specific to different categories respondents. A total of 74 respondents were interviewed for the qualitative phase of the research. Interviews started on the 22nd November 2016 and were finalised on the 30th March 2017.

A total of 19 community respondents gave feedback during the in depth interviews. They were interviewed from the 22th November 2016 – 03 March 2017. The communities interviewed reside adjacent to the two power stations. The majority of respondents have been living in these locations for a long time particularly around Hendrina Power Station. For example, there were a number of respondents who were pensioners and their ages ranged between 60- 98 years. They alluded to the fact that they were born in the area before the power station was constructed. Hendrina Power Station came into operation between June 1970 and December 1976. This renders the power station to have been in operation for more than 48 years from the first year of operation. The communities were eager to explain to the researcher their daily struggles pertaining to the air and water pollution in their vicinity

- A total of 26 NGO's respondents gave feedback during the in-depth interviews between the 20th December 2016 – 23 March 2017.

- A specific questionnaire was developed to elicit responses from NGO's respondents. The majority of respondents belong to HEJN non-governmental organization and 4 respondents are associated with labor unions.
- A total of 15 FA recyclers' respondents gave feedback during the in-depth interviews. They were interviewed from the 11th November 2016 – 08 March 2017. Ash recyclers that are involved in cement manufacturing, brick making and ceresphere extraction recyclers were interviewed, it included both established and emerging ash recyclers.

- A total of 14 Environmental and Engineering Practitioners respondents gave feedback during the in depth interviews. They were interviewed from the 11th November 2016 – 08th March 2017.

- Eskom's' environmental practitioners and engineers as well as academics were interview. Some respondents are directly involved in the management of FA pollution mitigation and disposal.

The majority of respondents were familiar with the legislative compliance requirements associated with FA. The breakdown of qualitative categories of informants are presented in Table 4.2 below.

Table 4.2: The breakdown of qualitative categories of respondents

No	Category	Number of respondents	Individual interviews/ Focus group
1	Local community	8	Hendrina individual interviews
	Local community	1	Kendal individual interviews
2	Local community	4	Hendrina focus group
3	Local community	6	Kendal focus group
4	Non Profit and Non-Governmental Organisations (NGO's)	26	Individual Interviews
5	Environmental/ engineering Practitioners	14	Individual interviews
6	Ash recyclers	15	Individual interviews
TOTAL		**74**	

4.7 Data analysis

Data analysis includes secondary data analysis, modelling and simulation studies, historical studies, content analysis and textual studies (Mouton, 2004). Data analysis for the qualitative research phase was conducted through grounded theory and content analysis approaches. Both approaches were found to be suitable given the detailed qualitative data obtained from the respondents through in-depth interviews. STATISTICA (data analysis software system), version 13.2 (www.statsoft.com) was employed for quantitative data analysis. Statistical analysis incorporated tests that were employed to test for internal consistency and reliability. It provided descriptive statistics for the whole sampled group of respondents, giving an overall statistical profile of respondents. Leedy and Ormrod (2005) indicate that, in the analysis of quantitative research data, characteristics are reduced to variables, which are analysed using statistical univariate and multivariate data analysis techniques. The analyses conducted were: Descriptive statistics; One-sample t-Tests and Chi-squared tests.

4.7.1 Grounded theory

Grounded theory is one of the theories that is decades old and has been applied in qualitative research approaches for many years. Strauss and Corbin (1998: 12) describe grounded theory as “theory that was derived from data, systematically gathered and analysed through the research process, data collection, analysis, and eventual theory stand in close relationship to one another”. This method of analysis is more inclined to large volume of qualitative data and social science researchers have found it to be a useful tool of data analysis. Grounded theory “was first formalised in the social sciences field and it typically begins with both a research situation and with data” (Glaser, 1998: 28). Grounded theory provides a platform to systematically analyse data that is not numeric and simplify text data to enable an easy deduction of themes of the views of the respondent.

This method was used to analyse the primary data obtained during in-depth individual interviews. The first step undertaken was to develop a spreadsheet where the identified themes, key words, key arguments, debates/ theories engaged and relevant policies and legislations were tabulated. Following that process, rows in a spread sheet were created for each theme that was identified to which relevant quotes were then allocated.

This method was found to be effective because it provided a structure for the results and discussion section in which key findings were made, as shown in Annexure: 10; 11; 12 and 13. Once this process was complete, key findings were engaged with the theories identified. This method proved to be effective because it also provided a structure for the results and discussion section and contained the themes that were identified and all the quotes and literature associated with a particular key finding. Charmaz (2006: 2) states that "grounded theory consists of systemic, yet flexible guidelines for collecting and analysing qualitative data to construct theories grounded in the data themselves". Grounded theory provided a platform for qualitative data analysis in this study, data gathered from all in-depth individual interviews and the focus group were categorised into themes, as presented in Chapter 5 and Chapter 6. The results analysis in terms of the implications to the community's environmental justice and a just transition to a clean energy production were conducted in Chapter 7.

4.7.2 Content analysis

Content analysis involves the reviewing of documents, field notes, correspondences and other pieces of written information in terms of content and themes, it involves the examination of the content in line with the research (Leedy and Ormrod, 2005; Blumberg, Cooper and Schindler, 2008). Content analysis is useful particularly when large volume of data is obtained from various sources that are addressing the research problem. This examination of the written word means that the researcher is studying one type of communication that occurs in the sample selected and this may be comprised of words, phrases, sentences, paragraphs, pictures and symbols or ideas (Blumberg, Cooper and Schindler, 2008). The researcher analysed the main themes in order to identify factors that influence the coal FA waste management challenges in the South African power generation sector and possible recycling opportunities. Literature reviews identified factors that include: coal quality; ash handling; ash classification and recycling opportunity. The identified factors were analysed statistically during the quantitative phases of the study.

4.8 Quantitative Research Methodology

A total of 103 respondents involved in coal fired power generation sector participated in the survey. In order to obtain the demographic profile of the respondents, descriptive statistics was employed. Descriptive studies is also known as statistical research, this approach describes the data and characteristics about the population or phenomenon being studied (Mouton, 2004; Leedey and Ormrod, 2005). The researcher was able to ascertain biographical information of all respondents including the category of each respondent. In Section 4.6.3.1 the demographic profile of respondents is discussed and descriptive statistics analysis is presented in figures and tables for the whole sample followed by sections that present a summary of statistics analysing the relationship of responses about factors.

Challenges were encountered mainly with the collection of data from ash recyclers and government's officials. There was reluctance to participate in the research encountered from established ash recyclers; it was also a challenge to identify government's officials who are involved in the licensing of ash recycling due to the absence of a specific office that focuses on ash waste. Respondents were surveyed about four factors that were identified from literature and found to have significant influence on the management and handling of FA waste. The factors include: coal quality; ash handling; ash classification as hazardous waste and recycling opportunity. These factors were tested amongst the respondents to determine their level of agreement in terms of the factors influence in the management of ash generated from a power station.

4.8.1 Questionnaire design

The research instrument was designed to have the 5 point Likert-type interval questions per factor. The questionnaire had an instruction section where it stipulated how the 5 point Likert-type interval scale were to be used and respondents were guided to indicate their extent of agreement or disagreement with regard to each statement. The covering letter of the research instrument with the instruction is shown in Annexure 1. The Likert scale questions were from 1–5 where 1 = strongly disagree; 2 = disagree; 3 = Neutral; 4 = agree; 5 = strongly agree.

4.8.2 Reliability of the Measuring Instrument

According to Hair et al. (2006) the purpose of a research instrument reliability assessment was to ensure that responses have internal consistency and are not too varied at different points in time. STATISTICA 13 was used to test for internal reliability of the measuring instrument in order to determine the degree to which the test scores were accurate and consistent. Christmann and Van Aelst (2006: 1661) propose “a robust Cronbach’s alpha estimate that is able to resist outliers and thus measures the internal consistency of the most central part of the observations. Two (2) factors showed moderate reliability with Cronbach’s alpha values of 0.50 (Coal quality) and 0.58 (Recycling opportunity). Two factors showed low but acceptable Cronbach’s alpha value 0.47 (Ash handling) and 0.46 (Ash classification) respectively. In general, there is an acceptable internal consistency among the factors. Table 4.3 illustrates Cronbach’s alpha assessments of factors for the study.

Table 4.3: Cronbach's alpha coefficients for the factors	
Study test results (n=103)	
Number of items	**Alphas**
A: Coal quality	0.50
B: Ash handling	0.47
C: Ash classification	0.46
D: Recycling opportunity	0.58

4.8.3 Validity of the Research Instrument

The content validity of the research instrument was enhanced by conducting extensive literature reviews and the questionnaire gathered relevant information. The questionnaire was tested amongst Eskom’s respondents who were asked to comment about the questionnaire and valuable inputs were included in the questionnaire. The questionnaire had 24 questions. The instrument was found to have a high content validity based on the 103 respondents who attempted to give feedback on all questions.

In order to enhance the criterion validity, questions in the questionnaires were probing in nature; related or similar questions were rephrased and presented in different ways in order to detect whether respondents were showing a consistent pattern of responses. Previous research work that focused on other aspects of coal ash management was perused in order to guide the construction of the research instrument. The research instrument inclusion of Likert scale questions, demographic questions and having different questions that measure different dimensions of ash coal management enhanced the construct validity. The study has high construct validity, given the high responses that were received and it was found to be relevant and reliable without bias.

4.6.3.1 Demographic profile of respondents

A population of respondents consisted of Eskom employees, government officials, non-governmental members and ash recyclers. Given the large value chain of the coal based energy sector, a minimum of 80 respondents were targeted. A total of 103 responses were received. The majority of the respondents were made up of Eskom employees (34.95%), followed by NGOs (29.13%), government (21.36%) and recyclers (14.56%) as shown in Table 4.4. The researcher was able to get a large number of respondents because of his employment in the energy sector and familiarity with other stakeholders in the industry.

Table 4.4: Distribution of sample population

Category	**Freq**	**%**	**Cum %**
Eskom	36	34.95	34.95
Gov	22	21.36	56.31
NGO	30	29.13	85.44
Recycler	15	14.56	100.00
Total	**103**	**100.00**	

Table 4.5 shows approximately 70% (72 out of 103) of respondents completed the questionnaire physically after questionnaires were hand delivered to them, and mainly consisted of 31 Eskom employees, 30 NGO employees, 10 recyclers and 1 government official.

Among the 30% (31 out of 103) of respondents who responded electronically through emails, the majority of the respondents were government officials (21 respondents), followed by both Eskom (5 respondents) and Recyclers (5 respondents). The researcher hand delivered the questionnaires to a larger number of respondents.

Table 4.5: Questionnaire Completion Method

No.	Research participants	Electronically completed	Physically completed
1	Eskom	5	31
2	NGO	0	30
3	Government	21	1
4	Recyclers	5	10
Total		**31**	**72**

It was possible to ascertain the gender of all respondents. As illustrated in Table 4.6, a total of 65 (63.11%) male respondents completed the questionnaires and a total 38 (36.89%) female respondents completed the questionnaires.

Table 4.6: Frequency distribution by gender.

Gender	Freq	%	Cum %
Male	65	63.11	63.11
Female	38	36.89	100.00
Total	**103**	**100.00**	

4.9 Ethical Considerations

The researcher applied to the University of the Witwatersrand Human Research Ethics Committee (Non-Medical) and an approval clearance certificate was issued (Protocol Number: H16/9/24). During the course of data collection, the researcher ensured that all ethical standards were complied with. The researcher ensured that the study did not involve any fraudulent activities and maintained honesty by reporting real data, methods, procedures and findings without bias in research design, data review, analysis and interpretation (Mouton 2004). The researcher also ensured that all ethical considerations were observed during interviews as stipulated by Mouton (2004: 243):

- "The right to confidentiality: Respondents confidential information was not disclosed without their consent.

- The right to privacy: The privacy of respondents was respected at all times and was not be compromised during the study.

- The right to anonymity: Respondents details were not disclosed without their consent.

- The right to informed consent: Respondents were informed about the study and their right not to participate if they so wish".

4.10 Limitations of the Study

This study was focused on FA management in ash dump facilities of the two selected power stations. The research assessed the influence of ash management activities on air quality, water quality, land pollution and human health. No laboratory tests on FA were conducted by the study. Neither analysis nor focus on the detailed chemistry and metallurgical nature of FA was conducted; reports that have been generated previously on the chemical and mineralogical composition in relation to the topic were used as a source of information in the study. The researcher's association with Eskom positively affected the willingness of respondents to participate in the research and the type of information they shared because some of the respondents had interacted with the researcher previously before the research project was initiated.

All reasonable measures were employed to eliminate bias in terms of feedback from respondents but not all bias can be eliminated or accounted for in qualitative research. This was taken into consideration when interpreting the results and making conclusions.

4.11 CONCLUSION

This chapter discussed the research methodology adopted for the study. The study is based on two case studies which are Hendrina and Kendal power stations. The study was conducted by employing an exploratory study approach. The chapter also explained the population that was studied. The method of data collection included focus groups and semi structured interviews. The chapter also elaborated on the data analysis adopted for the study. These included the grounded theory and content analysis. The ethical considerations that were observed during the study were also stipulated. The chapter was concluded by indicating the limitations of the study. A high response rate was achieved higher than the numbers that were anticipated by the researcher and this can be attributed to the researcher's familiarity with the interested/ affected parties in the coal fired power generation sector. The mixed research methodology adopted was able to address main research question and sub questions.

5 CHAPTER FIVE- Results and Analysis: Impact of Fly Ash on Communities and the Environment

Chapter 5 discusses the results that were obtained using the methodology discussed in Chapter 4. In-depth interviews of communities, NGO's and engineering/ environmental practitioner's categories of respondents were undertaken to elicit their responses with regard to the negative impact of FA to their wellbeing. This chapter also draws on the findings of other studies that were conducted in the two selected power stations. "Pollution often poses disproportionately high threats to poor people; they are the most affected by rising costs of living and often by health impacts of pollution and have the least resources available to cope with socio-economic shocks and environmental changes" (Swilling, Musango and Wakeford, 2015: 15).

5.1 Environmental Impacts of FA around Hendrina Power Station

Coal ash has a direct influence to the fauna and flora biodiversity. "Fresh ash has a high pH of about 12 and stockpiled ash undergoes weathering and leaching processes that stabilises the pH and precipitates soluble minerals" (Petrik, 2004: 22). The high pH renders ash disposal sites to be alkaline and intolerant to species that cannot survive such a condition. In the study that involved comparison of the floristic composition of the ash disposal area with the composition of an adjacent natural grassland, Morgenthal., et.al. (2001: 531) infer that "in Hendrina Power station the vegetation on ash disposal areas would probably never achieve the same floristic composition and life form characteristics that prevail in the natural grassland, due to the drastic environmental differences. "Establishing natural grassland on the disposal site area will require far more financial inputs and habitat amelioration." (Morgenthal et.al. 2001: 531).

Hendrina Power Station made an application to DEA and it was submitted to on 2nd February 2011, to conduct and EIA study in order to extend the Hendrina Wet Ash Disposal Facility. An Air Quality Evaluation report (2011:11) states that "the main pollutant of concern associated with the ash dam facility operations is particulate matter and the finer fractions of PM10 (particulates with a diameter less than 10 µm) and PM2.5 (diameter less than 2.5 µm) linked with potential health impacts, PM10 is primarily associated with mechanically generated dust whereas PM2.5 is associated with combustion sources".

5.1.1 In-depth interviews of Hendrina Power station community

Twelve (12) respondents of the community residing close to the Hendrina Power Station ash dump indicated that the exposure to air pollution happens throughout the year during windy days. Ten (10) respondents indicated that they are impacted directly by water and air pollution. The impact is dire for the most vulnerable in the communities particularly the elderly and children. “Children in particular are vulnerable to the pollution from fossil fuels, they spend more time outdoors, breathe 50 percent more air per pound of body weight than adults, ingest polluted air while their respiratory systems are still developing and are less likely to recognize symptoms, leading to delays in treatment” (Sovacool et al., 2016: 6). Respondent’s concerns are mainly their health and that of their children, as indicated by the respondents below:

> “I have been living here for four years and my children and grandchildren health is affected, if the wind direction changes the ash cover our house and our furniture. My daughter suffers from coughing fits. My daughter in-law suffers from asthma due to the air pollution”.
>
> (Resident next to Hendrina Ash dump #1. 02 December 2016).

The community that resides next to Hendrina power station is poor, their poverty is manifested largely by the housing structures that are mainly constructed with mud and corrugated iron shacks. The respondent below revealed the dilemma of relying on contaminated water due to lack of access to clean water.

> “We use to use ash water for household use including bathing, cooking and drinking and the water is very salty. My children became very sick and they were hospitalised, my daughter’s skin was burned. Ash dust also covers our furniture and clothes in the house”.
>
> (Resident next to Hendrina Ash dump #8, 10; 4 22 November 2016).

A community was congregated to be interviewed by the researcher as group, the respondents were found at their area of residence and the majority of them indicated that they are unemployed. They indicated that they have been trying to look for employment from the nearby power station (Hendrina).

Swilling, Musango and Wakeford (2016: 15) indicate that “to deal with social problems poverty, inequality and unemployment structural transformation should be seen as part and parcel of this transitioning process, with the goal of being a ‘green society’, not just a green economy”. A group that was interviewed indicated the impact of air pollution was a major problem for them as they stated below.

> “The challenges that we experience are mainly allergy, coughing, sneezing and itching”. We have stayed in the area since 1980; both summer and winter the problem persist”.
>
> (Residents next to Hendrina Ash dump #5; 6; 7; 9; 11. 14 December 2016).

5.2 Health Impacts of Fly Ash Kendal Power Station community

Bench Marks Foundation (2014: 19) indicate that, “Eskom owned Kendal Power Station lies between the N4 Highway and the town of Ogies west of Witbank, Duvha Power Station lies south of Witbank, next to the BHP Billiton Middelburg mine”. The Kendal power station is surrounded by several collieries in close proximity to it. Bench Marks Foundation (2014: 22) state that “given the high concentration of a large number of mines in a very small area around the Kendal Power Station, communities must be suffering from ‘consultation fatigue’, particularly in that there is no legal obligation on mining companies to address any of the issues raised by communities or individuals during such meetings”.

New Ash dump EIA was recently finalised at Kendal power station. A final EIA Report (2016: 9) states that “the wind-blown dust from the ash disposal facility is potentially significant during periods of high winds given the close proximity of sensitive receptors to the site. It is recommended that the sidewalls of the ash disposal facility must be vegetated by means of the application of a topsoil layer and seeding with appropriate grass seeds and the un-active surface should be stabilised with topsoil and seeded with appropriate grass seed as soon as possible. A water spraying system should be implemented on the surface of the ash disposal facility covering the outer perimeter of the facility”.

One of the communities (Khayalethu Village) consulted during the aforementioned 2016 EIA indicated, that “the community claims that they experience impacts from the current Kendal ash disposal facility, such as health impacts and dust. They further claim that the dust settling on the roofs impact on the harvesting of rainwater”. Bench Marks Foundation (2014: 14) observes that “councillors and community members note that the increase in smoke and dust in the Kendal and Ogies area is causing increasing respiratory problems and that it is straining the public health infrastructure in the area”.

5.2.1 In-depth interviews of Kendal Power station community

Seven (7) respondents of the community residing adjacent to Kendal Power were interviewed. Six (6) agreed to be interviewed as a group. A focus group of was given opportunities to express their views and to write their view down in the questionnaire that was given to them. They expressed the views similar to that of the respondents from Hendrina power station. They indicated that they are exposed to air pollution throughout the year during windy days. The general consensus from the respondents is that coal ash create allergy, coughing, sneezing and itching” asthma conditions as indicated below:

> “Living and working in this area means that we are exposed to sinus issues, coughing, and skin and eyes irritation from excessive dust exposure and during windy days you can barely see because the ash is like mist covering the whole area. Most employees and their families have chest issues. They also breathe the dust even when they are sleeping. The clothes that we wash become very dirty when it is hanged in the line. It is also difficult to have lunch in the area”.
>
> (Resident next to Kendal Power station Ash dump #13;14;15;16;17;18, 03 March 2017).

One respondent was interviewed separately because he wanted to leave the site of the interview urgently. The respondent manages a poultry faming business next to the ash dump and he indicated his frustrations that are caused by dust that impact his chicken production business.

He emphasised that no one engaged them about their pollution exposure as stated below:

> "The dust from the ash dump is affecting my poultry farming business. This is a challenge throughout the year. The air that we breathe here is polluted by dust".
>
> (Poultry farm owner next to Kendal Power station Ash dump #19, 03 March 2017).

5.3 Analysis of Local Communities' Feedback

The livelihood of local communities is compromised by living in close proximity to ash dump facilities. Sovacool et al., (2016: 6) argue that "the community's livelihoods are greatly impacted by energy production activities, power plants release a variety of noxious pollutants into the air that threaten human health and the vitality of crops, fisheries, forests, and natural habitats, these are unevenly distributed and produce inequitable impacts on children and poor communities". Literature reviews confirmed that coal ash in its various forms, contains high levels of arsenic, mercury, lead, selenium, and other heavy metals that threaten wildlife, aquatic life, and human life (Gottlieb, Gilbert and Evans, 2010). Coal ash disposal methods contribute to poor air and water quality if the ash is not properly handled (Zhu, 2011; Fatoba, 2007).

Empirical evidence obtained from in-depth interviews from community's perspective revealed that coal ash is impacting on the health of the communities' particularly with respiratory illnesses like asthma; sinus issues, coughing, skin and eyes irritation allergy, coughing, sneezing and skin itching. Respondents also indicated the impact of ash dust to their livelihood; particularly farming that includes poultry, livestock and game farming. The results reveal the communities have been living in these areas for a long time without voicing concerns about their situation. The focus of communities have been largely a focus on meeting their day-to-day needs and an effort to adapt to the situation. The communities were reflecting a feeling of being helpless and without any recourse to improve their situation. The majority of respondents demonstrated that they have adapted to the situation particularly because most of them have lived in this areas for many years.

5.3.1 Fly ash air pollution

Literature reviews have exposed air pollution challenges in areas that are adjacent to the dumping sites. “In South Africa, thermal coals used for domestic power and fuel production have much lower calorific (energy), and higher ash values and are supplied mostly from screened run-of-mine production” (Eberhard, 2011: 14). The dependence on poor quality coal to generate power is responsible for the generation of large quantities of ash and pollution as indicated by respondents below.

> “The chemical composition of poor quality coal results in serious pollution in the atmosphere. Communities must be educated about the impact of FA to their health and must be taught about strategies to minimise exposure”.
>
> (Practitioners # 01, 12 January 2017).

Practitioners emphasised the fact that poor quality usage is the root cause of the generation of large quantities of ash that lifts from ash dump facilities. The accumulation of ash poses more challenges in terms of dust suppression initiatives. The respondents below support the views of the respondent above (Practitioners # 01):

> “I believe that the coal quality does contribute to the amount of pollutants that a certain power station experiences. If the quality is poor, it may results in high concentrations of pollutants”.
>
> (Practitioners 10 # 11 November 2016).

There are limited studies that explain or model the impact of FA in relation to the usage of poor quality, it is difficult to perform accurate environmental impact for coal FA based on its quality during combustion (Zhu, 2011). Practitioners work with coal on daily basis and their judgement is influenced by the information that they have in their disposal during power generation.

5.3.2 Fly ash water contamination

Literature reviews revealed that South African Power utility (Eskom) is a strategic water use in South Africa, without raw water supply the country will not be able to generate electricity (Zhu, 2011; Petrik, 2004). “The use of fresh water resources for industrial applications, particularly electricity production, mining and manufacturing, places an increased burden on the country’s fresh water resources and it has been postulated that the country’s fresh water resources will be fully utilised within the next twenty to thirty years if the current growth in water demand and use (or abuse) is not curbed or altered” (Petrik, 2004: 12). A respondent below elaborates on the impact of ash from Hendrina Power Station to the Woestalien stream, which flows closer to the power station:

> “The Woestalien stream has been contaminated by ash from the power station for years”.
>
> (NGO representative # 1, 05 January 2017).

Practitioners below concur with the respondent above (NGO representative # 1) and they put the technical perspective to the reasons why water contamination cannot be avoided entirely as stated below:

> “Unfortunately most Eskom power station ash dumps / dams are constructed without a protective lining system underneath. In trying to minimise pollution the power station tries not to over wet the dumps, control pools on the ash dams, ensure that drains are functional etc”.
>
> (Practitioners 10 # 11 November 2016).

Respondents were eager to expose the negative impacts of ash on the environment. The other area of interest shown by the respondent below is the aesthetic value of the area that diminishes with the rising of the ash dump. Ash dumpsites do rise sometimes to a hight that can be seen from a distance away. Both Kendal power station and Hendrina power station are still active and from a distance, it is easy to see the conspicuous grayish mountain.

The respondent below summarises the impacts in an integrated manner:

> "Ash dumps and dams result in the following additional impacts
>
> - Runoff from the ash dumps / dams can impact surface water resources
> - Seepage from the dumps/dams can "day-light" and impact on surface water resources
> - The "mountains" of ash are an eye-sore. They modify and impact on the landscape.
> - They take up land (footprint) that could be used for other things e.g. agriculture, housing etc.
> - Dust from the dump / dam can impact on nearby land e.g. agricultural land – making it less productive".
>
> (Practitioners 10 # 11 November 2016).

Power generation is an authorised activity that has a number of permits and licenses issued by the authority from the local, provincial and national level. The conditions in the licenses and permits are meant to mitigate the negative impacts that emanate from power generation. The respondent below is concerned about the lack of compliance to authorisations and legislative obligations. The culture of compliance is poor and enforcement from the authorities is not effective as stated below:

> "We have rules and regulations in the country, yet the compliance to them is rather poorly implemented. There is no reason whatsoever why power stations should be allowed to pollute and exceed agreed limits, without government taking harsh action against them. It is going to take some time to get a culture change where compliance to the law is mandatory, and we start viewing our environmental problems in a serious light. We need to adopt a first world mentality. If power plants in Germany can operate with hardly any pollution whatsoever, why are we so different?".
>
> (Practitioners # 04, 17 January 2017).

5.3.3 Analysis and non-governmental organisation feedback

NGO's confirmed that FA pollution affects the communities that they represent and that intervention is required to manage the impact because is affecting the health of communities. They raised concerns that communities are not consulted about the pollution they are experiencing. NGO's state that power stations must engage communities regularly. Their feedback paints a picture of an employer (Eskom) who has no regard to the wellbeing of local communities.

5.3.4 Analysis of Environmental and Engineering practitioners feedback

Practitioners agree that FA pollution is affecting the communities, and are aware of management programmes that are in place to manage emissions. They indicate that the poor quality of coal that is used during power generation is responsible for pollution. Power stations are advised to involve communities and initiate projects. Legislation in the past created the current legacy of pollution because it never prescribed lining of the dams and wastewater dams facilities. Analysis of practitioners' responses reveals that practitioners are concerned about the lack of law enforcement by the authorities. Practitioner's views generally point to the areas of improvement to be ash management operations and strict legal enforcement from the authorities. Environmental and engineering practitioners generally shared the same sentiments and there were no divergent views.

5.4 Quantitative Analysis about coal quality (A) and ash handling (B)

Quantitative analysis was also conducted to confirm the views of respondents that were made during the qualitative phase of the study. Factors that were suggested to be responsible for pollution were tested through survey research. Descriptive statistics conducted on the data indicate that coal quality and ash handling as factors that have a significant influence on pollution.

5.4.1 Descriptive statistics about Factor: A (coal quality)

Coal quality impact was premised on the argument that, the more ash is generated, the more pollution challenges are experienced in relation to ash management.

Munnik, Hochmann and Hlabane (2010: 11) observe that “the good quality coal is exported; leaving the lesser quality to be burned by SA coal fired power stations, adding to SA’s carbon footprint and emissions”. A total number of 75 (72.82%) of respondents agreed with a statement that power stations use of poor quality coal producing more ash and contributing to pollution, 22 (21.36%) were neutral and 6 (5.83%) disagreed with the statement. These results support the views that poor coal quality used in power stations has a direct influence to more ash generation and pollution. Refer to Annexure 6 for the results.

5.4.2 One sample T-tests statistics about Factor: A (coal quality)

One sample T-tests were conducted for factor A to determine whether the population mean value for these factors can be regarded as either positive ($\mu >$ 3.40), neutral $\mu <$ 3.0) or negative ($\mu <$ 2.60). Factor A has a mean score of 3.89; this indicates that the majority of respondents agree about the influence coal quality to pollution. Refer to Annexure 7 for the results. Respondents are generally agreeing that usage of poor coal quality contributes to environmental pollution.

5.4.3 Chi-squared tests for Factor: A (coal quality)

The Chi-squared tests were conducted to determine whether there is an association between the different categories of respondents regarding factor A, in addition to the differences between responses from different categories. Chi-squared tests reveal that the majority of the respondents from Eskom (58.33%); Government (59.09%); NGOs (53.33%) are in support of the view that coal quality has an influence to pollution and recyclers (66.67%) were not in support of factor A. Eskom and government officials have the highest percentage in terms of agreement that coal quality has influence in the management coal ash. Recyclers were not in agreement and this can be explained by the fact that recyclers are not involved in power generation and pollution management. Chi-squared tests are important for the study, it exposed the different views from different categories of respondents Table 5.1 illustrates Chi-squared tests of Factor A.

Table 5.1: Chi-squared tests on Factor A (coal quality)

Responses	Eskom	Gov	NGO	Recyclers	Total
Factor A (p=0,000)					
Disagree	2	0	4	0	6
	33.33	0.00	66.67	0.00	100.00
	5.56	0.00	13.33	0.00	5.83
Neutral	4	2	6	10	22
	18.18	9.09	27.27	45.45	100.00
	11.11	9.09	20.00	66.67	21.36
Agree	21	13	16	2	52
	40.38	25.00	30.77	3.85	100.00
	58.33	59.09	53.33	13.33	50.49
Strongly Agree	9	7	4	3	23
	39.13	30.43	17.39	13.04	100.00
	25.00	31.82	13.33	20.00	22.33
Total	36	22	30	15	103
	34.95	21.36	29.13	14.56	100.00
	100.00	100.00	100.00	100.00	100.00

Analysis of factor A (coal quality) using descriptive statistics; one sample T-tests and Chi-squared tests revealed the views of respondents as a category. It was imperative that the understanding of the influence of coal quality to pollution by different categories was revealed in the study. It exposed the gaps in the understanding of ash management challenges in the coal fired power generation sector. Results analysis has shown that ash recyclers lack the understanding about the impact of FA. This pose challenges because ash still needs to be managed even when it is in the control of recycling enterprises. The results are also revealing the fact that, the more power stations generate ash due to usage of poor quality coal the more the challenges in terms of addressing pollution associated with coal ash. Understanding of the views of respondents as a category is fundamental and it can serve as a guideline in terms of identifying areas of improvement in terms of ash waste management.

5.4.4 Descriptive statistics about Factor: B (ash handling)

In terms of ash handling, the descriptive statistics indicate that, about 53 (51.46%) were neutral (neither in agreement or in disagreement), with the statement that the method of ash handling (dry ash or wet ashing), transportation and disposal influence the pollution that the community experience in terms of air and water pollution. A total number of 38 (36.90%) agree and 12 (11.65%). Refer to Annexure 6 for the results.

5.4.5 One sample T-tests statistics about Factor: B (ash handling)

The Factor B mean value was 3.29 indicating that the majority of respondents had a neutral view about Ash handling's influence to pollution. The factors can be regarded as either in agreement ($\mu > 3.40$), neutral $\mu < 3.0$) or disagreement ($\mu < 2.60$). The results indicate that the majority of respondents are neutral to an agreement about the influence ash handling to pollution. This can be explained by the fact that respondents based their judgement based on two power stations one has a dry ashing system (Kendal) and Hendrina has a wet ashing system. The results are illustrated in ANNEXURE 7.

5.4.6 Chi-squared tests for Factor B (ash handling)

The Chi-squared tests indicate that the majority of respondents in government (63.64%) agree that ash handling is the main cause of pollution, Eskom (52.78%) are neutral, NGOs (50.00%) were also 'neutral', while the majority of the recyclers (86.67%) were 'neutral' as well for Factor B. Eskom handles coal ash as either dry or wet ash methods. Government officials appreciated the impact of ash in all forms of handling contrary to Eskom and the recyclers. Handling of coal ash begins as soon as coal is burned and to a point where it is disposed at an ash disposal facility. Table 5.2 illustrates Chi-squared tests on Factor B. Government respondents are in full agreement that ash handling influences the pollution that is experienced in areas neighboring ash disposal facilities irrespective of the ash handling method, contrary to Eskom, NGO'S and recyclers categories of respondents.

Table 5. 2: Chi-squared tests on Factor B (ash handling)

Responses	Eskom	Gov	NGO	Recyclers	Total
Factor B (p=0,015)					
Strongly disagree	0	0	1	0	1
	0.00	0.00	100.00	0.00	100.00
	0.00	0.00	3.33	0.00	0.97
Disagree	5	1	5	0	11
	45.45	9.09	45.45	0.00	100.00
	13.89	4.55	16.67	0.00	10.68
Neutral	19	6	15	13	53
	35.85	11.32	28.30	24.53	100.00
	52.78	27.27	50.00	86.67	51.46
Agree	11	14	6	2	33
	33.33	42.42	18.18	6.06	100.00
	30.56	63.64	20.00	13.33	32.04
Strongly Agree	1	1	3	0	5
	20.00	20.00	60.00	0.00	100.00
	2.78	4.55	10.00	0.00	4.85
Total	36	22	30	15	103
	34.95	21.36	29.13	14.56	100.00
	100.00	100.00	100.00	100.00	100.00

Analysis of factor B (ash handling) using descriptive statistics; one sample T-tests and Chi-squared tests revealed the views of respondents as a category. Respondents are largely neutral about the impact of coal ash handling, government's respondents were largely in agreement as compared to other categories of respondents. Ash handling as a factor was generally not fully supported by all the respondents.

5.5 CONCLUSION

The main objective of this chapter was to identify the impact of FA to the receiving environment and the wellbeing of local communities. The results were presented and analysed both qualitatively and quantitatively. In-depth interviews revealed that respondents are unanimous about the pollution that local communities are experiencing. Respondents further indicated the impact of FA to their livelihoods that depend on farming.

Quantitative results and analysis revealed that respondents have different views with regard to the factors that contribute to pollution. Practitioners and NGO's share the same perspectives with regard to the influence of coal quality and ash handling to pollution that local community's experience. Ash recyclers are either neutral or negative, which is a reflection of their lack of knowledge with regard to the pollution predicament that local communities find themselves in or they lack of appreciation of the hazards that are associated with FA. Results revealed that government is not adequately fulfilling their mandate to enforce compliance to legislation as expressed by a number of respondents during in-depth interviews. Environmental and engineering practitioners and NGO's respondents advanced the arguments that articulated their concerns regarding compliance enforcement that is not assisting to mitigate the pollution.

NGO's and practitioners are aware of the problems created by FA, but Ash recyclers feedback reveals a lack of appreciation of the impact of FA to the environment and human health, presumably because they don't think it is important to find out. The reasons for being oblivious by ash recyclers are possibly because they see ash as a resource or raw material and not as hazardous waste. They seem not to be concerned by the impact of ash to people's wellbeing. These views can have broad implications to a just transition through FA recycling that is discussed in the chapter that follow (Chapter 6).

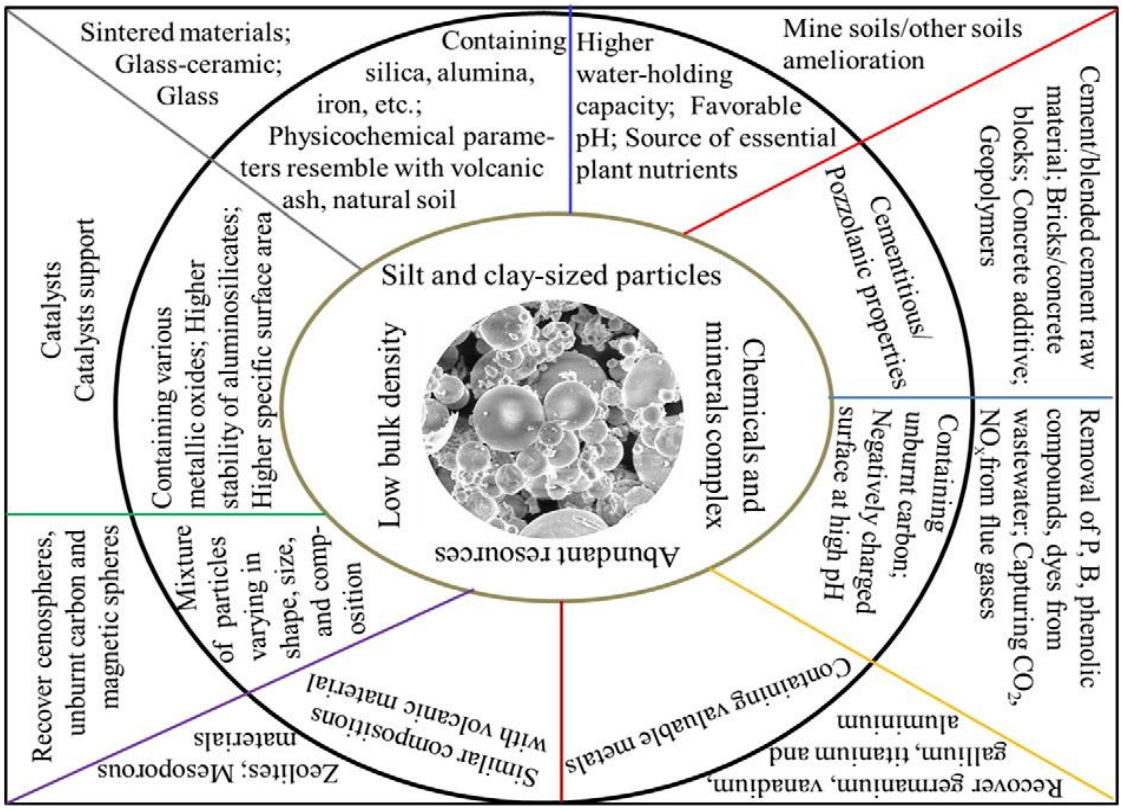
6 CHAPTER SIX - Results and Analysis: Potential Recycling Opportunities and Barriers thereof

Chapter 6 discusses results and analysis on potential recycling opportunities and barriers thereof to benefit local communities. In-depth interviews of ash recyclers, NGO's and practitioners categories of respondents were undertaken to elicit their responses with regard to the potential recycling opportunities and barriers that impede recycling to benefits local communities. Ash recyclers were visited at their areas of operations. Local communities were excluded in terms of in-depth interviews regarding ash recycling after it was noticed during interviews that they generally lacked knowledge pertaining to ash recycling.

6.1 Uses of Fly-Ash

FA has many beneficial uses and in order to take advantage of FA utilisation efficiently, Van der Merwe et al. (2014:74) advocate for "an accurate characterisation of the chemical composition and mineralogy of FA before considerations of industrial applications. In regard to chemical composition, coal is a complex composite primarily composed of heavy metals. There are a number of potential applications of fly ash in the world, Yao et al. (2015 : 14; and Petrik (2004: 48) identified some of the potential uses of FA to include: cement production and/or concrete products; mine filling, structural fills or embankments; stabilisation of waste materials; road base or sub base materials; roller compacted dams, pavements, roads, embankments, ash dykes, road blocks, kerb stones; as fill and grouting mixes; building sector for use in bricks, blocks, tiles, cement, concrete, plaster; land reclamation, filling low lying areas, raising ground levels; agriculture and wasteland area development; hydro sector, irrigation, drains, water supply & drainage, lining of rivers, tributaries, canals, minors, sub-minors and other specialised use of ash e.g. collecting cenospheres from floating. Yao et al. (2015:109) outlines various industrial applications and alternatives of FA that can be considered for recycling in Figure 6.1.

Figure 6.1: Various applications of coal fly ash



Source: Yao et al. (2015:109).

6.1.1 Construction industry

FA has been found to be a useful material in the construction sector around the world. “FA has predominantly been used as a substitute for material in the construction industry, especially either as a raw material or as an additive in the cement industry” (Yao et al., 2015: 110). Coal ash has cementitious properties (pozzolan). Because of such pozzalanic properties, FA is mainly used in construction related applications (Petrik, 2004). Research indicates that Class F FA is an acceptable pozzolan in blended cement, and it contains the properties that are beneficial for binding purposes (Wang et al., 2016). There is the potential that FA can be revolutionised as a cleaner alternative to cement production. “Finding alternatives to ordinary cement is of extreme importance due to high levels of carbon dioxide (CO2) emissions associated with its manufacturing process” (Assi et al., 2016: 807).

FA has beneficial environmental benefits, particularly in road construction environment “it could be utilised for a cleaner production of pervious concrete possessing due to the greater structural strength and compatible hydrological property compared to the ordinary pervious concrete” (Soto-Perez and Hwang, 2016: 112). Asphalt is widely used for road construction around the world. Application of FA in asphalt pavement has been widely researched. Although FA has been used in concrete research for years, there is very limited application in asphalt pavements. The experimental results reveal that it can be used a filler material, filler modification by FA gives better strength with lesser deformation compared to that of the conventional mix” (Mistry and Roy, 2016: 5). There is evidence that FA can also be used for making geopolymer, which acts as a cement-like product. “The production of FA-based geopolymer is mainly based on alkali activated geopolymerization which can occur under mild conditions and is considered as a cleaner process due to much lower CO2 emission than that from the production of cement” (Zhuang et al., 2016: 253).

6.1.2 Potential use of Fly ash as an agricultural industry additive

Research pertaining to blending of ash to stabilise soils and fertilizers are still underway. FA has alkaline properties due to the high pH; it can be used as a neutralising agent, particularly in acidic soils to improve fertility (Parab, Sinha and Mishra, 2015). FA inherently contains harmful elements including heavy metals, but it has been found to have potential for beneficial use in agriculture due to its efficacy in modifying and improving soil health and improving crop performance (Usmani and Kumar, 2016). Usmani and Kumar (2016: 62) argue that “the application of FA can increases yields of all crops, including cereals, oil seeds, sugarcane, cotton, vegetables, pulses, and the like, and its residual effects last for 6–8 years, thus, modifying FA by vermi-composting improves its ability to act as a fertilizer”.

The application of FA for food production requires strict control. Yao et al. (2015: 108) caution that “FA application improves the physical, chemical and biological qualities of soils to which it is applied; however, harmful effects such as the low availability of some nutrient elements have been reported including the undesirable effects excess salinity and toxic elements”. Singh et al., (2016) observes that a considerable amount of research has been carried out to blend FA with varieties of organic and inorganic materials, like lime, gypsum, red mud, farmyard manure, sewage sludge, composts, vermin compost, etc.

Petrik, 2004: 28; Yao et al. (2015:108) advocate that agricultural application of FA has more advantages that include the following:

- FA input reduces the bulk density of the soil mixture
- It can significantly increase the soil mixture's water-holding capacity
- FA also reduces the cohesiveness of soil particles.
- Enhancing nutrient availability,
- Decreasing bio-availability of toxic metals,
- Buffering soil pH, enhancing soil organic matter content,
- Indirectly stimulating microbial activity,
- Overall improving soil health and increasing crop yield

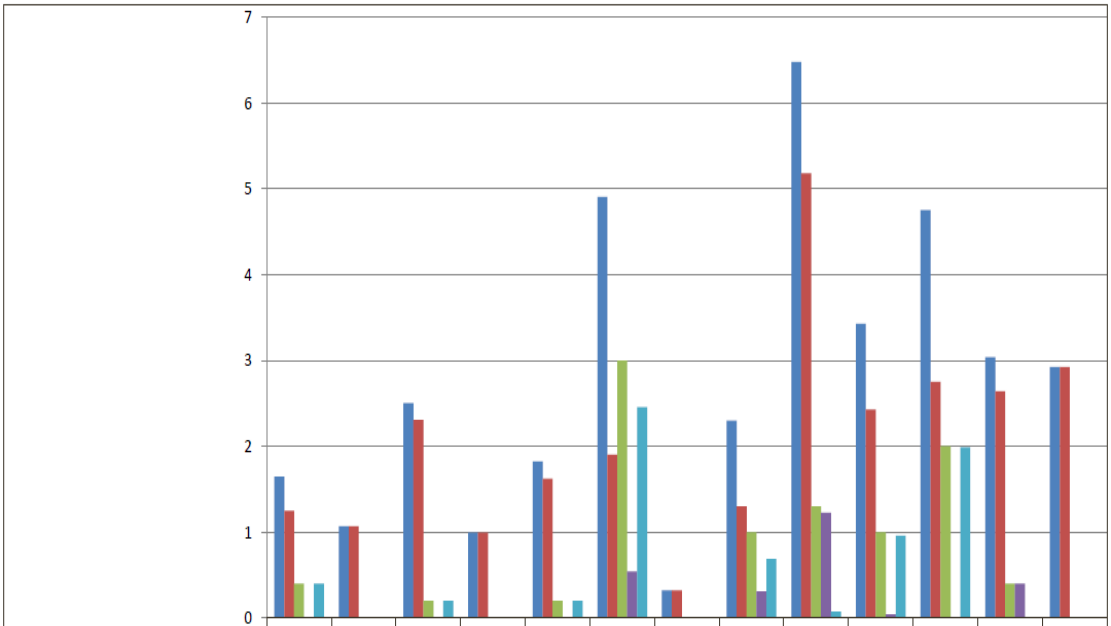
6.1.3 Fly ash use as backfill and acid mine drainage neutralisation

Debates about the use of FA as back fill material is raging, the concerns relate to the potential ground water contamination that can result from leaching of heavy metals from FA when it mixes with water. "Cemented coal gangue-FA backfill (CGFB) mixtures are utilised as the filling materials for backfilling the underground openings in coal mines" (Wu, Yang and Liu, 2015: 218). Acid mine drainage is a challenge particularly in areas of intensive mining. "Utilisation of FA as ameliorant for the neutralisation of acid mine drainage (AMD) has proved to be feasible" (Petrik, 2004: 8). In the study about the use of FA for the control and treatment of acid mine drainage, Raynolds (2004: 960) infers that "the use of FA to treat AMD has been proven effective with FA on Mpumalanga AMD, the sulphates and heavy metals are reduced and the pH increased.

6.2 Existing Fly Ash Utilisation in South Africa

South Africa has been recycling coal ash for decades, mainly through cement manufacturing companies and limited quantities were used for brick making and construction. “In 2008 South Africa was producing more than 25 million tons of ash per annum, of which nearly 1.2 million tons were utilised for different purposes, i.e. as back mine fill, as soil stabiliser in geotechnical application, land filling, an extender for cement and concrete applications, and as an absorbent for inorganic wastes” (Bada and Potgieter- Vermaak, 2008: 38). A limited amount of ash is sold to customers largely in cement manufacturing. “It is currently estimated that about 7% of the Eskom ash is sold from 6 of the 13 Eskom coal-fired power stations” (Reynolds-Clausen and Singh, 2016: 1). Estimated ash volumes available per power station are illustrated in figure 5.2.

Figure 6.2: Estimated ash volumes available per power station



	Arnot	Camden	Duvha	Grootvlei	Hendrina	Kendal	Komati	Kriel	Lethabo	Majuba	Matimba	Matla	Tutuka
Produced(Mt)	1.6503	1.068	2.506	0.996	1.824	4.906	0.324	2.302	6.48	3.428	4.752	3.04	2.926
Ash used for effluent sink	1.2503	1.068	2.306	0.996	1.624	1.906	0.324	1.302	5.18	2.428	2.752	2.64	2.926
Saleable (Mt)	0.4	0	0.2	0	0.2	3	0	1	1.3	1	2	0.4	0
Ash Sold (Mt)	0	0	0	0	0	0.542	0	0.312	1.227	0.042	0.012	0.4	0
Opportunity for further sales (Mt)	0.4	0	0.2	0	0.2	2.458	0	0.688	0.073	0.958	1.988	0	0

Reynolds-Clausen and Singh (2016: 3)

South African coal ash has been researched extensively. “The beneficiation of South African FA after it has been put through a process of air classification, electrostatic recovery and/or density separation has been investigated before, and specific size fractions of FA, with specific physical and chemical properties, may be used in suitable applications” Van der Merwe et al. (2014: 74). South Africa is one of the countries that are recycling coal ash in large volumes. Photo 5 shows bricks manufactured from course ash near Middleburg.

Photo 5: Bricks manufactured from course ash near Middleburg



Brick making is one of the recycling activities that use both bottom ash and FA in large quantities. Bottom ash replaces coarse sand that is usually more expensive because it is mined from borrow pits that are in some cases far from the brick manufacturing sites. Bricks have a good market given South Africa’s housing sector particularly low cost housing and ash reduces the cost of brick making.

The old fleet of Eskom's power stations use largely a wet ashing system. This makes the wet ash dump facilities ideal for the collection of cenosphere. There are very limited enterprises that are involved in the collection of this product that is used as ceramic and other related industries. Photo 6 below shows the cenospheres and processed to be Cenolite at Kriel power station.

Photo 6: Collected cenospheres and processed to be Cenolite



6.2.1 Potential recycling opportunities at Hendrina power station

Hendrina Power station is currently not recycling any ash. The power station operates a wet ashing dump site. The potential of recycling ash at Hendrina power station is high, it operates five compartments of ash dams and some of the dams have already been decommissioned. There is a potential to recycle FA and coarse ash that is dry without interrupting ashing activities. The power station also has a potential to recycle moist ash and to extract cenosphere as well.

The only challenge that the power station has is that it is located far away from industries. There are communities around the power station, but the larger numbers in terms of beneficiation are located at Hendrina Township (Kwazamakuhle) which is approximately 20 km away. The power station presents an opportunity to set up a recycling facility in the vicinity of the power station. The only disadvantage is the distance between the power station and the market. The age of the power station indicate that it might be retired in few years' time and this presents an opportunity to recycle the whole dump site, which could take decades to sustain the socio economic situation of the community. Hendrina power station is also located close to the mining and farming areas and this presents a challenge in terms of securing the land for ash recycling facilities.

6.2.2 Current and potential recycling opportunities at Kendal power station

Kendal Power Station is one of the modern base load power stations that is strategically located in terms of ash recycling opportunity and a model power station in terms of FA recycling. Kendal operates a dry ashing system. Kendal is one of the power station that sells its ash to a number of customers. Some of the customers in 2017 that used ash as cement blender were:

- Ash Resources: Cement blender
- Sephaku Cement: Cement blender

Located next to the busy N12 highway that link both Gauteng and Mpumalanga province, it is ideal to expand ash sales and to also venture into small scale community ash recycling enterprises to benefit local communities including communities at the larger township of Phola Park. The ash dump site at Kendal has reached its life span. Plans are under way to construct another ash dump facility which will provide an opportunity to mine ash directly from the dump site without interfering with the operations. The dormant ash dump facilities will provide an opportunity for brick and construction customers to collect their ash. A similar situation exists where Hendrina power station is located close to the mining and farming areas which presents a challenge in terms of acquiring land for ash recycling facilities. The biggest beneficiaries of ash from Kendal Power station have not been the local communities directly but it has been well-established cement manufacturing companies.

6.2.3 Future Eskom's ash utilisation strategy

Eskom's power stations generate a large quantity of ash on a daily basis. Eskom is leading a drive to get more players in the ash recycling industry. There is a realisation that local communities can benefit from ash recycling, so the beneficiation strategy is informed by the need for inclusive recycling opportunity. In order to manage the increased utilisation of ash Eskom has developed an ash strategy that has been approved by the board. "Eskom's ash strategy aims to utilise ash to benefit from an associated avoided cost linked to the handling and storage of the ash and to facilitate that, a regulation 9 submission has been handed to DEA to allow for the exclusion of the hazardous classification of ash, when used in brick making, cement, road construction, soil amelioration and mine backfilling" (Reynolds-Clausen and Singh, 2016: 11).

In terms of the strategy the scope of the programme was developed, including a programme roadmap and implementation plan" (Reynolds-Clausen and Singh, 2016: 2). The strategy details are:

- "The adoption of a cost avoidance rather than a revenue recovery model.
- The development of an ash strategy per power station.
- Consultation with Department of Environmental Affairs and relative government departments, in order to change the ash classification.
- Submission of exclusion documents to government, on behalf of industry, to ease the legislative constraints on users.
- Unlock legislative constraints.
- Explore all possible ash utilisation technologies and applications.
- Collaboration with industrial stakeholders.
- Development of customer interfaces for sales, take off points etc.
- Conduct research (pilot plants, literature reviews, technology development).
- Stakeholder engagement to increase awareness of ash".

6.3 Potential New Ash Recycling Opportunities and Benefits in South Africa

South Africa has a challenge of unemployment, recycling FA can be a good alternative to disposal, and could achieve significant economic and environmental benefits (Singh et al., 2016). To facilitate the beneficiation of coal ash through, literature revealed a number of factors that must be considered to ensure success of small-scale enterprises. All respondents were optimistic about the potential opportunities that can be realised through ash recycling as stated by the respondents below:

> "Millions of tons of FA are already used for the manufacturing of cement and bricks. If a community wants to get involved in brick making, they can do so, the technology is available as well as the FA. FA is a minor cost component in brick making; the challenge is to get the rest of the business going. Manufacturing cement is a huge industrial process and communities cannot become involved is such projects. The challenge is to find an industrial use for FA that can generate income. Communities do not have the capabilities of doing this type of development".
>
> (FA ash recycler # 02, 11 November 2017)

For decades the potential opportunities of ash recycling was not shared with communities. Respondents gave feedback during the in-depth interviews that revealed a potential ash recycling opportunity and the challenges that can revolutionaries a recycling regime as indicated by one of the respondents below:

> "I know there are a couple of concepts that people are considering, for example: Using FA for road surfacing; Cement making; Brick; Back filling of mine voids; Treatment of AMD; making paints, etc. Identifying and raising awareness of potential uses of FA is important. However, due diligent needs to be done to ensure that there are no negative consequences (from a safety, health and environment point of view). There will be a need to train and develop skills for community members to use the FA. Eskom might need to partner with community members to demonstrate the potential uses of ash".
>
> (Practitioners 10 # 11 November 2016).

Eskom's old fleet will be eventually decommissioned in the future, particularly because the new stations under construction (Kusile and Medupi) are currently supplying the grid. This will present another opportunity for recyclers to plan and work on the ash dump and this can potentially benefit current Eskom employees who cannot be absorbed elsewhere when some of the power stations are decommissioned. The respondent below gives example of the similar situation in the past:

> "There are power stations that successfully recycled their ash after they were decommissioned and they are Klip and Vaal Power Stations. Explore the possibility of introducing ash to the agricultural sector and pumping it to used mines".
>
> (NGO representative # 1, 05 January 2017).

6.4 Job Creation and Enterprises Development

Local communities have always been overlooked in the past when there are opportunities. When appropriately supported, SMEs and small-scale entrepreneurs can play an important role in solid waste management. While harmful wastes in dump facilities can be managed through appropriate incineration, small scale entrepreneurs can play a role in the recycling of less harmful wastes, including composting of the organic materials (United Nations, 2014). NGOs operate within communities and they have the opportunity to see fist hand the dire socio economic situation that communities find themselves in as indicated by the respondent below:

> "Employment opportunities can be created by recycling ash especially brick making".
>
> (NGO representative # 14, 17 March 2017).

Failure of community projects is well documented in literature. Greediness and mismanagement are some of the leading factors that destroy the prospects of improving the socio economic situation of a community. Without adequate support, one the NGO representative was skeptical about community's involvement in the recycling ash.

Without proper oversight projects that are meant to benefit communities becomes source of strife. The respondent below alluded to his experiences:

> "The sustainability of recycling initiatives cannot be guaranteed due to communities' unrealistic expectations and reckless profit taking, financial management cannot be achieved as evidenced by many projects that failed".
>
> (Labour union representative # 2, 20 December 2017).

6.5 Barriers to Ash Recycling

6.5.1 Challenges in creating markets for fly ash materials

Market development is a multi-stakeholders initiative that can be driven by government. There is market for ash recycling, the value chain need to be established and legislated where necessary for example: all houses that are built for communities can be constructed through the usage of ash bricks. "It is imperative to develop new markets that consume high volumes of ash - these include road construction and agriculture/land rehabilitation" (Reynolds-Clausen and Singh, 2016: 1). Respondents below indicate the challenges that are associated with marketing of the products:

> "FA products are durable. FA is used to impart durability to concrete; the utilisation of FA as a cement extender and concrete additive "consumes" almost 2 million tons per annum".
>
> (FA ash recycler # 01, 11 November 2017).

There is a sense of resistance from those who are benefitting from the current status quo. Swilling, Masango and Wake ford (2016) argue that there is hope that current dynamics in both waste management reform could reduce the waste disposal burden in South Africa by two- thirds.

A respondent below does not approve an equitable or inclusive initiative that can benefit a larger portion of the community as stated below:

> “Millions of tons of FA are already used for the manufacturing of cement and bricks. If a community wants to get involved in brick making, they can do so, the technology is available as well as the FA. FA is a minor cost component in brick making; the challenge is to get the rest of the business going. Manufacturing cement is a huge industrial process and communities cannot become involved in such projects. Other uses of FA still have to be developed, which is not a community project. The challenge is to find an industrial use for FA that can generate income. Communities do not have the capabilities of doing this type of development.
>
> (FA recycler # 02, 11 November 2017).

Market development will be at the heart of the successful recycling regime in South Africa. Those who choose to invest in recycling face a great obstacle. After operating one of the few cenosphere recycling plant at Kriel Power Station, a respondent had few reservations because the market for the products is mainly overseas. Transportation is a major hindrance as stated below

> “We collect cenospheres from the ash dams which are high value, as opposed to BBA or PFA which is low value. The challenge lies in transporting it to customers which are usually far from source. Transport then becomes much more expensive than cargo being transported”.
>
> (FA recycler # 05, 02 March 2017).

To aid the development of ash recycling business, it is imperative that Eskom, partner with the communities by providing land where communities can set up their facilities and manufacture bricks close to where the main resource (ash dump).

To ensure sustainability mentoring programs will be needed to assist communities as stated by the respondents below:

> "Eskom is leading a strong advocacy campaign for ash utilisation and calls on ash producers and off takers to support the initiative. The development of small brick making facilities in close proximity to power stations will be ideal for the local community. Recyclers face a number of challenges in relation to the profitability of recycling enterprises as indicated below".
>
> (Practitioners # 05, 17 January 2017).

This respondent articulated the views similar to the respondent above (Practitioners # 05). Transportation of the final product must be aligned to where the market is identified. If the local area has housing challenges, relevant departments can be engaged to source the building materials from the local manufactures in order to enable them to manage the enterprise at a smaller scale in the beginning.

> "Transportation costs and low demand for the final product. FA material needs to be closer to communities that are likely to initiate or that are willing to explore possibilities of recycling ash e.g. brick making. The concerns being raised by majority of potential recycler are distance of the FA (raw material) away from labour areas and this increases transportations costs".
>
> (Practitioners # 03, 12 December 2016).

6.5.2 Legal barriers to ash recycling

The South African legislative framework pertaining to waste management strictly governs ash utilisation and classifies it as a hazardous waste; amendments and unlocking the waste legislation would be a key enabler to market development of ash applications. "It is for this reason that Eskom has rejuvenated its ash utilisation project by submitting a landmark application to DEA on behalf of the industry" (Reynolds-Clausen and Singh, 2016: 1).

Respondents acknowledge the legal barrier below:

> “The development of new applications have been slowed down by the governments’ decision to have FA classified as a waste product, without giving proper details how it must be controlled. New FA application developments have thus moved into a wait and see mode”.
>
> (FA recycler # 02, 11 November 2017).

Van der Merwe et al., (2014: 74) argue that “in recent years, the classification of coal ash as hazardous waste compounded by a growing concern about pollution and increasing landfill costs is stimulating research into new ways to utilise FA for economically beneficial applications. The engagement with the authorities is continuing in order to enable potential recycler to invest. Without the relaxation of the rigid legislation as observed by the respondent below, the prospects of expanded ash recycling will remain a far-fetched wish for many:

> “The creation of ash mountains is a convectional practice which must be ceased. Ash dumps must be lined and be used as source for creation of industrial materials e.g. use ash for production of cement, bricks, use in asphalt, etc. Legislation to rigid to allow use of ash as industrial input”.
>
> (Practitioners # 08, 08 December 2016).

There are those who have already noticed the benefits of using ash in the manufacturing of bricks as a cost effective measure and profitable venture. Without clear and formal direction pertaining to acquisition and permitting, informal sourcing is bound. The respondent below alludes to the fact that access must be clearly communicated:

> “We use ash as raw material for bricks they replace the price of sand that is very high, as a black entrepreneur it is difficult for us to get a permit at Eskom to get ash on our own, we have to access it via other companies”
>
> (FA recycler # 13, 08 March 2017).

6.6 Analysis of the Results about Potential Recycling Opportunities and Barriers Thereof

6.6.1 Analysis of recycler's views

The results are revealing optimism amongst ash recyclers that are involved in cement manufacturing, brick making and cenosphere extraction that were interviewed. Respondents indicated that recycling can be conducted during any season of the year. In terms of the durability of products that are produced from ash, all respondents indicated that FA produce quality products that compete with products manufactured from other raw materials. Respondents indicated that recycling can benefit the local community and they believe that the community needs support to start and manage recycling projects. One of the biggest obstacles to be overcome is the transportation cost of the market and the recycling areas. Recyclers are more concerned about access to ash in larger quantities.

6.6.2 Analysis of NGO's views about coal ash recycling

The results are revealing support for ash recycling. NGO's support the argument that recycling can benefit local communities economically. They also advocated for interventions from relevant governmental departments and Eskom to facilitate the recycling projects for the community. Additional suggestions from NGO's were that: "a study to identify an ash business for the community must be conducted; ash bricks can be used to eradicate shacks and eventually solve the housing issues in the long-term.

6.6.3 Analysis of practitioners views about coal ash recycling

Practitioners are advocating for the involvement of all stakeholders. Power stations are advised to involve communities and initiate projects. Eskom need to invest in the commercialisation of FA and stimulate this market according to practitioners. And they state that innovative solutions around the use of FA need to be developed and lessons must be learned from other countries. Practitioners believe that recycling will reduce unemployment and it will improve the delivery of infrastructure.

6.7 Analysis of Ash Classification (C) and Recycling Opportunity (D)

Quantitative analysis was also conducted to confirm the views of respondents that were made during the qualitative phase of the study. Ash classification as hazardous waste and lack of recycling opportunity are regarded as the main factors impeding the widespread recycling of ash in South Africa.

6.7.1 Descriptive statistics about Factor: C (Ash Classification)

The classification of ash as hazardous waste was discussed in the previous chapters. Respondents that were surveyed supported literature in terms of seeing ash classification as hazardous waste by the legislation as an impediment to ash recycling in South Africa. A total of number of 66 (64.08%) agreed that ash classification as a hazardous waste is limiting recycling opportunities, 28 (27.18%) were neutral and 9 (8.74%) disagreed. Respondents agree that the classification of ash as hazardous waste is impeding recycling. Refer to Annexure 6 for the results.

6.7.2 One sample T-tests statistics about Factor: C (Ash Classification)

One sample T-tests were conducted for factor C to determine whether the population mean value for these factors can be regarded as either in agreement ($\mu > 3.40$), neutral $\mu < 3.0$) or disagreement ($\mu < 2.60$). Factor C has a mean score of 3.79; this indicates that the majority of respondents are in agreement about the impact of ash classification as hazardous waste as a factor influencing the limited recycling of ash. Refer to Annexure 7 for the results.

6.7.3 Chi-squared tests for Factor C (Ash Classification)

The Chi-squared tests indicate that majority of the respondents in Eskom (45.83%), Government (36.36%); NGOs (46.67%) are in agreement category, while majority of the recyclers (46.67%) are also ‘in agreement’ for Factor C. Ash classification is an obstacle that is impacting in the recycling of coal ash. Table 6.1 illustrates the Chi - squared tests on Factor C.

Table 6.1: Chi - squared tests on Factor C

Responses	Eskom	Gov	NGO	Recyclers	Total
Factor C (p=0,458)					
Disagree	2	2	5	0	9
	22.22	22.22	55.56	0.00	100.00
	5.56	9.09	16.67	0.00	8.74
Neutral	10	7	8	3	28
	35.71	25.00	28.57	10.71	100.00
	27.78	31.82	26.67	20.00	27.18
Agree	13	8	14	7	42
	30.95	19.05	33.33	16.67	100.00
	36.11	36.36	46.67	46.67	40.78
Strongly Agree	11	5	3	5	24
	45.83	20.83	12.50	20.83	100.00
	30.56	22.73	10.00	33.33	23.30
Total	36	22	30	15	103
	34.95	21.36	29.13	14.56	100.00
	100.00	100.00	100.00	100.00	100.00

Analysis of factor C (Ash Classification) using descriptive statistics; one sample T-tests and Chi-squared tests revealed the views of respondents as a category. Respondents are largely in agreement that the classification of ash as hazardous waste is limiting ash recycling in South Africa. The same arguments were revealed during literature review. Relaxation of legislation in terms of permitting requirements is advocated as a major obstacle particularly to local communities.

6.7.4 Descriptive statistics about Factor: D (Recycling Opportunity)

Recycling opportunity is critical to ensure that local communities can benefit economically. Generally about 89 (86.41%) agree that local communities can benefit economically from the recycling of ash, 12 (11.65%) are neutral and 2 (1.94%) are negative. Respondents agree that ash can change the socio economic situation of local communities. Refer to Annexure 6 for the results.

6.7.5 One sample T-tests statistics about Factor: D (Recycling Opportunity)

One sample T-tests were conducted for factor D to determine whether the population mean value for these factors can be regarded as either in agreement ($\mu > 3.40$), neutral $\mu < 3.0$) or disagreement ($\mu < 2.60$). Factor D has a mean score of 4.11; this indicates that the majority of respondents are in agreement about the socio economic benefits that can be attained by the local communities. Refer to Annexure 7 for the results.

6.7.6 Chi-squared tests for Factor D (Recycling Opportunity)

The Chi-squared tests indicate that the majority of the respondents in Eskom (61.11%), Government (54.55%) and NGOs (56.67%) are situated in the 'agree' category, while majority of the recyclers (73.33%) are 'in agreement' for Factor D. Table 6.2: Chi-squared tests on Factor D. All respondents agreed that recycling can improve the management of coal ash and can improve the socio economic situation of the community waste significantly. Table 6.2 illustrates Chi-squared tests on Factor D.

Table 6.2: Chi-squared tests on Factor D

Responses	Eskom	Gov	NGO	Recyclers	Total
Factor D (p=0,116)					
Disagree	1	0	1	0	2
	50.00	0.00	50.00	0.00	100.00
	2.78	0.00	3.33	0.00	1.94
Neutral	2	1	8	1	12
	16.67	8.33	66.67	8.33	100.00
	5.56	4.55	26.67	6.67	11.65
Agree	22	12	17	11	62
	35.48	19.35	27.42	17.74	100.00
	61.11	54.55	56.67	73.33	60.19
Strongly Agree	11	9	4	3	27
	40.74	33.33	14.81	11.11	100.00
	30.56	40.91	13.33	20.00	26.21
Total	36	22	30	15	103
	34.95	21.36	29.13	14.56	100.00
	100.00	100.00	100.00	100.00	100.00

Respondents indicated a number of challenges in terms of the absence of recycling opportunities. Not all respondents were in agreement in terms of seeing recycling as a possible solution to improve the socio economic situation of local communities. Some of the NGO's do not think it is possible to empower communities to manage successful recycling ventures because of lack of skills and political influences. Analysis of factor D (Recycling opportunity) using descriptive statistics; one sample T-tests and Chi-squared tests revealed the views of respondents as a category and they all agree that recycling opportunities can successfully improve the lives of local communities.

6.8 CONCLUSION

Chapter 6 explained the results and analysis: potential recycling opportunities and barriers thereof. This chapter addressed the objective that is intended to explore the challenges and interventions that can be employed to ensure that FA recycling opportunities benefit local communities in South Africa. Respondents' feedback analysed was that of recyclers, NGO's and practitioners and it excluded communities because of their limited exposure to ash recycling activities. Both in-depth interviews and surveys conducted on respondents agree that the classification of coal ash as hazardous waste is impeding the widespread recycling, and similarly socio economic situation improvement to the local communities can be attained through ash recycling. Respondents indicated that support and partnership is required in order to ensure that the community can recycle ash sustainably. The intervention that is required includes market development, relaxation of the legislation that governs ash and creating an environment that ensures that the opportunities are inclusive to all local communities.

7 CHAPTER SEVEN - Results and analysis: implications to the community's environmental justice and a just transition to a clean energy production

This chapter discusses the implications of the results that were presented in chapter 5 and 6 in the context of environmental justice and just transition theories. The study's results have revealed the negative impacts that FA is having on the local communities of the two selected power stations. The communities are experiencing an environmental injustice by being exposed to pollution that affect their wellbeing. A transition to cleaner energy production is necessary in order to protect the community's right to an environment that enhances their wellbeing. South Africa is embarking on the route to cleaner energy production. Some of Eskoms Power stations are old because they were commissioned in the 1960's and 1970's, they are nearing their lifespan. To aid a just transition, ash recycling has a potential to address the socio economic situation of the employees who are currently employed by power stations as well as local communities.

7.1 Implications for Communities' Environmental Justice

The goal of environmental justice is to ensure that local communities constitutional right of an environment that enhance their wellbeing is being realised. Environmental justice can only be enhanced in a setting were the socio-economic situation of the community is adequately served. Swilling, Musango and Wakeford (2015: 8) caution that the "structural transformations needed for a just transition will only be achieved when there is a socio-political regime that rests on a strategic coalition of interests that shares this paradigm, uses state institutions to drive a just transition and adopts an appropriate policy and legislative programme that is aligned with the overall goal". A sound environmental justice can only be felt when the needs of the community are served sustainably. Communities must be made aware of their environmental rights as stipulated in section 24 of the South African constitution. Empirical evidence acquired through both the qualitative and quantitative approaches support the views of the community that ash disposal facilities affect their health due to FA exposure.

7.1.1 Impact of fly ash to the communities health and their livelihoods

In-depth interviews have revealed that communities who reside in farmsteads and informal settlements adjacent to ash dams are poor people who usually do not have sustainable means to provide for themselves. Their livelihoods of farming are also impacted by the exposure to coal ash. The communities residing in close proximities to the selected sites have been residing in the indicated sites for long periods and they continue to raise their children in these environments. It is imperative that the Power station's management engage the communities and enquire about the levels of pollution that communities are experiencing.

The respondents included residents who resided in the area next to Hendrina power station before it was constructed. This implies that a few generations have suffered. The European Centre for the Development of Vocational Training [Cedefop], (2009) observes that the environmental challenges raise serious concerns for the welfare of current and future generations, responses should be driven by reinforcing policies for environment, energy, transportation, employment, and training. Ash recycling in the case of Hendrina power station will be a new activity that has never been conducted before and it has the potential to introduce an economic activity that never existed in the area before.

7.2 Implications of fly ash's impact to communities and a just transition theory

Literature review revealed that Eskom will be generating electricity through coal fired power stations for the foreseeable future. The communities that reside next to Hendrina and Kendal Power station will still be in an environment that impacts their lives. Any solution that seeks to address their predicament must appreciate this fact. "A just transition consists of a dual commitment to human well-being (with respect to income, education and health) and sustainability (with respect to decarbonisation, resource efficiency and ecosystem restoration), however, to understand these processes we need a better understanding of political dynamics, and for this purpose the notion of a socio-political regime" (Swilling, Musango and Wakeford, 2015: 18). A strong possibility exists that intervention to benefit communities can be hijacked by political formations that can seek publicity at the expense of a genuine socio economic situation of local communities, impacting on a just transition

Addressing the community's pollution predicament requires a focus on the socio economic situation of the community. Interviews and observations during research revealed that most of the community's members are poor and unemployed. A transition from a polluted environment can be achieved by assisting the community's in terms of employment, education and health care. "The situation is dire in rural areas, the ground reality of the rural societies indicate that the failed development is the result of the lack of transparency, management, effectiveness of development aid along with the poor quality of communication of development agencies and organisations with the rural people" (Sharma, 2011: 135). The situation of communities in the sites under study indicated that that they lack access to basic services like water, electricity, healthcare and decent roads. This also reflects the neglect from the local municipality's service delivery departments. The impact of ash to communities livelihoods have to be managed in a transparent way and communities have to be involved in all decisions that affect their lives.

7.3 A Just Transition through Fly Ash Recycling

A just transition is possible through FA recycling. When Hendrina and Kendal Power station are retired, there is a potential of ash recycling providing opportunities for employees. The South African government still wants to introduce more renewable energy into the grid. This will have an impact to the operations of coal-fired power stations. "South Africa as a country is currently heavily reliant on non-renewable electricity generation, and coal is expected to play a dominant role in the near future when taking into account the abundance of the commodity locally" (Thopil and Pouris, 2015: 2813). Ash recycling has the potential to provide employment to communities that reside adjacent to power station ash dump facilities. Local communities can be grouped into business cooperatives that are business incubated in preparation for ash recycling opportunities.

Some of Eskom's power stations particularly Hendrina are reaching their design life, it is inevitable that eventually some will be decommissioned and the respondents demonstrated their awareness of that reality. "Communities that have been home to the electric generation units of the past, particularly struggling coal-fired power plants, are especially vulnerable when power stations reach their end of operation. There is a need to address the impact of lost jobs and declining economic activity" (Hamilton, Valova and Rábago, 2017: 6). Respondent alluded to the potential of recycling ash after the end of life for a power station.

The communities in the two sites demonstrated lack of awareness of any recycling activities in their communities. Future ash handling legislation must appreciate the need to protect the local communities from pollution and involvement in recycling activities. A transition to clean energy will mitigate the pollution, water consumption and other natural resources through high-efficiency strategies, to de-carbonise the economy and reduce greenhouse-gas emissions, to minimise or avoid altogether all forms of waste and pollution (CCI, 2008).

7.4 Conclusion

This chapter discussed the results and analysis of the results focusing on the implications of FA pollution to the Community Environmental Justice and Just Transitions theories. Pollution impact in relation to the Environmental Justice framework was explained in the previous chapter (Chapter 3). The discussion further analysed the implication of the pollution to the communities' wellbeing in relation to a just transition theory. A just transition through FA recycling was discussed and it covered aspects of coal quality; recycling opportunity and ash handling. The chapter exposed community's pollution predicament and the need to focus on the socio economic situation of the community. The chapter also noted the fact that most of the community's members are poor and unemployed. The chapter highlighted a research finding that a transition to clean energy will mitigate pollution and improve the living conditions of local communities. Chapter 8 presents the conclusions of the whole study.

8 CHAPTER EIGHT- Conclusions and Recommendations

This final chapter presents conclusions drawn from the results of this study and recommendations of the research. It is essential that findings and conclusions representing inferences drawn from the results are presented at the final chapter (Blumberg, Cooper and Schindler, 2008). This study focused on the coal FA waste management challenges in the South African coal power generation sector and possible recycling opportunities with particular focus on Hendrina and Kendal power stations. The study was aimed at exploring how the management of coal ash waste in South Africa can be improved to minimise its impact on the environment and human health and to explore the potential recycling applications that can benefit local communities. Recommendations based on contemporary literature and empirical findings in the current study are presented in this chapter and they are linked to the results and analysis presented in chapter 5, 6 and 7. Research questions and objectives and how they were met by the study are also explained. The final part of the chapter highlights the implications of the research to policy makers and recommendations for future studies.

8.1 Research Conclusions

The study comprised of qualitative and quantitative methods, the qualitative phase was conducted through in-depth interviews in order to draw on the experiences of the respondents that also included local communities. The quantitative phase was conducted through semi structured questionnaires that involved a survey of stakeholders in the coal fired power stations sector. The study also drew insights from the: Ecological modernisation theory; Green economy; Just transition and the Environmental justice theories. Given the focus of the research topic and its emphasis on the impact of FA on the local communities and the recycling opportunities to meet their socio economic needs, the Environmental justice and the Just transition theories were employed to address the aim of the research. Investigations into the impact of coal ash to local communities and its recycling thereof are not new concepts in general but limited studies have drawn insights from these theories. This study has revealed the fact that, ash waste is affecting the wellbeing of the local communities and there are limited recycling initiatives benefitting local communities.

The local communities that are affected by ash waste generated from power stations are mainly the poor and marginalised communities. Empirical evidence obtained from community's in-depth interviews revealed that coal ash is impacting on the health of the communities' causing respiratory illnesses like asthma; sinus issues, coughing, skin and eyes irritation allergy, coughing, sneezing and skin itching. Kenis and Lievens, (2016: 20) "observe that another problem is not about how to make the just transition from fossil fuel capitalism to a clean energy, more precisely, the question is whether it is possible to effectively realise such a transition in a short enough lapse of time if the chosen pathway is through the market". Given that coal fired power stations will still be part of the community for a long time, to facilitate a just transition, the power stations will have to have to address meaningful issues pertaining to the use of good quality coal, improved ash disposal management and create opportunities for ash recycling.

"Just transition conceptual theory that captures the complexities of the transition toward a zero-carbon society, while examining the opportunities for public policy interventions and solutions that are, most importantly, inclusive of the concerns of workers" (Rosemberg, 2017: 6). Stations that have not been active in terms of ash recycling are in the process of exploring available opportunities and the customer base to sell ash as a measure to reduce the accumulation of ash. Engagements between Eskom and other stakeholders are underway to facilitate the expansion of ash use in different sectors in the country. Limited ash recycling initiatives to benefit local communities remain a point of interest because there is glaringly limited progress to revolutionise coal ash waste to be beneficial economically particularly to local communities. The priority of coal fired power generation sector to sell tons of ash is moving at a snail pace.

A shift in ash recycling regime is urgently needed in favour of inclusive green economy initiatives that benefit local communities. There is a need to train and develop skills for community members to recycle coal ash. Eskom needs to partner with community members to demonstrate the potential uses of ash. However due diligence needs to be done to ensure that there are no negative consequences (from a safety, health and environment point of view).

8.2 Addressing the Research Questions

8.2.1 The primary research question

The primary research question was stated as follows: **How can the management of FA waste from coal fired power stations be improved to minimise the negative impacts and enhance potential benefits?**

The Impact of FA waste to the environment and human health and their livelihood have been explained in Chapter 2 (Background: Understanding the South African coal industry and coal combustion for power generation). The quest for profits and pressure for production from companies and lack of pollution regulations enforcement by the authorities leave local communities in vicious circles of poverty and squalor. Literature review also exposed how the power stations selected for the study can manage the impact by analysing the pollution problem through the environmental just framework and how FA recycling can benefit local communities in the context of a just transition theory. The predicament that poor people find themselves in impacts the social justice, environmental justice and ecological justice domains tied together. Schlosberg 2004 (524) observes that the “poor suffer both social and environmental inequity”. The main research question was answered through the identification of factors (coal quality; ash handling; ash classification and recycling opportunity) that must be managed in order to ensure that FA waste from coal fired power stations can be improved to minimise the negative impacts and enhance potential benefits

The identified factors were analysed statistically during the quantitative phase of the study. Potential recycling opportunities and barriers were identified from literature reviews and from respondents through in-depth interviews and analysed in the results chapter (Chapter 5). The study answered the main research question by focusing on the measures that must be addressed to minimise the pollution impact to local communities. Feedback from all categories of respondents revealed that the management ash disposal facilities is not adequate, communities indicated that they are on the receiving end of pollution. The study also revealed the lack of involvement of local communities regarding ash recycling. The primary research question was further supported by the secondary research questions that are answered in Table 8.1 below.

Table 8.1: Research sub questions	
Q_1	**What impacts are FA disposal facilities having on the natural environment and neighboring communities?** The study drew insights about coal ash disposal facilities impact to the environment from literature. Literature indicated the impacts of FA disposal to include air, water and land pollution. Literature also indicated the impact of FA to human health and the community's livelihood that involve farming. Eskom's disposal sites were found to be responsible for water and air pollution. In-depth interviews revealed the experiences of local communities who have confirmed their predicament of being exposed pollution for many years and are struggling with respiratory diseases. Legal enforcement to protect communities by government were found to be inadequate and no engagement from Eskom with the communities is being undertaken to address pollution.
Q_2	**Which interventions can be employed to ensure that FA recycling opportunities benefit local communities in South Africa?** The study confirmed the current recycling activities that are taking place in South Africa. Local communities where found not to be benefiting from current ash recycling activities, the main beneficiaries were found to be cement manufacturing companies that collect ash particularly from Kendal power station. The study revealed many interventions that are needed and they include: empowering communities through ash recycling trainings, developing the market, relaxing legislation to enable access to ash, involvement of departments that can benefit from ash recycle products and an involvement of local communities.
Q_3	**What are the prospects of a just transition to clean energy sources and environmental justice through FA recycling?** Literature reviews' about a just transition to clean energy production from fossil fuels were conducted including a discussion about the constraints of transitioning away from the mineral energy complex economy in South Africa's energy mix. The study found that a transition is possible in the context of an environmental justice and a just transition theory. The study find that service delivery need to be improved including access to water, electricity, health care and other necessities by the local communities. A just transition was found to be possible with a potential to benefit both local communities and employees when some of the power stations are decommissioned in the future.

8.3 Addressing the Research Objectives

The primary objective of this research was to explore the short, medium and long-term activities and interventions needed to manage FA waste in the coal fired power stations in order reduce its impact and to optimise social and economic benefits to the affected local communities in South Africa.

Literature was reviewed and a research problem was identified as stated in Chapter 1. A clear link should always be established between the original study objectives and respective conclusions (Diamantopoulos and Schlegelmilch, 2006). The primary objective of this study was achieved through literature reviews and empirical investigations of the research questions identified by the study in chapter 1. The research followed a mixed methodology design by employing both qualitative and quantitative approaches to address the research objective.

The two selected case study power stations were constructed and commissioned in a period when there were no strict environmental legislations in South Africa to ensure that the disposal sites were lined to prevent leachates contaminants from leaching into the ground. This has resulted in the contamination of ground water for many years. The study found that the short-term intervention include relocating communities away from highly polluted areas to prevent their exposure to water and air pollution. The medium intervention includes monitoring of pollution in the ground and surface water and screen communities in terms of the health impacts that they have experienced. The study also infer that intervention must also include the strict enforcement of legislation by the authorities.

In the longer-term, intervention must include ensuring that all future ash dams are constructed in compliance with the legislation and they must be strategically located not to cause environmental impact to communities and lined. Intensive ash recycling can provide sustainable job opportunities to local communities and in the process heaps of coal ash can be consumed leading to the elimination of the environmental impacts associated with the ash disposal sites. The ash recycling revolution can have positive impacts to the local socio-economic situation of local communities. The loss of employment for employees of coal-fired power station can also be alleviated through recycling opportunities. This study infers that a just transition is possible through ash recycling on a long-term. Secondary objectives are addressed in table 8.2 below.

Table 8.2: Secondary research objectives	
O_1	**To identify the impact of FA to the receiving environment and the wellbeing of local communities:** The study identified the impact FA impact to the receiving environment and the wellbeing of local communities. The results were presented and analysed both qualitatively and quantitatively. In-depth interviews revealed that respondents are unanimous about the pollution that local communities are experiencing. Respondents further indicated the impact of FA to their livelihoods that depend on farming. Quantitative results and analysis revealed the factors that respondents supported as the main factors contributing to the management challenges of ash in South African coal fired power station's sector. Communities confirmed the impact of FA to their wellbeing and livelihoods. Respiratory illnesses were confirmed as the main challenge to the community's health.
O_2	**To explore the challenges and interventions that can be employed to ensure that FA recycling opportunities benefit local communities in South Africa:** Both in-depth interviews and surveys conducted on respondents agree that the classification of coal ash as hazardous waste is impeding the widespread recycling, and there is an agreement by all respondents that socio economic situation improvement to the local communities can be attained through ash recycling. The study exposed interventions that are needed to ensure that local communities can benefit and amongst the immediate intervention is that: communities must be made aware about the ash recycling opportunities.
O_3	**To expose the prospects of an environmental justice and a just transition to clean energy sources through FA recycling** The results were presented in the context of environmental justice and just transition theories in Chapter 7. The discussion further analysed the implication of the pollution to the communities' wellbeing in relation to an environmental justice framework. The study revealed that the community's right to the environment that enhances their wellbeing was being trampled on. Communities lack awareness of ash recycling needs attention and a just transition through FA recycling was found to be possible as a long term solution to change the socio economic situation of the community and that of the power station's employees when the power stations are decommissioned.

8.4 RECOMMENDATIONS OF THE STUDY

The findings are concluded based the Environmental justice and a Just transition framework. Local communities also indicated the impact of ash dust to their livelihood; particularly farming that includes poultry, livestock and game farming. Interviews of Non-Governmental Organisation revealed their concerns about poor community consultations by power stations about the impact of ash waste to their wellbeing. Environmental justice is based on the principle that all people have a right to be protected from environmental pollution and interventions are required to restore the environmental justice for local communities.

8.4.1 Fly ash impact mitigation to the environment and the local community

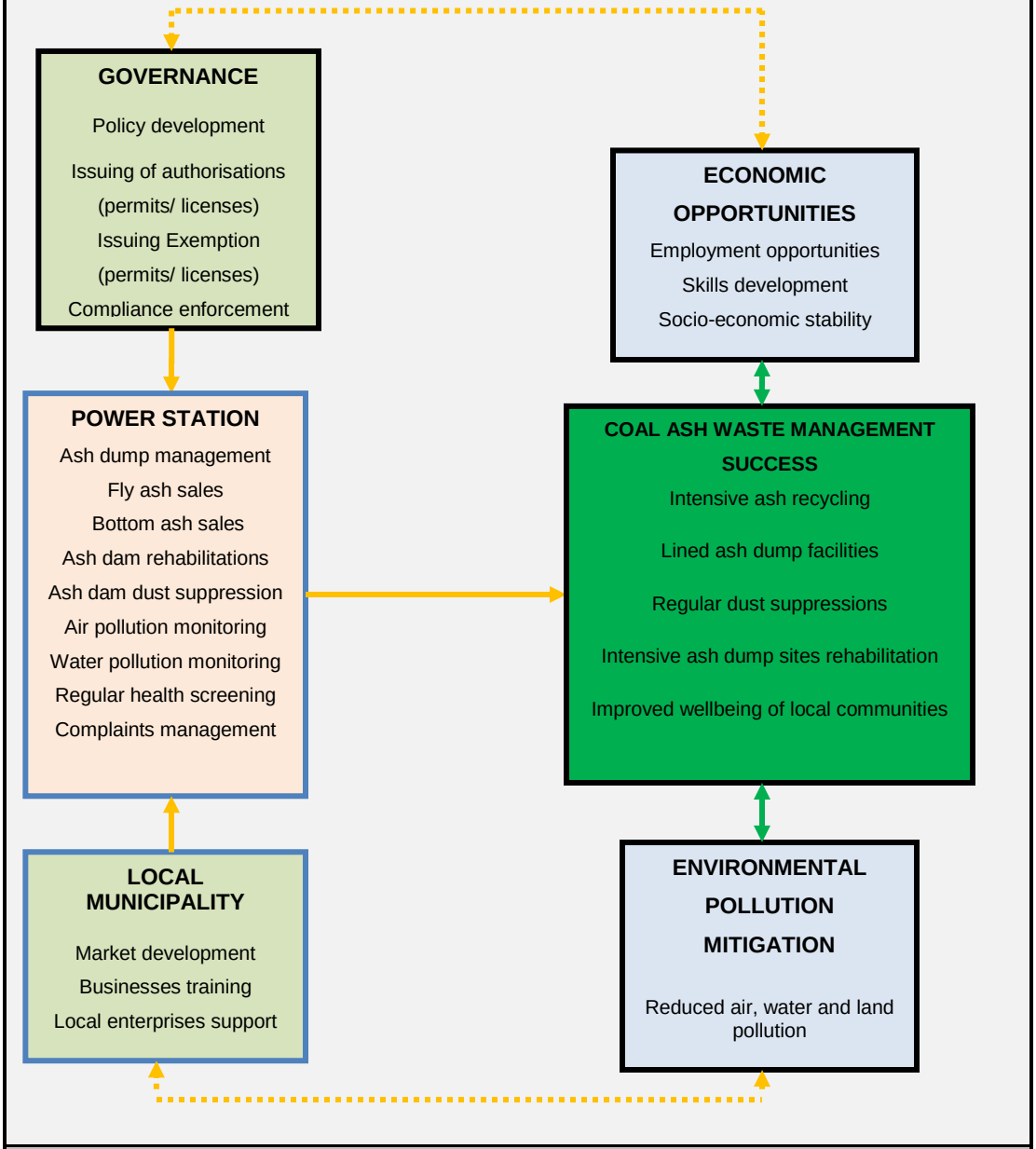
The study recommends that power stations must take responsibility of health screening of communities that are residing closer to ash dumping sites and where necessary relocate them away from high pollution risk areas. South African burns cheap coal to keep the primary energy costs as low as possible. This allows the country to produce cheap electricity; as a result a lot of ash requiring land for disposal is generated. An innovative way for intensive rehabilitation and dust suppression is necessary. The issue of ground water contamination will be addressed when new ash dams are lined to contain effluent. In the longer term communities that reside closer to the ash dumps and in areas of high risk must be relocated to areas of low risk.

8.4.2 Potential recycling opportunities and overcoming barriers

A shift in ash recycling regime is needed in the short term, in favour of inclusive green economy initiatives that benefit local communities and facilitate a just transition to a clean energy production in the long term. The concerns being raised by the majority of potential recyclers are distance of the FA (raw material) away from the market, which increases transportations costs. Strategic associations between the other departments like human settlement; public works and others can be directed to ash recycling products to revolutionise the use of ash. The interaction and involvement between stakeholders to facilitate a change is illustrated in figure 8.1 below.

8.4.3 Community's environmental justice and just transition

Figure 8.1: A recommended empirical model to manage coal ash waste



Source: Researcher's own construction

8.4.4 Implication of the study to policy makers

Environmental pollution management is well regulated in South Africa, only the enforcement must be strengthened. Scholarly debates supporting a transition to clean energy production are raging. Beneficiation of ash waste to local communities remains elusive in the South African power generation sector. South Africa will be dependent on coal for power generation for many decades to come, before a complete transition is achieved where more energy will be generated from non-fossil fuel sources. Ash recyclers demonstrated optimism in their responses about the potential of intensive ash recycling generating more sustainable employment in future. Attention must be given to the market development to ensure that ash recycling can become a viable business. The empirical results infer that that there is a need for an intervention from all stakeholders that include: government; power stations management and community leadership structure, as illustrated in figure 8.1 above.

8.4.5 Recommendation for future studies

It is recommended that future studies explore ways in which coal ash can be used as a catalyst for an ash recycling industrial revolution in the Nkangala district in order to stimulate job creation in the region. Future studies need to reveal the role of other stakeholders, including civic society, environmental activists and interested and affected parties in ash coal ash beneficiation projects. A similar study can also be conducted in other sectors that generate a considerable amount of waste that is stockpiled on land; these include mines, steel industries and timber factories.

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ANNEXURE 1: COMMUNITY LETTER: QUALITATIVE QUESTIONNAIRE

School of Geography, Archaeology and Environmental Studies

Private Bag 3, Wits 2050, South Africa Enquiries: **GEOGRAPHY:** TEL: +27 11 717-6503 •
ARCHAEOLOGY: TEL: +27 11 717-6045 •
http://www.wits.ac.za/geography/

Dear Respondent 26 October 2016

I am a Master of Science (MSc): Geography and environmental Studies student conducting research in conjunction with the University of the Witwatersrand (Wits). My research topic is: **Coal fly ash waste management challenges in the South African power generation sector and possible recycling opportunities: A case study of Hendrina and Kendal Power Stations.** The main aim of the study is to explore how the management of fly ash (FA) waste in South Africa can be improved to minimise its impact on the environment and human health and also to investigate the potential recycling applications that can significantly reduce the high amount of FA disposal on land and benefit local communities.

This questionnaire is to be answered by respondents impacted, affected or interested on fly ash impact to communities that are living adjacent to the ash dump sites and any interested and affected parties. There are two sections. Section A (Demographic information) and B (Interview/ feedback questions). To ensure full accuracy of the results, complete both sections. It should take about 45 minutes to conduct the interview. Kindly note that your anonymity is assured and all responses will be treated in the strictest confidence.

Thank you for your willingness to contribute to the success of this research project.

Yours faithfully,



Justice Ramagoma: Student
082 261 9361

013 296 3013

Email: RamagoMJ@eskom.co.za

Dr Melanie Samson: Supervisor
Tel: 011 717 6521

Email: melanie.samson@wits.ac.za

ANNEXURE 2: QUALITATIVE RESEARCH QUESTIONNAIRE: COMMUNITY

School of Geography, Archaeology and Environmental Studies

Private Bag 3, Wits 2050, South Africa Enquiries: **GEOGRAPHY:** TEL: +27 11 717-6503 •
ARCHAEOLOGY: TEL: +27 11 717-6045 •
http://www.wits.ac.za/geography/

Formal Consent Form

I understand that:

Justice Ramagoma has requested an interview for his project, "Research Project: **Coal fly ash waste management challenges in the South African power generation sector and possible recycling opportunities: A case study of Hendrina and Kendal Power Stations.".** He has explained the following:

- He is Master's degree student conducting research through the University of the Witwatersrand.
- He has provided the title of his research
- I have been selected to be interviewed as he is interested in understanding the pollution challenges that are associated with fly ash to me/ us as a communities or community representatives.
- The information received from this interview will be kept secured on a password secured computer and used in his final Masters' research report.
- The duration of the interview is between 30 to 45 minutes.
- My participation is completely voluntary and if I feel uncomfortable at any point in the interview, the interview will be cancelled without penalty.
- All information I provide will be confidential and my name will be kept anonymous.
- Relevant quotes may be used in the research if I provide consent.
- He does not foresee any risks to me or loss of benefits due to my association with this study.
- He will provide a summary of his research findings to me on request.
- Should I have any questions or concerns regarding the research, he has provided me with relevant contact details.



Justice Ramagoma: Student
082 261 9361
013 296 3013

I hereby agree to participate in the research. Yes ☐ No ☐
I agree that the researcher may quote my information in his research report. Yes ☐ No ☐

Signatures:

I_____, consent to participate in Justice Ramagoma's research. My signature below indicates my consent.

Participant

Signature_____ **Date**_____

ANNEXURE 3: QUALITATIVE RESEARCH QUESTIONNAIRE: NGO'S

School of Geography, Archaeology and Environmental Studies

Private Bag 3, Wits 2050, South Africa Enquiries: **GEOGRAPHY:** TEL: +27 11 717-6503 •
ARCHAEOLOGY: TEL: +27 11 717-6045 •
http://www.wits.ac.za/geography/

Dear Research Participant

The research project topic is: **Coal fly ash waste management challenges in the South African power generation sector and possible recycling opportunities: A case study of Hendrina and Kendal Power Stations.**

SECTION A: Demographic Information (anonymity will be assured and responses will be treated with the strictest confidentiality)

Please complete the demographic section first

1	**Affected by the power station from**	**Eskom**		**Sasol**	
2	**Affected by power station:**	**Hendrina**		**Kendal**	
3	**Category of the affected party:**	**Community**		**NGO/ UNION**	
4	**Years of exposure to pollution:**	**1 up to 5**		**More than 5**	
5	**Gender:**	**Male**		**Female**	
6	**Level of education (Grade 12)**	**No grade 12**		**Have grade 12**	
7	**Type of impact exposed to:**	**Air emissions**		**Soil/water**	

SECTION B: Questionnaire

Coal fly ash waste pose pollution challenges to communities that reside adjacent to coal fired power generation. With reference to your exposure or experience of representing affected communities, please indicate your views/ opinion pertaining to the statements (questions) below. Please note that there are no correct or incorrect answers, we are only interested in your opinion. Please answer all questions.

1. How are you and other people in your community affected by living so close to the power station?…….

2. Fly ash is a by-product of coal combustion in thermal power plants, what fly ash pollution have you experienced or noticed? …….....

3. How are you and your family personally affected by fly ash? ……

4. What are the ways that fly ash affects the community? ……..

5. What concerns do you have regarding communities exposure to fly ash?……

6. In which season of the year is the community largely exposed to pollution from fly ash dump site?……

7. Is fly ash having an impact to soil, surface water and ground water in the communities' area?…….

8. What are the health impacts that have been experienced due the pollution that is indicated above?…….....

9. Has the power station ever enquired if ever you are impacted by the fly ash?……

10. Are you happy with the initiatives employed to address your exposure to the pollution from the ash?……..

11. Do you think coal should continue to be used to generate electricity?……..

12. Do you think the pollution problem is exacerbated by the wet ashing/ dry ashing process?…….

13. Does the pollution from fly ash dump sites affect your livelihood?…….

14. Does the pollution have an impact on your property?……..

15. Are you aware of any fly ash recycling initiatives currently taking place?…….

16. Can fly ash recycling opportunities benefit the local communities in your view?…….

17. Is there any intervention or assistance that the community need to be able to recycle or use fly ash? ……..

18. Do you have any further comment about the research topic?……..

ANNEXURE 4: QUALITATIVE RESEARCH QUESTIONNAIRE: PRACTITIONERS

School of Geography, Archaeology and Environmental Studies

Private Bag 3, Wits 2050, South Africa Enquiries: **GEOGRAPHY:** TEL: +27 11 717-6503 •
ARCHAEOLOGY: TEL: +27 11 717-6045 •
http://www.wits.ac.za/geography/

Dear Research Participant

The research project topic is: **Coal fly ash waste management challenges in the South African power generation sector and possible recycling opportunities: A case study of Hendrina and Kendal Power Stations.**

SECTION A: Demographic Information (anonymity will be assured and responses will be treated with the strictest confidentiality)

Please complete the demographic section first

1	**Associated with SASOL or Eskom Ash**	**ESKOM**		**SASOL**	
2	**Years of association with fly ash (years):**	**1 up to 5**		**More than 5**	
3	**Gender:**	**Male**		**Female**	
4	**Focus area:**	**Environmental**		**Engineering**	
5	**Involvement in fly ash recycling:**	**Yes**		**No**	

SECTION B: Questionnaire

Coal fly ash waste generates environmental pollution challenges and impacts the well-being of communities that reside adjacent to coal fired power generation. There are various possible recycling opportunities that can be considered in order to benefit local communities. With reference to your exposure/ involvement to fly ash waste management please indicate your views/ opinion pertaining to the statements (questions) below. Please note that there are no correct or incorrect answers, we are only interested in your opinion. Please answer all questions.

1. What are the fly ash environmental pollution challenges that are generated by the power station that you are familiar with?

Fly ash dust emissions	
Health impacts to affected communities	
Ground water and soil pollution	
Other (specify	

Additional views……

2. What type of interventions is being employed to minimise pollution that is being generated by fly ash from the power station?

To prevent soil and water contamination	
To reduce air emissions	
Other (specify	

Additional views……

3. What is your view about the coal quality that is currently being used to generate electricity in relation to pollution that is experienced?……..……..

4. Do you think there is any viable method of storing ash other than the ash dump method that is currently being used? …….....

5. Do you think the pollution impact to the soil, surface water and ground water can be reversed? ……..

6. Do you think the air emissions pollution impact to the atmosphere can be minimised?……..

7. Are the ash dump rehabilitation programmes effectively addressing air emissions pollution in your view?……

8. What can be done to reduce exposure of communities neighbouring the power stations to fly ash pollution?.....

9. Do you think the pollution problem is exacerbated by the wet ashing/ dry ashing process?…….

10. At what state is ash more ideal to recycle (wet or dry)? ……

11. Is there any fly ash being sold in the power station that you are familiar with?…..

12. Are you aware of any fly ash recycling initiatives/ sustainability projects currently taking place to benefit local communities?……

13. What benefits have you noticed from fly ash recycling activities?

……..

14. What obstacles hinder fly ash recycling opportunities in your view?……

15. Is there any intervention or assistance that the communities need to be able to recycle fly ash? ……...

16. Can fly ash recycling be a trigger to a fly ash industrial revolution in coal fired power stations vicinity?

In next 5 years	
In next 10 years	
In next 15 years and beyond	
It will not possible	

Any additional comment…….....

17. Do you have any further comment about the research topic?……..……..

ANNEXURE 5: QUALITATIVE RESEARCH QUESTIONNAIRE: RECYCLERS

School of Geography, Archaeology and Environmental Studies

Private Bag 3, Wits 2050, South Africa Enquiries: **GEOGRAPHY:** TEL: +27 11 717-6503 •
ARCHAEOLOGY: TEL: +27 11 717-6045 •
http://www.wits.ac.za/geography/

Dear Research Participant

The research project topic is: **Coal fly ash waste management challenges in the South African power generation sector and possible recycling opportunities: A case study of Hendrina and Kendal Power Stations.**

SECTION A: Demographic Information (anonymity will be assured and responses will be treated with the strictest confidentiality)

Please complete the demographic section first

1	**Associated with Eskom or Sasol fly ash:**	**Eskom**		**SASOL**	
2	**Nature of the association with fly ash:**	**Recycler**		**Use ash products**	
3	**Years of association with fly ash (years):**	**1 up to 5**		**More than 5**	
4	**Gender:**	**Male**		**Female**	

SECTION B: Questionnaire

There are various possible fly ash recycling opportunities that can be considered in order to benefit local communities. With reference to your exposure/ involvement to fly ash recycling/ or use of fly ash products, please indicate your views/ opinion pertaining to the statements (questions) below. Please note that there are no correct or incorrect answers, we are only interested in your opinion. Please answer all questions.

1. What are the environmental pollution challenges that you have experienced or exposed to, emanating from fly ash dump sites? ……...

2. In which season of the year have you been exposed to pollution from fly ash dump site?……..

3. What are the health impacts that you have experienced due the pollution that is indicated above?…….....

4. Do you think the pollution problem is exacerbated by the wet ashing/ dry ashing process?…….

5. At what state is ash more ideal to recycle (wet or dry)? ……..

6. At what season is it more ideal to recycle fly ash (summer or winter)?….....

7. How durable are products made from fly ash compared their counterparts?…….

8. What can be done to reduce exposure of communities neighbouring the power stations to fly ash pollution? …….

9. Is there any fly ash being sold in the power station that you are associated with?….....

10. Are you aware of any fly ash recycling initiatives/ sustainability projects currently taking place to benefit local communities?……

11. What benefits have you noticed from fly ash recycling activities?

……

12. What obstacles hinder fly ash recycling opportunities in your view?……

13. Is there any intervention or assistance that the communities need to be able to recycle fly ash? ……...

14. Can fly ash recycling be a trigger to a fly ash industrial revolution in coal fired power stations vicinity?

In next 5 years	
In next 10 years	
In next 15 years and beyond	

Any additional comment…….....

15. Do you have any further comments about the research topic?……

ANNEXURE 6: DESCRIPTIVE STATISCTICS OF RESPONDENTS PER FACTOR

Factors	Disagree		Neutral		Agree		
	[1.00 to 2.6)		[2.6 to 3.4)		(3.4 to 5.00]		Total
A	6	5.825243	22	21.35922	75	72.81553	100
B	12	11.65049	53	51.45631	38	36.8932	100
C	9	8.737864	28	27.18447	66	64.07767	100
D	2	1.941748	12	11.65049	89	86.40777	100

ANNEXURE 7: ONE-SAMPLE T-TESTS: FACTORS A TO L

Factor	Mean	S.D.	T	p (μ=3.57)	Cohen's d	p (μ=4.43)	T	Cohen's d
A	3.89	0.08	4.0225	.0001	0.396	.000	-6.681	-0.658
B	3.29	0.08	-3.7113	.0002	-0.366	.000	-15.162	-1.494
C	3.79	0.09	2.4303	.0084	0.239	.000	-7.228	-0.712
D	4.11	0.07	8.1278	.0000	0.801	.000	-4.894	-0.482

ANNEXURE 8: CENTRAL TENDENCY QUESTIONNAIRE ITEMS

Variable	n	Mean	S.D.	Min	Q1	Median	Q3	Max
category	103	2.23	1.09	1.00	1.00	2.00	3.00	4.00
gender	103	0.37	0.48	0.00	0.00	0.00	1.00	1.00
a1	103	3.91	1.31	1.00	3.00	4.00	5.00	5.00
a5	103	2.61	1.31	1.00	1.00	2.00	4.00	5.00
a9	103	4.12	1.06	1.00	4.00	4.00	5.00	5.00
a13	103	4.17	0.93	1.00	4.00	4.00	5.00	5.00
a17	103	3.03	1.22	1.00	2.00	3.00	4.00	5.00
a21	103	3.72	1.21	1.00	3.00	4.00	5.00	5.00
b2	103	3.83	1.16	1.00	3.00	4.00	5.00	5.00
b6	103	2.30	1.15	1.00	1.00	2.00	3.00	5.00
b10	103	3.16	1.14	1.00	2.00	3.00	4.00	5.00
b14	103	3.22	1.15	1.00	2.00	3.00	4.00	5.00
b18	103	2.91	1.16	1.00	2.00	3.00	4.00	5.00
b22	103	3.87	1.13	1.00	3.00	4.00	5.00	5.00
c3	103	3.52	1.27	1.00	3.00	4.00	5.00	5.00
c7	103	3.45	1.03	1.00	3.00	3.00	4.00	5.00
c11	103	3.07	1.17	1.00	2.00	3.00	4.00	5.00
c15	103	3.69	1.00	1.00	3.00	4.00	4.00	5.00
c19	103	3.62	1.15	1.00	3.00	4.00	4.00	5.00
c23	103	3.36	1.07	1.00	3.00	3.00	4.00	5.00
d4	103	4.22	0.98	1.00	4.00	4.00	5.00	5.00
d8	103	4.34	0.90	1.00	4.00	5.00	5.00	5.00
d12	103	3.50	1.13	1.00	3.00	4.00	4.00	5.00
d16	103	3.74	1.06	1.00	3.00	4.00	4.00	5.00
d20	103	2.81	1.27	1.00	2.00	3.00	4.00	5.00
d24	103	4.33	0.88	1.00	4.00	5.00	5.00	5.00

ANNEXURE 9: FREQUENCY DISTRIBUTIONS: QUESTIONNAIRE ITEM

Question	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Total	
A1	10	9.71	4	3.88	20	19.42	20	19.42	49	47.57	103	100%
A5	26	25.24	26	25.24	24	23.30	16	15.53	11	10.68	103	100%
A9	1	0.97	11	10.68	13	12.62	28	27.18	50	48.54	103	100%
A13	2	1.94	4	3.88	13	12.62	39	37.86	45	43.69	103	100%
A17	12	11.65	25	24.27	27	26.21	26	25.24	13	12.62	103	100%
A21	6	5.83	11	10.68	24	23.30	27	26.21	35	33.98	103	100%
B2	4	3.88	11	10.68	22	21.36	28	27.18	38	36.89	103	100%
B6	29	28.16	38	36.89	16	15.53	16	15.53	4	3.88	103	100%
B10	11	10.68	17	16.50	29	28.16	37	35.92	9	8.74	103	100%
B14	10	9.71	16	15.53	31	30.10	33	32.04	13	12.62	103	100%
B18	12	11.65	28	27.18	29	28.16	25	24.27	9	8.74	103	100%
B22	3	2.91	10	9.71	24	23.30	26	25.24	40	38.83	103	100%
C3	10	9.71	13	12.62	20	19.42	33	32.04	27	26.21	103	100%
C7	2	1.94	16	15.53	38	36.89	28	27.18	19	18.45	103	100%
C11	11	10.68	23	22.33	27	26.21	32	31.07	10	9.71	103	100%
C15	2	1.94	11	10.68	27	26.21	40	38.83	23	22.33	103	100%
C19	7	6.80	9	8.74	25	24.27	37	35.92	25	24.27	103	100%
C23	4	3.88	20	19.42	28	27.18	37	35.92	14	13.59	103	100%
D4	3	2.91	3	2.91	13	12.62	33	32.04	51	49.51	103	100%
D8	2	1.94	4	3.88	6	5.83	36	34.95	55	53.40	103	100%
D12	6	5.83	14	13.59	25	24.27	38	36.89	20	19.42	103	100%
D16	3	2.91	14	13.59	14	13.59	48	46.60	24	23.30	103	100%
D20	18	17.48	28	27.18	25	24.27	20	19.42	12	11.65	103	100%
D24	1	0.97	3	2.91	13	12.62	30	29.13	56	54.37	103	100%

ANNEXURE 10: COMMUNITY RESEARCH QESTIONNARE FEEDBACK ANALYSIS

Topics	Theme/s	Respondents' Number	Key arguments	Debates/ theories engaged	Relevant policies and legislations
Impacted by pollution	Exposure to dust and contaminated water;	1; 2; 3; 4; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19	Community's health affected; Children/ grandchildren also affected;	Integrated environmental Management	Constitution of the Republic of South Africa (No. 108 of 1996), as amended (Section 24 of the Constitution)
		5; 6	Pullenshope community and N4 informal settlements not affected		
Impact management	Environmental pollution and Impact to health	1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19	Water contamination and air pollution	Environmental Impact Assessment; Land degradation	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.
Seasonal prevalence of pollution	Winter or summer conditions	1; 2; 3; 4; 5; 7; 9; 11; 12; 13; 14; 16; 17; 18; 19	Throughout the year	Pollution dispersion model	National Environmental Management: Air Quality Act (No. 39 of 2004) (NEM: AQA), as amended.
		6; 8; 10; 15;	Winter season		
Pollution Health impact	Respiratory illnesses	1; 2; 3; 4; 7; 8; 9; 10; 12; 13; 14; 15; 16; 17; 18; 19	Asthma; coughing fits; allergies	Environmental health	Occupational Health and Safety Act (No. 85 of 1993) (OHSA); National Health (Act 61 Of 2003)
		5; 6; 11	Not affected		
Community engagement	Engaged about pollution risks	1; 2; 6; 7; 8; 9; 12; 13; 14; 15; 17; 18; 19	Not engaged	Interested and affected parties consultations	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.
		3; 4; 10; 11	Engaged		
Success of measures to address the pollution	Ash dam rehabilitations and pollution monitoring,	1; 3; 4; 7; 8; 10; 11; 12;	Yes;	Environmental rehabilitation	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.
		2; 5; 6; 9; 13; 14; 15; 16; 17; 18; 19	No		
Future of coal fired power stations	Support fossil fuel energy sources renewable energy energy.	1; 10; 12	Do not support the use of coal for electricity generation	Green energy (Renewable energy)	National Energy Act (No 34, 2008).
		2;	The are no many alternatives		
		3; 4; 5; 6; 7; 8; 9; 11; 13; 14; 15; 16; 17; 18; 19	Not sure		
Method of ash handling and impact	Ash slurry dumping or dry ash dumping.	1; 2; 4; 10; 12	No deference with both ashing systems	Environmental risk management	Hazardous Substances Act (No. 15 of 1973) (HSA); National Water Act (No. 36 of 1998) (NWA), as amended.
		3; 5; 6; 7; 9; 11; 13; 14; 15; 16; 17; 18; 19	Not sure		
Pollution impact to livelihood	Livestock, crops or other business ventures.	1; 2; 3; 4; 7; 8; 12; 13; 14;15; 16; 17; 18; 19	Crops and livestock impacted	Integrated environmental	National Environmental Management Act (No. 107 of 1998) (NEMA), as

		5; 6; 9; 11	Livelihood not impacted	Management	amended.
Pollution impact to the property/ assets	Impact to the buildings; furniture; clothes and household amenities.	1; 2; 3; 4; 7; 8; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19	Ash covers the buildings; furniture, clothes and dirty the houses	Integrated environmental Management	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.
		5; 6; 9	Property not impacted		
Fly ash Recycling	Ash used for brick making, agriculture, construction, etc.	1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 12; 13; 14; 15; 16; 17; 18; 19	Not aware of any recycling initiatives	Cradle to Grave Waste Management Principle	National Environmental Management: Waste Act (No. 59 of 2008) (NEM:WA), as amended
			Aware		
Community Beneficiation	Recycling project s for the youth	1; 2; 4; 12	Recycling can benefit the communities	Waste management	Local Economic Development (LED) Policy
		3; 5; 6; 7; 8; 9; 10; 11; 13; 14; 15;16; 17; 18; 19	Not sure whether recycling can benefit the communities	Ecological modernisation Theory	
Required community's support	Funding, training , communities and youth empowerment initiatives	1; 2;	Support from relevant departments and Eskom can assist a great deal	Green economy	Local Economic Development (LED) Policy
		3; 4; 5; 6; 7; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19	Not sure if there is support needed for the community		
Further comments		2; 4; 3; 8; 10; 11	Interested in the outcome of the study; The site that will be provided for grazing if the community is relocated; located in an area nearby where there is no much impact		
		1; 5; 6; 9; 12; 13; 14; 15; 16; 17; 18; 19	No further comments		

ANNEXURE 11: NON-GOVERMENTAL ORGANISATIONS RESEARCH QESTIONNARE FEEDBACK ANALYSIS

Topics	Theme/s	Respondents' Number	Key arguments	Debates/ theories engaged	Relevant policies and legislations
Fly ash Pollution	Exposure to dust and contaminated water.	1; 2; 3; 4;5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21; 22; 23; 24; 25; 26	Exposed to fly ash dust	Integrated environmental Management	Constitution of the Republic of South Africa (No. 108 of 1996), as amended (Section 24 of the Constitution)
			Not exposed		
Impact management	Environmental pollution and Impact to health.	1; 2; 3; 4;5; 6; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 21; 22; 23; 24; 25; 26	Interventions required	Environmental Impact Assessment; Land degradation	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.
			No interventions required		
Seasonal prevalence of pollution	Winter and Summer conditions	1; 2; 3; 5; 9; 11; 12; 14; 15; 16; 17; 26	Throughout the year during windy days	Pollution dispersion model	National Environmental Management: Air Quality Act (No. 39 of 2004) (NEM: AQA), as amended.
		4; 6; 10; 13; 18; 21; 24; 25;	Winter season		
		22; 23	Summer		
Pollution Health impact to the community	Respiratory illnesses	1; 2; 3; 4; 5; 6; 11; 12; 13; 14; 15; 16; 17; 18; 21; 22; 24; 25; 26	Affected	Environmental health	Occupational Health and Safety Act (No. 85 of 1993) (OHSA); National Health (Act 61 Of 2003)
			Not affected		
Measures to address the pollution	Ash dam rehabilitations and pollution monitoring	1; 2; 4; 5; 8; 9; 10; 11; 13; 14; 15; 16; 17; 18; 21; 22; 23; 25;	Yes;	Environmental rehabilitation	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.
		3; 6; 15; 24; 26	Not satisfied.		
Future of coal fired power stations	Fossil fuel energy and transition to renewable	1; 2; 3; 6; 9; 11; 12; 15; 17; 18; 26	Do not support the use of coal for electricity generation, rather use nuclear and hydrogen and renewable energy	Green energy (Renewable energy); Nuclear energy and hydrogen	National Energy Act (No 34, 2008).
		4; 5; 13; 15; 16; 20;22; 23; 25	Do support it, there are no many reliable alternatives		
		10	Support both		
Ash handling method and pollution	Ash slurry dumping or dry ash dumping.	1; 2; 6; 13; 15; 17; 21;22	Dry ashing	Environmental risk management	Hazardous Substances Act (No. 15 of 1973) (HSA); National Water Act (No. 36 of 1998) (NWA), as amended.
		2;3; 5; 24	Wet		
		4; 9; 11; 12; 25	Not sure		

Pollution impact to livelihood	Livestock, crops or other business ventures.	1; 2; 3; 4; 5; 6; 7; 9; 11; 12; 13; 14; 15; 16; 17	Crops and livestock impacted	Integrated environmental Management	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.
			Livelihood not impacted		
Fly ash Recycling	Possible recycling opportunities	1; 4; 5; 6; 12; 15; 24; 25	Aware of recycling initiatives	Cradle to Grave Waste Management Principle	National Environmental Management: Waste Act (No. 59 of 2008) (NEM:WA), as amended
		2; 3; 7; 8; 9; 10; 11; 13; 14; 16; 17; 18; 21; 22; 23;	Not aware		
Community Beneficiation	Recycling project s for the youth and the community	1; 2; 3; 4; 5; 6; 9; 10; 11; 12; 13; 14; 16; 17; 18; 21; 22; 23; 24; 25; 26	Recycling can benefit the communities	Waste management	Local Economic Development (LED) Policy
		2; 7; 8;	Not sure whether recycling can benefit the communities	Ecological modernisation theory	
Required community's	Support from relevant departments and Eskom	1; 2; 4; 5; 6;9; 10; 11; 12; 13; 14; 21; 23; 24; 25; 26	Support required from relevant departments and Eskom	Green economy	Local Economic Development (LED) Policy
		3; 15;17; 18; 22	Not sure if there is support needed for the community; communities have unrealistic expectations, largely due reckless profit taking; such projects are usually un sustainable.		
Further comments		1; 2; 3	Conduct a study to identify an ash business for the community, ash bricks can be used to eradicate shacks and eventually solve the housing issues, it also be supplied to other needy neighbouring countries, Communities are never consulted about their state of health. The power stations must do more for the community; the study will help the community		
		4; 6	No further comments		

ANNEXURE 12: RECYCLERS AND USERS RESEARCH QESTIONNARE FEEDBACK ANALYSIS

Topics	Theme/s	Respondents' Number	Key arguments	Debates/ theories engaged	Relevant policies and legislations
Fly ash pollution	Exposure to dust and contaminated water.	1; 3; 4; 5; 6; 7; 8; 9;	Airborne fly ash in windy conditions;	Integrated environmental Management	Constitution of the Republic of South Africa (No. 108 of 1996), as amended (Section 24 of the Constitution)
		2; 10; 11; 12; 13; 14; 14; 15	Not exposed to pollution		
Prevalence of pollution	Environmental pollution and Impact to health.	5; 6; 7; 8 ;13; 14	Throughout the year	Environmental Impact Assessment; Land degradation	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.
		1; 2;3; 4; 9;	Dry season (winter)		
		10; 11;12; 15	Not sure		
Pollution Health impact	Respiratory illnesses		Asthma; coughing fits; allergies; communities must be screened for respiratory illnesses	Environmental health	Occupational Health and Safety Act (No. 85 of 1993) (OHSA); National Health (Act 61 Of 2003)
		1; 2; 3; 4; 5; 6;7; 8; 9; 10; 11; 12; 13; 14; 15	Not affected		
Ash handling method	Respiratory illnesses	3; 4; 13	Dry ashing	Environmental risk management	Hazardous Substances Act (No. 15 of 1973) (HSA); National Water Act (No. 36 of 1998) (NWA), as amended
		5;	Wet ashing		
		1; 5; 7; 6; 8; 9; 11; 12; 14; 15	Not sure		
Recycling obstacles	Encountered obstacles hindering recycling	1;2; 3; 5; 6;7; 8; 9; 10; 13; 14; 14; 15	Legislation uncertainty, technology, Cost factor; Skills; market, investment (funds) and lack of market for the products. High transport cost for low value item; logistics of loading ash from the power station; Eskom	Classification of fly ash as a hazardous substance	National Environmental Management: Waste Act (No. 59 of 2008) (NEM:WA), as amended
		11; 12; 14	Not sure		
Ideal state of recycling	Dry or wet ash	1; 3; 4;5; 8; 9; 10; 11; 12; 14	Wet	Fly ash specifications	South African National Standard: SANS 50450
		2; 6; 13; 15	Both		
			Dry		
Fly ash recycling season	Impact of Wet or dry season for recycling	1;2; 3; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15	Throughout the year	Fly ash specifications	South African National Standard: SANS 50450
			Wet		

			Dry		
Durability of products from Fly ash	Use of flysh as raw materials; concerns about quality;	1;2;3;4;5;6;7;8;9;10; 11; 12; 13; 14; 15	Durable	Fly ash specifications	South African National Standard: SANS 50450
			Not durable		
Benefits of recycling to the Community	Recycling project s for the youth	1; 5; 6; 8; 9; 10; 11; 12; 13; 14; 15	The utilisation of fly ash as a cement extender and concrete additive "consumes" almost 2 million tons per annum	Green economy; Cost and Benefit Analysis	Local Economic Development (LED) Policy
		2;7	Not sure whether recycling can benefit the communities, communities do not have capacities to process fly ash		
Required community support	Funding, training, communities and youth empowerment	1; 5; 6; 7; 8; 13; 14; 15	Training to produce bricks and other products	Green economy	Local Economic Development (LED) Policy
		4; 2; 3; 9; 10; 11; 12	Not sure		
Fly ash Industrial revolution	Industrial development of fly ash to a diverse and extensive application	1; 3; 4; 9; 13	Yes if agricultural applications are allowed; if its classification as hazardous is hanged to non-hazardous. If bricks industry is intensified	Industrialisation	Local Economic Development (LED) Policy
		5; 6; 7; 8; 10; 11; 12; 15	Not sure;		
Further comments		1; 3; 5;6; 7; 9; 10; 13;	This research topic is long overdue. It will serve to stimulate discussion and the broad population will be made more aware of opportunities to use fly ash. We need to follow the example of Europe, USA, China, etc to use ash as a valuable resource and not regard it as a problematic waste; Spend time going to various sites to get a first-hand experience; safety at the ash dams; We collect cenospheres from the ash dams which are high value, as opposed to BBA or PFA which is low value. The challenge		

		lies in transporting it to customers which are usually far from source. Transport then becomes much more expensive than cargo being transported; access to ash will make the business to be more profitable.		
	2; 4; 8;11; 12; 14; 15	No further comments		

ANNEXURE 13: PRACTITIONERS QUALITATIVE RESEARCH QESTIONNARE FEEDBACK ANALYSIS

Topics	Theme/s	Respondents' Number	Key arguments	Debates/ theories engaged	Relevant policies and legislations
Fly ash pollution	Exposure to dust and contaminated water.	1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14	Air pollution; community and employees impacted; The fly ash also have a negative impact in plants, because they close stomata; Aesthetic impact	Integrated environmental Management	Constitution of the Republic of South Africa (No. 108 of 1996), as amended (Section 24 of the Constitution)
Impact management	Environmental pollution and Impact to health.	1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14	Monitoring water contamination and air emissions; conduct dust suppression required; Water recycling, zero effluent recycling; offsetting programme	Environmental Impact Assessment; Land degradation	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.
Coal quality and pollution impact	Poor quality coal and high quality coal management	1; 2; 3; 4; 6; 9; 10; 11; 12; 13; 14	The coal reserves that is being mined will not improve for the better; Poor quality coal generate more ash and more emission; cheap coal is cost effective; Washing the coal may be beneficial but we are a water-scarce country, coal quality and ash produced,	Pollution offset	National Environmental Management: Air Quality Act (No. 39 of 2004) (NEM: AQA), as amended.
		5; 7; 8	Not sure		
Mitigation of pollution impact	Rehabilitation and Pollution mitigation	1; 2; 3; 4; 5; 6; 12; 13;	By rehabilitation, Cut of drains; contaminated water treatment processing e.g. reverse osmosis, compliance monitoring; natural dilution from the atmosphere;	Environmental rehabilitation; Water treatment processes	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.
		7; 8; 9; 10; 11; 14	Not sure; No		
Ash disposal method	Ash disposal methods	1; 2; 3; 4; 5; 6; 10; 11; 12	Landfill; Recycling the ash; un-used mines and huge opencast pits that can be filled with ash	Waste recycling	National Environmental Management: Waste Act (No. 59 of 2008) (NEM:WA), as amended
		7; 8; 13; 14	Not sure		
Community' exposure to pollution	Awareness's and rehabilitations	1; 2;3 ; 4; 5; 6; 10; 11; 12; 13; 14	Communities awareness programmes; rehabilitations of exposed sections of ash dumps, strict compliance enforcement;	Environmental rehabilitation	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.

			health screening ; proper and timeous rehabilitation; decommission old sites; relocate communities upwind of the ash dumps; Communities must be contracted in rehabilitations projects		
		7;8; 14	Not sure		
Fly ash handling method and pollution	Ash slurry dumping or dry ash dumping.	1; 2; 3; 4; 5;	Dry ashing	Environmental risk management	Hazardous Substances Act (No. 15 of 1973) (HSA); National Water Act (No. 36 of 1998) (NWA), as amended.
		6; 7;8; 9; 10, 11; 12; 13; 14	Both / not sure		
Fly ash recycling initiatives	Ash used for brick making, agriculture, construction, cement manufacturing etc.	2; 3; 6; 7; 9; 10; 12; 13; 14	Aware of recycling initiatives, replacing lime with ash during cement production	Waste recycling	National Environmental Management: Waste Act (No. 59 of 2008) (NEM:WA), as amended
		1; 4; 5; 8; 11	Not aware		
Ash recycling benefits	Recyclers employment opportunities	1; 2; 3; 6; 8; 10; 13;	Economic benefits to the communities; reducing the footprint and increasing the life span of ash dumps	Green economy	National Environmental Management Act (No. 107 of 1998) (NEMA), as amended.
		5; 7;9; 11; 12; 14	No sure		
Recycling obstacles	Overcoming ash recycling obstacles	1; 2;3; 4; 6; 9; 10; 11; 12; 13;	Legislative uncertainty and confusion; transport costs of the ash is prohibitive; Factory Start-up costs, high carbon in ash values for the cement industry, skills development, technology associated with re-using the ash; authorisation for companies; properties of fly ash are restrictive ; Funding for project preparations like to conduct studies like EIA	Classification of fly ash as a hazardous substance	National Environmental Management: Waste Act (No. 59 of 2008) (NEM:WA), as amended
		5; 7; 8; 14	Not sure		
Required community's support	Funding, training , communities and youth empowerment initiatives	2; 3; 4; 6; 7; 9; 10; 13; 14	Support from relevant departments and Eskom can assist a great deal by especially sustainable management, effective business plans; skills and technology training; Ensure that the market for fly ash is open to small industries and communities. also ensure	Green economy	Local Economic Development (LED) Policy

			funding of small scale projects; classification of ash ash as hazardous waste; buy the community a plant and required equipment's.		
		1; 5; 8	Not sure		
Fly ash Industrial revolution	Industrial development of fly ash to a diverse and extensive application	1; 2; 3; 4; 7; 9; 10; 12; 13;	If its classification as hazardous is changed to non-hazardous. If bricks industry is intensified; Yes if used in agricultural applications;	Industrialisation	Local Economic Development (LED) Policy
		5; 6; 8; 14	Not sure/ not possible		
Further comments		1; 2; 3; 5; 7; 13;	Power stations must involve communities and initiate projects, consider aluminium extraction from ash and silica for industrial use, this can be beneficial to mankind; I would rather re-cycle all the fly ash than look at an ash dump that will scar the landscape for the next 100 years; We need to adopt a first world mentality. If power plants in Germany can operate with hardly any pollution whatsoever, why are we so different?; I wish you well with your study and I believe it will play a profound role in curbing air pollution in those power stations; the study must also look at operational problems of ash. New power stations must be designed to minimise pollution; Eskom need to invest in the commercialisation of fly ash and simulate this market. Otherwise it will take much longer to take off. Innovative solutions around the use of fly ash need to be developed; the information gathered will be most useful; FA recycling will reduce unemployment, and it will improve infrastructure.		
		4; 8; 9; 12; 14	No further comments		