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Investigating the possibilities of scaling up Municipal solid waste-to-energy technologies in emerging economies: a case study of Simmer and Jack Waste-to-energy technology in Germiston, Gauteng

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2021

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University of Witwatersrand, School of Architecture and Planning

Investigating the possibilities of scaling up Municipal solid waste-to-energy technologies in Emerging Economies: A case study of Simmer and Jack Waste-to-Energy Technology in Germiston, Gauteng

By

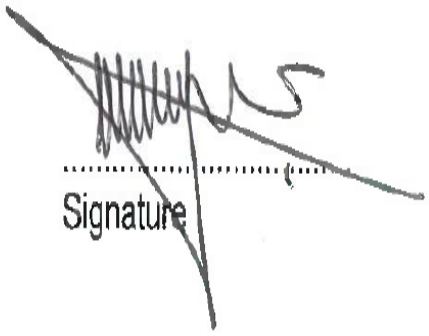
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A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Architecture (Sustainable Energy Efficient Cities)

Johannesburg, 2021

Declaration

I declare that this research report is my own unaided work. It is being submitted to the Degree of Masters of Architecture in Sustainable and Energy Efficient Cities to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.



Signature

15 November 2021

Date

Abstract

This research investigated the barriers encountered in upscaling municipal solid WtE technology in Ekurhuleni using Simmer and Jack WtE plant as a case study. The study came about after the realisation that while African countries witnessed a “high rate of population growth due rural-urban migration, industrialisation and urbanisation as well as improvements in production processes and standards of living” (Dlamini, Simatele, and Kubanza, 2019: 249) over the past decades, perpetual generation of solid waste has become an environmental challenge. And yet, even with the establishment of infrastructure to facilitate the conversion of WtE, the uptake of renewable energy in South Africa still remains a challenge. The literature reviewed in the study demonstrated that there is a multiplicity of barriers that hamper the successful implementation of WtE projects, and these include economic, social, legal, financial, technical, political and environmental barriers. Interviews with officials in CoE also confirmed the existence of barriers of this nature in the case of Simmer and Jack plant. It is in line with these findings then that the study recommended the importance of addressing these barriers for the successful uptake of WtE projects in cities of the global South.

Acknowledgements

First and foremost, I would like to express my profound, sincere and deepest appreciation to the following individuals for their contribution to this research, and for encouraging me throughout the development of this study.

My Supervisor, Dr Sechaba Maape for his inspiration, understanding and critical thinking in ensuring the commencement and finalisation of this study. I would like to further salute him for his academic excellence and rigour in fulfilling his mentorship responsibilities towards me.

My wife Martha Nembudani (Seshweni), my daughters Keneilwe Matamela Seshweni and Lebogang Mosibudi Seshweni, and my son Lehlogonolo Matlala Seshweni (Jnr) for their undivided and unconditional support throughout my study.

I would like to thank the Ekurhuleni Metropolitan Municipality officials from Renewable energy and solid waste management Department staff for providing me with important documents about Simmer and Jack Waste-to-Energy project.

Lastly, I would like to extend my sincere gratitude to the University of the Witwatersrand School of Architecture and Planning, staff and the administrative personnel for their unwavering support throughout my academic journey.

"Praise and Glory to God for whom nothing is too hard"…Elisabeth Elliot

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Acronyms

CDM	Clean Development Mechanism
CE	Circular Economy
CoJ	City of Johannesburg Metropolitan Municipality
CoT	City of Tshwane Metropolitan Municipality
CoE	City of Ekurhuleni Metropolitan Municipality
EC	European Commission
EMF	Ellen Macarthur Foundation
GHG	Greenhouse Gas
ISSWM	Integrated Sustainable Solid Waste Management
IPPs	Independent Power Producers
IRENA	International Renewable Energy Agency
MSM	Municipal Solid Waste Management
MSW	Municipal Solid Waste
NAC	National Association of Countries
NIMBY	Not-In-My-Back-Yard
SDG	Sustainable Development Goals
SWM	Solid Waste Management
SMWM	Sustainable Municipal Waste Management
WEC	World Energy Council
WMT	Waste Management Theory
WtE	Waste-to-Energy
UN	United Nations
UNEP	United Nations Environment Programme
USA	United States of America
USEPA	United States Environmental Protection Agency
PESTEL	Political, Economic, Social, Techincal, Environment and Legal

Chapter One: Introduction

1.1. Background

> *"As the world hurtles toward its urban future, the amount of solid waste, one of the most important by-products of an urban lifestyle, is growing even faster than the rate of urbanization. Ten years ago, there were 2.9 billion urban residents who generated about 0.64 kg of MSW per person per day (0.68 billion tonnes per year)"* *Hoornweg and Bhada-Tata, 2012: ix.*

Improvements in living standards and an increased urbanisation process globally have led to municipal solid waste (MSW) treatment becoming a global environmental problem. Waste to Energy (WtE) projects have shown to be efficient means of managing MSW, as they can generate power while also saving land resources by decreasing the size and volume of MSW (Song, et al 2017). In the case of Africa, there has been a high rate of urbanisation owing mostly to an increase in rural to urban migration (Dlamini, Simatele, and Kubanza, 2019:249). In this regard, there is no doubt that the growth of cities contributes to the general increase in waste production. According to Kushwaha, Randhawa, Marshall, Desai (2018), the amount of waste generated varies from low to high-income countries.

Interestingly, while on one hand the globals population is rapidly increasing on the other hand this created an energy demand. Contemporary, developed, and developing countries face a global challenge to match the surging demand for energy. Traditional solutions to matching the energy demand have relied on increased use of fossil fuels such as gas, coal, and oil (Lange et al., 2020; Harrouz et al., 2017). Over the years, renewable energy supply has proved to offer solutions to both challenges of global warming and energy demand while also reducing waste disposal (Song and Song, 2019; Nikoobakht et al., 2018). Literature has shown the availability of clean energy is essential for human advancement and economic growth (Rawat and Sauni, 2015). Renewable energy has the merit of matching energy demand while reducing greenhouse gas emissions. This has proven essential for addressing climate change and conserve ecosystems (Jing, 2016). Renewable energy has also shown additional

merits, such as being a cost-effective energy source that even underprivileged communities in remote locations can utilize, making it a sustainable energy source (Rawat and Sauni, 2015).

The growth in the need to adopt sustainable development practices has led to an increase in the use of renewable energy (Nikoobakht et al., 2018). This trend has become evident in policy changes in developed or developing countries to promote the use of renewable energy. Seetharaman, *et al* (2019) have outlined how by 2005 over 55 countries had developed the initiatives through policy changes that support the adoption of renewable energy. In 2013 this number had increased to 144 countries, which reflected the global consensus to reduce greenhouse gas emissions (ibid). This is an indication that interest in renewable energy has been on the rise across the world.

Despite an increased interest in renewable energy across the world witnessed by the establishment of WtE infrastructure, dissemination and scale-up of renewable energy has been affected by political and regulatory frameworks. Karatayev *et al,* (2016) have outlined how some frameworks continue to advocate using fossil fuels. In South Africa, the energy policies at the National and local levels are supported by the Constitution of 1996 which mandates the state to ensure affordable energy. While this has resulted in an increasing rate of implementation of green projects in some municipalities, these had to go through a difficult legislative and policy transition, yet after all that work, now that the projects are being implemented, they are not being operationalised.

The City of Ekurhuleni has identified four operational flagship projects (Landfills) namely; Rietfontein, Rooikraal, Weltevreden and Simmer and Jack in line with Clean Development Mechanism (CDM). The projects are focused on reducing carbon emissions in line with the international treaties to combat global warming. Notable international treaties for climate change include the Kyoto protocol, Paris Agreement and the Intergovernmental Panel on Climate Change In response to these global efforts, various strategies have been proposed to reduce emission. Ekurhuleni Waste Management Service annual report (2010/2011, 8), has outlined the CDM “allows emission-reduction (or emission removal) projects in developing countries to earn certified emission reduction (CER) credits, each value to one ton of carbon dioxide. The CERs can be traded and sold and used for industrialised countries to meet part

of the emission target under the climate change control". In as much as the municipality had targeted to attain 10% renewable energy from the investment of one-megawatt gas electricity plant at Simmer and Jack landfill plant, the target has not been met. At Simmer and Jack plant the waste is compressed in order for it to decompose and create methane gas. The gas is then collected through pipes that feed it directly to the flare where it is burnt to generate electricity. The project is yet to achieve its overall aim of generating renewable energy from the municipality's solid waste is still lying around within the municipal jurisdiction. The project sought to decrease electricity dependency from Eskom by 7 GWh/year but has not been able to do that. Currently the project is already feeding the municipal power grid. It stems from this background therefore that this research seeks to investigate the barriers encountered in scaling up Municipal solid WtE technologies in emerging economies using a case study of Simmer and Jack WtE Technology in Ekurhuleni, Gauteng.

1.2. Problem Statement

In as much as solid waste is a critical challenge on a global level, at the local level, municipalities have also been grappling with the control and dissemination of solid waste from a sustainable development perspective. Emanating from the fact that human actions produce waste and how waste is managed, collected, stored, and disposed of triggers serious public health hazards and environmental concerns (Zhu *et al,* 2008). The State of Environment Report, (2018) has outlined that in South Africa, about 42 million m^3 of solid waste is generated annually. Gauteng alone, where the City of Ekurhuleni is located, contributed 42% of the waste generated in 2010 (Muzenda *et al*, (2011). The waste comprises of illegal dumping particularly in the informal areas and industrial waste. De Ligneris (2013) has also outlined that in 2013 the province contributed the highest tons of waste generated which was at 3.02 million tons. In the City of Ekurhuleni, about 1, 2 million tons of waste were landfilled between July 2014 and June 2015 (CoE, 2015). This figure might have increased per yearly basis considering the high rate of urbanization and the proliferation of informal settlement that has occurred in the municipality since 2015, precisely, the visible scenery of much informal settlement in the municipality is characterized by heaps of solid waste, particularly in vacant open spaces. The municipality has invested in

Waste-to-energy technology to manage solid waste management in Simmer and Jack landfill in Ekurhuleni. It is thus prudent to carry out an extensive investigation into the CoE's Simmer and Jack landfill project to unearth what is causing little uptake regarding the use of the WtE?

1.3. Aim of the study

The study aims to investigate the City of Ekurhuleni's waste to energy from the current status to identify challenges and opportunities, if there are any, of scaling up the Municipal solid waste-to-energy technologies, using a case study of Simmer and Jack Waste-to-Energy landfill project.

1.4. Research questions

Main Research Question

- ✓ What are the barriers and opportunities affecting the deployment of renewable energy?

Sub-Questions

- ✓ What strategies can be used to break the barriers that hinder the deployment of renewable energy?
- ✓ What are the barriers and opportunities of upscaling municipal solid waste technology at Simmer and Jack Plant?
- ✓ What is the state of renewable energy at Simmer and Jack Plant?

1.5. Objectives

The objectives that guided the research are:

- ✓ To investigate the barriers and opportunities affecting the deployment of renewable energy.
- ✓ To investigate the barriers and opportunities of upscaling municipal solid waste technology at Simmer and Jack Plant.

- ✓ To recommend interventions that could assist the CoE to overcome the barriers of upscaling municipal solid WtE technology.

1.6. Justification and Significance of the study

The perpetual surge in the disposal of municipal solid waste in open spaces is a significant challenge considering that it threatens human health and induces climate change. While there has been studies into these areas elsewhere, not much is known about the state or situation of Waste to Energy in South African local municipalities. Focusing on assessing CoE's Waste to Energy situation as is the case with this study can help us understand the South African governance and service systems in which the WtE system has been inserted and how this has responded to the WtE system. This research assists in unpacking if these local government systems and structures have the capacity to implement WtE. This is significant because it will help us see if these WtE technologies are contingent on the political and social context they are embedded in, and if we need to have other supporting governance systems in place to mediate between these technologies and our service providers at a local scale.

1.7. Research design

This research adopts a qualitative methodology which is informed by a case study research design. While the study relies on the case of Simmer and Jack landfill project in CoE as was highlighted earlier, qualitative research methodology is preferred in this case because it allows for the investigation of subjects in their social setting. To gather data for this study, qualitative research techniques such as observations, in-depth interviews, and secondary sources of data shall be relied upon. Interviews shall be conducted with 12 officials from CoE with knowledge on the subject under study. 2 experts on waste to energy shall also be engaged. Observation methods shall be done at Simmer and Jack Landfill to unpack the status quo of the plant and the opportunities and challenges that are being experienced. Lastly, the study shall review both local and international literature about waste to energy with the purpose of putting this research within its scholarly setting.

1.8. Expected Findings/Hypothesis

The study envisaged that while WtE technologies have a great potential and opportunities for the realization of socio-economic and environmental benefits, existing systems in municipalities are not capacitated enough (human capacity) to support these technologies and this acts as one of the barriers hampering the successful implementation of WtE projects.

1.9. Ethical Consideration

Given that the information gathered from respondents is crucial and sometimes sensitive, this study valued the ethical issues of conducting research. The study applied the ethical guidelines recommended by the school and before embarking on this research journey, an ethics certificate was applied for and awarded by the University's ethics committee. The researcher also ensured that all participants involved in this research were aware of their role by clearly outlining the aims and objectives of the study in the participant information sheet. The participant sheet was made available to the participants prior to the interviewing process. Interviewing processes only commenced after the researcher was satisfied that the respondents understood their roles in the research. Informed consent forms and questionnaires were sent to the participants for signatures. The consent form gave respondents options to either partake in the research or not. The participants were informed the data collected would only be used for academic purposes hence confidentiality and anonymity in reporting the findings was guaranteed.

1.10. Limitations of the Study

The research examined the Simmer and Jack Waste-to-Energy landfill project in Ekurhuleni. This means that the findings arrived herein might not resonate or be generalized with other South African experiences with regards to WtE projects due to varying local conditions among other things. Additionally, although the research opted to investigate this topic from an inside out method considering that the researcher is a CoE employee in the housing department, securing interview appointments with some important informant or getting access to crucial information such as reports on

renewable energy was a difficult task especially due to the Covid-19 pandemic that restricted movement and meeting of people. However, to overcome this, the researcher decided to rely on some documents that were already in the public domain and while interviews were conducted both physically and via online platforms.

Chapter Two: Literature Review and Conceptual Framework

2.1. Introduction

This chapter outlines this study within its scholarly context. The research attempts to understand why an already implemented project in CoE is not being utilised optimally and what opportunities there are for better usage and upscaling. As such, this chapter critically considers the barriers encountered in the implementation of renewable energy. The literature, therefore, looks at examples of implementation of WtE projects across the globe that are not being utilised at full capacity and demonstrate why this is the case and how people overcame this. The argument is that in SA the Independent Power Producers (IPPs) are similar situation where we already have the infrastructure, but it is has not been fully deployed. Hence this research is investigating infrastructure that has already been implemented to understand why it is not being utilised. Ultimately, the chapter makes a courtesy call of discussing the advantages of upscaling WtE technology with the aim of presenting a balanced argument.

2.2. Definition of terms

2.2.1. Waste

Waste has mostly been defined from a legal perspective. However, this legal definition of waste is sometimes and rarely outline the possibility of possible after-use of the material. The United Kingdom Environmental Protection Act (1990:100) provides a legal definition of waste as “any substance that comprises of an affluent, scarp or unwanted materials or substance which is supposed to be disposed or broken or worn out”. Further, Ogu (2000: 105) notes that the term “wastes” (or “solid waste”) refers “to household refuse, market waste, street sweepings and waste materials from institutions such as schools, colleges and commercial establishments”. In the case of South Africa, the Environment Conservation Act (ECA) outlines waste in terms of its unwanted or superfluous nature (Oelofse and Godfrey, 2014). Similarly, the National Water Act defines waste in terms of polluting potential (ibid). The legal definitions have

implications in that they don't steer conversations around the possibility of harnessing waste to produce energy or they cause confusion in the debate about recycling. Hence, this study argues for a definition of waste that has the capacity to ignite debate on the need to recycle waste. It is only through these lenses that waste is viewed as a resource and not a burden.

2.2.2. Municipal Solid Waste Management (MSWM)

MSWM refers to the responsibility taken by municipalities to manage solid waste in areas of their jurisdictions. From an academic point of view, MSWM is the "collection, transfer, treatment, recycling, resource recovery and disposal of solid waste in urban areas" Schübeler *et al,* (1996: 18). This is also supported by Kaluli *et al,* (2011; 80) who defines waste management as "the incorporation, transportation, processing and disposal of the waste". Municipal solid waste management (MSWM) is the management of Municipal solid waste (MSW) with MSW as having been defined by Schübeler *et al,* (1996: 18) as "refuse from households, non-hazardous solid waste from industrial, commercial and institutional establishments (including hospitals), market waste, yard waste and street sweepings" within municipalities.

2.2.3. Waste to Energy (WtE)

WtE is also viewed in literature as the process of obtaining energy from waste. It involves the process of obtaining energy in the form of electricity, heat, biogas, or other alternative energy sources from waste (Mutz *et al,* 2017). As such numerous technologies have been developed such as direct combustion, gasification, pyrolysis and thermal. Direct combustion refers to a high-pressure process where organic waste is combusted in a furnace or boiler (Yip and Chua, 2008). It is the most known biomass conversion of electricity from waste. While gasification refers to the incineration or combustion and waste is covered into syngas fuel (Tan et al, 2015). Lastly, pyrolysis is the process of converting waste to liquid, gaseous and solid fractions. The end product can be used to power turbines and engines.

2.2.4. Landfilling

Landfilling is understood as the process of disposing of waste (solid/ semi-solid) into the ground. The process ensures that the waste materials are isolated from the environment hence compacting or covering might be essential. Likewise, the United States Environmental Protection Agency (USEPA), (1988) defines 'landfill' is as a "facility in which solid waste from municipal and/or industrial sources is disposed of; sanitary landfills are those that are operated in accordance with environmental protection standards where wastes are spread, compacted and covered with a layer of earth daily".

2.3. Waste Management Theory (WMT)

The process and practice of managing waste become popular around the 1970s. This was the case particularly in developed countries and the main aim was to reduce the environmental impacts of waste (Tanskanen, 2000). As a result, WMT was coined to route "environmental sciences into engineering design" (Pangrácz, 2002:1). What this entails is the emphasis and need for a paradigm shift from the conventional system of managing solid waste to a sustainable technological system. According to Pangrácz, (2002:1) WMT is a "unified body of knowledge about waste and waste management". Furthermore, the theory advocated establishing landfill sites to control and manage waste (Read, 2003; Yi et al., 2018). Pangrácz et al., (2004:471), posit that the WMT denotes a "more in-depth account of the domain and contains conceptual analyses of waste, the activity upon waste, and a holistic view of the goals of waste management". The principles underpinning this paradigm were that waste management would reduce human health risk and create a sustainable environment (Moya et al., 2017). This is anchored by the assumption that "describes a target prescribes action upon it, which implicates that sustainable waste management depends greatly upon how waste is defined" (Pangrácz, 2002:1). This makes this theory critical for this study considering that technology is applied in addressing solid waste at its center (Dastjerdi et al., 2019; Rasheed et al., 2021).

2.4. Theory of diffusion

According to Lacerdia *et al*, (2014), the paradigm of diffusion is one of the fundamental characteristics in theorising the developments of energy provision. The theory involves the processes developed by society when implementing innovation (ibid). Diffusion has also been described as "the process by which innovation is communicated through certain channels over time among members of the social system" (Rogers, 1998:11). Consequently, innovation is "an idea, practice or object that is perceived as new by an individual or other unit of adoption" (Sahin, 2006 in Seetharaman, *et al*. 2018:03). Diffusion as a theory dates back to the 1950s when Lewin (1951) refered to it as a theory of social change. Particularly when seeking to encourage lasting individual changes through changing group standards. Over the past years, there has been a shift focusing on external conditions as these have a higher probability of being more influential than group standards (Darnton, 2008). More fundamentally, diffusion defines the often random movement of a character and in relation to this study, this theory outlines the attitude and perception of people or officials concerning the use of renewable energy. This has implications on identifying the cause of the slow uptake of WtE despite the availability of infrastructure, as is the case in CoE.

2.5. Barriers in scaling up renewable energy generation

Irrespective of the progressive and encouraging commitment from many countries across the globe to move away from high to low emission, only a small amount of energy is generated from renewable energy, particularly around developing communities in Africa (Seetharaman, et al. 2018). This is attributed to a plethora of barriers that range from several economic, technical, institutional and social-cultural barriers (Elavarasan et al., 2020; Naber et al., 2017). On one hand, the barriers hamper the ability of renewable energy to be used as an alternative of traditional energy and on the other hand, it hampers the attainment of the required large utilisation of WtE equipment to cultivate renewable energy (Nasirov et al, 2015; Busch et ., 2017).

None the less, in as much as literature, outlines that there have been numerous studies that sought to identify the scaling up of waste to energy, little is known about

the barriers that hinder the successful utilisation of already existing waste to energy technology (Elavarasan et al., 2020; Busch et ., 2017). In its attempt to show the causes of failure by many countries to fully utilise waste to energy infrastructure or to produce renewable energy to the infrastructure's capacity, this chapter does so by demonstrating how these barriers can be broken. Hence, the objective is to find a solution to overcoming the factors that hinder the deployment of renewable energy.

2.5.1. Social and Public Perception Barriers

Literature reveals that the movement from conventional resources such as fossil fuel to WtE technology has been met with intense public opposition and resistance (Seetharaman, *et al.* 2018:04). According to Goldsmiths (2015), this resistance and opposition stem from a lack of sufficient awareness of renewable energy benefits. The public rather thinks of holding on to conventional methods than give up their land meant for agriculture and tourism for the purpose of setting up renewable energy plants. Even in cases where WtE plants have already been assembled, such as the case of CoE, uptake of renewable energy remains a challenge due to this social mindset that values traditional sources of energy at the expense of clean energy. However, Paravantis *et al.* (2014) note that sustainable development stems from human desires' satisfaction through socially recognized technological systems and suitable policies and regulatory tools. According to Nasirov *et al.,* (2015), the critical issues concerning public understanding of renewable energy are the following:

i. insufficient information regarding ecological and financial benefits;
ii. inadequate awareness of renewable energy technologies;
iii. Uncertainties about the financial feasibility of RE installation projects.

Additionally, 'Not in my backyard' (NIMBY) syndrome has also affected renewable energy harnessing to full capacity. In this category, while people might support renewable energy generally, they might not support the idea of having projects and plants need in their neighbourhood. Jianjun and Chen, (2014), have outlined how global trends have shown proposals for renewable power usually face opposition from grassroots organizations, national interest groups, individual citizens, environmental groups, and political leaders. Nasirov *et al.,* 2015 have also articulated the common

causes of public opposition: lack of public participation, fears of environmental degradation, and landscape changes caused by deploying the developmental activities.

As such, the success of any projects hinges on the perception of its recipients whose citizens are custodians of these projects. Hence, the cycle of a project and including its processes is not complete when local people are not involved. According to Yan *et al,* (2020), Reddy, (1991) and Mercedes *et al,* (2019) citizens are capable of going against a waste-to-energy project due to ignorance and uncertainty among others. In a study carried out in Brazil by Coelho (2019: 219), “there is a significant concern from local communities about WtE technology due to their fear of pollutant emissions (dioxins and furans) from incineration systems”. Portugal also experienced similar criticism and attitude from the local residents regarding the WtE Valorsul project (Coelho, 2019). Reddy (1991) argues that people are sensitive particularly when it comes to WtE plant as they believe that their properties will depreciate. It is also believed that municipal waste technology contributes adversely to air pollution. As such, stakeholder engagement is paramount when implementing a project to avoid “not in my backyard” syndrome.

Social barriers can also be due to the incompetence of technical professionals which can be coupled with lack of training. Ansari et al., (2016) have outlined how this usually prevents renewable energy technologies from scaling new heights. Once renewable energy plants are installed, they will need to be maintained hence there is needs to train professionals who will maintain the plants so that they work to their full potential. According to Karakaya and Sriwannawit, (2015), the critical obstacle to renewable energy being widely deployed is the shortage of a workforce that is well equipped and skilled to operate, build, design, maintain and finance renewable energy projects.

2.5.2. Economic and financial barriers

Raza et al., 2015 have outlined how financial and economic barriers are induced by competition from fossil fuels, preference of conventional or traditional energy sources over renewable energy, shortage of capital, lack of financial institutions and lack of investors. While renewable energy has been accepted, its plants remain at an infant stage or piecemeal without being widespread because of these factors. For example, there is a general perception that WtE technology is expensive and scholars such as Mercedes et al, (2019), Vujic *et al.,* (2015), Reddy (1991) and Yan *et al.*, 2020) concur that only a few cities can afford to procure and maintain WtE plants. In the case of Brazil, Mercedes et al (2019) note that, the cost of two plants in São Paulo amounted to US$ 400 million.

In relation to tough competition from fossil fuel, it appears as if traditional energy sources such as fossil fuels will continue to be in demand in the future. EIA's International Energy Outlook (2016) report predicts in 2040 fossil fuels will contribute approximately 78% of global energy. Seetharaman, *et al.* (2018) have also outlined how in 2016, about 55% of investment in supply and power generation was for fossil fuel, with renewable energy accounting for 16%. Dulal *et al.,* (2013) have described the abundance and accessibility as the critical element why fossil fuel sources (such as coal) are still heavily relied upon, despite the investment in renewable energy plants. Since 2014, global trends have changed. Oil, as measured by the Brent crude contract, which was priced at $115.71/barrel in June 2014, fell to $27.10 on 20 January 2016, a huge drop of 76 per cent (Seetharaman, *et al.* 2018:07). Similarly, the ARA coal contract dropped from $84/tonne in April 2014 to $36.30 in February 2016. There was a huge decline in the price of natural gas, which slid from around $4.50/MMBtu in June 2014 to $1.91 in mid- February 2016 (ibid). The same was also witnessed during the coronavirus pandemic when major world economies went into lockdown. Prices for traditional fuels such as coal and oil dropped drastically. These global trends reveal that investment has been made to use alternative environmentally friendly energy sources, fossil fuels are currently cheaper to utilise, and this has negatively affected the adoption of renewable energy.

2.5.3. Political Barriers

According to Reddy (1991: 5), most WtE technologies are “destined to fail because of the government’s disinterest, lack of political will and, lack of technical and managerial skills”. For instance, in Greece, between 1995-2000, WtE concepts were rejected by the Greek Government because they were perceived to be exorbitant and not suitable for local conditions (Mavropoulos *et al,* 2007). Mavropoulos *et al,* (2007: 8), have described the main reason for rejections was “the high cost and the unsuitability of incineration for the national local conditions”. Additionally, political interference can also influence the success and failure of WtE capital projects. If politicians lack interest or have little knowledge about WtE projects, they won’t support the implementation of such projects.

2.5.4. Regulatory barriers

Renewable energy implementation has been hindered by issues such as policies, administrative and bureaucratic hurdles, unrealistic government goals, lack of certification and standards and inadequate incentives (Stokes, 2013). Addressing the inconsistency in which energy should be utilised, there is a need for development of regulatory policies that clearly address how the energy industry should grow (Seetharaman, *et al.,* 2018). Ineffective policies tend to result in confusion within different departments over the implementation of renewable energy or even over the allocation of subsidies to these projects (ibid). Furthermore, Zhang *et al*., (2014) argue that the significant challenge for deploying renewable energy projects is insufficient policies that can equip governmental agencies while also being able to integrate RET with the global market.

Taking this argument further, while the government has made many efforts to promote renewable energy by removing a tax on imports of the equipment and parts required for renewable energy, these measures have been inadequate (Seetharaman*, et al*. 2018). “Feed-in tariffs are the measures by which governments aim to subsidize renewable energy sources to make them cost-competitive with fossil fuel-based technologies, but the absence of these adequate financial incentives results in high

costs that hinder the industry's development, operation and maintenance, and stagnate the future" (Sun and Nie, 2015 in Seetharaman, *et al*., 2018:8).

While obstacles limiting the implementation of renewable energy are manifold, some of these emanate from administrative and bureaucratic complexities (Ahlborg & Hammar, 2014). In relation to administrative barriers, delays and restrictions in planning affect the pace at which a renewable energy plant can function to its full capacity. This is further coupled with lack of communication and coordination between different authorities, particularly those in charge of traditional energy sectors and those in the renewable energy sector (ibid). Delays in obtaining approval from authorities have significantly impacted the development phase by delaying the project timeline. Obtaining permission has led to higher costs due to lobbying. Consequently, investment in renewable energy is negatively affected due to such issues delaying the timeline (Ahlborg & Hammar, 2014).

Goldsmiths, (2015) has outlined the lack of alignment between policy targets and implementation processes. This is usually caused by a lack of comprehension of the implementation process and the possible loopholes that may affect it based on realistic targets (ibid). It is the responsibility of the government to resolve these issues. Hence they need to be more responsive and reactive. Finally, certificates and standards are required to ensure that the equipment and parts manufactured or procured from overseas align with the importing company standards. Compliance with local laws is enforced through the certifications of companies. In Emodi *et al.,* (2014) the lack of certifications and standards leads to confusion and delays in the operations of energy producers.

2.6. Breaking barriers in the deployment of renewable energy

Byrnes et al., (2013) have highlighted the importance of the deployment of renewable energy, however barriers exist that are preventing further penetration and development of renewable energy to greater lengths. According to Seetharaman, *et al.,* (2018:09), “bureaucratic procedures in the deployment of renewable energy are considered the biggest hindrance, and this demotivates investors and entrepreneurs from entering and investing in renewable energy”. Likewise, Nesamalar *et a*l., (2017) note that the misalignment of government policies at national and local levels doesn’t attract investment in the energy sector. Huang et al., (2013) has indicated that investors would rather invest in countries that have simple and straightforward procedures unlike countries with complicated administrative procedures.

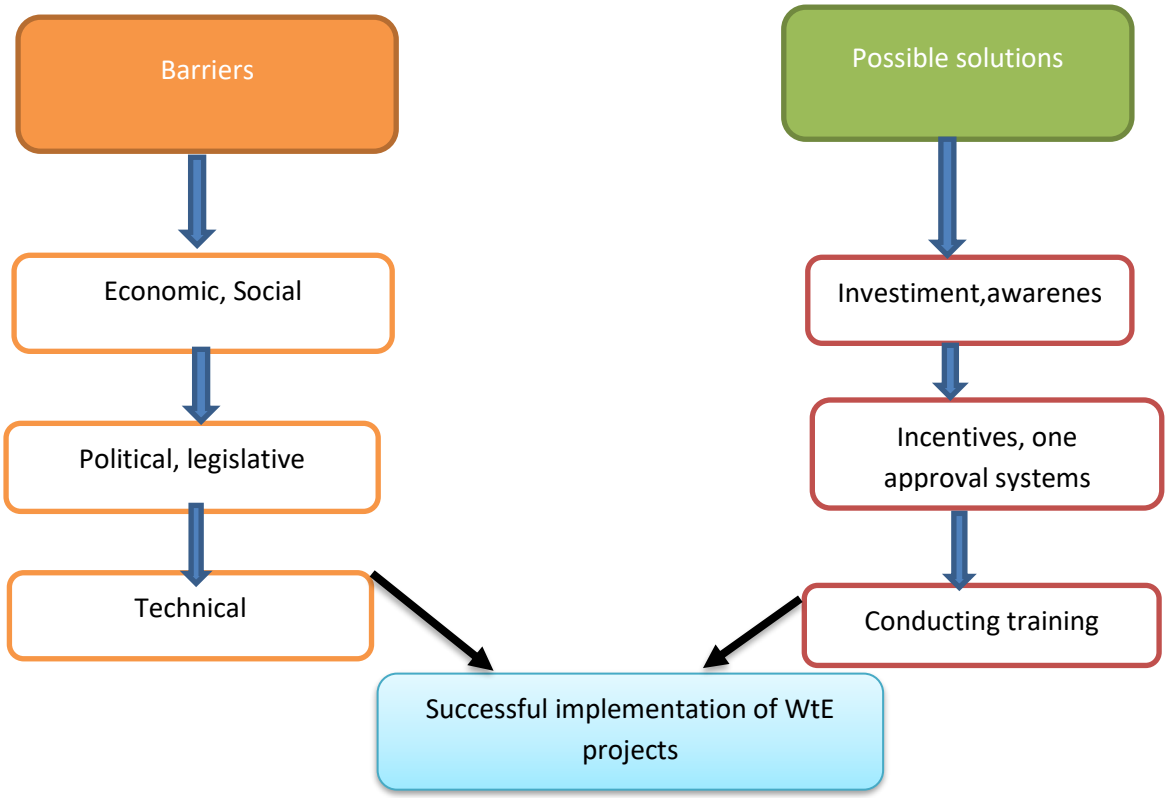
While Raza *et al.* (2015) have outlined the socio-economic development of any country relies on energy. Hence, through using many renewable energy resources, nations can help fulfill energy deficiencies without damaging nature. This will ultimately lead to creating many employment opportunities in the operation, designing, maintenance and building of renewable energy project infrastructures (Seetharaman, *et al.,* 2018:09). In addition, according to Yan *et al.*, (2020:230) “the operation of a modern WtE plant is highly automatic; even artificial intelligence has started to be applied.” It goes without saying that training becomes mandatory for both operation and maintenance pre-construction. Most WtE projects fail to sustain their life cycle due to the scarcity of skills and/or expertise to maintain the plant (Elavarasan et al., 2020; Rawea et al., 2018).

There is a need for continued research to upscale WtE projects and raise awareness of environmental damage to ensure sustainability. Alternative energies that have minimal impact on the environment and are inexhaustible, such as renewable energy, can solve the long-fought sustainability problem. However, despite ongoing awareness of the manifold advantages of renewable energy, the diffusion of renewable energy is limited globally. This restriction has been attributed to social, economic, technological, and regulatory barriers (Moorthy et al., 2019; Naber et al., 2017).

2.7. Conceptual Framework

Drawing from the information presented in the chapter, this conceptual framework as indicated in figure 2.1, reveals the importance of crosslinking the barriers hindering the implementation of WtE with the necessary solution for successfully implementing WtE technologies. It is important to observe that in this chain of breaking WtE barriers, the government plays a crucial role in ensuring that a stringent law is adopted. The framework reveals a need to identify and address key barriers and possible solutions to the success of the project. The solutions to the barriers defined here, will translate to be key drivers for the successful introduction of waste-to-energy initiatives. Almost all of the presented barriers have an adverse influence and represent important elements for development of waste management systems. The framework also help us understand the necessary support that might be required to be able to interrogate WtE policies and legislation both at national and local level.

Figure 2.1. Show the conceptual framework



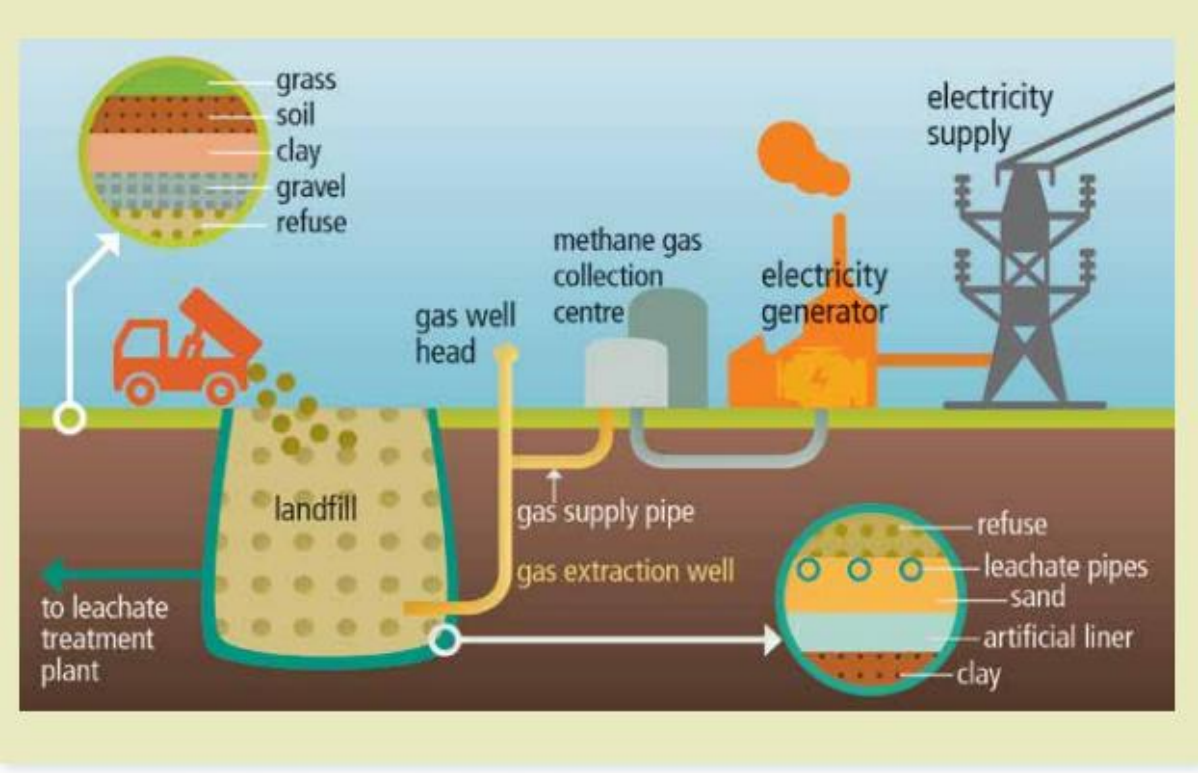
Overcoming WtE Barriers. Source: Author, 2020

2.8. Electricity as an energy source from Landfill gas

Landfill gas to energy is the process of generating energy from the municipality landfill. According to Jaramillo and Mathews (2005), the production of landfill gas is gauged based on the decay model and is affected by the quantity of waste disposed into the landfill. Godlove and Singleton (2010), have outlined how financing options for landfill methane projects are vast, with each incentive carrying its own specific set of qualifications and rules. As such about 140 Nm3 production rate per tonne of methane is needed for a landfilled waste (Godlove and Singleton, 2010). A portion of one half of the landfill gas is estimated to be recoverable through pipes and can be used for energy recovery. The assumed amount of energy collected biogas is 3.12 E+09MJ, considering a lower biogas heating value of 17.73J/m3 (ibid). Electricity is then produced after burning biogas in turbines with an efficiency of 28% to produce 2.43E+08 kWh per year. However, to set up a landfill gas project to generate electricity is dependent upon a number of factors. Some of them include the cost of waste collection and treatment, generating electricity involves incurring additional costs such as those associated with purchasing generators and connecting the project to the nearest electricity grid. According to Godlove and Singleton (2010), for direct use of the project, there are also costs associated with purchasing rights of way and the installation of a necessary pipeline to the point of energy use from the treatment.

The landfills produce gas when waste materials decompose as indicated in figure 2.2. The gas collector wells that create a vacuum within the decomposing waste are drilled into the mound of landfilled MSW to suck the gas that is later transported along the pipes to the gas pump and flare station. The gas is then converted into electrical energy by the turbines and a step-up transformer is used to assist in feeding the electricity of the same voltage into the municipality's grid (Gumbo, 2014). The natural gas is then created which is capable of powering generators to produce renewable electric power (Frankson, 2019; Scheutz and Kjeldsen, 2019). The gas is collected and piped to a processor to remove moisture and other gas before powering the turbine to power an electric generator.

Fig. 2.2. Show electricity generated from landfill gas.



Adopted from Gumbo, (2014).

2.8.1. Implementation and Managing of Landfill gas through an integrated sustainable waste Management Approach.

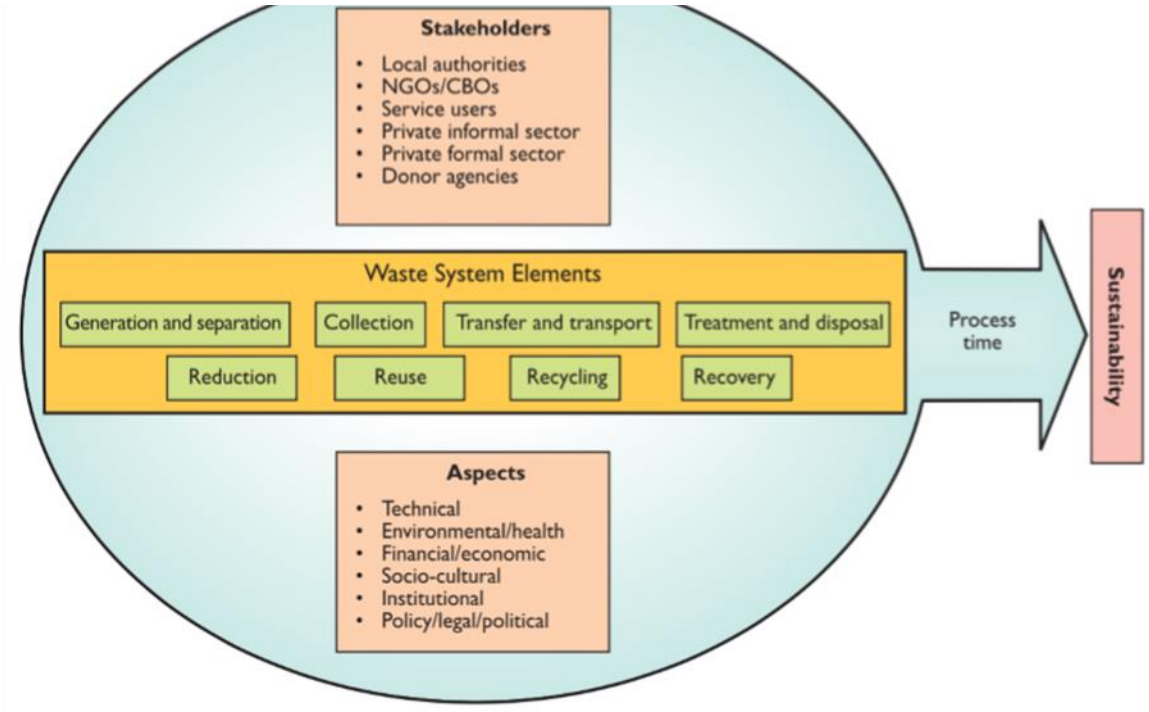
This approach consist of three dimensions that are important to understand the process of managing solid waste plants (See figure 2.3). According to Yukalang et al., (2017:03),the main dimensions are “(i) inclusion of the stakeholders who have an interest in WtE, (ii) an understanding of the flow of waste materials from generation points until final disposal, and (iii); identification/selection of aspects that frame the analysis (such as social, institutional, political, financial, economic, environmental, technical and stakeholder’s challenges)” Yukalang et al, (2017) indicate that this integrated approach is very important in that it enable the identification and isolation of barriers hindering the successful implementation of renewable energy namely electricity from landfill gas. The stakeholders involved in this management approach includes organizations that have a stake or interest in the generation of electricity through waste management systems (Khatib, 2011:43). Examples of these includes the municipality and households.

Furthermore, integration is critical in the implementation and management of solid waste projects particularly those intended to produce electricity. Integration involves the inclusion of all elements such as political, environmental, financial and social into a landfill gas to electricity project. “The different dimensions are interrelated and their linkages institutionally, legally, and economically enable the overall function of the system” Khalib (2011: 44). Therefore, the integrated approach considers MSW management through landfills considers not only the technological system with infrastructure and facilities that facilitate handling, disposal and generation of energy. As a management system, MSW is interlinked with various other factors such as physical environment, socio-economic settings, and growth in public demands and management scenarios (Sowunmi, 2019).

Additionally, risk management in construction projects can also be utilised to managing landfill gas to electricity projects. Karim et al (2012) outlined that in developing a risk management strategy, the critical initial phase should be identifying the risk. This phase is undertaken through “brainstorming, prompt list, checklist, work breakdown structure, Delphi technique, or by asking expert.” The following step is

evaluating the risk and the potential impacts on the project. Karim (2012:08) argues that risk "can be evaluated based on the possibility of risk occurrence and severity of its impact by developing risk matrix." In landfill gas to electricity projects, the stakeholders involved in the project are required to negotiate the risk. As noted by Karim (2012:11), negotiating risks "normally takes place after signing the contract. This is the most important step as it reflects the risk management assessment updates continuously." The partners and stakeholders, after conducting evaluations, then divide the risk according to their respective capabilities. The following step involves handling the risk, this can be done through the following: "avoid, reduce, share, transfer, defer, mitigate, contingence, insurance or accept the risk." Lastly, the risk is controlled and monitored through a risk reporting mechanism such as, "listing the details associated with risk such as type of risk, its probability of occurrences, its impact on project, possible treatment" (ibid). It is also important to note the monitoring step is continuous during the project lifetime (ibid).

Figure 2.3: Indicates implementation and Managing of Landfill gas through an integrated sustainable waste Management Approach.



Adopted from Van de Klundert and Anschütz, 2001

2.8.2. Strategies on implementation of WtE technologies

While the previous section attempted to explain the implementation and management of WtE projects, it is important to observe that managing waste projects remains a significant challenge faced by many countries that adopted renewable energy initiatives. According to Pan et al (2015), while the fundamental phases for waste management are prevention, recovery, and disposal, conversion of waste to energy remains the essential strategy. Scarlat, (2015) has outlined that WtE technologies are crucial for future development. Hence those responsible for implementing this technology should consider the social, environmental, and economic impacts during the decision-making process.

The first and most important strategy on the implementation of WtE technologies is the adoption of government policy that addresses the challenges of energy security and the development of the WtE sector. This will ultimately lead to a sustainable development of a society (White, et al 2010). While old policies used to be categorised into different sites covering different things, currently, there has been growing improvement in integrating policies that cover plans with a multi-disciplinary method. D'Alisa et al, (2012) argue that this is one way of accomplishing an efficient and effective WtE supply chain.

Additionally, technical assistance can be provided through formulating a strategic action plan to ensure that WtE technologies are successfully implemented. According to Oyedepo (2014), through a strategic action plan, local authorities can be assisted in developing the WtE projects into smaller manageable projects. This will further enable the easy identification of activities and assistance required before commercialising WtE projects. It is in the system that other stakeholders such as the private sector can be involved considering that the local authorities tasked with managing waste are not capacitated enough to run WtE projects. Therefore, the public private partnership in this sector are crucial (Karak *et al*.2012).

In relation to financial strategies, offering incentives to support WtE technologies remains one of the best way of improving the deployment of renewable energy. In countries such as India, financial incentives enabled the building of capacity to provide

additional power generation from the waste in a decentralised and cost effective manner through various projects (Menikpura, 2016). As such, the strategy can be used as a roadmap for most cost-effective deployment plans for WtE projects. In addition to financial strategies, research and development should be prioritised in developing countries (Vaish et al, 2016). Research and development will enable the local municipalities to avoid buying fake waste to energy technologies that is sold to them by vendors. Through education, those tasked with the implementation of WtE technologies can easily check the state and suitability of equipments that they purchase. Education is also an important aspect in that it enables the development of expertise that has long been missing within the WtE chain.

2.8.3. Development of WtE in Serbia- A case Study

Serbia is known to have made noteworthy development in relation to the progress of a legislative framework in waste management (Vujiv et al, 2015). This was done through aligning existing laws with the current European legislation which emphasise the importance of adopting and developing waste to energy technologies. The chief legislation that has seen a great improvement in converting waste to energy in Serbia is the National Waste Management Strategy of 2002, which has been improved over the years (ibid). The legislation is supported by other policies such as the Law on Waste Management of 2009 and Waste landfilling of 2010 among others. The division of institutions responsible for waste management starting from the national level up to the local level has enabled Serbia to achieve the EU goals (ibid). The Ministry of Energy, Serbia, further established sub ministries of departments to ensure that legislation and frameworks on WtE technologies are purely defined. Lastly, in relation to financing WtE projects, majority of funds from the citizens thereby making them stakeholders in these projects. However, the state through local government also plays an important part of subsidising operations of municipal waste management companies. At an international level, many incentives in Serbia have come from EU grants and other European banks that have opened credit lines for companies involved in WtE projects.

2.8.4. Advantages of converting landfill gas to energy

The major benefit of landfill gas to energy is that, it limits carbon emissions thereby assisting in combating climate change (Yi et al., 2018). This will also see an improvement in the environment, air quality and conserve vegetation. Even in the process of setting up the landfill project, employment opportunities are created thus there is a huge economic gain which comes from this method of converting waste to energy (Islam, 2018). Municipalities are also posed to benefit from Landfill gas project in that they can sell the end product, be it the gas or electricity generated to users.

2.8.5. Disadvantages of converting landfill gas to energy

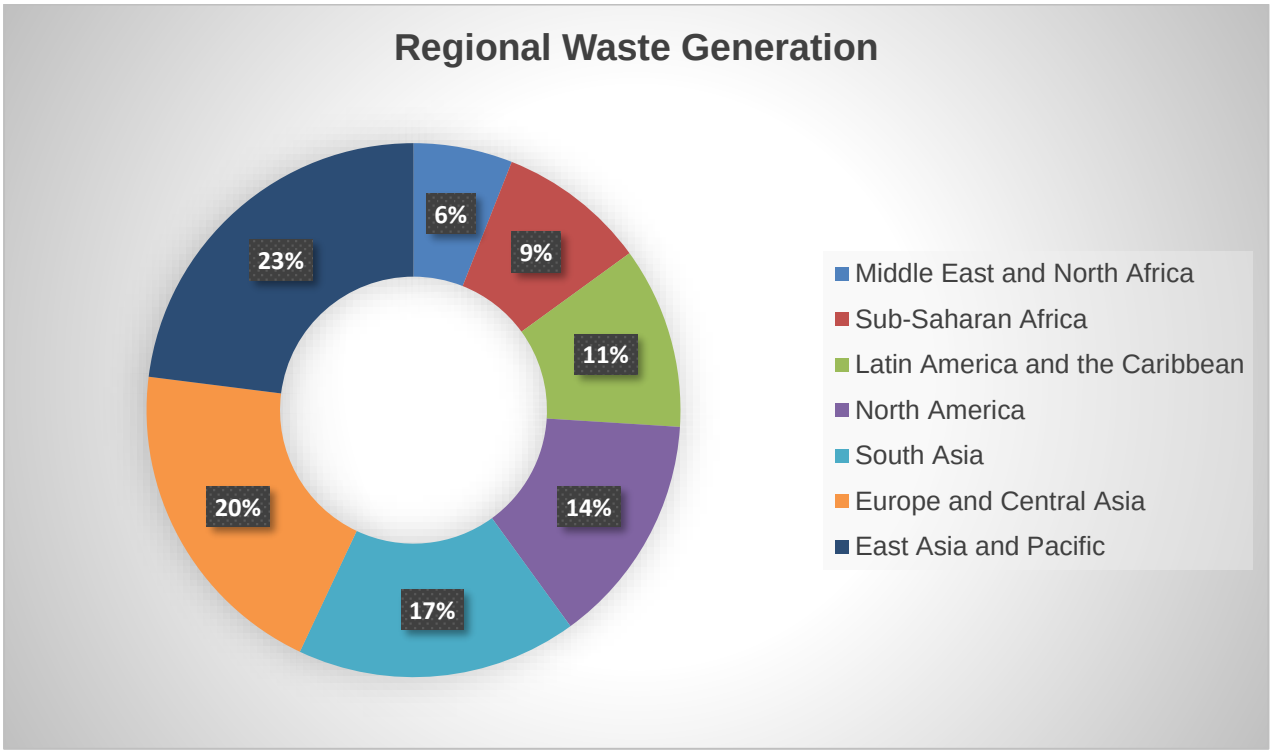
The major disadvantage of landfill gas is that it requires a large piece of land for infrastructure (Dhanya et al., 2020). This is a challenge, especially when many municipalities struggle for land to settle excess populations, and identify sites for waste energy projects. Additionally, to successfully reap the advantages of landfill gas to energy, the landfill site must be open for a long period (Mukherjee et al., 2020).

2.9. Urbanization and solid waste generation

The high rates of urbanisation have compounded both the developed and developing world. In this context, solid waste has become a global challenge considering that it has grown proportionally with the process of urbanisation (Chen, 2018). It has been widely observed in literature that the growth of urban populations is positively correlated not only with the generation of municipal solid waste in the urban centers of the world but also with energy consumption. Given this correlation there is a need for new research to covert waste to energy. As observed by Ugwuanyi and Isufe (2012: 13), “the challenge of solid waste management includes inadequate infrastructure, the paucity of policy and legal framework, poor environmental planning, budgetary and operational constraints, overpopulation, and inadequate environmental education”. Waste generation has been recognised as a natural product of population growth, urbanisation, and economic development over the years. Academic literature shows that a long time ago, humanity led a rural lifestyle that was based on agriculture and hunting as a livelihood strategy (Sharma and Jain, 2019; Tun and Juchelkova,

2018). However, as time went by, a reasonable number began to reside in towns. According to Ugwuanyi and Isufe (2012), in the 1800s, about 3% of the world's population resided in urban areas. Further, in the 1990s, the urban population increased by about 30% due to the high rate of urbanisation (ibid). Currently, there is an estimation that the global population of the people residing in urban centres will rise to 66% in 2050s (Kaza *et al.,* 2018). Meanwhile, in relation to waste production, East Asia, the Pacific, Europe and Central Asia regions generate 43% of waste due to urbanisation (ibid). (See figure 2.4)

Figure 2.4: Indicates Waste Generation per Region.



Source: Kaza *et al.,* (2018).

In the case of Africa, while the continent is urbanising at a slow pace compared to other regions. It is estimated that by 2050, 50% of the population will be residing in the metropolis (Ugwuanyi and Isufe, 2012). In this regards, there is no doubt that municipal solid waste generation will be a major concern. Thus, rapid urbanisation will lead to serious environmental health hazards that need to be mitigated.

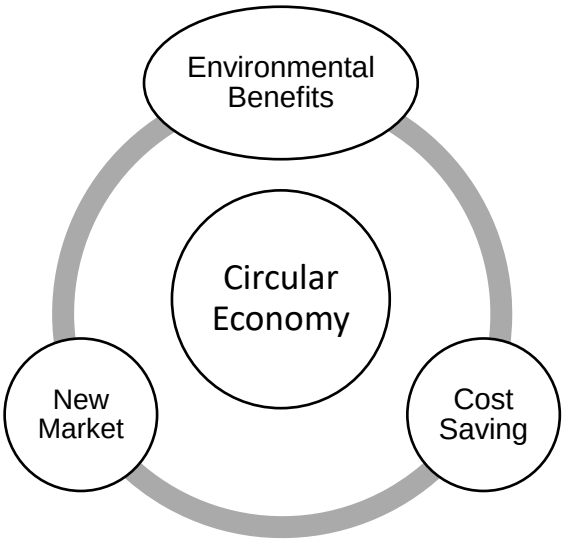
2.10. The role of WtE in Circular Economy (CE)

According to EMF (2015) cited in Peart (2016:17) “the concept of the CE has come about as a result of the realisation that current societal trends in levels of resource extraction and consumption in order to live the way we do might mean we leave future generations with less ability to provide for themselves”. Van Caneghem *et al,* (2018:1) defines CE as “an economy that focuses on maintaining the value of products, materials and resources in circulation for as long as possible, thus minimizing waste generation and resource consumption”. As such WtE technology plays a fundamental role in a CE. “It offers the opportunity to extract value out of material at the same time as providing an alternative energy source” (Peart, 2016:3). Additionally, Van Caneghem *et al,* (2018) notes that central to CE concept is the understanding that creation of job opportunities and new business opportunities, jobs and innovativation will imply innovative mechanisms of producing and consuming. From a theoretical perspective, CE refers to an umbrella concept, uniting a broad variety of aims and concepts relating to ensuring sustainability ecosystems. The role CE is crucial in a society as to it encourage both social cohesion and integration. Among other benefits, CE assists in avoiding continuous depletion of resources at the pace that “surpasses the Earth's capacity to replenish them in terms of climate and biodiversity, air, soil and water pollution” (Monfreda *et al*., 2004:233). Another benefit of CE is in terms of reducing carbon dioxide emissions levels (ibid).

In a study carried out by Peart (2016), there is evidence that the shift towards a circular economy is one of the significant EU policies that will assist Europe and developing countries to attain 17 goals that are embedded in the UN SDGs in particular Goal 12. WtE is an example of such efforts to ensure sustainability as it seeks environmental benefits through utilization of waste to create energy. Given more investments into WtE this has the potential to enhance efforts to create new economic markets while also reducing costs of energy production. Goal 12 advocates for sustainable consumption and production patterns (see figure 2.5). Taranic *et al,* (2016: 2) highlight that transition to the circular economy is anchored by “three fundamental pillars namely;

1) environmental benefits, particularly in terms of reduced impacts and reduced resource usage;
2) cost savings from reduced natural resource needs; and
3) the creation of new markets, providing additional economic benefits of CE practices, e.g. in terms of jobs creation or wealth creation".

Figure 2.5: Indicates the three circular economy pillars.



Source: Taranic, Behrens and Topi (2016: 2).

2.11. Need for Energy Recovery from Waste

The demand for energy increased exponentially over the years due to population growth as well as the improved living standard (El-Sheltawy *et al,* 2016). Hence new sources of energy have emerged due to this increase in demand for energy. According to Silwal (2019) research, energy recovery is an integral component of WtE, that is performed through the combustion of MSW and is a preferred option from an environmental protection perspective. The combustion or digestions of MSW assist the municipalities to reduce waste and also recover energy from waste (Vertakova, 2019). Silwal (2019) further indicates that renewable energy is generated through combustion process. In addition, energy recovery from the MSW contributes to (i) fossil fuel replacement and (ii) minimization of the methane generation in a landfill site. Cities in developed and developing countries should invest in WtE technology because

it has the ability to recover energy and reduce GHG emission from the landfills (Iqbal et al., 2019; Botello-Álvarez et al., 2018).

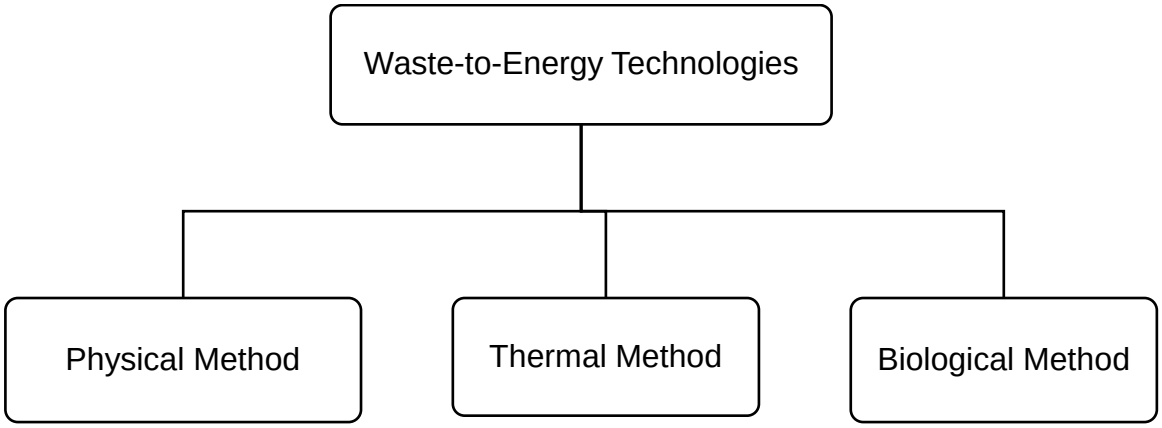
2.12. The need for Waste-to-Energy technology

Kothari *et al,* (2010) cited in Kumar and Samadar (2017), indicate that the global energy demands are expected to rise by the end of the current century. Further, Kumar and Samadar (2017: 409) argue that "the currently available energy supply is much lower the actual energy required for consumption in many developing countries". There is evidence elsewhere that the major source of energy around the world is fossil fuel (Ouda *et al.,* 2016 cited in Kumar and Smadar, 2017). However, considering the alarming rate of fossil fuel depletion and its negative environmental impacts, such as causing greenhouse gases and climate change, it is clear that investment in WtE is essential. Hence, WtE technology is necessary for facilitating the conversion of MSW into energy so as to meet the energy demand. Additionally, Moya et al, (2017) state that WtE technologies are significant for developing economies mainly due to the potential of transforming MSW into energy and also curbing the environmental problem. According to Silwal (2019), WtE technologies are an essential element of the waste management to combat climate change and global warming impacts.

2.13. Waste-to-Energy Technologies

The World Energy Council (WEC) (2013:28) defines WtE technology as the "technologies that comprise of any waste treatment process that generates energy in the form of electricity, liquid or gaseous fuels or heat, using waste as a feedstock". Globally many nations are steadily investing in renewable energy abandoning reliance on fossil fuel (Rafati *et al.,* 2016) . This comes after the realisation that the energy crisis is threatening humankind (ibid). The three methods or technologies of Incineration, Gasification and Pyrolysis have already been discussed under the landfill gas section (see figure 2.6).

Fig 2.6: indicates WtE Technologies.



Source: Rafati *et al,* (2016)

2.14. Case Studies of Waste-to-Energy technology

The examples identified in this research are relevant in that they were implemented, and they yielded positive results such as the generation of electricity through different WtE technologies. This presentation of these case studies is also aimed at highlighting the benefits and barriers that cut across developed and developing the countries.

2.14.1. Case study of WtE in the United State of America

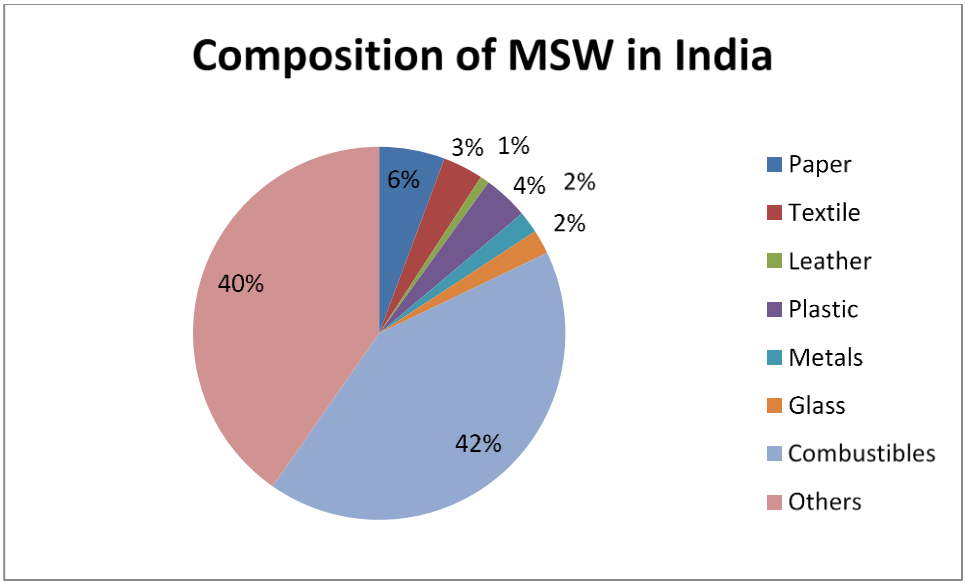
The US generates 387 million tons of solid waste annually (Themelis and Mussche, 2014). However, 8% of the waste generated is used in WtE plants (ibid). Furthermore, Themelis and Mussche (2014) noted that recycling or composting constitutes 25% and the balance of 64% is allocated to sanitary landfills. Van Haaren and Themelis (2010) cited in Themelis and Moustache (2014: 6), maintain that in some states like in Maine in particular and Connecticut, only 10 - 15% of the MSW is landfilled while 50% of the waste produced is used for energy production. This is evidence that the USA has made tremendous strides in investing in WtE technology and on the two-stage gasification process. Hence Castaldi *et al,* (2010) note that in the USA, processes such as (i) gasification of waste materials to generate syngas which is combusted to energy

generation and (ii) the process which produces good control and management of emission.

2.14.2. Indian Case Study

India has proved to be one of the developing countries that have witnessed rapid urbanisation. The amount of SW produced has increased exponentially and waste disposal challenges have been the result of this. According to Singh *et al,* (2014), India like any other developing country generates a significant amount MSW at an alarming rate of about 55 million tons per annum. Singh *et al,* (2014) observe that around 38 million cubic meters per annum of sewage water are also produced in India. However, Sebastian *et al.,* (2020) argues that most of the waste in India are disposed of in landfills. Hence, there is high potential to convert this waste into energy.

Figure 2.7: Indicates the average composition of MSW in India.



Source: El-Sheltawy et al., (2016).

El-Sheltawy *et al,* (2016) highlight that India generated power from the liquid municipal waste and solid waste estimated around 1700 MW (see figure 2.7). According to El-Sheltawy et al, (2016), the Ministry of New and Renewable Energy projected that an additional increase of 1,300 MW of power from industrial wastes in the near future. It

is indicated that over 135 megawatts of the project have been implemented in different industries such as distilleries, pulp and paper mills, and food processing amongst others (El-Sheltawy *et al.,* 2016). Jabalpur and Hyderabad WtE projects were implemented in 2015 and each is estimated to produce 11 MW. In 2016, two more projects were commissioned in Nalgonda and Chennai and 16.9 MW of power is further expected. India has invested heavily on different types of WtE technologies according to the waste type.

Table 2.14.2: Indicates Waste Type and Complementing WtE Process.

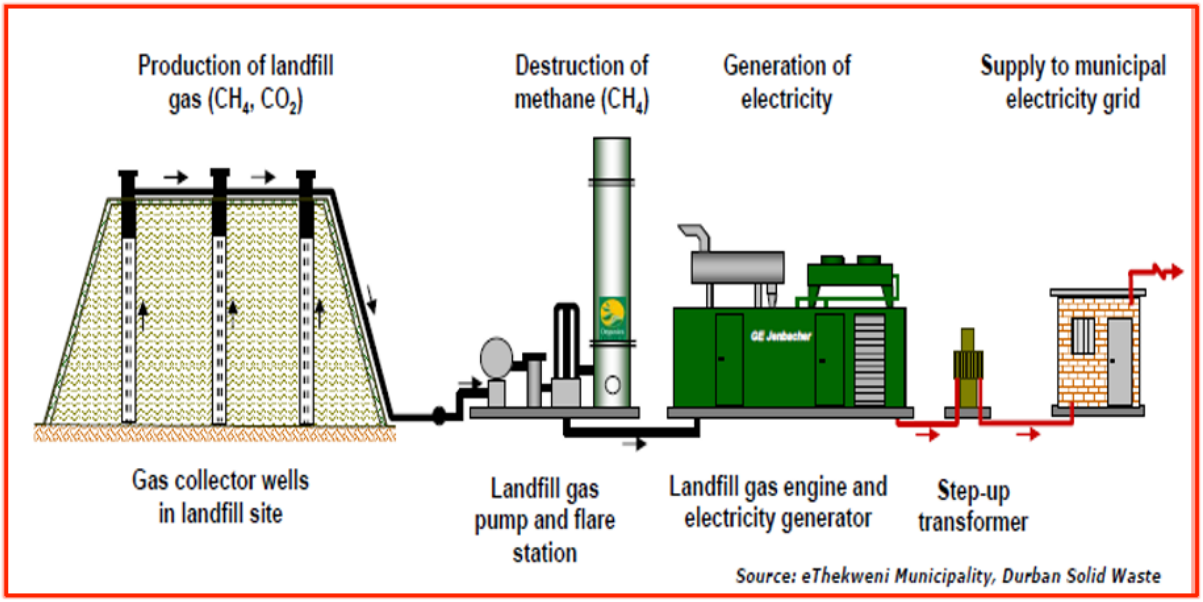
Waste Type	**Process**
Liquids	Bio methanation
Solids	Gasification/Pyrolysis and Incineration/Combustion
Semi-solids	Bio methanation, Gasification/Pyrolysis and Incineration/Combustion

Source: El-Sheltawy *et al. (*2016).

2.14.3. Waste-to-Energy: South Africa

According to Gumbo (2014: 46) “urbanization, industrialization and globalization are positively correlated with municipal solid waste generation and energy consumption in global urban centres”. Many municipalities have opted for the landfill method to manage solid waste and yet they are still grappling to manage through this conventional method. However, following this challenge, municipalities in South Africa such as eThekwini and City of Tshwane have decided to invest in WtE technology in order to manage solid waste in a sustainable manner. For example, Stafford (2020) notes that in South Africa, eThekwini municipality is the best case study in the country. The municipality managed to implement a landfills gas project which generates 7.5 MW power of electricity. This landfill gas to electricity project was implemented in 2014 in partnership with the World Bank such a project was due to the ability of the project to reduce carbon emissions and the generation of electricity.

Fig 2.8: Indicates the eThekwini Landfill gas to electricity project.



Adapted from Gumbo, (2014).

Another successful project implemented in South Africa is the industrial biogas plant in Bronkhorstspruit in the City of Tshwane (CoT). According to Stafford (2020: 201), the project has an "electrical capacity of 4.4 MW electricity with a purchase power agreement for the sale of electricity to the BMW car production plant in Roslyn". The agreement that was signed between the CoT and BMW for electrical requirements is for a 10-year duration. The biogas plant which generates electricity from manure and waste from the slaughterhouse is located at a nearby farm. However, both these processes of converting waste into energy have had their benefits and challenges.

2.15. Benefits of upscaling Waste-to-Energy Technology

"Waste should not be perceived as waste, rather a misplaced resource that has the potential to be converted into reusable new materials, energy and other products with value" (Ofori, 2016: 12). What this entails is that if waste is managed well, it can end up being a resource with beneficial uses in a circular economy. This perspective was also emphasised in the definition of waste to energy (WtE) earlier on in the chapter.

Current literature on WtE emphasises the need for urgent interventions to address the alarming global increase of MSW generation. Scholars such as Dlamini *et al,* (2019) point out that urbanisation; population increase and financial opportunities are the contributing issues that lead to the rise of MSW generation. As a result, SWM has become a thorny issue on the municipal service delivery agenda. Further, Dlamini *et al,* (2019) allude that municipalities are grappling to effectively manage solid waste in their jurisdictions mainly due to ageing waste infrastructure and perpetual generation of waste.

In the case of City of Johannesburg, Muzenda *et al.,* (2012) posit that the City is battling to effectively implement a sound SWM system to address the challenge of solid waste. And yet, there is evidence elsewhere that waste should not be viewed as a nuisance but rather as a resource (Gumbo 2014). This is echoed by Koech (2015: 8) who argues that "energy recovered from waste can be used for generation of electricity, generation of heat and generation of power (commonly referred to as combined heat and power)". Moreover, Faiza *et al.,* (2018) maintain that the implementation of WtE technology projects gives plenty of benefits such employment opportunities, energy, carbon credits and carbon finance, financing and tax incentives, and environmental benefits. While some of these were already mentioned in the section on landfill gas energy, they are repeated here to give a holistic view of these in relation to the broader impact of converting waste to energy through different methods.

2.15.1 Employment Creation

WtE projects can play a pivotal role in enhancing economic growth which is a major gain to the country. This is the case because WtE projects create both temporary and permanent jobs opportunities during the construction and maintenance stage. Employment opportunities include on-site and offsite employees. The employees are responsible for plant oversight and maintenance at the regions, national firms that own and operate waste-to-energy facilities (Berenyi, 2013). According to the report commissioned by the National Association of Countries (2015:4), "during the construction stage, about 300 jobs, both direct and indirect, are created from 1,500 tons of waste in a WtE facility per day". The report further alludes that "during the

operational phase an average of 59 new job opportunities are created mainly for operation and maintenance of the facility" (ibid).

2.15.2. Energy Benefits

Considering the ever-increasing demand for electricity, WtE can play a pivotal role to mitigate this high demand. For example, scholars such as Abdeshahian *et al.*, (2016) cited in Faizal *et al.,* 2018) observes that by 2030, electricity consumption will rise to 4.85x1012 MJ and 2.34x105 in Malaysia due to economic growth and technology advancement. However, due to the abundance of waste, Malaysia has invested in Langkawi WtE plant, which generates about 1 Mega Watt of electricity from 100 tonnes of MSW (Faizel *et al.,* (2018:97). Similarly, in Ukraine, a biogas plant produces 3300 m3 of methane gas (CH4) which then can generate electricity for a capacity of 180 kWh whereas an electricity-generating incinerator in the UK generates 519 kWh per tonne of MSW (Faizel *et al.,* (2018:97).

2.15.3. Economic Benefits

Converting waste to energy is quite important for economic growth. For instance, in the United State, there have been reports of high financial returns generated from the WtE industry (Berenyi, 2013). The revenue is accumulated from the sale of electricity generated from the waste. Faizel *et al,* (2018) indicate that Malaysia is developing at an alarming pace due to economic growth and this has a direct implication on energy consumption. Likewise, in order to manage the economic development pressure, Malaysia resolved to invest more on renewable energy sources such as WtE to sustainably uplift the economical muscles of the country (*Faizel et al.*, 2018). This means that from an economical perspective, implementation and investing in WtE technologies provides opportunies. Furthermore, Faizel *et al.,* (2018: 96) observe that "among all WtE plans, incinerator could generate the highest amount of heat energy and electricity which comes with a high profit".

2.15.4. Carbon Credits and Carbon Finance

WtE technologies are fundamental in reducing greenhouse gas emissions and also to qualify for emission reduction certification under the Clean Development Mechanism (CDM). Most developing countries have signed the Kyoto protocol, which is aimed at reducing the levels of carbon dioxide (Koech, 2015). Siddigui *et al*, (2013) indicate that most countries benefit from carbon finance to build the landfill to gas projects. Another additional revenue generation is through Renewable Energy Certificates. These are some of the options that the municipality can benefit through the WtE technology investment.

2.15.5. Environment Benefits

WtE projects are essential in promoting sustainability in the environment in that they reduce the number of carbon emissions and improve air quality (Koech, 2015). The National Association of Countries (NAC) (2015:6) argues that landfills are "the third-largest human-generated source of methane emissions in the US". All landfills produce methane as a by-product of the breakdown of waste, therefore, there is a need to invest in WtE technologies because methane is also a strong gas just like carbon dioxide. Hence, Hoornweg and Bhada-Tata (2002) argue that greenhouse gas (GHG) emission emanating from MSW amount to 5% (1,460 mtCO2e) of total global greenhouse gas emissions. Additionally, according to Faizel *et al*, (2018: 97), "most landfills are unable to absorb more solid waste because they have reached their threshold". These landfills "leave a multitude of bad environmental impacts such as nauseous odours, leachate formation and greenhouse gas emissions resulting from the MSW decomposition" (ibid). As such, while converting waste into gas through landfill has its advantages, it's more beneficial to invest in WtE than landfills.

2.16. Conclusion

The chapter interrogated both international and local literature on WtE with the purpose of putting this study within its scholarly context. The literature review highlighted that while countries such as South Africa have developed WtE infrastructure to some extent, the full utilisation of this infrastructure to produce renewable energy remains relative. The chapter unravelled the barriers related with the full implementation of renewable energy and went on to make a case for the benefits of overcoming these barriers. Through grouping the factors that affect the implementation of renewable energy, the chapter came up with a conceptual framework dubbed Political, Economic, Social, Techincal, Environment and Legal (PESTEL) which assisted in analysing the barriers of upscaling Waste-to-energy projects in the emerging economies. A study on the effects of various barriers on the implementation of renewable energy is crucial as it assists organisations to invest significantly in developing advanced technologies. These have the potential to ensure renewable energy usage is optimized and become a lucrative energy source.

Chapter Three: Research methodology

3.1. Introduction

The purpose of this chapter is to outline the methodology used in the study. The methodology is an integral part of the study, as it details the steps and techniques which the researcher follows to collect data in the study area. According to Kothari (2004:1), the research method is “the science of how a research project can be undertaken and describes the stages that researchers go through whilst they decide upon the best means of addressing their research problem and the logic behind their reasoning”. This chapter discusses the methodology that was adopted to investigate the state, barriers and opportunities of scaling up municipal solid WtE technologies in emerging economies using Simmer and Jack landfill in CoE as a case study.

3.2. Methodology

Qualitative research methodology in the form of a case study informed the research. The methodology employed both a description and analysis approach. A qualitative methodology was suited for this study because it leads to a synthetic, comprehensive and interpretive assessment (Mouton, 1996). Qualitative approach utilises descriptive data obtained of numerous sources (ibid). This was helpful in this research to enable the understanding of individual’s attitudes toward WtE projects. Further, qualitative methodology enabled more insights into the state, barriers and opportunities of WtE technologies as the researcher was able to engage with officials responsible for the operation currently underway at Simmer and Jack plant.

3.3. Case Study

A case study is understood as “an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used” (Yin (1984: 23). Furthermore, Merriam (2008) and Yin (2003) note that a case study research design is best suited for answering the how, why, and what questions. For this study, Simmer and Jack WtE landfill plant were chosen as a case study with the aim of investigating the challenges that are faced at the site which might be hindering the full utilisation of the plant to harness renewable energy in the CoE. The choice of Simmer and Jack WtE as a case study was based on the fact that it is a project aimed at generating energy from solid waste management in CoE. While this project has the potential to generate WtE, this research identified that it has not been used to its full capacity. However, if utilised to its full capacity, Simmer and Jack has the potential to combat pollution and also managing solid waste sustainably. Creswell *et al*, (2007) note that the case study is important for research as it allows the researcher to obtain valuable and credible information through qualitative techniques for example surveys, interviews, participant observation and focus groups. The area of study chosen for this research is ideal because it offers an opportunity to be able to identify and unpack issues that might appear complex from a distance.

3.4. Data Gathering techniques or methods

This study utilised both primary and secondary sources of data gathering to accomplish the aim of the research. Semi-structured interviews with the municipal officials and experts working with solid waste management and renewable energy formed part of the primary data. Observation and photography methods were utilised to assess the state of the Simmer and Jack plant in order to identify the technological barriers that might be hindering the plant to achieve its intended objectives. Secondary sources of data included data relevant municipal documents, journals and government publications relating to the research topic. These were reviewed to adequately appreciate and identify the legal, economic, social and political barriers that might be preventing the full uptake of renewable energy in CoE despite the existence of WtE infrastructures such as Simmer and Jack landfill plant.

3.4.1. Unstructured Questionnaires and In-depth Interviews

In order to establish a grounded theory for the study, the unstructured interview approach was relied upon. The unstructured interview approach is “an approach where unstructured questionnaires are employed, containing a number of open-ended questions, whose wording and the order can be changed by the interviewer” (Sarantakos, 2005:268). Through this approach, as an interviewer, I acted freely, the structures of my interviews were flexible and the restrictions were minimal, hence they took the form of an interview guide rather than rules (see, Sarantakos, 2005: 268). The interview enabled me to engage the participants in a logical and chronological manner in order to obtain the anticipated information for this research.

In utilising in-depth interviews, I engaged participants in a session where I asked them questions on the barriers experienced in WtE which is the subject under study. According to Boeije (2010: 61), the structure of an interview was designed separately for each interviewee. Some researches use unstructured or open-ended questions to address their research questions (ibid), just like I did. Through unstructured interviews, I was able to solicit important information about the state, opportunities and barriers of WtE in CoE since these were the phenomenon I was researching about. The researcher was able to obtain information about the benefits and barriers of upscaling WtE in Ekurhuleni using Simmer and Jack as a case study.

The unstructured interview technique yielded significant information for the research, as I was able to engage with officials or key informant participants through the interviewing process. While I had proposed to Interview 16 participants, which included 10 officials and 6 experts (3 academics and 3 environmentalists), I ended up relying only on interviewing 10 officials from CoE. The officials were opted for in this study because they are the people involved in renewable energy projects hence, they are aware of the challenges and barriers they encounter in running WtE technologies. The difficulties in engaging academics and environmental specialist were induced by the Covid-19 lockdown that took place at a time when I was about to gather data for the research (March 2020 to September 2020). Luckily, by the inception of the lockdown, I had already engaged with 8 official through a face to face interview process. The other two officials were interviewed virtually. One of them asked that I send them the

interview guide prior to our engagement through skype. The other one didn't see any need to prepare for the interview hence I didn't send them the questions before having a zoom meeting with them. I also tried to convince academics and environmentalists that are not employees of CoE to partake in the interview process virtually, but my emails were not returned despite writing to them on numerous occasions. I ended up conceding that engaging them virtually was impossible and given the time frame I am expected to conclude this research, I had to improvise. As such, to supplement the data (might be narrow) that I solicited from officials, I engaged documents, municipal reports and journal articles about WtE with a focus on South Africa and CoE to be precise.

Table 3.4.1: Indicates the profile of 10 officials who were interviewed.

Participants	**Department**
Official 1	Renewable Energy Department
Officials 2	Renewable Energy Department
Official 3	Renewable Energy Department
Official 4	Environmental Management
Official 5	Environmental Management
Official 6	Environmental Management
Official 7	Environmental Management
Official 8	General work 1 (Simmer and Jack Landfill Plant)
Official 9	General worker 2 (Simmer and Jack Landfill Plant)
Official 10	General worker 3 ((Simmer and Jack Landfill Plant)

3.4.2. Observations

Observations are commonly used in research. This data collection method involves "driving and walking around the study area looking and listening in a systematic and purposeful manner about the phenomena of interest" (Given, 2008: 572). The observation method works effectively when incorporated with other approaches such as document analysis and interviews. In relation to this study, I crisscrossed the study area (Simmer and Jack plant) several times in order to observe its state and the processes happening there. While I did this on foot and sometimes driving through the plant, I was also familiar to some conditions at the site considering that I am an employee of the municipality although in a different department. Observation at this stage meant for gathering data on the site. Additionally, having developed this research through engaging different perspectives and literature of Landfill gas to electricity, my visit to the site was specifically directed by clear objectives of not only to view the site but to do so with a clear purpose, which was to identify the challenges and opportunities that are faced at the site. The observation technique also enabled me to identify some of the participants that were keen to contribute to this research through interviews. These included general workers.

3.4.3. Literature Review

The literature review is a "systematic search of published work to find out what is already known about the intended research topic" (Robinson & Reed, 1998: 58). In addition, Leedy (1989: 66) indicates that "the more knowledgeable you are, the better you will be able to understand your problem." This research reviewed existing literature on solid waste to energy from numerous countries. The literature review provided a wealth of information particularly on the waste to energy as a mechanism or intervention to manage municipal solid waste management. The material reviewed ranges from journals, academic thesis and reports, and government publications. The following chapter on findings will attempt to infuse both information gathered through first-hand experience and that from municipal documents with the purposes of holistically answering research questions guiding this study.

3.5. Data Analysis

Content analysis is a fundamental method that can be used to analyse written and verbal data (Cole 1988). This method is fundamental and relevant for this study considering that the data that I gathered was informed by literature which opened up gaps about the barriers that hinder WtE uptake and the possible strategies to deal with those barriers. It was from this literature that the researcher was able to engage in face to face interviews to either confirm or dispute scholarly thought around the subject. Data analysis also entailed the identification of strategies that can enable the process of breaking the barriers that hinder the successful implementation of WtE projects. Guided by the research questions, data analysis also involved the assessment of the state of the Simmer and Jack plant in City of Ekurhuleni and the opportunities of WtE projects. Additionally, the risk management framework and the integrated waste management plan were critical in unpacking the process of implementing and managing waste ot energy projects.

3.6. Research Reliability and Validity

Research reliability and validity are interrelated, although they mean different things. The two are fundamental concepts that anchor the credence of the research. According to Silverman (2014), reliability is attained through the dependability of the research, whereas validity is defined as the authenticity of the research findings. The data collected in this research was satisfactory reliable in that repeatability on similar results by another researcher is highly probable in a similar context as alluded by Bryman & Bell, (2007) and Stokes (2011). Silverman (2014) mentions that transparency and comprehensiveness during the research is one of the criteria for accomplishing reliability of data. It is fundamental to indicate that these functions were observed throughout the research. The data collected was validated through follow up questions and meetings with the participants. Fact check was also applied through verifying information that one respondent provided, with what the other respondent aired out to ensure that the information that was being given can be relied upon.

3.7. Limitaions and Reflections on the methodology and positionality

This researcher acknowleged that data provided by officials from CoE was to be balanced with that gathered from other experts who such as academic and environmental specialist to avoid biasedness. As was highlighted earlier on, only officials from CoE were interviewed and there were challenges in engaging academics and environmental specialists due to the Covid-19 lockdown. However, to ensure that the data obtained for this research was valid and can be relied upon, I also relied on secondary data to supplement that which was obtained through primary sources. This secondary data involved a thorough literature review of relevant literature on the subject under study, as was mentioned earlier. Perhaps also worth mentioning, is the fact that considering that I am a city official, accessing different municipal documents and reports was not a challenge. My positionality also enhanced my chances of engaging with officials through interviews although we did not know each other prior to this engagement. These engagements were quite important in that they allowed me to write about the state of WtE in CoE from an inside out perspective, something that I think is a strength to this study. Researching on municipality from outside or a distance might be problematic due to different factors such as trust between the researcher and those being researched hence, I feel strongly that by utilising the inside out approach, I was able to overcome some of these challenges.

3.8. Ethical Considerations

Ethics of conducting a research were observed in this study. First, as a researcher, I sought an ethics applications to the University's ethics committee and an approval was granted before embarking on the data collection process. During data collection, I ensured that the participants were aware of the purpose of this study and that their involvement was specifically to assist in soliciting data for my academic work and nothing more. Further, participants were allowed to withdraw from the interviewing process anytime they wished. For the interviews that were done telephonically, the research ensured that the conversation that was happening was only between the researcher and the interviewee. Lastly, whenever respondents had questions, I address their queries and concerns.

3.9. Conclusion

This chapter presented the approach relied upon for obtaining data for the research. The chapter highlighted the importance of relying on qualitative methodology in the form of a case study research. Further, the chapter also justified the use of different techniques such as in-depth interview, observation and desktop literature in the study. It was also important to not only justify the preferred methods but to also motivate for the uniqueness of the research brought to this study. While this was done to give a clear picture of the interview setting, it was also a way of showing how rich and reliable is the information that was gathered despite failure to engage other respondents such as academics and environmentalist. As such, the following chapter presents the context of this study and also seeks to offer a solid understanding of the state of CoE's WtE.

Chapter Four: Overview of the Study Area

4.1. Introduction

This chapter provides the history and background of the Ekurhuleni Metropolitan Municipality. It does so through presenting the demographic statics, economic status, energy demand and the solid waste management strategy. To contextualise the study area, the chapter highlights the background and location of the Simmer and Jack WtE project. The chapter also gives a description of the existing SWM legislation and policy within the CoE.

4.2. Brief Overview of Ekurhuleni Metropolitan Municipality

The formation of Ekurhuleni Metropolitan Municipality in 2000 followed the restructuring of eight other municipalities in the former East Rand Region by the department of local government. Ekurhuleni municipality has 9 local authorities and 101 wards and is ranked as the fourth-largest municipality in South Africa. The municipality is situated to the eastern portion of Gauteng province, which has led to it being known as the East Rand. Statistics South Africa (2011) has outlined the municipality has 192, 355 hectares of land with approximately 3.2 million people residing in 900,000 households (CoE Full Term Report 2006-2011, 2011).

In a developmental approach and aimed to address its communities' needs, COE combined 11 councils into one local government authority. These “councils are Alberton, Benoni, Boksburg, Brakpan, Edenvale, Germiston, Kempton Park/Tembisa, Nigel, Springs, Khayalami Metropolitan Council and Eastern Gauteng Service Council” (CoE, 2010). Approximately 28 percent of Gauteng’s population, with a population density of 1 400 people per square kilometre (CoE, 2010). It has been noted the ‘township’ and informal areas have a high population density. This is reflected by the high number of people 22 percent living in informal settlements due to inadequate housing. Statistics South Africa (2011) has outlined approximately 40 percent of the community is unemployed despite the community having a high number in the working group.

The municipality was formed through a conglomeration of nine municipalities. This has led to challenges to outline the core (Nhamo., 2021). Other challenges due to the conglomeration are reflected through the equity profile (Maponya et al., 2021). Low development densities have been located at the urban periphery, similar to historical trends of locating disadvantaged areas (CoE, 2010: 9). The current housing backlog is increasing, leading to an increase in shacks, which are currently approximately 135 000 and 36 000 backyard shacks.

Table 4.2: Indicates Statistics on Ekurhuleni Metropolitan Municipality.

Surface Area	1,924 km2
Population	3.2 million (StatsSA,2011)
Population Density	1,400 people per km2
Proportion of Gauteng Population	28%
Population Growth (2004-07)	1.6%
Main Income Areas	Manufacturing, Trade, Social Services
Electricity Use per Annum	15,513,201,926 kWh
Emissions per Capita	7.7 tCO2e
Annual Budget	R21 Billion (+- 2.19 billion USD)
Budget for IDP Projects	R2 Billion

Source: Census (2011) and Stats SA (2015).

4.3. Demographic Profile of Ekurhuleni Metropolitan Municipality

Table 4.3a. Indicates the demographics of the City of Ekurhuleni.

Place	Area (KM²)	Population	Most Spoken Languages
Alberton	80.45	89, 392	Afrikaans 49% and English 38%
Bapsfontein	0.31	936	Zulu 34%, Pedi and Sotho 13%
Bedfordview	15.43	21, 294	English 71%
Benoni	1187.99	94, 341	English 46%, Afrikaans 24% and Zulu 12%

Boksburg	164.05	158, 649	Afrikaans 30%, English 22% and Zulu 15%
Brakpan	196.35	62, 113	Afrikaans 55%, English 15% and Zulu 13%
Cerutiville	0.41	2, 151	Zulu 67%, Afrikaans 12% and Sotho 12%
Chief Albert Lithuli Park	1.12	2, 896	Zulu 44%, Pedi 15%, Sotho 12% and Xhosa 11%
Daveyton	14.17	131, 390	Zulu 40%, Pedi 16%, Xhosa 12% and Sotho 11%
Duduza	10.74	71, 960	Zulu 63% and Sotho 19%
Dukathole	1.07	18, 537	Xhosa 26%, Zulu 25%, Pedi 18% and Sotho 11%
Edenvale	20.38	40, 624	English 74%
Etwatwa	21.26	124, 435	Zulu 47%, Pedi 13% and Tsonga 11%
Germiston	129.14	139, 719	Afrikaans 27%, English 26%, Zulu 13% and Xhosa 10%
Katlehong	61.42	349, 866	Zulu 39%, Sotho 25% and Xhosa 13%
Kempton Park	158.50	117, 271	Afrikaans 47% and English 28%
KwaThema	13.93	99, 517	Zulu 57%
Lindelani Village	1.60	7, 514	Zulu 41% and Pedi 20%
Midrand	13.41	5, 095	Afrikaans 31%, Pedi 15%, English 12% and Zulu 11%
Nigel	129.29	28, 706	Afrikaans 51%, English 19% and Zulu 17%
Reiger Park	5.70	36, 004	Afrikaans 48%, Pedi 12% and Xhosa 11%
Springs	172.18	80, 776	Afrikaans 39%, English 21% and Zulu 14%

Tembisa	32.44	348,693	Pedi 35%, Zulu 25% and Tsonga 12%
Thokoza	8.65	85, 106	Zulu 39%, Sotho 27% and Xhosa 20%
Tsakane	29.74	144,289	Zulu 57% and Sotho 11%
Vosloorus	28.65	150,277%	Zulu 48% and Sotho 19%
Wattville	4.78	49,927	Zulu 43%, English 16% and Sotho 10%
The remainder of the Municipality	420.74	18, 795	Zulu 26%, Pedi 21%, Tsonga 14% and Sotho 10%

Source: Stats SA (2015).

Figure 4.1: Indicates Service Delivery regions of Ekurhuleni Metropolitan Municipality.



Source: Municipalities of South Africa (2020).

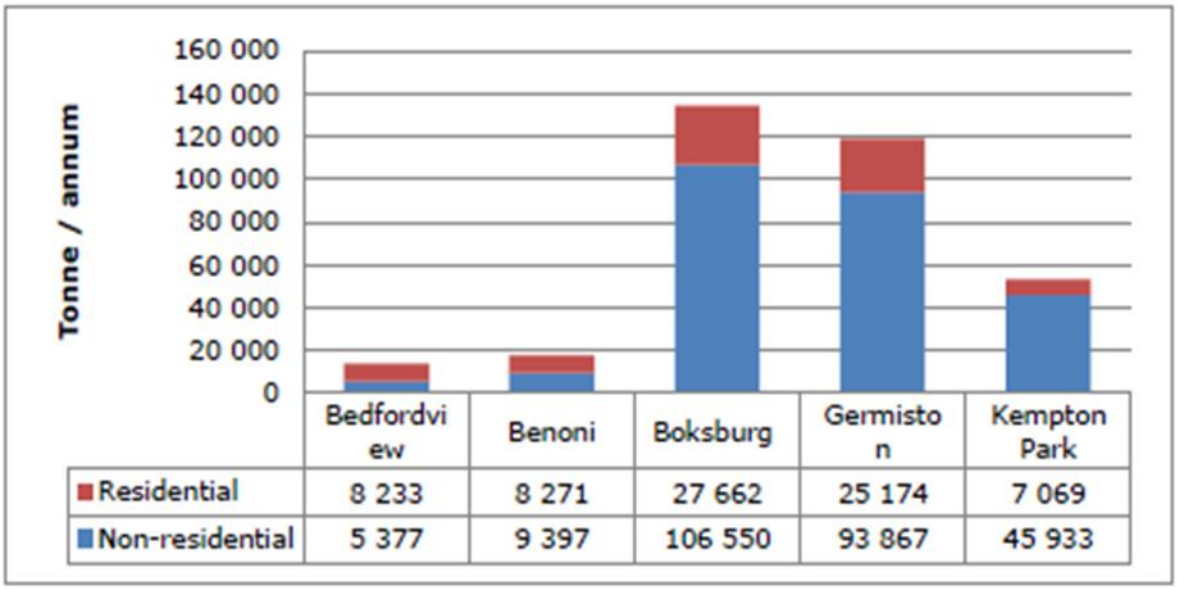
4.4. Socio-economic profile

In CoE approximately one-third of the population is in poverty (Ekurhuleni Growth Development Strategy, 2011). Also a portion of the population reside in peri-urban areas far from urban amenities, this has led to an increase in the high unemployment rate 40%, as they reside far from employment opportunities. Ekurhuleni Growth Development Strategy (2011) has also outlined there are 112 formal settlements, however there still need to improve on basic services as many reside in over 170 000 informal residential units. Also these informal units are located need rivers, flood lines, waste dumps and sprouts. Consequently the municipality is trying to eradicate informal settlements by providing subsidy-linked housing near urban amenities, however there are challenges regarding identifying land and financial resources (Ekurhuleni Growth Development Strategy (2011).

4.5. Ekurhuleni Metropolitan Municipality Waste management practice

The whole of South Africa generated nearly 42 cubic metres of solid waste by 2012 and Gauteng province where Ekurhuleni Metropolitan Municipality is located generated the largest portion (Nkosi and Muzenda, 2012). According to the South Africa Constitution (Act No. 108 of 1996), the management of solid waste is a function of the local government and the City of Ekurhuleni is not an exception in this regard. Further, like any other municipalities, CoE is required through the National Environmental Management Waste Act (No. 59 of 2008) to formulate and integrate Waste Management Plans. While other municipalities such as Mafikeng, eThekwini and City of Johannesburg have made strides in drafting an Integrated Management Plan, CoE has made little progress in this regard (Gumbi, 2015).

Fig 4.2: Indicates Waste generated in Ekurhuleni Metropolitan Municipality.



Source: Ekurhuleni Metropolitan Municipality Waste Management Plan (2012).

Nonetheless, the division of CoE into three operational service delivery areas, namely, the eastern service delivery area (ESDA), south service delivery area (SSDA), and the northern service delivery area (NSDA) has enabled it to deal with the Management of Waste at its disposal. There are waste depots across all the Service Delivery Areas). The figure 4.5 gives an overview of waste management infrastructure (landfill sites and transfer stations) in the CoE. Currently, the municipality owns 5 operational landfill sites and 3 are privately owned. In addition, the CoE operates 15 waste transfer stations throughout the municipality. The operations are currently outsourced to private waste management contractors. CoE allows waste pickers to reclaim recyclables at operational waste transfer sites before being transported to landfill sites, intending to divert more waste away from landfill. This operation is undertaken through service contracts except for Kempton Park. The CoE responds to environmental complaints by privately owned facilities, after that, it refers non-compliance detected to the competent authorities (Provincial and National Department) as per mandate.

Meanwhile, there has been an increase in the percentage of informal units in areas with proximity to illegal dumpsites (CoE IDP, 2016-17). This situation was a result of the reclaiming of recyclables from operational landfill sites which is permitted in terms

of the condition of the WML/Permits. Consequently, the informal units have recyclables collected from landfills.

4.6. Solid Waste Generation

According to Pienaar *et al.,* (2016) during the 2014/2015 financial year an amount of 1 151 537 tons of waste have been landfilled in CoE. Table 4.6 indicates the average tonnage of waste in the study between 2008-2011 financial years.

Table 4.6: Indicates Waste Generation in tones in Ekurhuleni Metropolitan Municipality.

Period (Financial Years)	**Average**	**Total**
2008/9	23 678 per month	284 147
2009/10	22 986 per month	275 826
2010/11	35 814 per month	429 771
Total	82 478 per month	989 744

Source: Service Annual Report, (2011/2012).

Table 4.6 clearly indicates that waste generation has reached an alarming point in the research area, leading to severe issues to the life span of the landfill.

Figure 4.3: Indicates the municipal solid waste at Simmer and Jack landfill site.

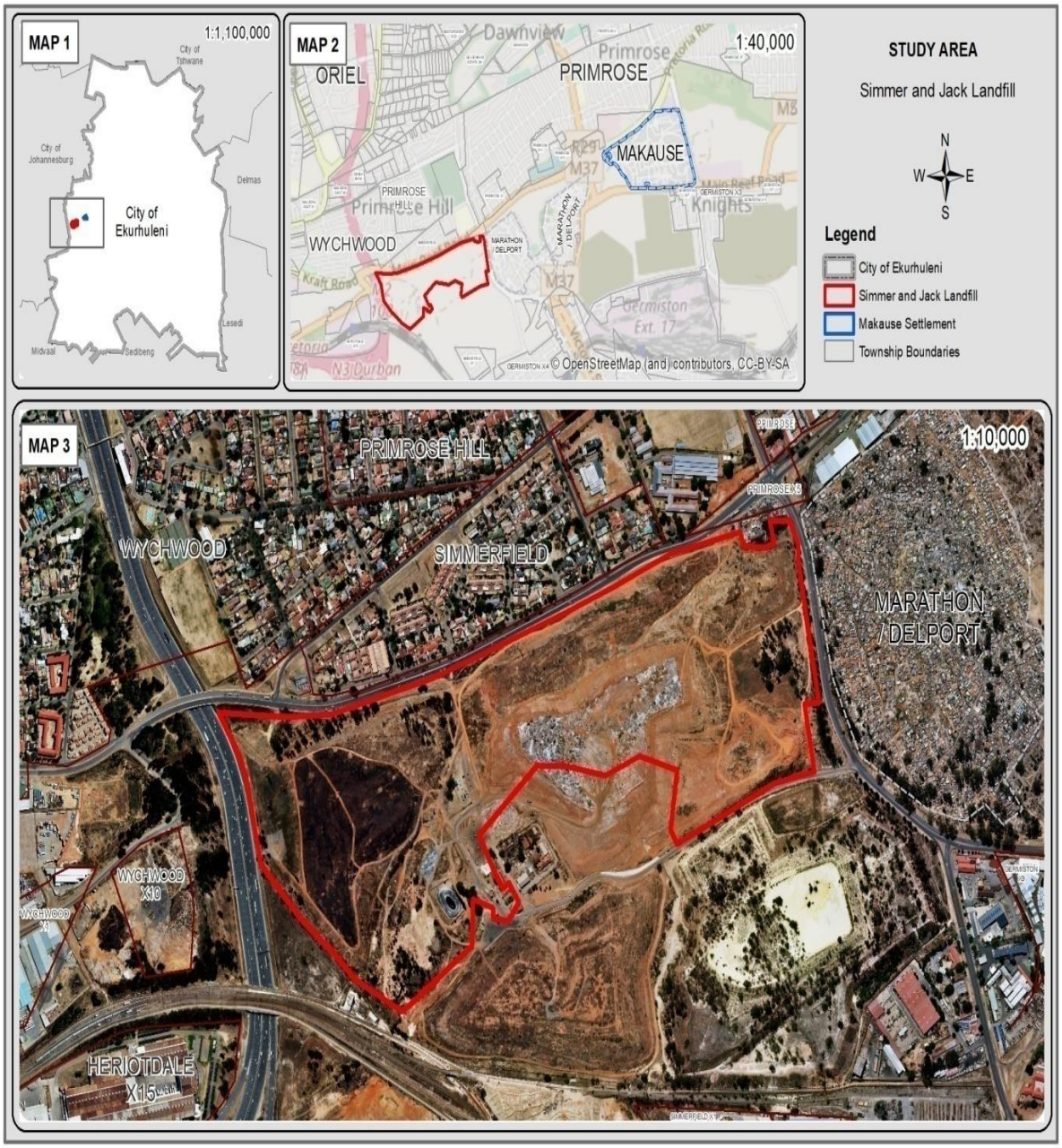


Source: Author, (2019)

4.7. Location Simmer and Jack Waste-to-Energy project

Simmer and Jack WtE is located on Portion 2 of the farm Elandsfontein 90IR. The study area is bordered on the eastern side of the N3 highway and the area adjacent to Makausu informal settlements as indicated by figure 4.7. The study area measures 74 hectors in extent, and it can be accessed through Johan Rissik road.

Fig 4.4: Indicates the Location map of Simmer and Jack Landfill plant.



Source: Author, 2019

4.7.1. Aim of Simmer and Jack Landfill Waste-to-Energy project

The CoE identified operational flagship projects (Landfills) namely; Rietfontein, Rooikraal, Weltevreden and Simmer and Jack in line with Clean Development Management (CDM). The CDM projects are aimed at reducing emissions from the landfills. CoE is complying with the international efforts to combat global warming. The treaty obliges emerging countries to reduce greenhouses gas emissions. According to the Ekurhuleni Waste Management Service annual report (2010/2011, 8), the CDM "allows emission-reduction (or emission removal) projects in developing countries to earn certified emission reduction (CER) credits, each value to one ton of carbon dioxide. The CERs can be traded and sold, and used for industrialised countries to meet part of the emission target under the Kyoto Protocol".

The CoE municipality set a target of accomplishing a 10% renewable energy target through the installation of a 1MW landfill gas to electricity plant. The rationale behind the project was to generate renewable energy from the municipal solid waste. In addition, the project is aimed at reducing electricity dependency from Eskom by 7 GWh/year. The project is currently supplying the municipal grid with power but it's not operating at full capacity. While the project has positive benefits in terms of improving air quality and the environmental conditions particularly to the communities residing adjacent to the site, there are barriers that have been hindering the successful uptake of renewable energy in CoE.

Fig 4.5. Indicates Simmer and Jack waste-to-energy plant.



Source: Author, 2019

4.8. Conclusion

This chapter presented an overview of CoE since it's the study area of this research. It did so by discussing the history and background information of the context and further looked into the demographics and the socio-economic profile of the municipality. Additionally, the chapter provided the rationale behind the Ekurhuleni Metropolitan Municipality's move of investing in the novel WtE project at Simmer and Jack landfill. While this is one of the pioneer projects which the municipality sought to generate energy from the landfill and also managing the emissions from the area, the general impression is that there are barriers that have impacted on the full uptake of renewable energy in the CoE. This is despite after having infrastructures like the Simmer and Jack Plant. The following chapter presents these barriers as gathered through data collection process component of the report.

Chapter 5: Presentation of Findings and Discussions

5.1. Introduction

It is interesting that was once deemed waste in cities is not garbage after all. The tonnes of garbage that were once written are reports from a normative and negative perspective is money in actual fact. This is the era that we are now living in where waste can easily be converted into energy through different technologies. Of note is the ability of these waste to energy projects to generate more money that can be used for feeding other individual renewable energy projects. WtE technologies has the ability to retain the money invested in them if successfully implemented. Nonetheless, without getting too excited about this, what are the challenges, barriers and obstacles that hinder the successful rolling out of waste to energy technologies. This research noted that even where infrastructure for waste to energy technology has been provided, countries, including South Africa still struggle to fully realise the benefits of these technologies. In the case of the Ekurhuleni Metropolitan Municipality, which is the study area of this research, despite the existence of Simmer and Jack Landfill plant, the municipality has not managed to utilise this facility to its full capacity. The purpose of this chapter, therefore, is to present the state, barriers and benefits of WtE projects (Simmer and Jack) in the CoE. These findings are presented in thematic narratives as was guided by research questions following interviews with officials tasked with renewable energy in the CoE.

5.2. The history and state of Simmer and Jack Waste-to-Energy Plant

Simmer and Jack landfill site located in Germiston is the most recent project aimed at meeting the CoE's 10% renewable energy target. It is a 1MW landfill gas to electricity plant which was commissioned in September 2014, has the potential to reduce electricity purchases from Eskom by 7 GWh/year. Asked about the history and overview of the project, one official maintained that:

> This Simmer and Jack landfill gas to electricity project stemmed from the initial feasibility study and trial of landfill gas extraction and flaring which was done by the Ekurhuleni Municipality's Waste Department in 2005. It was then that a two-staged Carbon Development Mechanism (CDM) project was projected (Interview with official 1, 2020).

There was a need for a clarification particularly on the meaning of CDM and the official went on to say that:

> The projection of a 2 phased CDM simply related to the initial landfill gas extraction and flaring, followed by gas to electricity generation development. Gas extraction and flaring have taken place since August 2007 at four CoE landfill sites, including Simmer and Jack, (Interview with Official 1, 2020).

This historical information to the existence of Simmer and Jack landfill plant suggest that while the Simmer and Jack plant was commissioned in 2014, it was planned well together with other three projects before being launched. This planning is quite crucial to this study because it assist in the location of the barriers that have hindered the full uptake of WtE in CoE.

Furthermore, prior to the commission of the Simmer and Jack, the CDM was already faced with challenges. An official claimed that:

> The challenges we encountered as the department during the planning phase is that the CDM failed to deliver financing and we had to apply for council funding. We motivated this through the municipal commitment to a 10% renewable energy supply, set out in the Energy and Climate Strategy (2007). Fortunately, the council approved the project and in January 2013 a tender was published for the design, supply installation and commissioning of landfill gas to electricity plant (Interview with official 2, 2020).

Following these processes, a contract to construct an energy pant was awarded to Ener-G Systems in June 2013. The Simmer and Jack Landfill Site was chosen as the most suitable site for this first plant, and the 1 MW Simmer and Jack plant was

commissioned in September 2014. Asked about the current operational capacity of the plant, a general manager from Simmer and Jack said that:

> Currently, our plant is currently feeding power into the Eskom grid. The generator has been operational since the commissioning of the plant although there are hiccups here and there (Interview with official 5, 2020).

Unfortunately, the official couldn't clarify on the amount of energy that the plant is currently generating. He, however, indicated that Simmer and Jack produce 3 000 Nm cubic/hr, with a landfill size of 429 771 tonnes and a capacity to generate 1 – 2 MW. The official added that in operating of the gas generators on the Flare, they involve mainly the youth. Here is what he said:

> Listen, my friend, since we are talking about the current state of the Simmer and Jack plant, I think you should know this. We committed ourselves to convert waste into gas and into electricity through the participation of youth and the previously disadvantage (Interview with official 5, 2020).

While this response points right to the advantages of converting waste to energy, a presentation which shall be given later in the chapter, it also assists in knowing how far the plant goes in helping the most vulnerable and disadvantaged members of the community. Currently, the plant employs two young able-bodied male black workers, one disabled worker, two black women, six black men and three white subcontractors. Positions occupied by this personnel are based on 3-year contract duration. However, there is a consideration for the previously disadvantaged individuals and members of the community to have their contracts renewed when they expire.

Concerning the business model, the municipality's gas harvesting and flaring (burning) phase have been developed and financed by the city. The whole project was envisaged and modelled as a CDM project, with an anticipated revenue stream from carbon credits, which was meant to finance phase 2, the electricity generation component. Edesa (the Spanish Utility) was committed to investing in the certification process and purchasing the carbon credits. Nevertheless, with the lengthy CDM carbon credit certification process, the virtual collapse of the carbon market, and the

economic downturn, Edesa cancelled its contract with the municipality. Their exit left the project stranded, and the city assisted through their capital expenditure budget. This shows some of the challenges that have hindered the success of the project. This is important to note as it points to some of the hindrances and barriers that have affected the project.

There was also a need to understand the current operations and maintenance of the plant. A general worker at the plant provided useful information about this and went on to say that:

> Just like the construction and commissioning of the electricity generating plant, the operations and maintenance of Simmer and Jack plant has been outsourced to a service provider called Ener-G Systems (Interview with Respondent 6, 2020).

This was echoed by an official who further added that:

> The operation and maintenance contract was built into the development and installation contract, through an O&M item listed under the Bill of Contract. The O&M contract is advertised as a tender after every 3 years (Interview with official 3, 2020).

5.3. Barriers affecting the full operations of Simmer and Jack Plant

The Ekurhuleni Metropolitan Municipality also faced several barriers during the implementation of WtE projects particularly at Simmer and Jack Plant. These barriers are presented and discussed in the section in relation to their themes.

5.3.1. Political Barriers

Political barriers appeared to be a significant challenge facing the full implementation of WtE projects in CoE. One official bemoaned the imposition of taxes on imported materials and machinery that are used in the generation of energy from waste. He had this to say:

> You know, in the case of Simmer and Jack, the cost of an MW generator set including installation was around R12.8 million. This is a huge amount of money, my brother. Do you know that the installation of landfill gas extraction wells and flare systems for all the 4 landfill sites that CoE cost R69.7 million? These figures could have been reduced if the taxes or duty of importing materials was removed. I think this is where South Africa is lagging behind in terms of advancing the generation of WtE (Interview with Official 3, 2020).

These utterances should not be taken lightly. The fact that a government official laments how policies in the importation of WtE materials are working as a barrier to the implementation of renewable energy leaves a lot to be desired. What this also suggests is that lack of political will to reform the energy sector has far many repurcusions particularly for WtE projects. Of course, a lot of changes have happened since the commissioning of the Simmer and Jack plant in 2014 and there has been scrapping of importation duty on materials such as solar panels but nothing has really changed in relation to the materials used for generating electricity from gas. Materials such as generators and transformers are still acquired at high and exorbitant prices which makes the generation of energy from waste far much expensive.

Another official could not agree with these revelations. His stance was that the government has done a lot to amend regulations on energy in the country.

> Listen, man, personally I think the adjustments that were made to the environmental regulations, landfill to gas extraction projects are important because a full EIA process is no longer needed for these projects. Similarly, as electricity was to be fed into the municipal grid, for municipal ‘own consumption’, no wheeling agreement or generation license process needed to be undertaken

> (exempted from generating license requirements in terms of Schedule 2 of the Electricity Regulation Act, 4 of 2006), (Interview with official 4, 2020).

In as much as these sentiments reveal a positive move towards ironing out barriers in the renewable energy sector, it, however, doesn't respond precisely to the reduction in prices of importing equipment needed in WtE generation. This, therefore, remains an area that should be reformed. It is also on record that from the planning to the commissioning of Simmer and Jack plant, there have been some delays due to frustrations that came with importing materials at exorbitant prices. One official spoke about this.

> In the context of taxes and tariffs paid for importing machinery and equipment from abroad for the generation of renewable energy, most of the project developers had been demotivated. As a municipality, we have not only been demotivated by the imposed taxes but also unawareness of government about energy projects (Interview with official 1, 2020).

What this suggests is that relevant political personnel had not been much aware of the long-term gain of WtE projects; thus, they believed that such projects are costly projects, which the government cannot afford; hence, their efforts in influencing policy or regulations are minimal. Consequently, leading to the lack of adequate incentives for the development of WtE. This claim was confirmed through an interview with a municipal official who revealed that the South African government has not shown full commitment to providing supporting infrastructure for this type of project. The lack of provision of supporting infrastructure by the government is negatively affecting the successful implementation of WtE projects.

An analysis of the Simmer and Jack project from its planning to its commissioning phase revealed delays that can be attributed to government officials responsible for approving WtE proposals. One official called this "difficulties in getting approval for WtE project proposals from government authorities". This suggests that while there are those proposals that are delayed and get approved, there might be those that are actually turned down. This might be common practice elsewhere, but when a

government is not well informed about WtE projects, they are likely to turn down the viable proposal and approve the complex ones.

An official from the municipality could not take this barrier lightly and refused to take the blame on behalf of the municipality. Actually, he felt that the national government is the one to blame for this.

> People that work in local government are quite aware of WtE projects and I think the national government is the one with the problem. We know very well that working in this context of renewable energy is very difficult especially if you take orders from the national government. I can tell you for a fact that our strategies for WtE projects are embedded in the national strategy although there is a lot of misalignment. This misalignment causes a lot of challenges and delays operations here on the ground (Interview with official 2, 2020).

To resolve these problems, one official argues that in as much as a national policy on WtE should be present, it should be aligned to local government policies. There is a need to involve all stakeholders in developing such a policy.

5.3.2. Economic Barriers

The participants engaged in this research agreed that the requirement of high investment is one of the most critical economic barriers. South Africa in general is bedevilled by lack of funds to invest in these kinds of high-level investments. One respondent had this to say:

> I told you about the amount of money that was spent on installing a generator for the Simmer and Jack plant (R12.8 million) and that for the CoE installation of landfill gas extraction wells and Flare systems for all the 4 landfills (R69.7 million). These are huge sums of money my friend (Interview with official 3, 2020).

The elevated investments are because of the expensive equipment and machinery. Moreover, one official stated that procurement, construction and engineering contractors charge high fees. One contractor engaged in this study could not confirm this claim. However, the probability of these contractors to charge exorbitant amount for their services, are very high given that there is absence of expert knowledge on WtE technologies in South Africa. Most municipalities have no preceding experienced personnel to handle WtE projects. Hence, contractors are handling the construction and designing of the WtE plants.

> In relation to this subject, we had had challenges with contractual capacity for the Simmer and Jack Plant. There was an error in the scope of work document resulting from failure to indicate the percentage guarantee that must be put up by the contractor. This resulted in delays for months. After being presented with the first invoice, the Finance Officer refused to pay on account of there being no guarantee in place. It was only later after negotiations between the Energy Division, who pointed out that the contractor had paid millions up front for the generator, that the Finance Department finally waivered the guarantee requirement (Interview with official 3, 2020).

Due to the lack of appropriately experienced contractors, additional costs are incurred because once the implementing stage is complete, the operational works of the WtE plant are given to a different maintenance and operation contractor. Moreover, all the officials from CoE agreed that WtE projects take a long time to recover the capital cost of projects.

> I don't want to lie here, WtE projects in COE are having a comparably low return on investment compared to other countries due to the lesser income gain through the project (Interview with official 3, 2020).

While this claim was difficult to verify, it is apparent that since the plants like Simmer and Jack feeds into the Eskom mainline, the charges for electricity to consumers remain the same as that charged by Eskom. In calculating these charges, there is no consideration of the cost incurred in generating the power, particularly in WtE plants. An official added to this and said that:

> The collapse of the anticipated emissions reduction/carbon credit revenue stream has presented challenges to WtE projects in COE. While the municipality stepped into the breach, providing financing from its own capital expenditure budget, the certification of carbon credits within CDM is very costly and without an investor and committed buyer of the credits may remain on hold (Interview with official 1, 2020).

This revelation is very concerning and shows that there are many drawbacks to the WtE project finances as operational costs are generally high. This might be reason enough to discourage developers of interfering in WtE projects becuse it will take a longer time to recover the capital cost.

Additionally, there was a discovery that the site where Simmer and Jack were located was unstable. This led to a need for additional funds to complete the civil works. Questioned about this one official said:

> We were lucky that the project had achieved savings and could accommodate this unanticipated cost. However, this can delay a project and indicates the need for some contingency budget to be built into project proposals and budgets (Interview with official 1, 2020).

Apart from these financial challenges, there are also barriers emanating from the bureaucratic nature of WtE operations as a result of hierarchal structures. This was echoed by officials from CoE.

The division between the gas extraction contract, managed by the Waste Services Department, and the electricity generation contract, managed by the Energy Department, can be challenging when coordinating activities (Interview with official 4, 2020). This suggests that there is a need for ongoing communication to reduce conflicting claims by service providers and to avoid around breakages.

5.3.3. Social barriers

As was highlighted earlier, there have been delays in WtE projects in COE and some of these delays can be attributed to social barriers. In the case of Simmer and Jack, even after its commissioning, there have been social challenges that have affected its operations. Of recent, there was a fire that erupted at the landfill and the operations had to be stopped on September 2020. One leading Media House, Alberton Record, had this headline on the 10th of September 2020, *The Simmer and Jack landfill site has been temporarily closed until further notice after a fire broke out on Tuesday, September 8.* In the same newspaper article, the Divisional Head of Waste Management was quoted as having said *"We have resolved to close off the landfill site from public use to allow disaster and emergency services work to continue uninterrupted. Also, we are closing the facility to allow the investigation to take place"* (Alberton Record, 10 September 2020).

These challenges are critical to the unravelling of barriers that hinder the operations of WtE projects. Whilst they are unfortunate events that are difficult to prepare for, the reality is that when they occur, they affect the production and conversion of waste to energy. To these challenges, respondents added resistance that comes from different sections of the society in accepting renewable energy projects.

> There have been cases where the general public protested against WtE projects in the city. I have no doubt that these protests resulted mainly due to the less awareness of the public on the importance of WtE projects to the nation as a whole. However, some protested because they felt that they needed to be given jobs in these projects (Interview with official 4, 2020).

These reactions from communities should not be taken for granted, as they point to the lack of consultation from the inception to the commissioning. This cannot only happen to the general public but can also involve failure to involve all stakeholders in WtE project. The retaliation from those that feel left out is likely to have negative effects on the entire project. Similarly, the not in my backyard syndrome usually results from the feeling of being left out and not been educated enough about WtE. Respondents particularly general workers from Simmer and Jack collectively agreed upon the fact,

poor attitudes of people and bad habits are a result of lack of consultation by the city officials about WtE projects.

> Simmer and Jack was contested by the general public because, although people require a solution to their waste, they don't see the establishment of the WtE within their residential area as a good initiative (Interview with official 7, 2020).

It was discovered that this form of resistance is also a result of the bad smells that are produced from landfill plants. It is within this scope that those residing closer to landfill site feel that it's unhealthy and in as much as they might be in support of the conversion of waste to energy, they need this to be done far away from their backyard.
Assessing the economic aspect, properties located closer to landfill sites are thought to be of less value than those that are located in areas with cleaner air quality and environment. Hence communities will rather resist a project that might lead to the depreciation of their properties even though the economic and climatic gain a high at a national level. An official added to this and went on to say:

> Yes, bad odour and nuisance from WtE plants disturb people who live nearby. The odour exhaled from plant operations consists of hydrogen sulphide, propionate, methyl mercaptan and ammonia, which gives bad smell and the situation is getting worst simultaneously with air pollution (Interview with official 4, 2020).

In addition to this, noise and vibration during construction could also be a barrier because residents around WtE projects may not be fond of such a nuisance and eventually might resist such developments. This research also found out that there are problems encountered in relation to waste segregation/ separation, particularly from communities. This has seen the municipality subcontracting the responsibility to other contractors to avoid serious problems at plants. Both an incinerator and aerobic digestion plant requires separation of biodegradable wastes and non-degradable waste. Since the public reluctant to segregate waste in the first instance, subcontracting this role increases the costs of converting waste to energy.

5.3.4. Technical

In South Africa the implementation of WtE projects has been limited due to access to advanced technology. As WtE is a new concept, that is dependent on utilisation of advanced technologies, South Africa is yet to develop the technical know-how to support its deployment. The importance of this barrier was outlined by, one official.

> In South Africa or even here in the major barrier that we are facing is the lack of expert knowledge for conceptualisation and design of WtE plants (Interview with official 2, 2020).

Consequently, this has impacted the entire process of WtE. Officials indicated both plants in CoE lack with properly trained and experienced technical staff for carrying operational and maintenance activities. Hence, they have resorted to outsourcing or subcontracting for the work to be done at these plants as was highlighted earlier. In light of this, there is a potential that when inexperienced personnel are recruited, there will be poor handling and maintenance of equipment. Consequently leading to machinery breakdowns, inefficiencies of equipment and machinery. Other barriers highlighted were the low calorific value and high moisture content of waste. An environmental manager maintained that:

> The largest waste composition is of biodegradable waste and with high moisture content, it causes inefficiencies in the energy generation process (Interview with official 4, 2020).

5.3.5. Legal barriers

In relation to the legal barrier, as was already mentioned, the implementation of WtE plants is hindered by the absence of a proper regulatory framework and lengthy process and delay in getting approvals from the government process. This frustrates and discourages the project developers. Some regulations are not aligned such as, the Provincial Council Act and National Environment Act. Therefore, the amount of approvals to be taken is a complex task in the implementation of WtE projects.

5.4. Strategies to overcome barriers

The strategies to reduce the barriers were gathered through interviews with respondents. For political barriers, officials validated that incentives like tax relief for imported materials and equipment are a necessity.

> From my point of view, all the cost of installing and generating electricity from WtE projects can be reduced if the tariffs on importing materials from abroad are removed or reduced (Interview with official 5, 2020).

These sentiments were echoed by another worker at Simmer and Jack who went on to add that:

> To reduce the cost of producing energy from waste, the cost all required infrastructure facilities and utilities such as electricity, water and access to roads for the WtE plants need to be provided (Interview with official 9, 2020).

What this suggests is that there is a need to involve the national government in WtE projects especially in the provision of infrastructure. This also highlights the importance of aligning national policies, especially from the national level to the local level so that municipalities will see renewable energy as a viable source of energy. As put by one official:

> I would recommend that there be a national policy for WtE implementations which introduces simple approval procedures to avoid delays and complications (Interview with official 7, 2020).

Convincing the national government to take up such policies is essential but also requires a holistic approach that ensures that all the stakeholders are educated and conscientious about the benefits of WtE. Officials engaged in this research agreed that it is the responsibility of the government to take a leading role in devising and spearheading waste to energy projects.

In relation to overcoming economic barriers, as was discussed previously, there is a need for high capital investment in WtE projects. To overcome this barrier some of the

respondents suggested that there should be more than one funder of WtE projects. This can be achieved through debt financing and syndicated loans. An official added to this and went further to suggest that:

> Some of the expenses we incur can be avoided. For example, the operational and maintenance cost can be minimised through proper maintenance and efficient utilisation of the plant (Interview with official 3, 2020).

Furthermore, respondents suggested that the government should supply guaranties, if CEB purchases electricity for a suitable price, then financial institutions would be willing to offer loans for project developers. This will eventually remove the burden for financing and running WtE projects from municipalities.

In relation to lack of awareness, interviewees recommended that the barrier can be reduced through awareness programmes. As such programmes facilitate convincing the community about the value of WtE projects. Interviewees further recommended the participation of the government in this perception.

> In my humble opinion, proper community engagement programmes driving community commitment and providing job opportunities for the capable people who live nearby the WtE projects are strategies that can be implemented to address social barriers (Interview with official 1, 2020).

This suggestion might help remove some of the bottlenecks that emanate from the resistance of the projects, particularly from the general public. While another barrier that was raised by respondents for WtE projects was that of bad odour, nuisance, noise and vibrations, they also suggested that these challenges could be reduced by maintaining proper storage of waste, applying proper machinery and using less noise-generating techniques, low-noise design, within a specially constructed noise proofed building, adapting a proper traffic mitigation plan and establishing the shortest routes.

For technical barriers respondents suggested that lack of expert knowledge for designing and operational works of WtE plants can be mitigated through outsourcing expertise knowledge from international organisations, conducting training programs

on WtE for relevant parties. This was suggested as a short term solution while a long term solution might involve introducing separate WtE related subjects to local universities as a long-term strategy for the issue.

Lastly, on legal barriers, some of the officials argued that to avoid delays, one roof approval system, which will be able to get all the approvals and permits from a single place is necessary. This also suggests that there is a need to devise an ideal legal framework with a proper approval protocol for implementation and operations of WtE plants.

5.5. Implications, Reflections, and Generalizability of Findings

There are several implications drawn from research with regards to the new knowledge generation for academic purposes and policy formulation and implementation in the local, provincial, and national spheres. In particular, on unpacking the barriers to WtE project implementation. There is a need for solutions to address these key barriers such as reducing the operational cost of producing energy from waste.

Solid waste management, global warming and the energy crisis have become the most pressing issues facing civilisation today. In response to these demands Simmer and Jack project have embraced innovative waste to energy technologies. Since one of the main challenges in innovation of MSW is lack of qualified personnel, it is recommended that through workshops and public engagement that people are made aware to what qualifications are needed to take part in the SWM innovations and training of personnel to improve skills set in the regions can be carried out.

The general implications and reflection of the study is to encourage citizen awareness of the importance of waste management. This could be done through education campigns on different ways in which they can separate solid waste as source, as this will help reduce the amount of time it would take if it took place at the landfill site.

5.6. Conclusion

While WtE projects are viable solutions to the challenge of climate change which is resulting in global warming, this chapter presented on the findings and discussion of the barriers that are hindering the successful uptake of renewable energy. The chapter began by presenting the state of Simmer and Jack plant including its history but went on to unravel the barriers that have been hindering the functioning of this facility to its full capacity. Both economic, political, social, legal and environmental barriers were noted as affecting the implementation of WtE projects. Interestingly, while respondents engaged in this study vented about the challenges they are facing, one way of the other they also had suggestions on possible ways to overcome these challenges. The solutions to barriers were presented in the last section. The following chapter summarises the study and goes on to make recommendations and providing the implication of the study.

Chapter 6: Conclusion and Recommendations

6.1. Introduction

This chapter concludes the research by summarizing the major arguments and findings obtained as guided by objectives and questions. The main findings resulting from the analysis and discussions of the barriers encountered in upscaling WtE technologies in the City of Ekurhuleni using Simmer and Jack WtE in Germiston from part of the summary. The chapter concludes by making recommendations, and also propose potential areas for future research.

6.2. Summary

It is fundamental to highlight that this research has rigorously interrogated the literature review on the barriers and benefits of adopting WtE technologies from developed and developing countries respectively. The research further gathered more valuable data through observation, interviews with the officials from within the City of Ekurhuleni and those at Simmer and Jack plant. The research made multiple conclusions based on analysis as follows:

The existing literature on WtE was reviewed and multiple barriers were identified. This is despite the study having envisaged that while WtE technologies have a great potential for the realization of socio-economic and environmental benefits, existing systems in municipalities are not capacitated enough to support these technologies and this act as one of the barriers hampering the successful implementation of WtE projects. This means that in as much as the expected findings were confirmed (technical barriers), the study went further to identify some of the challenges that affected the successful implementation of WtE projects.

The literature was presented from a global and local perspective but was not specific to the Simmer and Jack Case study. However, the barriers identified and discussed are quite similar to those experienced at Simmer and Jack plant. These barriers

include “unnecessary political interference to the tender process in both design and implementation phase” (Beloborodko et al. 2015; Cucchiella et al. 2017); “a deficiency of information on real cost” (Rawlins et al., 2014; Mutz et al., 2017); “difficulties in deciding the most suitable WtE technique”; “unwillingness to cooperate for the integration of knowledge between the research institutes and private organisations” and “the available technologies are not in a satisfactory level for the implementation of WtE facilities” (Rawlins et al., 2014; Leckner, 2015; Mutz et al., 2017). While these five barriers were identified through the literature, these were not confirmed in the case of Simmer and Jack Case because foreign EPC contractors currently handle the deployment of WtE projects.

Moreover, the literature further identified other barriers which are political, economic, social, technical, legal and environmental barriers. These also formed part of the findings that were obtained from the case study of Simmer and Jack. Important to note in this category are political barriers emanating from the unwillingness or lack of interest from important stakeholders such as the government to support WtE projects and viewing it as just but a new concept. This aligned with the results by Beloborodko et al, (2015) and Cucchiella et al, (2017) where the nation are less interest on promoting potential investors to invest in WtE projects was outlined as a significant barriers in developing countries. Interestingly, participants recommended that these kinds of barriers can be mitigated by increasing WtE campaigns to make sure that all stakeholders buy into these projects by seeing their benefits.

Rawlins et al. (2014) and Mutz et al. (2017) further revealed several barriers that they categorised similarly as political, economic, but emphasized technical barriers. Likewise this was observed in Simmer and Jack Case study as well through the case study findings with respect to lack of skilled personnel to design and maintain WtE plants and COE is currently relying on foreign contractors. Furthermore, the implementation of WtE projects in Simmer and Jack Case study is also suffering due to the pressure that arose from the public. This was categorised under social barriers and was similar to the findings of the study by Evangelisti et al. (2015).

Legal barriers outlined in this research are similar to the results from Beloborodko et al., (2015), Rawlins et al. (2014), and Mutz et al. (2017). In this regard, the lack of a

proper regulatory framework and lengthy process and delay in getting approvals from the government are the foremost legal barriers mentioned by officials in the case of Simmer and Jack project. These foremost barriers in Simmer and Jack Case study have let the implementation process to be dragged, as per case study findings.

6.3. Recommendations

While the uptake of WtE is increasing, campaigns and mass education remain critical to ensure that the uptake continue to increase to a point that WtE projects are implemented successfully. Furthermore, the government and international bodies such as the UN are critical drivers for overcoming challenges or barriers and creating opportunities in WtE projects. The emphasis of these towards the shift towards green and sustainable cities supported by government policy and regulations changes can play an influential role in enabling the successful implementation of green projects and realising the opportunities that these open up. The integrated Waste Management framework shows that cooperation and coordination among the governments, all the stakeholder involvement, public–private partnerships, and cooperation with international organizations including the UNEP, the World Bank, and the IRENA is vital for successful deployment of WtE projects. Equally, the choice of waste-to-energy technologies is essential based on the case study. Hence decision matrix parameters and technical parameters charts and management frameworks for numerous waste-to-energy projects will vary from one country to the other. The development of a multi-criteria decision analysis technique to inform environmental and sustainable energy planning decision making. Lastly, the critical assessment of various case studies on waste-to-energy processes has the potential to inform developing countries on how to utilise technology, which will open pathways for knowledge exchange and create new markets

6.4. Further Research

This research mainly focused on the possibilities of upscaling WtE in the CoE using Simmer and Jack WtE plant in Germiston as a Case study. Based on above-mentioned findings and recommendations, the research recommends further studies on the following issues:

(i) Investigating the role of Public-Private Partnership in upscaling WtE technologies in developing countries.
(ii) Investigating the Energy potential from MSW
(iii) The impact of Public Perception on WtE initiatives
(iv) Investigate implementation approaches to new sustainable energy projects.

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Appendix A- Questionnaires

1. Introduction

This study seeks to the possibilities of upscaling WtE technology in emerging economies using Simmer and Jack as case study. The information provided will remain confidential and will be used solely for academic purposes. The research will using the following questionnaires in order to answer the research questions indicated in chapter one.

1. Demographic Profile

1.1. Should you uncomfortable to provide your name and email address below, you can leave the space blank.

Name of Organization	
Interviewee Name	
Department Name	
Interviewee Designation	
Contact Number	
Email Address	

2. Social, Economic and Environmental benefits of Simmer and Jack WtE technology

2.1. Do you think Waste-to-Energy technology is important for the City? If yes why?.....
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2.2. What do you think are the social benefits of Simmer and Jack Waste-to- Energy technology?

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2.3. What do you think are the economic benefits of Simmer and Jack Waste-to-Energy technology?

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2.4. What do you think are the environmental benefits of Simmer and Jack Waste-to- Energy technology?

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……

3. Barriers for upscaling WtE in Ekurhuleni Metropolitan Municipality using Simmer and Jack as a case study

3.1. Based on your experience from Simmer and Jack WtE project, What do you think are the barriers or the obstacles that need to addressed in order to upscale WtE in Ekurhuleni?.....
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4. Interventions or Strategies to upscale WtE in Ekurhuleni Metropolitan Municipality

4.1. What intervention or strategies do you think the Ekurhuleni Metropolitan Municipality should put into place in order to upscale WtE technology in the City?.....
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4.2. Why do think those strategies will assist the City?……
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……

Thank you for your time

Appendix B-Ethics Certificate

SCHOOL OF ARCHITECTURE AND PLANNING
HUMAN RESEARCH ETHICS COMMITTEE

SCHOOL OF ARCHITECTURE & PLANNING

CLEARANCE CERTIFICATE
PROTOCOL NUMBER: SOAP079/08/2019

PROJECT TITLE:	Investigating the possibilities of scaling up Municipal Solid Waste to Energy technologies in Emerging Economies: A case study of Simmer and Jack in Germiston, Gauteng
INVESTIGATOR/S:	Elvis Seshweni (Student No: 400793)
SCHOOL:	Architecture and Planning
DEGREE PROGRAMME:	Master of Architecture (SEECH)
DATE CONSIDERED	23 June 2020
EXPIRY DATE:	23 June 2021
DECISION OF THE COMMITTEE:	Approved

CHAIRPERSON B C Boshoff
(Dr Brian Boshoff)

DATE: Signed under lockdown: 22.6.20

cc: Supervisor/s: Sechaba Maape

DECLARATION OF INVESTIGATORS
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to endure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

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Annexure C

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PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I ELVIS SESHWENI (Student number: 400793) am a student registered for the degree of MArch-SEEC in the academic year 2021

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this in not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature: _____ Date: 23/04/2021