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Investigating the usefulness of green dual fuel Metrobuses for Sustainability in Johannesburg, through the 'New beginning for Metrobus' programme.

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Daniel Brink

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Investigating the usefulness of green dual fuel Metrobuses for Sustainability in Johannesburg, through the 'New beginning for Metrobus' programme.

Johannesburg, 2016.

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DECLARATION

I declare that this research report is my own unaided work. It is being submitted to the Degree of Honours in Urban and Regional Planning to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

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11 day of 11, 2016

(day) *(month)* *(year)*

Abstract

In the face of Climate Change, all cities and their citizens are facing a choice as to how they will use and consume energy. In the variety of energy choices that exist, none are perfectly suited to solving the dynamic and wide ranging problem of Sustainability. The purpose of this report is aimed at investigating an alternative energy choice made by the City of Johannesburg. In order to determine the extent to which dual fuel buses are Sustainable, an exploration of the highly technical paradigm of Natural Gas Vehicles is necessary. Once the technical problems of Alternative and Renewable energy are understood, only then can the question be answered. The thrust of this research will attempt to answer this question by exploring Natural Gas Vehicle technology in Johannesburg and how it is, or could be Sustainable.

Dedication

I dedicate this work to my family, who has supported me through difficult times in my transition to become a professional.

And to my girlfriend Kayleigh Jade, I would like to thank for always pushing me to be the best version of myself that I can be.

Acknowledgments

I would like to acknowledge my supervisor, Dr Brian Boshoff, who has fed my interests and guided my mind. I have great respect and admiration for his philosophy, as well as gratitude for the enthusiasm he has given me for Sustainability.

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List of Abbreviation

CNG - Compressed Natural Gas

RE – Renewable Energy

RET – Renewable Energy Transport

GDS 2040 – Growth and Development Strategy 2040

NBM – New Beginning for Metrobus

CoJ – City of Johannesburg

NGV – Natural Gas Vehicles

LR – Literature Review

CF – Conceptual Framework

RQ – Research Question

SQ – Sub Question

SD – Sustainable Development

GE – Green Economy

LPG – Liquid Petroleum Gas

GHG – Green House Gas

VGS – Vehicle Gas Solutions

IDP – Integrated Development Plan

SITPF –Strategic Integrated Transport Plan Framework

TOD – Transit Oriented Development

OEM – Original Equipment Manufacturer

SANS – South African Norms and Standards

SAGA – South African Gas Association

CoC – Certificate of Compliance

IDC – Industrial Development Corporation

DEA – Department of Environmental Affairs

NEMA – National Environmental Management Act



Chapter One – Introduction - Figure 1: New Beginning for Metrobus personified - Shows images edited by Daniel Brink (Green Johannesburg, 2009; Roodepoort Record, 2015).

Investigating the usefulness of green dual fuel Metrobuses for Sustainability in Johannesburg, through the 'New beginning for Metrobus' programme.

Chapter One - Introduction

There are 22 335 773 Natural Gas Vehicles Worldwide; 26 629 Natural Gas Vehicle Refueling stations; and 86 countries where Natural Gas Vehicles exist.

Natural Gas Vehicle engines produce 25% less carbon dioxide than gasoline and 35% less than diesel.

Natural Gas Vehicles reduce carbon monoxide emissions by 95% compared to gasoline, hydrocarbon emissions by 80% and nitrogen oxides' by 30%

NGV Journal (2015)

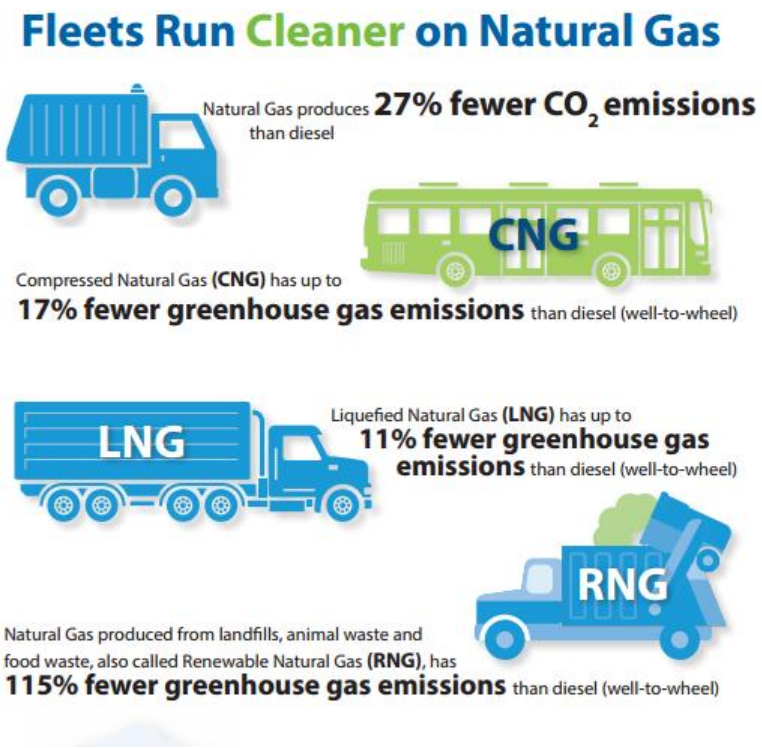
1.1 Overview

Metrobus in Johannesburg have launched the use of Natural Gas Vehicles (NGVs) in the public transport sector; this is an endeavour which will have positive and negative effects which are vitally important to the urban planning practitioner if the agenda of the Sustainable City is of any importance. This research report has a largely technical lens by which it views the qualitative exploration of its research title, however this research has placed value in understanding the facts and experiences of a variety of experts in relation to the Sustainable City and NGV movement.The NGVs which Metrobus have introduced are known as green dual fuel buses, which mean that they are propelled by two fuel types, namely Diesel and Compressed Natural Gas (CNG).

I have explored the endeavors of CNG technology in this report and how they help to achieve the criteria of sustainability amongst the multitude of challenges in a complex city-region. I have investigated whether the dual fuel Metrobuses contribute to achieving Sustainability in Johannesburg. In order to do this, I have interrogated the notion of whether dual fuel Metrobuses can achieve Sustainability, by breaking it down into the four spheres which comprise sustainability (O'Connor, 2006). I have investigated this dynamic transport potential in the CoJ and looked at experiences in other cities. In doing so, have explored the benefits of Sustainable transport and its impact on

Sustainability and promoting efficient and cost-effective transport solutions. Moreover I have seek to exemplified the strengths and limits of dual fuel Metrobuses in Johannesburg through looking at the case study of the 'New beginning for Metrobus' (NBM) through grey literature such as the Johannesburg 'Growth and development strategy 2040' (GDS 2040).

Title - Figure 2: Fleets Run Cleaner on Natural Gas. PennEast (2016)



1.2 Situating argument for Sustainability

Sustainability in cities and concepts such as the compact city is what has inspired my thinking around the investigation of dual fuel Metrobuses. These concepts have been explored in greater detail in the literature review; however they are central to my Research Question in providing a criterion with which to test the utility of dual fuel Metrobuses for the city.

According to O'Connor (2006) Sustainability is comprised by three main spheres and a fourth which holistically interrelates them all. It is imperative for the purposes of this research report to understand what Sustainability is as well as the concepts surrounding it, in order to determine whether the dual fuel Metrobuses will fulfill their criteria.

1.3 CNG as Renewable Energy in Johannesburg

The notion of moving towards more Sustainable means of transport can be seen in a multitude of successful instances across the globe, many of which I have examined in my literature review, however these instances have their own complexities and specificities. It is important therefore, to look at

the use of this concept within the context of South Africa and for the purposes of my essay I will limit this to the experience of Johannesburg with respect to the Case Study. I have interrogated the notion of Renewable Energy (RE) before narrowing down my interests to a specific brand of Renewable Energy Technology (RET) which is CNG and more specifically NGVs, with special interest in their ability to be used as public transport.

The first instance where I encountered the attempt to incorporate this more Sustainable method of transport was in the Gauteng 25-Year Integrated Transport Master Plan, where it emphasised the imperative for the transport sector to consider renewable sources of energy for its public transport systems (Department of Roads and Transport, 2012). What is more the policy discusses the need to adopt an approach which has less carbon impact to reduce the effects of climate change in general but also to become more cost-effective as a department (Department of Roads and Transport, 2012).

Interestingly the policy continues that there are a variety of different ways which this can be achieved, however it emphasises the use of compressed Biogas to do this. The City of Johannesburg (CoJ) has already undertaken research and development into its feasibility and sustainability of this RE source.

1.4 Using the 'NBM' programme as a Case Study

In line with the GDS 2040, the municipal entity known as 'Metrobus', unveiled a new fleet of buses in order to move towards a more 'Sustainable City' agenda, the NBM programme has been abbreviated for succinctness. I have used the NBM to examine the extent to which CNG technology is being used successfully in Johannesburg, wherein I have measured the success of this NGV in terms of how it fulfils the criteria of Sustainability.

Using the NBM as a case study has allowed me to a certain extent to investigate if CNG in conjunction with NGVs is Sustainable in our Johannesburg context. I believe this to be necessary due to the fact that precedent on this type of technology as Sustainable Public Transport has been praised in other parts of the world. I feel it is imperative to investigate whether the same or even similar results can be uncovered here in Johannesburg.

1.5 Research motivation and inspiration

My research title has its origins from my observations as a Johannesburg dweller but foremost as a cognisant urban planner with a 'Sustainability' inclined normative position. My observation was the new dual fuel Metrobus fleet in Johannesburg which led me to begin researching and interrogating the subject. After some desktop research I learned some of the shallow information around it which I used to begin constructing a research question. My agenda has been to find out to what extent the NBM is able to achieve the criteria of 'Sustainability' with special respect to the specificities which the case studies in Johannesburg present.

1.6 Origins of Case Study for this research

Through my endeavours in elucidating a clear concise research topic, I learned that the new dual fuel Metrobuses which I was seeing, were part of the GDS 2040 as part of a long-term strategy plan, which I investigated in my Literature Review (LR) later in this research report. According to (City of Johannesburg, 2011) the CoJ has studied and acknowledged the realities of climate change and have endorsed the decision to adopt a more environmentally Sustainable approach to growth in the city. In an attempt to become more environmentally Sustainable as well as reduce the city's impact on climate change, the CoJ has emphasised the move to a low-carbon economy (City of Johannesburg, 2011).

Interestingly, a lot of the spotlight of the move toward a low carbon economy has been on the endeavours of the Gautrain high-speed rail link and the 'Rea Vaya' Bus Rapid Transit system. Both these projects seek to increase public transport ridership and decrease private transport use which will lead to a decrease in congestion and thus lower carbon emissions in the city (City of Johannesburg, 2011). I have taken this idea further and argued that my case study the NBM is more effective in achieving the same agenda as well as being more environmentally Sustainable all-together.

1.7 Research Question

My research question is: How useful are dual fuel Metrobuses for Sustainability in Johannesburg?

1.8 Research Sub-Questions

The sub questions for which are as follows:

- What led to Metrobus using CNG in NGVs?
- What is CNG and NGVs about?
- What are the costs and benefits of using dual fuel Metrobuses?
- How do dual fuel Metrobuses contribute to the Sustainable City?
- What lessons can be taken from the case study, to increase the usefulness of NGV transport?

1.9 Research Methodology & Methods

The research methodology used to answer my Research Question (RQ) is based on qualitative methods; furthermore I will need to employ a descriptive exploratory study which focuses on the 'What?' and the 'How?' (Patton, 1990). According to Patton (1990) the exploratory part of my research is where I am looking at the question from a new angle which is assessing the sustainability of dual fuel Metrobuses. Moreover, my research is descriptive in the manner where it explores this phenomenon of dual fuel Metrobuses and to explain how Sustainable they are (Denzin & Lincoln, 1994). The definition of descriptive research, according to Maxwell (2012) is the attempt to uncover and makes sense of the observation which is identified, as well as to uncover further interrelated subject matter which will explain the observation and the concepts attached to it. The first method of my research is a thorough and widely researched Literature Review which has provided me with the range of concepts I have used to frame my study for the purposes of answering my Research Question. The literature review has provided me with the basis of information and awareness to ask intelligent and informed questions in my second method of fieldwork research which is in the form of semi-structured interviews.

The secondary method of Research which I have employed is a Case Study, more specifically the NBM. I have studied the NBM from a desktop study point of view before doing my fieldwork which elucidated the subject matter. I have purposefully sampled interviewees who are the most knowledgeable people about: the NBM; CNG technology; NGVs; and Sustainable Public Transport. My interviews have not only provided me with the information to analyse and answer my research question but have also provided me with information which has strengthened and reinforced my LR.

1.10 Ethical considerations

According to Recker (2012) I need ethical clearance for interviewing humans who will not constitute vulnerable groups. In my semi-structured interviews, I have asked and received consent to recording interviewees; however we have agreed that I will disseminate information about them anonymously.

Furthermore, I have strived not to misrepresent the individuals and groups who I have interviewed and have not affected the character or status of my interviewees negatively. What is more, I have not provided any incentives for interviewees as this may have distorted the interviewing process and compromised the interview environment for interviewers in the future.

Additionally, interviewees were notified that all interviews are completely voluntary and that the interviewee reserves the right to pullout and leave the interview at any time he or she wishes to do so, without needing to explain the reasons why.

The interviews undertaken for my research and case study, do not involve individuals who are vulnerable and therefore no ethical issues need to be addressed, however ethical clearance was obtained from the School of Architecture and Planning Research Ethics Committee. I have ensured that no ethical issues have been overlooked and that all the requirements of interviewees and the ethics committee concerning the use, dissemination and disposal of data and information has been and will be adhered to.

1.11 Chapter Outline

Chapter One - Introduction
This chapter introduces the direction of my research and sets the context for its objectives; furthermore it acts as a point of departure for the research. The chapter adds background, purpose, structure and the rationale behind my research agenda, as well as serving to state the standard research norms.

Chapter Two - Literature Review & Conceptual Framework
Chapter two represents a thorough and searching investigation of the subject matter relating to my topic area. This chapter provides insight into my topic area which informed my research instruments during my fieldwork. This chapter was essential in educating me on the multitude of concepts, discourses and ideas which have allowed me to answer my RQ effectively as

well as an understanding of the specificities which my research presents as a case study.

Chapter Three - Research Methodology and Methods

This chapter enlightens the reader as to the science behind my method and what the purpose of this kind of methodology is. Furthermore, this chapter has argued and investigated the merits and limits of my fieldwork, as well as the way in which I have implemented this technique. This chapter has highlighted and clarified the methods which I have used and what the precedent for using these methods are.

Chapter Four - Point of departure for the 'New beginning of Metrobus'

In this chapter I have elucidated the NBM, where I have discussed its origins and the intended role it played in the GDS 2040. Furthermore, this section features a focused look at what the GDS 2040 is about including its stakeholders and how it relates to achieving Sustainability in Johannesburg.

Chapter Five - Findings

In this chapter I have presented the findings of my fieldwork by organising the data in a succinct way. I have shown the fruits of my specialised research instruments used in my semi-structured interviews. After interviewing the various stakeholders involved with CNG, in Johannesburg including the service providers for Metrobus, I have highlighted information which has lead me to understand the Sustainability of dual fuel buses.

Chapter Six - Analysis of findings

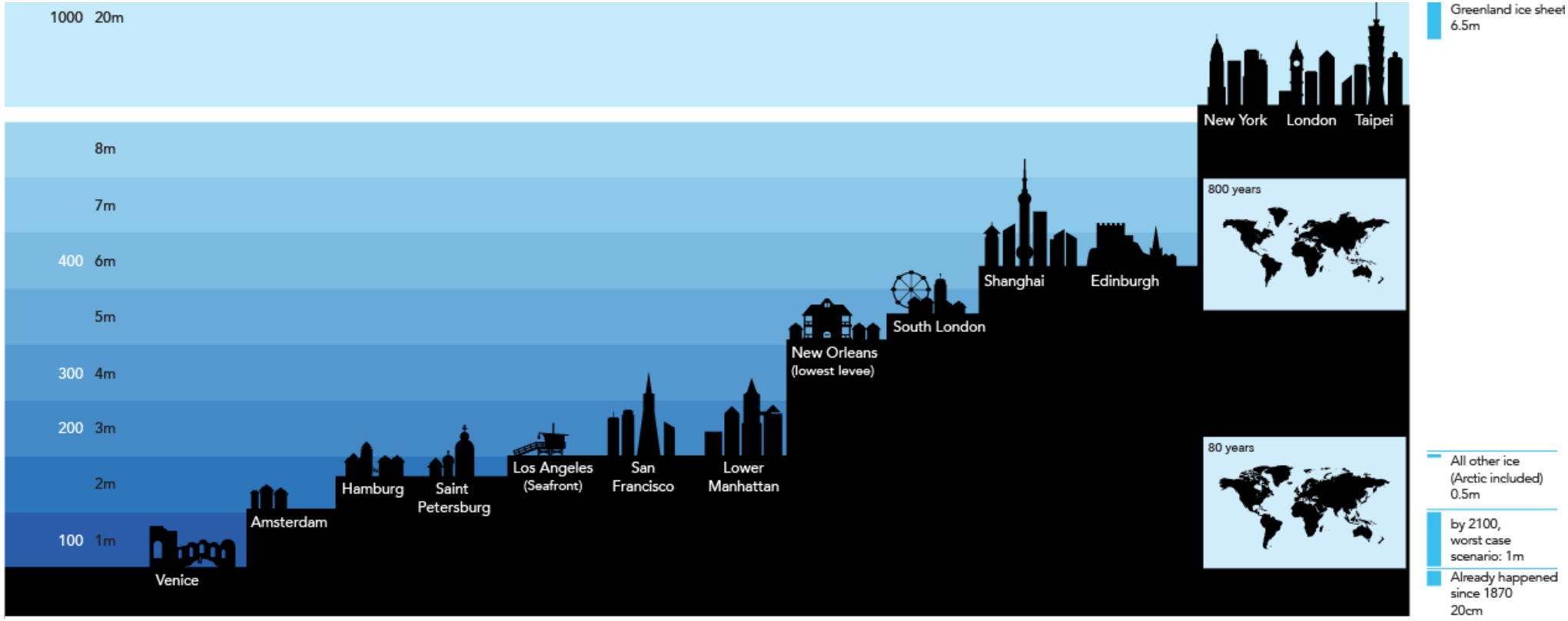
In this chapter I analysed the data I retrieved from my fieldwork and used it to answer my RQ and Sub Questions (SQs). The data pertaining directly to my case study was analysed in conjunction with the knowledge I obtained from my LR in order to answer my RQ. Other information which I gained from fieldwork which did not pertain to the case study directly was used to strengthen the LR and create a better understanding of the area of my research. Additionally after the research question was essentially answered, information gained from my fieldwork was used to extend my research as to how dual fuel buses can better add to Sustainability in Johannesburg.

Chapter Seven - Conclusion

This chapter summarises how I went about answering my RQ and SQs, what is more it provides a set of recommendations as to how Metrobus can further the Sustainability of their bus fleet.

Sustainability is a seemingly laudable goal - it tells us we need to live within our means, whether economic, ecological, or political - but it's insufficient for uncertain times. How can we live within our means when those very means can change, swiftly and unexpectedly, beneath us?

Jamais Cascio - (Brainy Quote)



Chapter Two - Literature Review & Conceptual Framework - Figure 3: Potential Global water levels if Climate Change is ignored. Information Is Beautiful (2016).

Chapter Two - Literature Review & Conceptual Framework

2.1 Overview

The introductory quote for this chapter begins to define what it means to begin to pursue the agenda of 'Sustainability', the quote also remarks on the fundamental difficulties of achieving this agenda in this day and age. In this section of my research report I have grappled with what achieving 'Sustainability' in the context of Johannesburg, South Africa entails.

Investigating the usefulness of dual fuel Metrobuses for Sustainability in Johannesburg, through the 'NBM' programme.

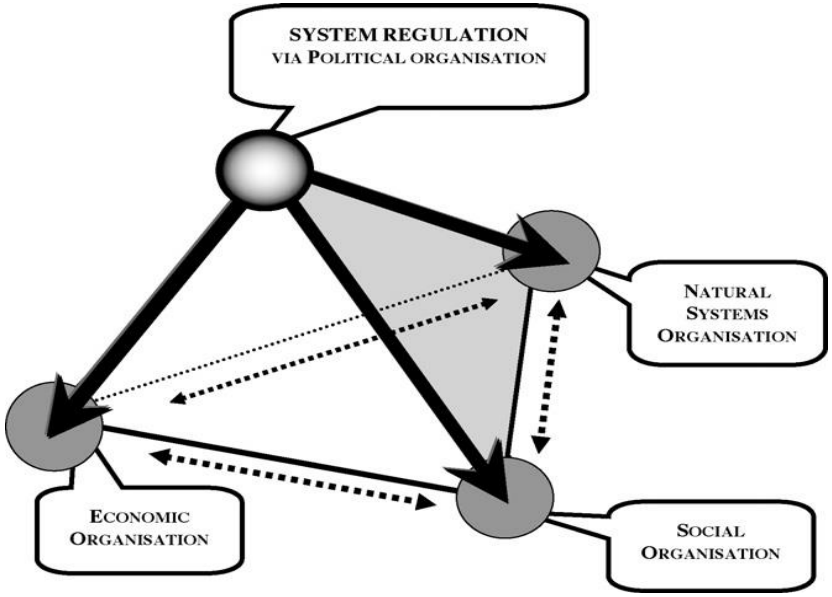
The title of my Research Report has helped me to focus on the most pertinent words which I have used to investigate the multitude of academic sources available. The three words: CNG, Metrobuses & Sustainability are most relevant for the purposes of answering the RQ and SQs. By looking at the problem statement of my research, which is to assess the extent to which dual fuel Metrobuses contribute to the ‘Sustainable City’ I have broken down my LR into concepts, ideas, arguments and polices which have framed my study as a Conceptual Framework (CF). The CF is comprised of a multitude of ideas including Sustainability; Sustainable City; Sustainable Transport; Transport Planning; Green Economy; CNG Technology; Natural Gas Vehicles; Biogas; Compact City and Renewable Energy Technology. This LR has investigated academic sources, articles and grey literature in order to better understand my topic area. A concluding CF is then drawn from that and clarified in order to frame the study.

2.2 Sustainability & the Green Economy

The subject of Sustainability is one which has been widely researched and published, where there are many definitions to be found in the academic world. All the definitions generally point to the same imperative, which is to live within our means and not to affect the ability of the future human race to do the same (Tanguay, 2010). However, the definition which I am interested in is one which allows me to clarify a set of criteria, against which I can compare the experiences of duel fuel in Johannesburg.

According to (Tanguay, 2010) A common way of classifying 'Sustainability' or Sustainable Development (SD) is to conceptualise it is an inexorable interconnection of three key spheres of influence, namely: Economic; Environmental; and Social. However, O'Connor (2006) adds another dimension into the reasoning behind SD, where he argues that a fourth sphere needs to exist to regulate the economic sphere and its effect on the other two spheres.

Figure 4: Triangle of Sustainability. (O'Connor, 2006)



O'Connor (2006) continues that it is the economic sphere which undermines the ability of a system to reach overall Sustainability; therefore a governance sphere needs to be in place to enshrine the other spheres and to ensure that all spheres are operating in a system of mutual benefit.

SD it seems, is a complex concept which is not very clear for the purposes of trying to understand how a City or a plan can achieve all the requirements that it supposes. In order to achieve 'Sustainability' then it is necessary to achieve a balance of positive development in three spheres where development in each does not hinder the other. In order to take this idea further, will introduce the idea of Green Economy Sustainability, which I intend to help me to understand how this idea can be measured and applied to the case study which I am researching.

According to Khor (2011) the Green Economy (GE) concept is one which has not been positively accepted among a global audience, where it can easily be misunderstood and implemented to achieve counter-productive developments in cities. The GE concept widely refers to an economic agenda which seeks to relieve the burdens on the environment, where there is often tax incentives involved with the relieving of

environmental degradation (Khor, 2011).

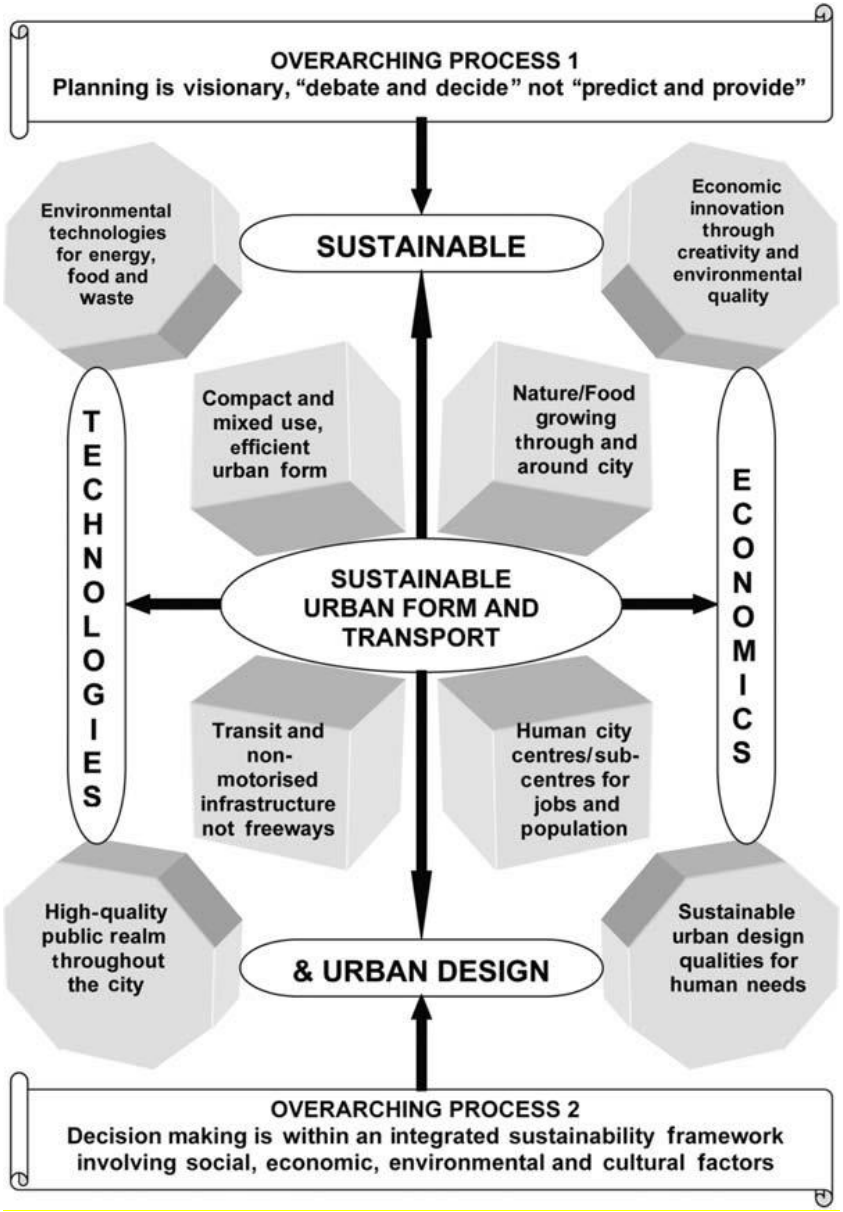
However, Khor (2011) emphasises the danger of using the GE concept in isolation of the concept of 'Sustainability' due to the fact that it prioritises environment as a normative position and does not consider the way in which this normative position could affect the social and economic spheres in a society. The GE concept has given rise to the concept of carbon tax which imposes tariffs on economies which have a large carbon footprint, meaning they produce a variety of goods and services which result in the excessive release of carbon emissions (Khor, 2011).

They key goals of the green economy are to promote healthy development of the city which does not negatively effect on the environment. This is to reduce the effects which cities have on Climate Change as they are the main contributors due to their high energy consumption. According to Met Office (2015) Climate Change is a long term shift in the planets average temperature and if left unchecked will result in extremely adverse effects to human settlements in cities. If principles like Sustainability and the green economy were not in place, there would be little to educate and regulate the way which we live and affect the environment in order to survive. Met Office (2015) argues that we need to reduce Greenhouse Gasses (GHGs) from the burning of fuels if we are to reduce climate change and therefore prevent negative affects to massive human populations.

2.3 'Sustainable' & 'Compact' Cities

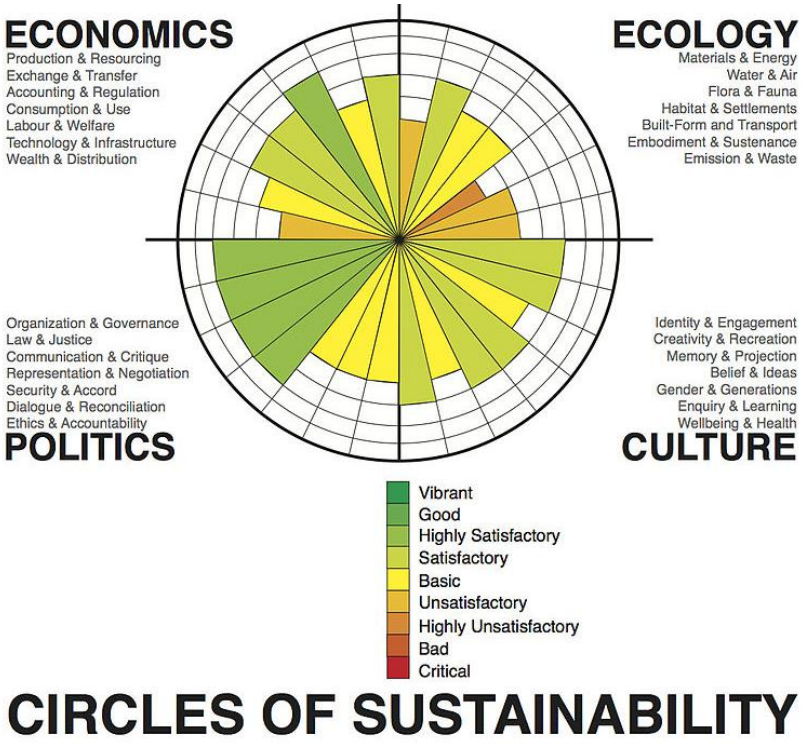
The 'Sustainable' city agenda is one which is being prioritised on a global level, according to Kenworthy (2006) the relationship between transport and the way the urban form is configured around it is fundamental to achieving sustainability. Kenworthy (2006) argues that mixed use and compaction of cities is essential together with the simultaneous collaboration of green lungs in the form of natural environment and open spaces. What is more, Kenworthy (2006) advocates the use of non-motorised transport and highlights the benefits of a walkable city as well as the use of highly innovative solutions for water energy and waste management of which there are many. Kenworthy (2006) continues that the motors of the city are its city centres and employment nodes which should be highly accessible by modes other than the private automobile.

Figure 5: Triangle of Sustainability. (Kenworthy, 2006)



As it has been highlighted that Cities need to be compact and designed in such a way to hold density, it is also important to understand the affect which cities have on climate change due to their high energy consumption. According to C40 Cities (2016) there is an association of cities known as the C40 Cities Climate leadership group who are determined to reduce the negative effects which cities have on Climate Change.

Figure 6: Johannesburg Sustainability profile. (Wikipedia (2013)



C40 Cities (2016) argues that in order to ensure the continued living of the human race in favourable and liveable environments, we have to be cognisant of Climate Change and the issues which exacerbate it. C40 Cities (2016) states that all cities can learn from one another to develop an appropriate urbanism for their dwellers. This urbanism will: allow us to live in a harmonious way with the planet; preserve it for future generations; and also create a more efficient way of living with our resources

2.4 Sustainable Transport

The concept and use of Sustainable transport has grown in research in the last 20 years, however government policies often struggle to mandate the use of it due to the lack of indicators to exemplify its progress in reaching its objectives and goals (Black et al., 2002). A number of Sustainable transport indicators are now conventionally used to measure the success of Sustainable transport including congestion levels; average speeds; convenience of parking; crash rates; and average traffic speeds (Litman, 2005). These indicators can assist me in my understanding of cities being 'Sustainable' from a social sphere of influence, where I can use this to test partial sustainability of my case study by measuring these indicators in Johannesburg. According to Litman (2005:7) “A Sustainable transport system is one that is accessible, safe, environmentally-friendly, and affordable”, this is a useful statement for me to measure the dual fuel Metrobuses and the case study which I am looking at in my research.

Moreover, Litman (2005:7) continues that “sustainability is not about threat analysis; sustainability is about systems analysis. Specifically, it is about how environmental, economic, and social systems interact to their mutual advantage or disadvantage at various space-based scales of operation”. This quote reveals a lot about the concept of sustainability and how it needs to be carefully understood in relation to my RQ and case study if I am to accurately produce appropriate findings in this study.

2.5 Renewable Energy - CNG vs Biogas

Biogas is a product which can be harnessed from Waste water treatment plants, Anaerobic digesters and Landfills, moreover when Biogas is cleaned and brought up to 92-98% methane it is referred to as Biomethane (Offsetters, 2011). Biomethane can then be compressed and used for fuel in NGVs. Biogas and

Landfillgas mean the same thing and but can be from different sources, however Biomethane refers to the cleaned Methane rich gas.

The production of Biomethane releases basically no carbon emissions due to the carbon neutrality of the process. Carbon Neutrality for Biomethane production means that the carbon emissions which Biomethane releases when burnt is no more than it would have released when decomposing naturally and therefore does not add extra carbon emissions to the planet (Offsetters, 2011).

Moreover, the reason why some Biomethane sources have a savings of up to 200% is because the methane which would have been naturally released is burnt and carbon dioxide is released, where methane is 20 times stronger than carbon dioxide as a GHG (Bio Nett, undated).

According to Offsetters (2011) when measuring the carbon emissions of CNG from Biomethane as opposed to Natural Gas, the well to wheel carbon emissions of Biomethane derived CNG is up to 100% less than Natural Gas derived CNG. Well to wheel is a concept which accounts for the carbon emissions produced in the entire lifecycle of a fuel from the source extraction to its burning and release out of the exhaust (Project Fever, 2016). Well to wheel carbon emissions measuring is a much more accurate measure of the environmental impact of a fuel. According to Bio Nett (undated) although electric cars are the cleanest fuel wheel to wheel, they have much greater carbon emissions from well to wheel.

Figure 7: Advantages of NGVs. Thinkaboutit (2016)



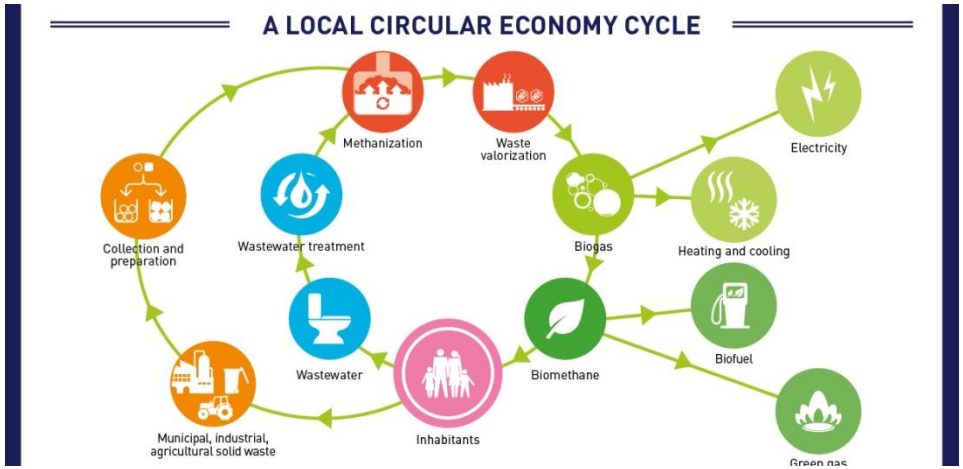
RE can be defined as any type energy fuel source which is not finitely scarce in the natural resource stocks of the planet, where it is not at risk of becoming depleted at any point in time and can be constantly made and remade with human or natural ingenuity (Painuly, 2001). Renewable Energy World (undated) states that

RE comes in a wide variety of forms including wind , hydro, biofuel, solar, geothermal, and ocean energy, which can be harnessed in new and constantly improving ways for efficiency and effectiveness.

Painuly (2001) argues that some RE types are more effective and economically feasible than others; furthermore there are certain barriers to RE adoption in certain contexts relating to political, legislative and economic agendas. Painuly (2001) continues that these barriers for RET include the technical and technological barriers, as well as limitations of non-cost-effective solutions, but more importantly the more complex issues such as market barriers are more difficult to navigate around.

Painuly (2001) laments the extent of market barriers which complicate the use and adoption of RET such as: political powers and functions; pricing differences due to regulatory tariffs and exchange rates; as well as environmental restrictions and social lobbying which may be present in certain contexts. For the purposes of this study I will be focusing on the RE of Biogas also known in some instances as: Biomethane; Landfill-gas; and Renewable Natural Gas, belongs to the category of bio-fuels (Bio 2 watt, undated). Biogas is completely renewable as an energy source and is made through a process of breaking down organic matter, where manure, sewage, solid waste, organic waste, plant material, crops, biomass and green waste can be used to create Biogas (Bio 2 watt, undated).

Figure 8: Biogas Sustainability. SUEZ Communication (2015)

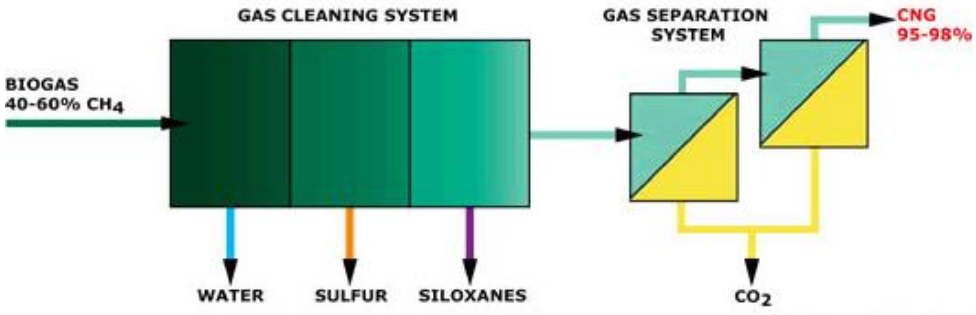


This means that Biogas can be made through the recycling of materials which would otherwise pollute the environment, also the process of creating Biogas produces a nutrient rich substance which can be further used to regenerate and nourish the environment (Bio 2 watt, undated). Biogas can be used for cooking as well as the generation of electricity and heat through gas engines, however for the purposes of this research I am

interested in the way that Biogas can be used in RET more specifically NGVs such as buses (Bio 2 watt, undated). According to AirScience Technologies Inc (2007) Biogas can be converted to CNG gas which can be used in NGVs which would make them RET and would also be fulfilling part of the criteria of “Sustainable Transport'.

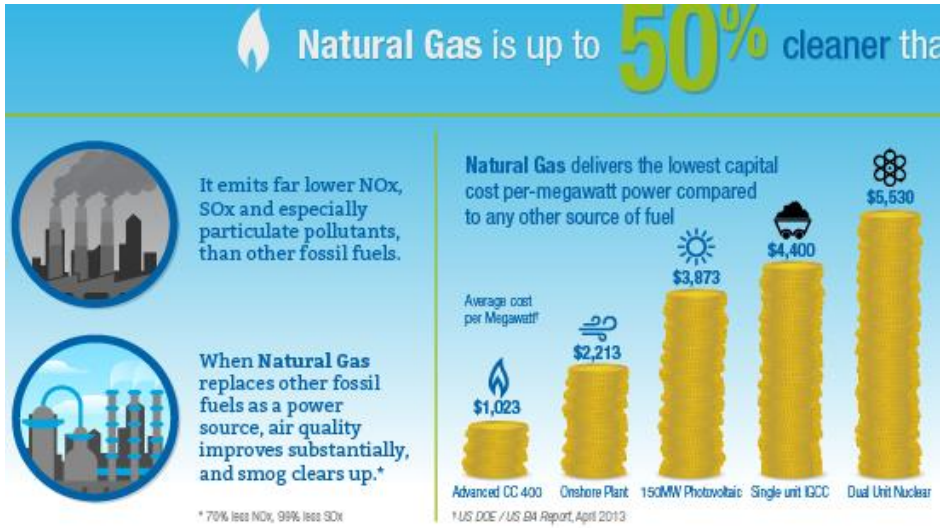
Biogas from landfills, waste water treatment plants and Anaerobic Digesters can be cleaned through a process, which releases certain other gases such as CO2; water; sulphur; and siloxanes in order to convert the Biogas to high octane CNG which can be used in NGVs such as the Metrobuses in my case study (AirScience Technologies Inc, 2007).

Figure 9: Cleaning process of Biogas. AirScience Technologies Inc (2007)



According to Westenbroek & Martin (2012) the Biogas plant can be health hazardous and possibly a risk to the environment; this is a factor which must be taken into account when managing the plant and the overall sustainability of this endeavour. However, according to Alberta (2008) the negative of cleaning Biogas is the high usage of water which is a considerably lesser environmental threat than that which is evident in use of conventional fuels such as diesel and petrol (Navaratnasamy et al., 2008).

Figure 10: Natural Gas is up to 50% cleaner than fossil fuels. IGU (2013)



According to Gazprom (undated), CNG is a gas which is stored at very high pressures in order to reduce its volume, also it is widely used as fuel for NGVs worldwide at a cheaper price to the economy and the environment. According to Consumer Energy Center (undated) CNG is non-corrosive, odorless and clear which is why a smell has to be added to it in order to tell whether leaks may occur. CNG is mainly composed of methane and is very safe as it only ignites at a concentration of 15% as opposed to Liquid Petroleum Gas (LPG) which is a mixture of propane and butane which is more dangerous to the environment as well as the hazard of explosion Consumer Energy Center (undated). What is more, Consumer Energy Center (undated) continues that CNG comes from the earth in oil wells, coal bed methane wells and Natural Gas wells, which makes it a non-renewable resource. Although CNG is non-renewable its use creates less carbon emissions than conventional fuels and when extracted from Biogas is completely renewable and furthermore less of a contributor to climate changes by carbon emissions.

2.6 Renewable Energy Technology - Natural Gas Vehicles

RET is the way in which different types of technology have been invented and adapted by mankind to utilise and harness the power of RE, there are a variety of RET types, however the type of RET which I am solely focused on in this research report is that which is used in NGVs. According to Alternative Fuels Data Center (2016) there are a variety of different types of NGVs from light motor vehicles to heavy trucks and everything in between, furthermore there are approximately 15.2 million NGVs worldwide, where there are a variety of legislative acts which give power to this RE source in different contexts worldwide.

Alternative Fuels Data Center (2016) states that there are different conventions of NGV technology some of which are pure CNG dedicated engines and some are dual fuel, meaning that the run on a combination of CNG and diesel or petrol. It is important to note that NGVs are not considered to be RET unless the fuel which they are using is coming from a bio-energy source which is called Biogas. The reason for this is that NGVs which use normal CNG which is methane gas is not renewable as it comes from inside the earth, as pockets of Natural Gas above oil pockets, whereas Biomethane comes from a variety of renewable resources and methods including landfills, manure etc. (Bio 2 watt, undated).

According to Rinkesh (undated) CNG is cheaper than conventional fuels and also produces less carbon emissions in its burning, furthermore CNG is safer, more versatile, abundant, easy to store and transport. Rinkesh (undated) continues that CNG has many more uses than conventional fuels, however it is toxic, non-renewable, expensive to install, less efficient in terms of fuel consumption and complex to use in NGVs for which the industry does not have as much infrastructure as conventional technology has. NGVs on CNG of which there are an abundance in the world are far more environmentally 'Sustainable' than normal oil based vehicles, however the key to even higher levels of 'Sustainability' rely on the way in which the NGVs use CNG which is extracted from Biogas. If this would be the case, then NGVs are using a biofuel form of RE and will produce even less carbon emissions in its burning process than normal CNG.

2.7 CNG – Strengths & Limitations

Evidence presented in previous chapters shows that CNG from Natural Gas burns cleaner than that of diesel or petrol and also has carbon emissions savings. However, Biomethane has almost 100% more carbon emissions savings and is Renewable but is also more complicated and costly to produce.

According to Koch (2014), one key drawback of using Natural Gas or even Biomethane is that if it leaks out of wherever it is being stored, the potency of it is 20 times as strong as the carbon dioxide which it is attempting to reduce in the first place. It is therefore imperative to make sure that the methane from Natural or Biomethane Gas is burnt before it escapes.

It is clear than that Natural Gas derived CNG is not as environmentally friendly as its Biomethane derived cousin, however Natural Gas CNG is seen as a bridge fuel by many environmentalists. Natural Gas as bridge fuel refers to the fact that it is only a temporary solution which will allow cities to reduce their dependency on oil based fossil fuels, while opening up the market to REs like Biomethane derived CNG.

Simply put, if we do not find a way to completely stop using fossil fuels, the earth will continue to heat up and will result in extremely negative results for all major cities. Some cities will become flooded and the equilibrium which the planets food, energy and biodiversity cycles will be broken.

Figure 11: CO2 Concentration on Earth as of 26/10/16 at 15:21 CAT. Poodwaddle (2016)



Figure 11. (Poodwaddle, 2016) shows that the UAH satellite, which measures the temperatures of the troposphere to have climbed above 440 PPM for the first time in recorded history which is the measure of CO2 levels.

2.8 Lessons of Conceptual Framework

They key lessons which I have synthesized from this LR are the difference between alternative and Renewable fuels which refers to Natural Gas derived CNG and Biomethane derived CNG respectively. It is clear that Biomethane would be more Sustainable, however the issue with attaining it mean it will take time. Another idea which frames my study is the concept of SD which is broken down into 3 spheres namely: Environmental; Economic; and Social but is controlled by a fourth known as the Governmental sphere. These spheres of Sustainability must be positively attributed to and not negatively affect one another in order to achieve Sustainability and SD in the City.



Chapter Three - Research Methodology and Method - Figure 12: Method of Unlocking Climate Action in Megacities. C40 Cities (2015)

Chapter Three - Research Methodology and Methods

3.1 Overview

After gathering knowledge on a variety of concepts, theories, discourses and ideas related to the central themes of the LR, I have a better understanding of my research. I understand CNG and Sustainability as broad concepts as well as all the ideas attached to them, this information has been used as a lens to look at my case study.

Using the case study as a method of research, I have examined its specific context and created research instruments in the form of interview schedules which will be informed by the LR and CF. I have undergone a process of interviewing stakeholders who are specifically knowledgeable about my case study as well as my research area in general. My interviews with relevant stakeholders will help me to gain insight into the case study as well as other pertinent information which will help me to answer my RQ and SQ.

3.2 Direction of Research

The problem statement of my research is seeking to assess the extent to which dual fuel Metrobuses contribute to the 'Sustainable City'. This problem statement is derived from my observation of the new dual fuel Metrobus fleet in Johannesburg. The RQ which I have developed as a result of the careful choosing of words to figure out what I want to know about my observation, has resulted in the following RQ: How useful are dual fuel Metrobuses for Sustainability in Johannesburg?

The reason for the wording of this RQ is focused on two main words which explain its purpose in relation to what and where which are fixed. The word useful, in terms of the dictionary definition: being of use or service indicates that something, in this instance – dual fuel Metrobuses is being of use or service to something.

That something is the second pivotal word which is Sustainability, which has its own criteria relating to three spheres namely, environmental, social and economic which has been instigated in the preceding LR. Therefore, the question asks, how do dual fuel Metrobuses be of use or service to achieving the 3 spheres

of sustainability holistically. This is the point of departure from which I start, in answering that very question.

The sub questions for which are as follows:

- What led to Metrobus using CNG in NGVs?
- What is CNG and NGVs about?
- What are the costs and benefits of using dual fuel Metrobuses?
- How do dual fuel Metrobuses contribute to the Sustainable City?
- What lessons can be taken from the case study, to increase the usefulness of NGV transport?

These sub questions have also been worded strategically and have a specific focus in seeking to answer the main research question, furthermore the structure of my semi-structured interviews and their questions also take cognisance of these sub-questions.

3.3 Understanding the purpose of my Research Methodology

My research methodology in this research report utilises Qualitative methods, where I will be studying the phenomenon of RET in relation to public transport. In using a case study the science behind this method is to make sense of whether it fulfills the criteria of 'Sustainability' which is another concept which is given meaning by people and therefore is qualitative (Denzin & Lincoln, 1994).

My research methodology uses a descriptive exploratory study, this endeavor is 'Descriptive' because it attempts to look at questions trying to understand the 'What' and the 'How' of a certain study, where these questions will be asked of the case study (Patton, 1990).

The science of my research or its methodology uses the descriptive approach, where it applies the 'What' and the 'How' to the RQ and SQ in order to produce information of a qualitative nature. Furthermore as my study is part exploratory, it will be inclined to have a certain angle in what it is trying to explore as it is not a completely new study, however there is a gap in

knowledge which can be exposed by putting a certain angle on the research question (Patton, 1990). The angle of my research question is to assess or measure the Sustainability of dual fuel Metrobuses and this is what makes my methodology of research exploratory.

Additionally, my research is also partly descriptive due to the fact that it seeks to explain something which I have observed as well as to explore further by uncovering information related to that topic area (Maxwell, 2012). The pursuit of trying to describe what I am seeing in my observation and my problem statement is what makes my research methodology descriptive, whereby I am attempting to explore the phenomenon of dual fuel Metrobuses and to uncover whether or not they are 'Sustainable' (Maxwell, 2012).

3.4 Emphasising the nature and purpose of my Research Methods

The method of my research is underpinned by the use of a case study which has been clarified before as the NBM, this case study has a specific fixed location which is Johannesburg and is centrally concerned with the municipal transport entity known as metrobus. What is more it is concerned with CNG technology for public transport buses, which narrows it down even further. Therefore, the function of the RQ in relation to the case study becomes how these specifics outlined by the case study meet the criterion which is demanded by the concept of 'Sustainability'. This is the key purpose of this research report, however in the pursuit of this answer, the fieldwork and methods will also allow me to extend my research beyond answering the RQ.

3.4.1 Method 1 – Literature Review

The first method which I will use to achieve my research is a LR, where I have investigated and explored a vast body of knowledge in the form of books, journals, grey literature, internet articles and social media. The rationale of how I chose this variety of sources comes directly from my observation and problem statement which is: How Sustainable is dual fuel Metrobuses in Johannesburg. This observation and problem statement is what helped me to distill my RQ and SQ; these also in turn informed my LR which has also enlightened me on the variety of concepts which revolve around my direction of research. My LR was concluded with a CF, which is the culmination of an investigation of ideas relating to the problem

statement and geared towards answering the RQ and SQ. The CF is a body of concepts which are going to frame the direction of my study and will later inform the semi-structured interview which I will undertake.

3.4.2 Method 2 – Semi-structured interviews

The second method of my fieldwork involves the choosing of purposefully sampled CNG enthusiasts to participate in my semi-structured interviews, what is more, I have employed the technique of snowball sampling in my interview method. According to Atkinson & Flint (2001) Snowball sampling makes use of the educated recommendations of interviewees in order to find similar or more appropriate interviewees whom would provide the desired information.

I have used this method of sampling when doing my fieldwork to help navigate me to the information which is appropriate to my study. The interviews have specialised interview schedules for each different company being interviewed, which are informed by the insight gained in the LR in order to ask pertinent questions. What is more, the interviews are semi-structured, meaning that they have a schedule of open ended insightful questions as mentioned before. The purpose of this is to gain as much information as possible and to let the interviews produce findings which are of an unbiased nature that can reflect the true nature of the RET which I am researching.

3.4.3 Strengths and limits of Case Studies

As has been highlighted earlier, I will be using a case study as my method of answering my RQ; the case study is the NBM and deals mainly with CNG transport technology which 'Metrobus' have unveiled in Johannesburg. Up to now I have explained how method 1 will educate me on the case study and method 2 will inform that educated understanding even further for the case study as well as recommendations beyond that.

However as a method, case studies are often criticised for being specialised and unable to make general assumptions about specified knowledge which can be applied to other work. However, According to Flyvbjerg (2006) case studies are useful in qualitative research for their ability to situate researchers in the specific realities of the environment which he/she is dealing with. This means that case studies are especially good at producing an understanding of the situation as it is experienced

by the people who are involved with it. In the context of the NBM, the people who I am interviewing have knowledge around this case study and have experienced it in the specific context of the case study in Johannesburg and relating to dual fuel Metrobuses, therefore the findings which I will produce are likely to be highly qualitative and will be used to answer a qualitative RQ.

3.4.4 Data gathering

In the pursuit of gathering data to answer the RQ and sub questions, I have listed the methods which have used, furthermore in order to answer the first SQ I have relied on the LR and other grey literature as to what led metrobus to start using CNG technology. In order to get information on the case study on the 'NBM' programme I have used purposeful sampling of Vehicle Gas Solutions and interviewed them with semi-structured interviews, this helped me to understand the way in which the NBM may or may not fulfill the criteria of 'Sustainability'.

In addition to this I also researched the experience and results of CNG in Johannesburg in order to answer some of my other SQ's, where I used purposeful sampling to interview representatives of the Renergen and NOVO Energy companies. I also interviewed officials in the Interwaste company, as they are an innovative company who are pioneering the production of RE in the form of Biogas.

3.5 Conclusion

The purpose of this chapter has been to elucidate the science behind the type of research I have chosen to do to and answer a specific brand of research question. The way in which I have practically implemented this brand of research has been outlined and clarified in detail. What is more, the specificities, strengths and limits of the endeavour of undertaking my research has been analysed and defended.



Chapter Four - Point of departure for the 'New beginning for Metrobus' - Figure 13: Vision for Alternative and Renewable Energy. C40 Cities (2015)

Chapter Four - Point of departure for the 'New beginning for Metrobus'

4.1 Overview

The NBM will serve as the tool of research by which I investigate the use of RE transport and the extent to which it attempts to achieve the requirements of Sustainability in Johannesburg. In order to paint a picture describing the NBM programme in detail I will make use of a variety of grey literature and articles that explain the context within which it sits at a policy level.

The NBM itself is an issue based study and therefore is located contextually in Johannesburg; however, the research which I have gathered in this report is dependent on a variety of sources. Sources which this research report depends on are from desktop studies and interviews in Johannesburg, where interviewees themselves provide a specific context that elucidate the case study and make it richer with specific knowledge. The NBM is part of a wider transport strategy by the CoJ which will be further detailed below through the lens of the Metrobus operational Plan and the Metrobus business plan.

Figure 14: Locality map of Johannesburg. (Wikipedia, 2005)

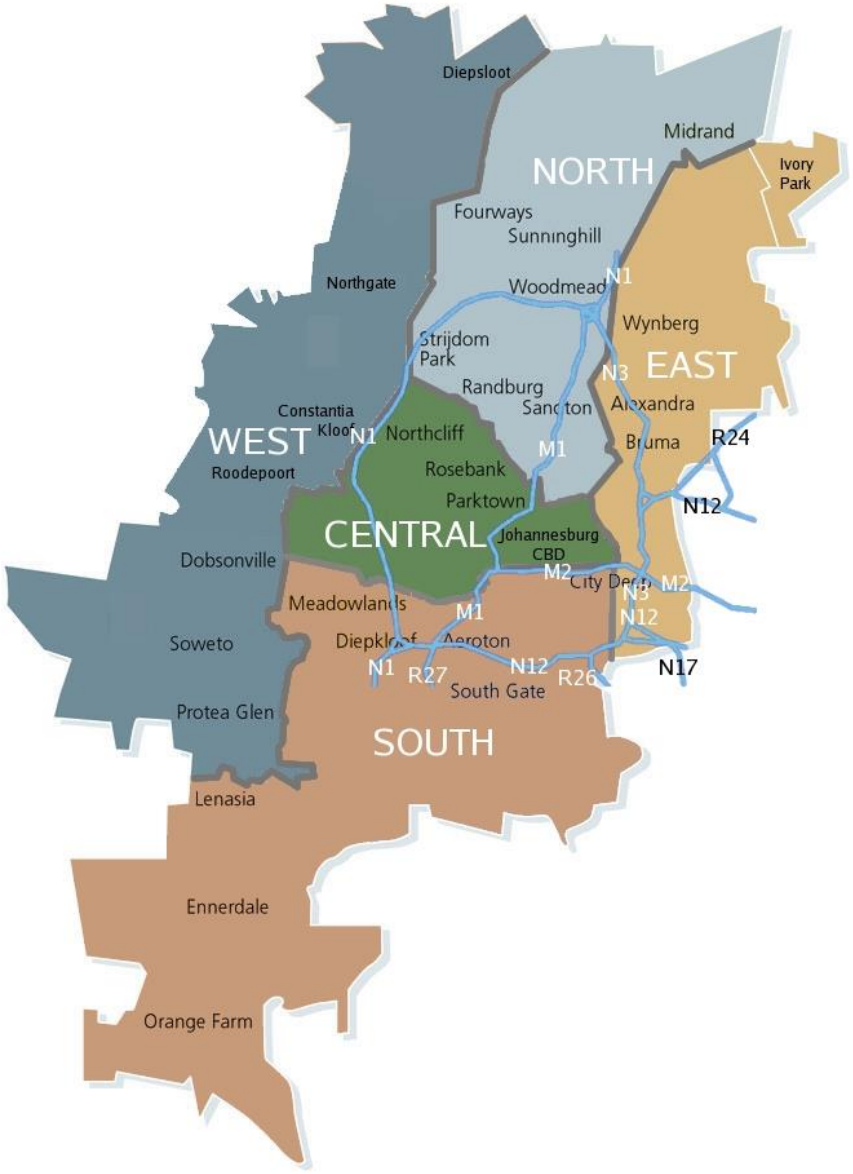
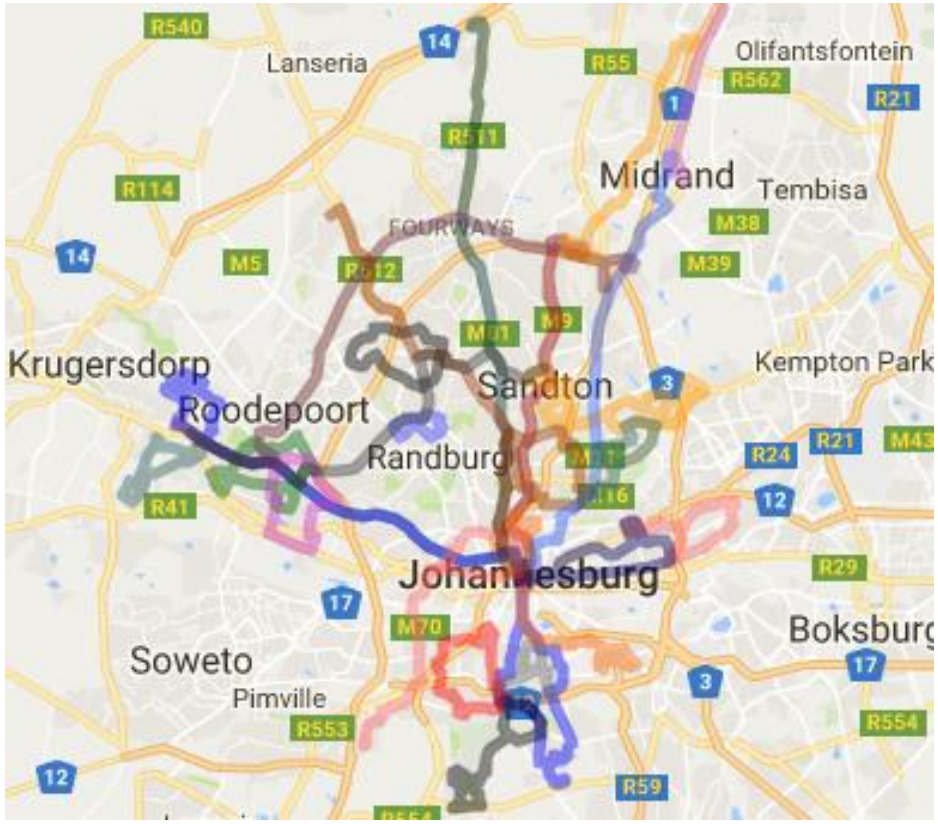


Figure 15: Location of Johannesburg in South Africa. (Wikimedia, 2011)



Figure 16: Metrobus routes in Johannesburg. Google Maps (2005)



4.2 Metrobus Operational Plan – context for 'turn-around strategy'

In May of 2014 the CoJ published the Metrobus operational plan which discussed a turn-around strategy for the future of the company and its public transport endeavours, furthermore the strategy highlighted the fact that it was to be guided by the city's: GDS; Integrated Development Plan (IDP); Strategic Integrated Transport Plan Framework (SITPF); Mayoral Committee mandate; as well as the National Land Transport Act (City of Johannesburg, 2014).

The Metrobus turn-around strategy includes a variety of different interventions; however the main intervention which is of interest to this report is the introduction of new green dual fuel buses. The Metrobus operational plan highlights the fact that the mandate of the Mayoral Committee is to integrate and align the variety of transport typologies such as the Rea Vaya, Gautrain and Metrorail (City of Johannesburg, 2014).

4.3 City of Johannesburg's Growth and Development Strategy 2040

According to NGV Global News (2014) the CNG technology in dual fuel Metrobuses will also find its way to the Rea Vaya buses, but more interestingly if the CoJ Mayoral Committee mandate is to integrate and align these transport typologies then the CNG technology may become used in the train systems as well due to the fact that this is possible and would serve to achieve an overall more Sustainable transport agenda for the city. The City of Johannesburg (2011) argues the imperative for a shift from private to public transport ridership in order to decrease carbon emissions, congestion, road infrastructure costs, air pollution and petrol prices.

The City of Johannesburg (2011) describes the importance of investment in a public transport system which can begin to integrate the segregated social groups of the city through the concept of transit oriented development (TOD) which shall give disadvantaged citizens access to the economic potential of the city. According to City of Johannesburg (2011), the development of a public transport system which caters to the masses of the public will make the city more resilient to macroeconomic effects

such as petrol price increases. City of Johannesburg (2011) continues that a comprehensive public transport system will have a positive impact on the reduction of carbon emissions due to the decrease of private automobiles on the road and increased ridership of environmentally friendly public transport of which the green dual fuel buses are boasting to be the best.

City of Johannesburg (2011) maintains that an improved public transport system to the broader social groups of the city will begin to integrate the segregated social enclaves which are sprawled around the urbanscape. Additionally, City of Johannesburg (2011) takes the view that the economy of the city will also benefit from the savings of carbon tax and petrol prices as well as by fostering economic growth through facilitating access to the economy for peripheral dwellers. The improvement of the public transport system and increased ridership especially on Rea-vaya and Metrobuses which are using green dual-fuel engines will improve the extent to which the city is becoming Sustainable as all the positives previously discussed amount to social, environmental and economic sustainability.

4.4 Strategic Integrated Transport Plan Framework

According to the City of Johannesburg (2013) the SITPF determined that Metrobus would be the key transport system for routes which had a medium level of ridership and demand, as well as to expand its coverage of transport routes in the city. City of Johannesburg (2013) continues that Metrobus will be vital to the future of the Rea-vaya system as they will act as the initial transport mode and then become a feeder to the routes of the Rea-vaya bus network. What is more, City of Johannesburg (2013) states that the fare management system of Rea-vaya and Metrobus will become allied thus improving the coverage of the overall bus public transport network. If the Metrobus and Rea-vaya buses become aligned in terms of end-user service as well as their energy consumption mode, then this would mean that the integrated public transport network of buses would have more of an impact in achieving the criteria of the Sustainable city.

The City of Johannesburg (2013) emphasises its policy towards reducing traffic congestion in the SITPF through TOD which was also discussed in the GDS, whereby this strategy is highly dependent on an efficient and effective public transport network with the right threshold population and densities to support it. It

makes sense then that a compact city is I needed to support this transport strategy, with the help of dual fuel buses, the compact city can be achieved with the help of a more environmentally friendly approach, without which the combined density of private cars and increased households would make the city unsustainable. City of Johannesburg (2013) asserts that the transport sector needs to be transformed, where it recognises the opportunities for job creation which arise from its transport initiatives.

Furthermore, the City of Johannesburg (2013) observes that the dual fuel buses which have been launched by Metrobus present opportunities for green economy growth, this is because the Natural Gas which is used in the buses themselves can be replaced by Biogas - discussed in the LR, as this is more green and in-fact a renewable source of energy which will create another set of downstream activities and subsequent economic opportunities.

In the SITPF, the City of Johannesburg (2013) highlights the forward linkages which can be created through Metrobus' use of CNG in its buses as it creates jobs in the waste management and agricultural sector but also this increases the overall environmental security and increases the extent to which the city is Sustainable. What is more, the SITPF also outlines the objective of Metrobus' new dual fuel fleet utilising alternative green fuels in order to develop an environmentally friendly public transport service and ultimately decrease carbon emissions per capita of transport (City of Johannesburg, 2013).

4.5 Metrobus Business Plan – 'New beginning for Metrobus'

Together with the Metrobus Operational Plan, the Metrobus Business Plan is a key piece of grey literature which defines the context of the NBM programme; according to City of Johannesburg (2013) the Metrobus Business Plan discussed a way forward to a spatially integrated city as mandated by the CoJs previous Executive Mayor, Councillor Parks Tau. Moreover, City of Johannesburg (2013) continues that along with this spatially integrated city, Parks Tau described what would later be named 'corridors of freedom', in relation to which he would state an agenda to connect the city using TOD and the innovation of green dual fuel buses.

Interestingly a noteworthy milestone on the 11th of April 2013 is included in the context of this report, *"The Mayoral Committee approved "that the tender for new Metrobuses is a tender for a turnkey solution including buses and for fuel that must be green and job creating and that the tender evaluation process determine the most economical, environmental and job creating option" (*City of Johannesburg, 2013, p.6). Additionally, City of Johannesburg (2013) describes a process of re-fleeting, whereby Metrobus would provide a more cost effective transport solution, which features reduced carbon producing-fuel efficient buses, which would be refuelled and operated from the Milpark and Roodepoort depots.

According to City of Johannesburg (2013) the Metrobus Business Plan recognises the issue of energy security in South Africa as well as the worldwide issue of climate change and global warming. In order to respond to these challenges a new fuel source for the Metrobus fleet was debated and identified. City of Johannesburg (2013) continues that CNG as an alternative fuel source for the Metrobus fleet made sense due to the facts that: there is extensive precedent and success with this fuel internationally; there was an existing pipeline of Natural Gas from Mozambique through Sasol; extensive gas infrastructure for the country had already planned with some already existing; Natural Gas could be replaced this with biogas from locally existing sources. What is more, City of Johannesburg (2013) argues that the adoption of CNG as the fuel source for the new Metrobuses would create backward and forward linkages in associated industries and supply chains relating to the innovation of NGVs such as the dual fuel Metrobuses. City of Johannesburg (2013) notes that job opportunities could be created in the maintenance and procurement of vehicles as well as the production of biogas, Natural Gas and conversion into CNG for the use of these vehicles.

4.6 'New beginning for Metrobus' - in detail

In further providing context of the NBM programme SACN (2015) notes that the first 70 dual fuel buses were launched by Metrobus, this became known as the NBM officially and consisted of the rehabilitation and procurement of 70 buses using both Euro 5 diesel and CNG calibrated engines. SACN continues that 40 new dual fuel buses were procured and another 30 old buses were restored and converted to dual fuel buses, this was made possible by VGS whom have been described in the findings later in this report.

Additionally, SACN asserts that the CoJ are paving the way for a more Sustainable transport industry by proving the possibility and efficacy of this kind of RE technology while at the same time creating opportunities for more downstream value chains to be created. SACN maintains that the kind of value chains which could arise from their flagship model duel fuel buses are that which involves the production of Biogas to replace the Natural Gas, which will currently be used in the dual fuel buses.

If these new dual fuel buses are environmentally friendly, economically viable and capable of stimulating economic growth as well as providing an improved transport experience for the public, then in theory this makes them Sustainable to a certain extent.

SACN highlights the fact that the rest of the Metrobus fleet will also be restored and converted to dual fuel buses which shall run on 70% CNG and 30% diesel, the CNG however will later be replaced by Biogas as it is an even greener fuel. Lastly, SACN observes that the branding of the buses themselves will have a similar look to that of the Rea-Vaya buses in order to signify that the two transport agencies are becoming increasingly integrated at a conceptual and physical level.

The NBM programme which is centrally defined by the launch of the 70 dual fuel buses on the 24th of July 2015, does not end there, the programme continues to progress and according to Department of Roads and Transport (2014), 190 new dual fuel buses are earmarked for June 2016. At the launch of the NBM programme, Executive Mayor at the time, Parks Tau stated that, *"We are at the beginning of a new journey not only of service to our residents, but a new journey of contributing to the green and blue economy and making our planet more sustainable for present and future generations"* (Department of Roads and Transport, 2014, p.23).

According to Department of Roads and Transport (2014) this NBM programme would initially result in the creation of 110 jobs in the local manufacturing industry most of which would go to VGS as they won the tender. Furthermore, Department of Roads and Transport (2014) comments that from August 2015 to June 2016, approximately 20 new dual fuel buses would be introduced to the Metrobus fleet each month as a part of the NBM programme. The NBM signifies the City of Johannesburg's commitment to a greater cause of the Sustainable City agenda which it shares with other cities in the C40 Cities initiative which shall be clarified in later parts of this report (Department of

Roads and Transport, 2014). What is more, the NBM programme is not the only initiative in South Africa to use NGVs as shown in the literature review, however it is the largest and the CoJ together with Gauteng province has also made significant strides towards making NGVs such as taxis and cars a possibility as well (Department of Roads and Transport, 2014). With the advent of NGVs in Metrobus, the question remains as to why this is not being done for one of the more popularised public transport projects - the Rea-Vaya, however according to NGV Global News (2014), Alex Bhiman was quoted in saying that Rea-Vaya would also adopt the use of CNG in their buses at the completion of their Phase 1c expansion which is also in line with the combined interests of the CoJ and its GDS to achieve sustainable projects which halt climate change. NGV Global News (2014) continues that the NGV 2014 conference highlighted the advantages and disadvantages of using CNG and Biogas in NGVs, as well as the discussion around building infrastructure to support the use of NGVs in Alexandra.

What is more, the CoJ are in talks with City Parks and the Johannesburg Fresh Produce Market on the topic of using their organic waste for feedstock in Anaerobic Digesters in order to produce Biogas (NGV Global News, 2014). Biogas which has been clarified in Chapter 2 of this report has a lot more advantages than Natural Gas and can be exchanged seamlessly with it. Moreover, the CoJ has engaged with City Parks and the Johannesburg Fresh Produce Market in securing 1.5 million tons of waste for the cause of producing Biogas (NGV Global News, 2014). Interestingly, the CoJ would be spending billions of Rands in the period of the next three years in re-fleeting its Metrobus automotive assets with 150 dual fuel buses, this agenda would be bolstered by a statement from a technical expert at the NGV 2014 conference who said, *“natural gas offered a 20-30% reduction in greenhouse gas emissions compared to diesel, while costing between 35-50% less”* (NGV Global News, 2014, p.1).

4.7 The C40 Cities Climate Leadership Group

After clarifying the roots of where the NBM gained its traction and momentum it is necessary to discuss its pertinence to an initiative which the CoJ has pledged its support, namely, the C40 Cities movement which has been clarified in Chapter 2 of this report. According to Powell (2014) the fifth biennial C40 Cities Mayors' Summit took place in Johannesburg from the 4th to the 6th of January 2014, where Parks Tau had the opportunity to

share with the world's mayors some of Johannesburg's approaches and concerns with regard to tackling the issue of climate change. Powell continues that Tau mentioned his objective of cutting emissions by 1.6m tonnes by 2020 and mentioned the difficulties facing cities with added pressures of scarcity in an era of climate change. According to Powell (2014), Parks Tau recognised the vital role which cities have to play in the contemporary world as they house half of the planets population on approximately 2% of the overall space. Powell notes that cities' account for 70% of global carbon emissions and consume about 66% of the global energy provision.

The issues raised by Parks Tau in the previous paragraph seem to lend legitimacy and imperative to the concepts of Sustainable and Compact Cities with comprehensive public transport systems using NGVs and other renewable transport typologies. Research which I have presented in Chapter 2 has shown that these interventions have the ability to reduce the extent to which climate change is being propelled. However, I seek to understand whether or not the NBM programme has similar successes as its international case study counterparts and also whether or not it can achieve overall Sustainability.

Figure 17: How much C02? Information Is Beautiful (2016)



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The C40 Cities conference highlights the importance of the NBM programme to the CoJ in how it is being implemented, which is partly due to the pledge the CoJ has made to this global movement and its powerful supporters. An interesting quote by Parks Tau reminded me of a key point of being part of a global movement like C40 Cities, where he said, *"We can keep each other accountable"* (Powell, 2014, p.1); this it seems is a necessary endeavour to halt a global epidemic like climate change.

The C40 Cities Mayors' Summit had representatives from 44 cities worldwide and combined they represent 15% of GDP worldwide, where the key theme of this conference was: *"Towards resilient and liveable megacities"* (Johannesburg Development Agency, 2014, p1.) According to Johannesburg Development Agency (2014) cities at the C40 Summit shared information on climate change and different methods by which they would fight this scourge, as well as information which highlights the fact that climate change can best be fought from the location of cities as that is also where the epicenter of climate change lies.

Figure 18 : CoJ Emissions. (C40 Cities, 2016)

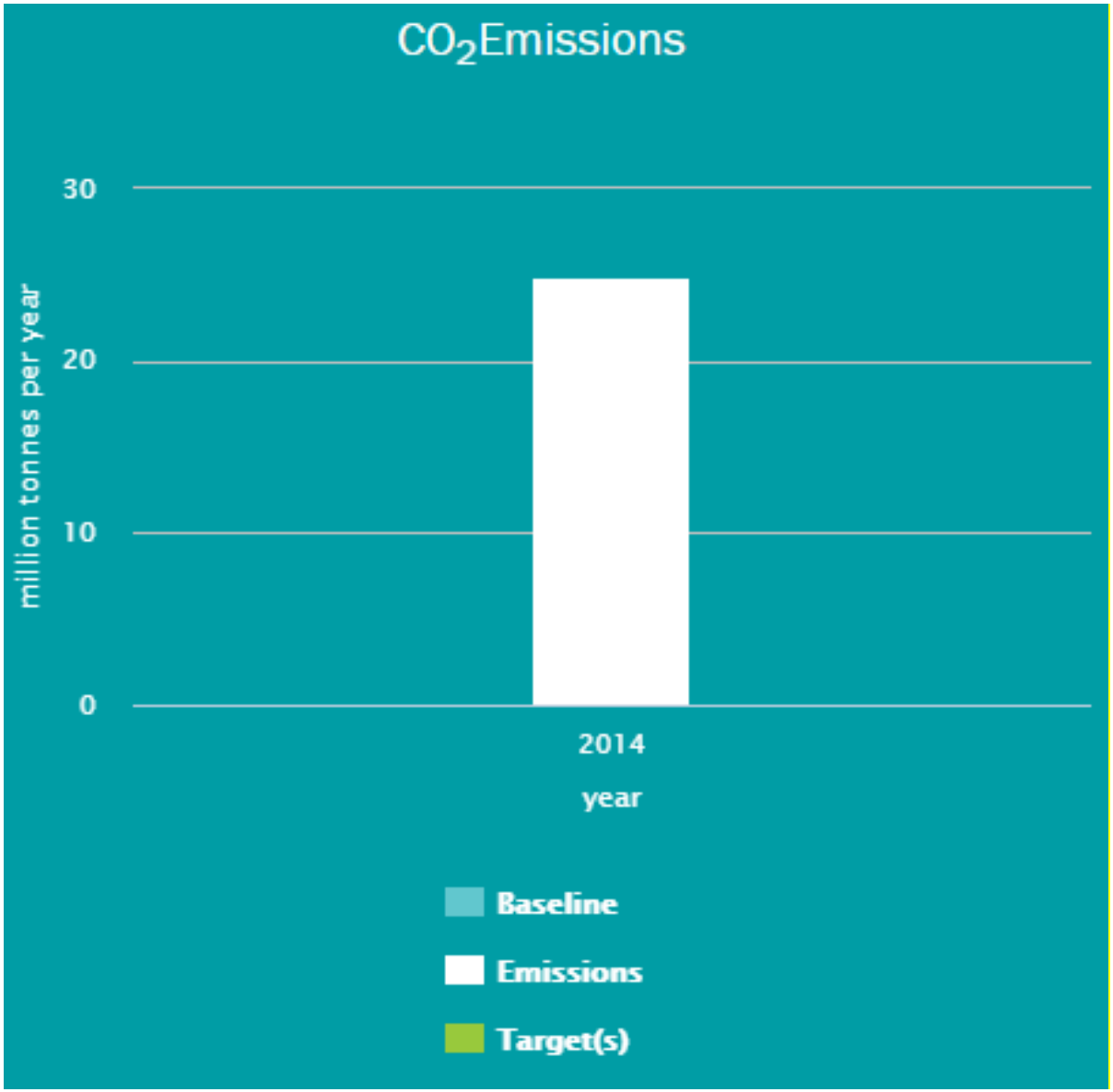


Figure 19: C40 Cities. (C40 Cities, 2016)



The C40 Cities Climate Leadership Group which is made up of all these important cities, mayors and the influence behind them are committed to helping one another to adopt strategies and plans to fight climate change. It is therefore valuable to note that one of Parks Tau's interventions and strategies as mayor was to conceptualise and implement the NBM programme as a practical way of reducing carbon emissions to reduce the CoJ's effect on Climate Change while at the same time also creating a more cost-effective public transport service.

It is clear that the NBM programme has the support of a variety of policies, agendas, movements and governmental agencies, as well as evidence from case studies around the world. However using the NBM programme as my own case study, I would like to see how this agenda plays out in the specific context of Johannesburg with its unique political and economic issues, by gathering information not only from the desktop studies which I have interrogated but more importantly the experts who are dealing with CNG and NGVs in a practical environment on a day-day basis. It is for this reason that I have purposefully sampled and interviewed a variety of organisations which produced findings in the forthcoming chapter.

The reality is gas prices should be much more expensive than they are because we're not incorporating the true damage to the environment and the hidden costs of mining oil and transporting it to the U.S. Whenever you have an unpriced externality, you have a bit of a market failure, to the degree that eternality remains unpriced.

Elon Musk - (Brainy Quote)



Chapter Five – Findings - Figure 20: Transforming Transport. (C40 Cities, 2015)

Chapter Five - Findings

5.1 Overview

The introductory quote of this chapter has the power to illuminate the real cost of being unsustainable, as this is not only measured by the high prices of oil and conventional fuels to which we are so addicted, but more importantly the cost of managing unsustainable urbanism should be measured by the irreparable damage which we are doing to our planet. The city which we live in is in a constant state of development, building, destroying and rebuilding, however the use of fossil fuels in our city would render all our effort to progress meaningless if the massive energy we use to sustain them does not come from a more carefully thought out source.

The purpose of this research is to find out if the new source of energy which the CoJ has chosen for one of the city's most important tools, public transport is a Sustainable one. The findings presented below have been collated from interviews with key stakeholders and experts whom are either involved directly with NBM programme or with the use and development of NGVs, CNG, Biogas and RE.

5.2 Vehicle Gas Solutions

In order to answer my RQ and investigate whether or not CNG was being used sustainably in NGVs in Johannesburg, I chose to purposefully sample the Original Equipment Manufacturer (OEM) for Metrobus which is Vehicle Gas Solutions (VGS). VGS was involved with the converting of 30 old Euro 4 diesel buses into dual fuel, after interviewing a member of VGS I was able to synthesize information which would help me in the investigation of CNG powered Metrobuses. Since I assured my interviewees their anonymity, I will be referring to the interviews anonymously, moreover in the VGS Interview, I had conducted the interview with a variety of open-ended questions from which the feedback was very enlightening.

5.2.1 Proof of concept for CNG technology

Interviewee A stated that VGS was involved with the conversion and maintenance of 30 old Metrobuses into dual-fuel technology; he also stated that the 40 new dual fuel buses were bought brand new from Mercedes. What is more the interviewee stated that 150 more Mercedes buses had been had been bought for the future of the NBM which also run on the same dual fuel

technology. Interviewee A states that VGS won the first tender and that they were the first to be able to convert the diesel buses and run them as dual fuel buses with the cleanest emissions results, this showed a proof of concept for the CoJ to continue with their agenda.

Interviewee A remarked on the challenges of converting the old Metrobuses which had been refurbished into dual-fuel buses, where it was said that an issue was finding a place for the actual CNG containers to be located was. The CNG cylinder containers are normally located on the roof in buses which are built to carry CNG originally, however the cylinders known as category 1 cylinders, were going to be too heavy to store on the old Metrobuses and therefore highlights an issue with NGV technology which is the storing of the CNG itself. Interviewee A, stated however, that the new dual fuel buses did not have this problem as they came expressly built as dual fuel buses and had the CNG storing cylinders on the roof which use lighter cylinders known as category 4 cylinders.

Interviewee A notes that VGS were also involved with the 40 fully dedicated CNG buses in Tshwane which run solely on CNG. Furthermore, Interviewee A remarked on the fact that the CoJ may adopt this technology in the future but for now the infrastructure of Johannesburg best supports dual fuel buses. The reason that dual fuel buses work better in Joburg is because there are not enough Natural Gas filling stations to support the length of trips which buses will be doing and the amount of buses which need to be filled. Herein lies a drawback of using NGVs in Johannesburg at this time.

Interviewee A states that the process of converting old refurbished buses to dual fuel buses is a very expensive process due to the fact that the product which VGS are using is new and the OEM's in Italy are still recovering costs of manufacturing and testing, as well as the fact that it has to be imported with a weak rand to Euro exchange rate. Moreover, interviewee A continues that the dual fuel technology in the form of conversion kits are still very expensive in SA especially because it is not manufactured here yet, however the fact that the cost of Natural Gas being cheap makes the process feasible as costs can be recovered there.

5.2.2 Political drive for NGVs in Johannesburg

Interviewee A states that the political drive towards going green by the city in its public transport sector has had a great influence on VGS, where Interviewee A has remarked on the positive thrust with which Parks Tau had approached this initiative and is what ultimately achieved its success. Interviewee A states that the NBM programme has been a crucial stepping stone of the startup of their business as OEMs, where they now have also expanded in the areas of other NGVs. What is more Interviewee A states that there are no incentives for NGV companies to use greener fuels however the endeavour of greening the Metrobus fleet was a high priority of the CoJ to become more environmentally friendly as they pledged to do in line with the C40 Cities initiative.

Interviewee A highlights that Taxis which have been converted to use CNG have been incentivised by companies like NOVO energy and CNG holdings with support from the Gauteng Provincial government which is something that has been explored in the LR. Interviewee A asserts that there are approximately 1000 taxis running on CNG technology which the owners were funded by the gas companies' CNG holdings and NOVO energy, who would later recoup this cost by selling the CNG with a mark up to cover these costs.

5.2.3 Infrastructure limitation for NGVs

Interviewee A maintains that a restriction or hurdle to the SA NGV market is the scarcity of Natural Gas as it is all piped in from Mozambique via Sasol and the infrastructure to distribute this gas is also insufficient. Interviewee A states that the NGV and CNG market will not necessarily have a negative impact upon the conventional fuel market as there will be a segment in the market for each of these fuels to thrive off of. Furthermore it was said that CNG was the most convenient and cleanest alternative fuel to resort to as electric vehicles would be unfeasible due to there being no infrastructure at all for them. Interviewee A also claims however that the new diesel Euro 5 engines actually have a very low carbon footprint similar to that of NGVs.

Interviewee A has a wealth of knowledge of the dual fuel engine and explains that the method of injecting gas into the dual fuel engine is the cleanest in terms of carbon emissions and also produces the same power which a normal diesel engine would.

Interviewee A maintains that their involvement with the NBM programme is also the maintenance of the converted buses which takes place at their premises.

5.2.4 Regulatory conditions for NGVs

Interviewee A, highlights that the CNG and NGV industry is regulated by the Department of Labour and South African Gas Association (SAGA) through the South African Norms and Standards Act (SANS), where a competency card is issued to be involved with the use and production of CNG and NGVs for which each vehicle must have a Certificate of Compliance (CoC) and of course there are training fees and costs associated with obtaining these licences.

Interviewee A laments the fact that the regulatory authorities only regulate those who actually are complying with the legislation and do not pursue the illegal NGV industry, where there seems to be a lack of government capacity in the Department of Labour to prohibit the illegal use of NGVs as all these issues have been reported to the relevant authorities.

5.2.5 Necessary Catalyst for NGV industry

Interviewee A maintains that his suppliers would eventually be able to begin manufacturing domestically if the volumes of conversion kits demanded were high enough, which would make NGV technology cheaper in Joburg. Interviewee A states that an extreme hurdle to NGVs in Johannesburg are the fact that when converting normal cars into NGVs the warranty would be void and that is why they chose to approach the Taxi industry as opposed to other automobile companies. Interviewee A says however that in order for NGVs to become more of an industry and become cheaper overall, that the fleet companies using smaller automobiles like DHL and Avis need to be penetrated and will then give demand to produce the technology locally.

What is more, Interviewee A states that the exposure around CNG and NGVs in South Africa is not yet sufficient enough to allow the NGV market to succeed on a commercial level. Whereas the exposure and drive towards NGVs in Europe is a lot more exciting, where information of how these NGVs can seriously save the planet while being cost effective and sustainable is an everyday reality.

Interviewee A maintains the success and exposure of CNG and NGVs in Johannesburg is largely due to Parks Tau's mandate to achieve reduced carbon emissions as he had advocated the CoJ's pledge to reducing climate change as a part of the C40 cities agenda.

5.2.6 Opportunity for Biogas in NGVs

As has been discussed in the LR, Biogas is cleaner than Natural Gas in terms of carbon emissions and is also a RE as opposed to Natural Gas. If Biogas is cleaned it is then known as Biomethane as the octane is increased to at least 90% methane content, which can then be compressed and used in NGVs. Interviewee A states however that there is no Biogas in Johannesburg and the production of this is needed to make the use of it in the transport sector more environmentally friendly. There are however, issues with the creation of this Biomethane and therefore its contribution to Sustainability needs to be carefully negotiated. Its production value chain needs to positively influence Sustainability and not detract from overall Sustainability, as it may be economically costly in the short term.

5.3 NOVO Energy

I interviewed the technology development company of NOVO Energy who has also been involved with cutting edge technology of NGVs in Johannesburg as well as Tshwane. NOVO was purposefully sampled as they are experts regarding the use and production of CNG as well as the use and maintenance of NGVs like those which are used in the NBM. As my interviewee from NOVO is going to be anonymous in this report I will refer to him as interviewee B.

5.3.1 Sourcing and specifics of Natural Gas

NOVO energy is involved with the sourcing of Natural Gas from Mozambique, where they have infrastructure in the form of industrial pipes which they can provide to consumers at gas filling stations. NOVO also has the ability to transport the gas in large containers on trucks to wherever it needs to be. Interviewee B states that NOVO are involved with delivering Natural Gas, Biogas and methane rich gas to market, these gases once brought to the correct specification and octane levels can be compressed and then used as fuel which is known as CNG. What is more NOVO has the ability to compress and

deliver the Natural Gas to wherever it needs to be within reason of economic feasibility. Essentially NOVO is a reseller of Natural Gas which is transported via Sasol's pipeline infrastructure to South Africa; however NOVO is also involved with the associated value chain of NGVs in the maintenance and conversion of this technology.

5.3.2 Biogas – advantages & disadvantages

Interviewee B states that the disadvantages of using and producing Biogas from Anaerobic Digesters (covered in the LR) are the capital cost of setting up the plant, the cost of feedstock for the Anaerobic Digester to ingest and the cost of cleaning the Biogas in order to use as a high octane fuel. What is more Interviewee B, laments the fact producing Biomethane with all these capital costs is not feasible because it is not competitive in relation to the price of Natural Gas which comes out of the Sasol reticulated pipeline that they resell. Moreover, Interviewee B highlights the fact that the CNG market exists in competition with other fuels like Diesel and Petrol due to the fact that it cannot compete with fuel sources like coal which powers electricity. Due to the fact that coal can produce a thousand joules of energy at R24, where Petrol costs R392 for the same energy equivalent, for CNG to out compete coal would be impossible but against conventional fuels is advantageous. This therefore shows the economic realities of producing and using CNG as a transport fuel as opposed to a power generator fuel to be converted to electricity.

When viewing CNG in this competitive market it does however have an advantage over Diesel and Petrol in terms of production but when the source is from a Biogas origin it begins to lose its advantage to Petrol and Diesel. Furthermore, Biomethane becomes less realistic when you factor in the cost of: compressing; transporting, and the initial capital costs of producing Biomethane. However, it is not completely unrealistic or off the table to produce and sell Biogas if the appropriate measures are in place.

According to Interviewee B, if the right measures are put in place in order to foster the supply of Biogas then this would be used as fuel in replacement of Natural Gas. Interviewee B, argues that in order to be cost-effective, Biogas must be sold and compressed on the site which it is made, which is due to the transport costs of an already expensively produced gas in relation to Natural Gas.

Figure 21: Price difference of Energy Equivalents.

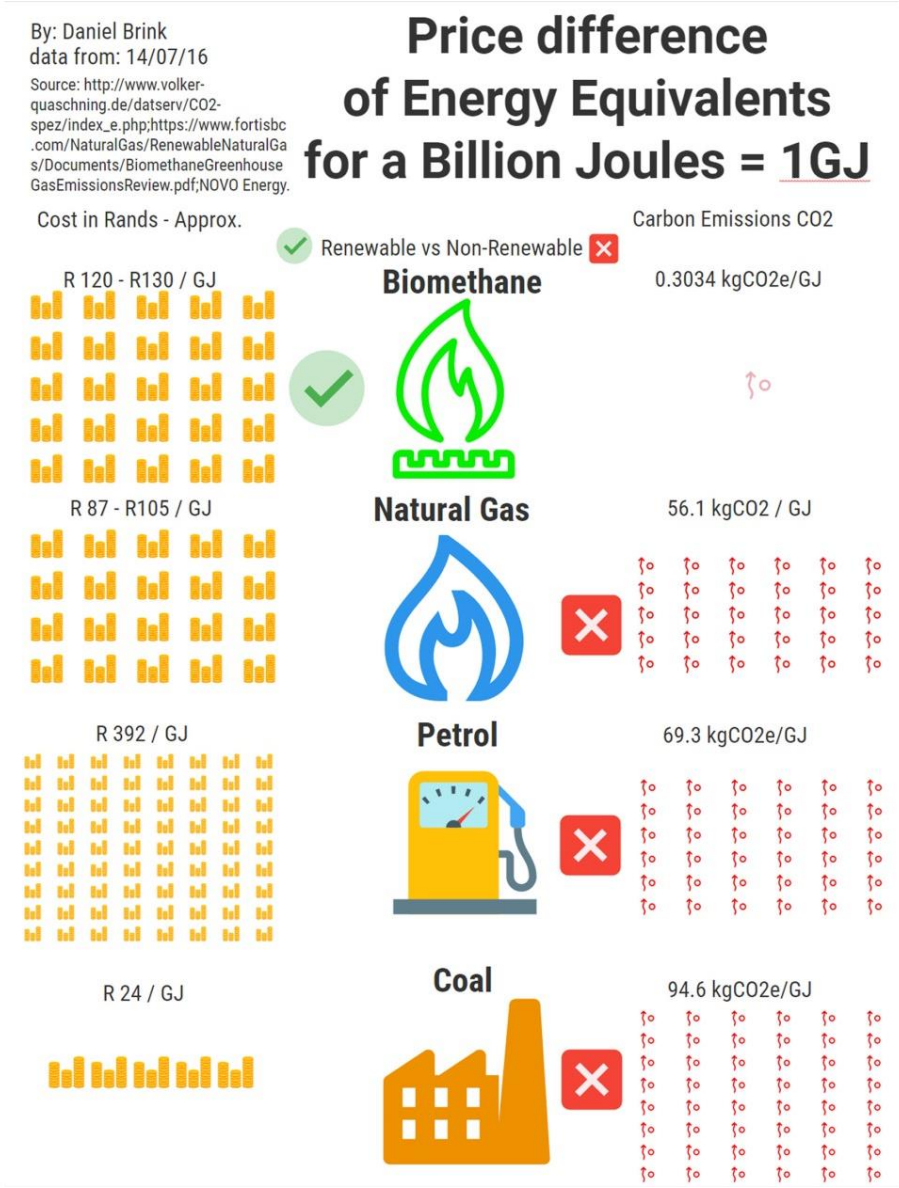


Figure 21 shows the relative price of Natural gas and Biomethane next to other fuels and also highlights the kg of CO2 emissions which they produce as well as which ones are renewable or not (Offsetters, 2011; Quaschning, 2015; Interviewee B).

Interviewee B states that the cheapest solution for Biogas would be to harness Biogas from landfills known as landfill gas, which comes from landfill waste sites. This would be substantially cheaper due to the cutting out of the cost of feedstock for the Biogas plant, as well as the cost of the plant itself. Furthermore, Interviewee B highlights the fact that landfills have specific conditions by which they can produce Biogas. The landfills have to be capped or covered at a certain height and only at a certain time after that, can the Biogas be taken out, cleaned and compressed for use in vehicles.

This process of turning Biogas from landfills into clean Biomethane with methane content of 92% and upwards was done by NOVO energy in the Sebenza municipality, the proof of concept evidenced there for consumers and stakeholders to see. The previous instance was covered in the LR under the Ekurhuleni metrowaste initiative, Interviewee B expands on the

fact that this initiative and others like it were highly politically charged and the use of the Biogas was intended for electricity generation purposes which is another use for Natural Gas however it is not as efficient and effective as when used in NGVs.

Interviewee B, remarks on the fact that landfills have a lifespan of about 15-20 years and that there is a peak and a trough of landfill gas production which needs to be understood when seeking to harness this gas as one would want to get it at its maximum production capability. This means that landfills basically run out of methane production after a while, however the rate at which Biomethane can be extracted from landfills does not exceed the speed at which landfill sites are being created.

What is more, water waste treatment is another form of Biogas production where the Biogas can be harnessed from and cleaned to become Biomethane. With that said this means that together with these alternatives and the possible creation of Biogas from Anaerobic Digesters, the potential supply of Biogas can always be greater than the demand for it as long as the right measures to produce it are adhered to.

Interviewee B has confirmed that the CoJ will acquire 150 new Mercedes Benz dual fuel buses via NOVO which will be maintained and operated with the help of NOVO as well as Vehicle Gas Solutions who are in charge of making sure this complex technology and all its specificities are understood and taken into account. This highlights the intent by the CoJ to move forward with this agenda and the economic complexities which go along with it.

5.3.3 Dangers of using Biogas, Natural Gas and CNG

What is more, Interviewee B states that the dangers of Biogas itself are only that if it escapes from its storage, it is highly rich in methane and is a GHG which is highly detrimental for the endeavour of climate change mitigation which is among others, the whole point of this fuel in the first place. Interviewee B continues that once Biogas is burnt and its energy used in whatever form is chosen then it is virtually harmless for the atmosphere and contains practically no CO2 emissions.

Interviewee B states that Natural Gas and Biomethane which are both methane rich are about 5 times lighter than air and are only flammable at concentrations of 5-15%, meaning that the

chances of it catching alight if leaked are highly unlikely as the gas dissipates too quickly and if there is too much of it also would not burn. Furthermore Natural Gas and Biomethane which are compressed into gas cylinders as CNG are safer than any conventional fuel including LPG.

What are more the procedures and licensing around the control of CNG use are highly stringent and regulated and the chances of an accident would only be a result of extreme negligence as this is highly unlikely. Interviewee B also remarks that steel cylinders which hold CNG are stronger than the petrol tank of a petrol or diesel automobile. Once more, Interviewee B maintains that the technology in the gas cylinders if compromised by collision or whatever kind of accident are so that the gas has a controlled release and is not enough to explode even if it were to be ignited.

5.3.4 Demand for CNG in Johannesburg market

Interviewee B states that NOVO themselves have barely tapped into one percent of the CNG market and that there are tremendously positive potentials for CNG in the market, where demand in a number of economic markets besides that of public transport technology includes: use in air-conditioning; electricity generation; transport logistics of raw materials; as well as industrial and commercial uses. According to Interviewee B, the current situation is that demand outstrips supply which shows a gap in the market for gas production and at the moment could be a hurdle to the use of NGVs along with the lack of infrastructure with which it is to be distributed. Plainly the demand for CNG is immense at the moment and the uses for which are also extremely diverse and becoming more diverse with the innovation of technological solutions to use Natural Gas as opposed to other fossil fuels like petrol, diesel or LPG.

5.3.5 Justifying the choice for Dual fuel technology

According to Interviewee B, the CoJ decided to go with dual-fuel buses rather than fully dedicated buses because of a report which was published by the Industrial Development Corporation (IDC) of South Africa. My interviewee continues that the IDC had a few different reasons why they analysed the dual-fuel buses as preferable. Interviewee B says these were that Johannesburg had limited infrastructure in terms of pipelines and filling stations, as well as the fact that this was a transition from diesel to gas. Interviewee B continues that the CoJ were not completely

comfortable with the availability of Natural Gas to be able to use completely dedicated buses and felt that the dual fuel buses would be a smoother progression towards NGVs.

Interviewee B, states that a serious drawback of dual fuel buses is that it is more effective on long distance trips due to fuel substitution reasons. Moreover, my interviewee laments the fact that the dual fuel buses are not as effective for inner city usage due to the stop-start nature of traffic and traffic lights in the city. Interviewee B states that basically this is because the dual fuel engine needs diesel to get the bus moving and the diesel can be substituted with Natural Gas in the engine.

This means that the dual fuel buses are not the correct decision for the Johannesburg context if the primary goal is to reduce carbon emissions as much as possible. Dedicated buses such as the Euro 6 buses being used in Tshwane would be more effective in this regard however there are other reasons why this was not possible but could be in the future. According to Interviewee B, the cost of converting a diesel Euro 4 bus into a duel fuel bus is about R200 000, furthermore, the cost of a new dual fuel Euro 5 bus from Mercedes costs in the region of over 2 million rand, give or take with the exchange rate. The extreme cost of these buses is obviously offset by the cheaper price of fuel and maintenance, where 190 new buses and 30 converted buses will be running on the roads of Johannesburg by the end of 2016.

According to Interviewee B, the use of dual fuel buses being used for public transport in the context of Johannesburg may produce carbon emissions equal to or even worse than that of the current Euro 4 diesel engines which are being used by the Rea Vaya buses. My interviewee believes this due to the issue with fuel substitution in stop-start instances as well as the fact that the Euro 4 engines in the Rea Vaya buses use have their own carbon emissions reducing technology. My interviewee was not certain on this as the data on the Euro 5 engine which makes up the dual fuel bus was not known to him.

5.3.6 Complexities of the CNG and NGV industry

According to Interviewee B, one of the main hurdles with regards to operating in a CNG industry is acquiring the gas supply itself as there are no on-shore gas deposits in South Africa. What is more, my interviewee states that the process of setting up infrastructure for this industry is highly capital intensive as well

as the fact that the market is highly regulated and the licensing to operate in this market is extensive and expensive. Interviewee B also highlights the fact that although the process of setting up is highly regulated by government, there are no state funding mechanisms to support this energy pursuit and all had to be privately funded.

Along with this, my interviewee maintains that initially the market had to be propelled and initiated by them as they made their services available. Interviewee B argues that by creating forward linkages to downstream value chains in the CNG industry ultimately caused the market to pull on and demand their services once they had been established. Interviewee B, states that NOVO energy basically had to sell the conversions of NGVs for free in order to show their efficacy and utility in order to get the market to demand their service for its advantages.

5.3.7 Feasibility of widespread NGVs in the city

Interviewee B asserts that there is plentiful knowledge, research, technicians and information in Johannesburg to feed a critical mass of people which would allow NGVs running on CNG to be possible on a widespread basis. However, my interviewee has highlighted the infrastructural challenges with making this transport type a reality and contributing to its overall sustainability. Interviewee B also brings to my attention that there are illegally converted vehicles which have not been converted by licensed entities. These illegal converted vehicles, Interviewee B says will not have been given a CoC and therefore will not be allowed to fill up their vehicles at a gas filling station.

Interviewee B maintains that demand for NGVs are existent, where there are pockets of individuals whom seek converted vehicles to use for personal use. Moreover, my interviewee states that demand for transport vehicles such as trucks and buses have more demand, but fleet delivery companies are becoming increasingly interested in this technology. In order to further make this technology a widespread reality and the extent to which NGVs can become sustainable relies on the technology reaching our shore. According to my interviewee critical mass of users of this technology will allow it to become cheaper through the concept of economies of scale. There are other macroeconomic factors which will also influence the reality of NGVs such as competing alternative fuel vehicles like electric cars according to my interviewee. Interviewee B highlights the fact that global vehicle OEMs have not really begun mass

producing NGVs and if this were to happen then the process of widespread NGVs could really be ignited. What is more, interviewee B argues that a central resource which would make NGVs and the CNG industry more feasible is the discovery or procurement of indigenous Natural Gas.

Interviewee B highlights the fact that NGVs can be in the form of Cars, Trucks, Buses, Ships, Trains, Motorbikes and even Aeroplanes, which shows the ability for CNG and NGVs to take the burden of the transport industry which is reliant on fossil fuels. Interviewee B is also of the opinion that NGVs have the potential to have an impact on the market of transport if it penetrates the market in such a way which offsets the demand for conventional fuels, this could also improve the country's trade deficit and help the country to not export so much crude oil.

Interviewee B, debunks a common myth about the range and consumption of NGVs, this is that the equivalent consumption of gas versus diesel or petrol will allow a vehicle to go further. According to Interviewee B, the range and consumption of a litre of diesel or petrol will give one the same range and consumption of a litre equivalent of Natural Gas. However, Interviewee B argues that the issue with the dual fuel buses is that the buses which were not built for CNG in the first place now have to carry the extra weight of heavy CNG cylinders as Natural Gas takes up more volume than petrol or diesel.

Moreover, Interviewee B states that the NGVs are restricted by how much energy they can fit into a cylinder, the more cylinders the more weight, which would counteract the energy needed to move that vehicle. Interviewee B also states that some NGVs have a better consumption to range ratio than petrol or diesel vehicles but the number of storage cylinders on the NGV must be correct. My interviewee continues that a strategic amount of CNG must be on board, not too much so that it becomes heavy and cannot get the range or consumption, which an equivalent volume of energy would provide for a petrol or diesel vehicle.

5.3.8 Environmental concerns of CNG & NGV industry

Interviewee B maintains that the extraction of Natural Gas is no more dangerous than that of conventional fuels, where some of the environmental concerns are that of carbon emissions and the fact that Natural Gas is non-renewable. What is more, the process of extracting Natural Gas could have some environmental impact depending on the way the gas is extracted,

says my interviewee. If hydraulic fracturing is used then certain chemicals can be hazardous to the water table, however there are also non-harmful extraction methods according to Interviewee B. Interviewee B, continues that the laying of pipes and setting up of extraction sites can have a footprint but more concerning is the instance of if the gas escapes without being burnt is the most hazardous as it is a concentrated GHG and will end up exacerbating climate change.

5.3.9 Potential state incentivisation of NGVs

Interviewee B, laments the fact that grants from the Department of Trade and Industry (DTI) which use to be available to help subsidise the development of alternative energy industries have been withdrawn. Interviewee B argues that many government tax incentives could be put in place to leverage this kind of energy industry. Interviewee B argues that incentives could be in the form of price reductions when renewing licenses on NGVs in the public transport sector or even in the form of reduced Etoll fees for NGVs. Another way to leverage the production and sourcing of NGVs and Natural Gas in order to make this transport alternative a reality, is to give tax incentives to licenced companies to produce Biogas and convert vehicles.

5.4 Interview with Renergen

After interviewing two companies who were immersed in the realities of CNG, NGVS and the sourcing of Natural Gas as well as Biogas, I was lucky enough to get some time with renewable energy company Renergen. When interviewing members of the company Renergen I was able to get some insights into a company who have managed to acquire rights to the first onshore Natural Gas reserves in South Africa. Access to onshore gas is of great importance for NGVs, the Natural Gas industry and the country in general. Since I have also promised to identify the interviewees from Renergen, Tetra 4 and Scania anonymously, I will collectively refer them as Interviewee C, since all the information was retrieved in the same interview.

5.4.1 Renergen's on-shore gas acquisition

Interviewee C states that Renergen together with its subsidiary Tetra 4 have managed to acquire rights to the first onshore Natural Gas reserves in the Welkom-Virginia Region of the Free State. Interviewee C, continues that Renergen have managed to begin extracting and compressing Natural Gas on site, which is either sold on site or put into cylinders on trucks and distributed

within 300 km of that area as an economically feasible at the moment. The Natural Gas which Renergen have found in the Free State area was found by drilling about 500 metres into the earth in multiple locations, according to Interviewee C.

Interviewee C asserts that the Natural Gas reserve which Renergen have commercialised, is an environmental marvel of the areas specific geology where deep seated bacteria, that exists on carbonaceous rock has produced a well of Natural Gas rich in methane. Moreover, according to Interviewee C, what this basically means is that this type of Natural Gas is deemed as a RE as opposed to the other Natural Gas reserves which are non-renewable. According to Interviewee C, the Natural Gas is being produced from the well biogenically, is being produced as quickly as the gas can be extracted; where research show that this well has been blowing gas since the 1950's.

5.4.2 Issues with storage of Natural Gas

As for the storing of Natural Gas, like Interviewee B from NOVO lamented, the issue is that even when compressed, CNG takes up a lot of volume, more than that of a petrol or diesel in terms of relative energy equivalents. According to Interviewee C, Renergen distributes CNG on trucks to its suppliers when it has been purchased, however it keeps its Natural Gas in its natural storage facility in the ground until it needs to be extracted, compressed and delivered to its consumer. This makes the process of selling CNG more cost effective as one of its drawbacks is that the storage of the CNG itself can be costly.

5.4.3 Environmental Impact of Natural Gas extraction

According to Interviewee C, the environmental impact of drilling into the geology of the Welkom-Virginia region will be minimal due to the unique geology of the area and the technologically advanced methods which they will employ. Interviewee C, states that the procedure will be as detrimental as drilling a borehole with no chemicals required to make the procedure successful and therefore no contaminating of the water table. Interviewee C highlights the fact that the whole process is regulated by the Department of Environmental Affairs (DEA), through the National Environmental Management Act (NEMA) whom has given Renergen the rights to extract Natural gas from their site under scrutiny of environmental concerns.

5.4.4 Social Impacts of Natural Gas endeavours

According to Interviewee C, Renergen and its partners have fostered the creation of bursaries, learnerships, internships and school development in the area of Virgina and Welkom. What is more, according to Interviewee C, the local bus service in the area will be supplied with CNG for its NGV buses which support the transport needs of the local community in a Sustainable manner.

5.4.5 Market challenges for CNG and NGVs

According to Interviewee C, the most favourable markets for CNG are in the transport markets such as Public Transport, which is being targeted in the NBM as well as fleet management which has also been identified by VGS and NOVO as the next markets to penetrate.

Interviewee C, states that the main challenge to NGVs running on CNG is the complete lack of infrastructure with which to refuel them, wherein the technology is here but is not supported by a network of supporting infrastructure. Another key hurdle to the endeavor of NGVs which have been highlighted by other interviewees, is the fact that there is not enough Natural Gas in Johannesburg, says Interviewee C.

5.4.6 Renergen impact on the future of NGVs

According to Interviewee C, the amount of Natural Gas which Tetra 4 is extracting from the ground per day would be equivalent of 40 000 litres of diesel. This number is set to increase according to Interviewee C, which means that the cost of CNG would be less than that of what is being brought in from Mozambique. Interviewee C states that in order for the CNG technology to become cheaper by manufacturing in Johannesburg would be unrealistic in the present and close future, where it is more cost-effective to import and use the European technology.

5.4.7 Advantages of using CNG and NGVs

According to Interviewee C, section 12L EE of the Income Tax Act states that tax incentives will be given tax payers who use alternative fuels like CNG. What is more, Interviewee C highlights the fact that savings from using NGVs will also be made by not having to pay the current emissions tax and carbon

tax which will be a reality in 2017. What is more, my interviewee remarks on the fact that the maintenance of the engines of NGVs is also cheaper due to being less frequent than vehicles using conventional fuels. These advantages coupled with the cheap price of Natural Gas in comparison to conventional fuels make NGVs a cost-effective solution once the capital costs have been incurred.

5.4.8 Dedicated buses vs Dual Fuel

According to Interviewee C, the dedicated CNG buses give you 20% less carbon emissions in comparison to vehicles on conventional fuels depending on the source of the Natural Gas. Interviewee C, argues that dual fuel buses work better on long distance trips in terms of CNG substitution to Diesel which is something which was also highlighted by Interviewee B. Interviewee C, also asserts that the dedicated buses have a better range than dual fuel buses due to the fact that the cylinders are category 4 and are lighter, therefore they can use less power to move the bus with the same amount of energy which would be in a converted dual fuel bus. Interviewee C highlights the fact that Mercedes Benz was the only OEM willing to provide a dual fuel solution for them as they had identified that this is what they wanted after testing the technology on the converted buses. According to Interviewee C, the Euro 5 diesel and CNG dual fuel buses provided to Metrobus by Mercedes Benz and NOVO, would produce carbon emissions which are basically same as the current Euro 4 diesel buses used by Rea Vaya. According to Interviewee C, due to the stop-start nature of the trips of the dual fuel buses they end up using about 70% diesel and 30% CNG, where the carbon emissions of which can't be measured, but if they were, they would not present a significant carbon emission reduction.

5.5 Interview with Interwaste

My last purposefully sampled interview was with the waste management company known as Interwaste. The reason I purposefully sampled this company was to explore their waste innovation initiatives. Due to the fact that Interwaste is involved with the removal and management of solid and organic waste, they have also begun turning this waste into a variety of different fuels. The fuel that I am most interested in is their Biogas from landfills which they have been producing. The potential of said Biogas for NGVs is of great importance as this is one of the most Sustainable form of this fuel in NGVs. Due to the fact that I have

also promised to identify my interviewees at Interwaste anonymously, I will refer to them here as Interviewee D.

5.5.1 Interwaste Biogas endeavours

Interviewee D states, that Interwaste produces large volumes of Biogas from landfills which are used for electricity generation, however they have been looking into the cleaning and compressing of this gas for us in NGVs. Moreover, Interviewee D highlights a number of complexities with the maintenance and creation of landfills which determines how much Natural Gas can be produced by a landfill. Interviewee D states that landfills have a lifespan which varies and depends on the way in which the landfill is managed. Interviewee D emphasises the amount of waste which one of their landfills received, sky rocketed from 8000 to 70 000 tons per month due to development happening around that area.

Interviewee D continues that this landfill will produce at least 1000 cubic meters of gas an hour for the next 30 years. Interviewee D, translates this into energy terms at 22 Mega Joules per cubic metre of natural gas, of which the Biogas is 55% percent Natural Gas also known as methane. Interviewee D maintains that landfills are constantly being filled up and new ones being developed, however the CoJ has not planned a landfill since 1990 and they have to find new space for landfills in farther locations.

5.5.2 Challenges of Producing Biogas

Interviewee D, also states that Interwaste use their food waste in Anaerobic Digesters to produce Biogas which is converted to electricity. Interviewee D asserts that using Biogas for electricity generation is easier than for use in NGVs due to the fact that it does not be compressed or cleaned as much. As Interwaste is a waste management company, they have licences to produce Biogas on the landfill site as well as with Anaerobic Digesters which is in their future plans. What is more, Interviewee D argues that the best way of producing Biogas is by using Anaerobic Digesters as you can control the feedstock and therefore control the type of Biogas comes out. Interviewee D claims that the feedstock going into an Anaerobic Digester will determine the extent to which you have to clean the Biogas in order to get Biomethane. What is more, Interviewee D highlights the fact that cleaning Biogas from landfills is more problematic as the elements in the landfill are so diverse.

Interviewee D agrees that producing Biomethane from their landfills is more expensive than just buying the Natural Gas from the Sasol pipeline and therefore they have not yet gone into compressing it and selling it which they have the potential to do. However, Interviewee D explains that Natural Gas companies like CNG holdings have approached them to use their landfill site as a compressing station where they would take the Biogas, clean it into Biomethane and then compress it and put it into their trucks and deliver it to wherever the demand for it is.

5.5.3 Market Potentials for Biogas

Interviewee D, asserts that there does exist demand for Biogas, most important of which, is that they have received interest from Metrobus who have shown interest in Biogas for their future endeavors. Interviewee D, states that although Biogas is an extremely green fuel, at the moment it does not make sense to sell economically. With that said, Interviewee D asserts that big municipalities like the CoJ have the drive and capability to procure it even though its cost is still high. Interviewee D states that the CNG market is still too young to make the production of Biogas for the express intention of use in NGVs, a reality.

Interviewee D believes that the conditions which shall force the use of NGVs using Biogas will be legislation such as carbon tax and emissions tax which has been emphasised by Interviewee C as well. Interviewee D maintains that no one in South Africa is using Biogas for NGVs by way of cleaning and compressing it, however there is a project in Cape Town which is earmarked to produce Biogas through an Anaerobic Digester which Afrox have agreed to buy and take to market.

"Natural gas is not a permanent solution to ending our addiction to imported oil. It is a bridge fuel to slash our oil dependence while buying us time to develop new technologies that will ultimately replace fossil transportation fuels."

Thomas Boone Pickens – (Nunez, 2014)



Chapter Six - Analysis of findings - Figure 22: Metrobus – powered by green fuel. Rea Vaya (2016)

Chapter Six - Analysis of findings

6.1 Overview

After gathering a wealth of information from my various interviews, I have grouped the information under themes and have distilled the information with regards as to how it answers my RQ. I have then analysed my findings as they pertain to my case study, the NBM, in order to elucidate how it reveals the extent to which it is Sustainable. Moreover, after I applied and analysed my findings to the question of my research, I used further information to recommend how this kind of Sustainable Public Transport can better add to the Sustainability of Johannesburg.

The introductory quote for this chapter intentionally gives away the key lessons of my findings which are that there are a lot of advantages, disadvantages and complexities involved with Natural Gas, CNG and NGVs. At the end of this chapter the reader will have a much better understanding of why Natural Gas is and should be a Bridge Fuel for Johannesburg's transport industry. A bridge to what is a question which has been illuminated by my findings and has been distilled at the end of this chapter.

6.2 Synthesis of NBM's drawbacks to Sustainability

Looking at the information given to me by my interviewees, I have grouped the information and analysed it into different themes which clarify the reasons why the NBM does not add to the Sustainability of Johannesburg.

6.2.1 High cost of NGVs and Infrastructure

Natural gas vehicles are very expensive at the moment as is the technology which is used to convert conventional vehicles to NGVs. The reason they are so expensive is because the technology is not manufactured here and has not been here for long enough. Furthermore, the infrastructure with which to distribute CNG does not exist in terms of pipelines and filling stations. Having a green fuel and environmentally friendly vehicles means nothing if they cannot be refueled and circulate the city efficiently. The capital cost of installing this infrastructure would be high of course, however the dual fuel Metrobuses which have been converted and procured cost in the region of

R200 000 and R 2 000 000 respectively. These issues with this sustainable transport are what detract from the City's Sustainability as it detracts from the economic sphere.

6.2.2 Issues with CNG as Fuel

As identified in the findings and LR, CNG is not a RE, meaning that a better alternative to this would be Biomethane which can be created in a number of ways clarified in the findings. Biomethane is more costly to produce and is currently not a feasible option chosen by any of the CNG sellers in the market. This means that all the dual fuel buses are running on Natural Gas which comes from Mozambique and is resold by various companies and parastatals. Although the price of CNG is cheaper than petrol or diesel, an indigenous source with much greater supply would even out the market equilibrium and reduce the price as demand currently outstrips supply. The issue with using CNG which is not from a Biogas source is that it is not renewable and therefore detracts from the cities Sustainability as it is a negative aspect towards the environment as it will eventually run out.

When looking at the well-wheel efficiency of CNG which was clarified in the LR, the environmental impact of extracting Natural Gas in Mozambique also adds to the negative environmental impact of the gas extraction. CNG as a fuel takes up a large volume of space and therefore has to be compressed in order to maximise the energy potential it has per area. Once the CNG is compressed and stored, the cylinders which it is stored in need to be of a special material so that they are not too heavy and weigh their carrying vehicle down as this would impair performance and range. This endeavour of storing the fuel in special cylinders and being restricted to how much a vehicle can carry obviously has costs and therefore detract from the ability with which dual fuel buses can make Johannesburg Sustainable.

6.2.3 Issues with Dual Fuel buses

The dual fuel buses which have been chosen by the CoJ for the NBM were chosen due to the lack of infrastructure as well as the scarcity of CNG. The decision was made in order to allow for flexibility to run on both or either fuel mode; however this means that the carbon emissions reductions which would have normally been up to 20% better than Diesel are now about the same. This means that the environmental initiative is not as effective as it

could be and therefore detracts from the extent to which it makes Johannesburg Sustainable.

6.2.4 Governance drawbacks to Sustainability

A fourth sphere of Sustainability is often referred to as the governance sphere, in relation to this, the NGV and CNG industry is heavily regulated by this in order make sure that vehicles pass a certain standard and maintain the safety of these vehicles which is paramount. The issue is however that the only entities who are being regulated are the ones who involved in the legal operations and illegal retro-fitters are not reprimanded. This instance shows limited governance capacity to deal with illegal issues and detracts from the extent to which the dual fuel buses make Johannesburg Sustainable.

6.3 Synthesis of NBM's benefits to Sustainability

I have furthermore grouped the rest of the information from interviewees and analysed it in different themes which seek to clarify the reasons why the NBM does add to the Sustainability of Johannesburg.

6.3.1 Relative cost saving relative to conventional Fuels

Although there is a shortage of Natural Gas in South Africa and Johannesburg, the price of Natural Gas and therefore CNG is significantly cheaper than Petrol and Diesel. The fact that CNG presents a significant savings in petrol price is the reason why dual fuel buses add to the economic dimension of overall Sustainability of Johannesburg.

6.3.2 Safety of Natural Gas, CNG and NGVs

There are many misconceptions about Natural Gas such as the fact that it is dangerous, however Natural Gas and therefore CNG is much safer than Diesel or Petrol. The reason it is safer is due to the fact that Natural Gas is only flammable in concentrations of 5-15% which is a tiny spectrum to potentially ignite and is highly unlikely.

Moreover CNG is stored in cylinders stronger than that of a conventional vehicles petrol tank and even if the gas were to escape due a massive force, the force at which the gas escapes due to its compression would not allow it to ignite. Natural Gas should not be confused with its highly flammable cousin LPG

which is a lot more dangerous. This safety of CNG and Natural Gas which is the fuel of the dual fuel Metrobuses is what attributes to the overall social dimension of Sustainability in Johannesburg.

6.3.3 Job Creation due to NBM

Since the introduction of the NBM, which has been rolled out in conjunction with a number government policies, it has seen the creation and development of pockets of industry relating to CNG and NGVs. The conversion and maintenance of NGVs in the dual fuel buses themselves has created jobs with OEMs locally such as NOVO energy and Vehicle Gas Solutions and all their employees. What is more, the sourcing of the gas from resellers which the dual-fuel buses need to be powered on has also initiated some economic growth. Additionally the advent of the NBM has created some pull in terms of the NGV and CNG industry in Johannesburg with other consumers identifying an alternative fuel solution to adapt to and therefore creating spinoff effects. These positive economic effects of the NBM programme can be considered as add to the overall Sustainability of Johannesburg.

6.3.4 Regulative aspect of NGVs and CNG

In relation to the governance sphere of Sustainability, it can be said that the NBM programme and the NGVs which it has given rise to be regulated by a competent body in the Department of Labour who have made sure that these vehicles comply with standards and are safe. With this attention to regulation, it has given power to entities to refuse non-compliant and illegal NGVs from refueling there vehicles and thus preventing dangerous vehicles from entering the market. This evidence of strong governance with specific regards to the NBM shows that they add to the Sustainability of Johannesburg from a regulative perspective.

6.3.5 Advantages of dual fuel NGVs

As it has been made clear that dual fuel buses do not have the carbon emission reduction advantages which they could have if they were dedicated, where they do benefit is the fact that the maintenance of their engines is cheaper due to the fact that they have less wear and tear on the engine and can come in less frequently to be fixed. Another benefit of NGVs such as dual fuel buses is that they have shown better consumption ratios as

opposed to Diesel buses and therefore are more cost-effective with fuel costs. These advantages represent a dimension of economic Sustainability which the dual fuel buses bring to Johannesburg.

6.4 Concluding insight of analysis for Sustainability

Lastly, I have grouped the overarching information which transcends my research question and analysed it in further themes which explore how the NBM and the Sustainable Public Transport agenda of the City can better add to the Sustainability of Johannesburg.

6.4.1 CNG as a Bridge Fuel

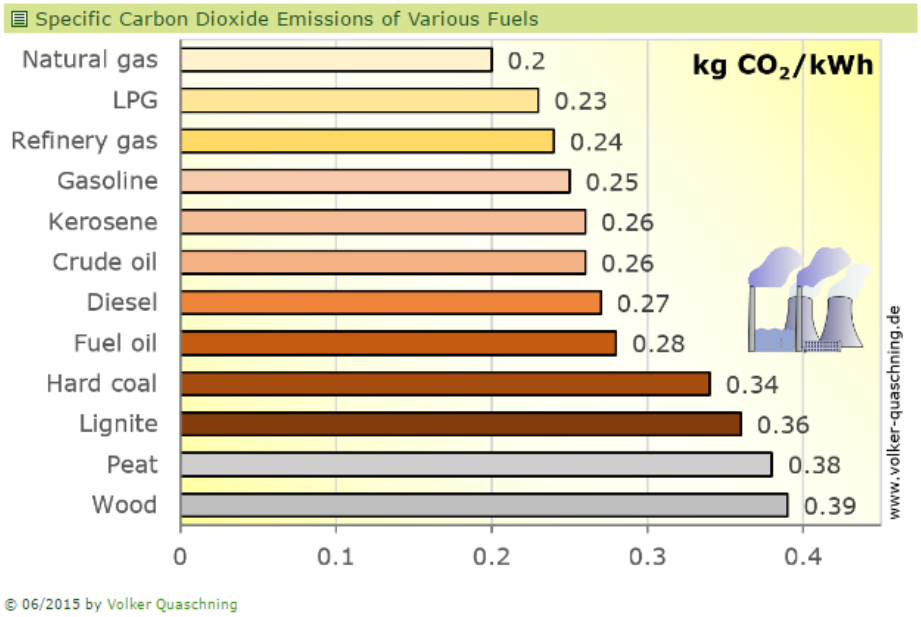
The concept of Natural Gas being a Bridge fuel has been mentioned in the LR, however in the case of Johannesburg through the lens of the NBM programme can now see why this is true. The choice to use Natural Gas and convert it to CNG for use in dual fuel buses has a number of reasons which have been thoroughly clarified; however I believe that the use of CNG in dual fuel form is just the beginning. Not only is CNG in dual fuel just the beginning, but it is a bridge to give rise to more Green and Renewable forms of energy. Use of CNG is a bridge because it will allow us to reduce our dependence to fossil fuels over time and allow us to replace them with other REs which are out of reach due to highly capital intensive infrastructure costs. Once infrastructure is built and markets are developed, the bridge can be transcended and we can begin utilising greener and more renewable fuels and technologies which were previously unfeasible. The options of what can be utilised once infrastructure is developed are just around the corner and the opportunities are available everywhere. I have outlined some of these opportunities to make Metrobus' NGVs contribute more effectively to the CoJs Sustainability in the following sections.

6.4.2 NBM going dedicated

If infrastructure of pipe reticulation and CNG filling stations can become abundant in the City with time, then Metrobus can begin adopting the dedicated buses which run solely on CNG and present a much higher reduction in Carbon Emissions. Dedicated CNG buses can achieve up to 20% reduction emissions in Carbon Emissions depending on the source of their CNG. What is more, dedicated buses have shown improved

consumption, range and reliability, as well as maintenance savings due to the fact that they are expressly built for the intention of using CNG. Dedicated buses would increase the extent to which the city would be Sustainable from the environmental perspective.

Figure 23: CO2 of Different Fuels. Volker Quaschning (2015)



6.4.3 using a Renewable Source of energy

In order to improve the extent to which the NBM programme adds to the environmental dimension of Johannesburg's Sustainability, a revolutionary initiative would be for the Buses to be run on CNG which has its origins as Biogas and Biomethane. If Metrobus begins running dedicated buses using CNG from a Biomethane source, assuming of course it has become feasible due to the infrastructure being in place and the compressed Biomethane supply becoming abundant then immense environmental benefits can be achieved.

Dedicated Metrobuses running on compressed Biomethane can achieve up to 200% reduction in carbon emissions due to the concept of well to wheel efficiency and carbon neutrality which has been explained in the LR. What is more these buses would catalyse a Natural Gas industry which would not only provide jobs for Biogas producers, cleaners and compressors but also for waste management. In the event of this being possible waste will be recycled for the gain of Bus fuel and economic growth will be stimulated through job creation and the bi products of which can be used as further spinoffs as fertilizer in the agricultural industry.

A company which is already producing Biogas known as Interwaste has displayed the ability to produce large volumes of Biogas but since the cleaning, compressing and selling of this is not feasible yet, it has not been done. However if the conditions become favourable in the market for this then the kind of capabilities are evident.

According to my research findings the Interwaste Landfill can produce 12 100 Mega Joules of natural gas per hour for the next 30 years once it is cleaned, this equates to 12.1 Giga Joules of energy every hour for 30 years. A Giga Joule of Natural Gas is equal to 27.7 litres of Diesel (Go with Natural Gas, 2014). If Interviewee B in my findings is correct and dual fuel buses can get the same power per Giga Joule as can be achieved from diesel buses, than dual fuel buses will be able to go 100 km on every Giga Joule, as Diesel buses get approximately 100 km per every 27 litres of diesel (Go with Natural Gas, 2014).

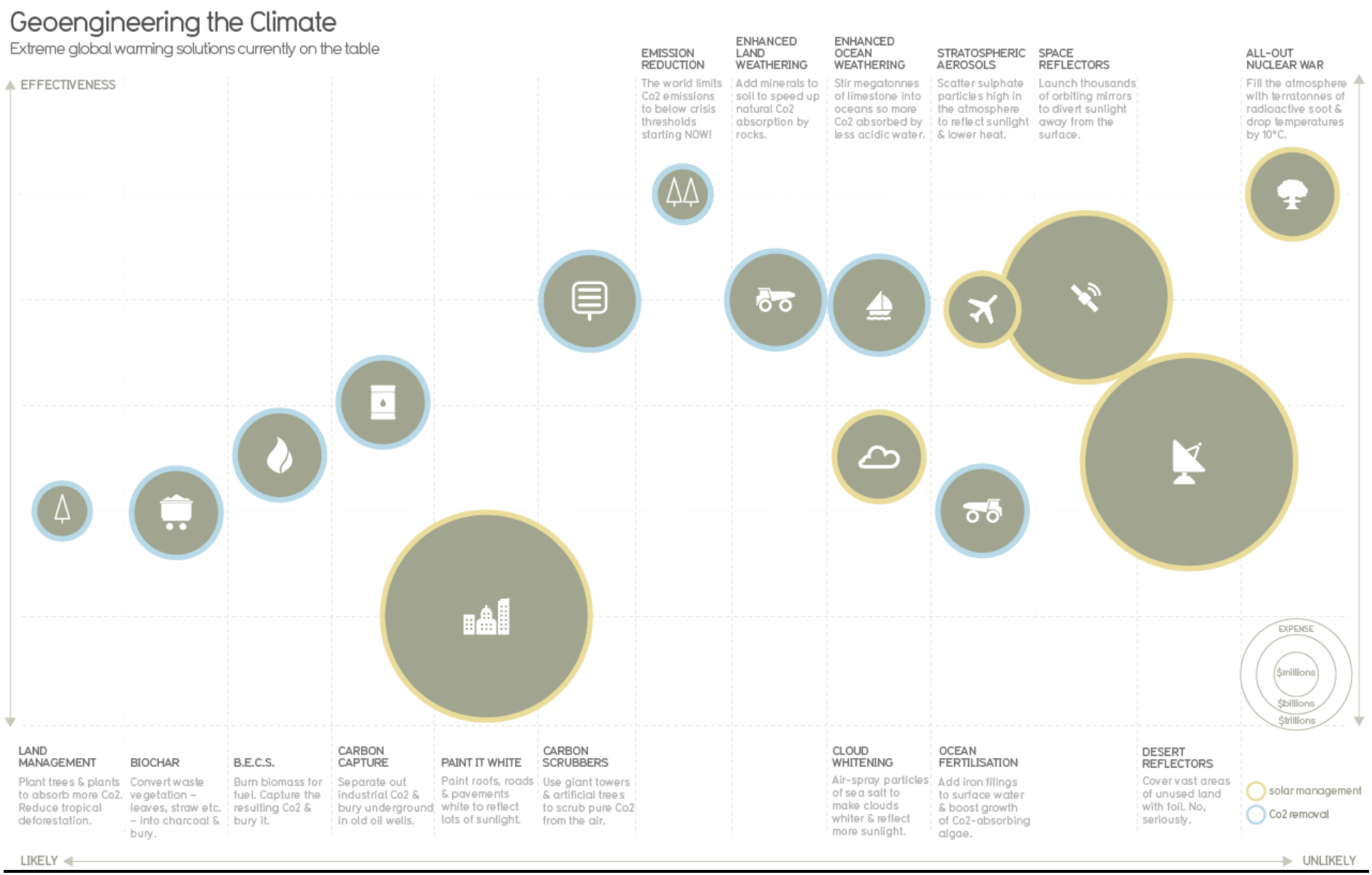
With this logic every Giga Joule of Natural Gas from an Interwaste landfill, will send a Dual Fuel bus 100km, thus the Interwaste Landfill in question would in theory be able to produce enough energy every hour to send a dual fuel bus 1210 km for the next 30 years. However, this is assuming that all the steps were taken to extract, clean and compress the Natural Gas to put into the dual fuel bus which comes with its own complexities. If the appropriate steps are taken to reach this goal of Sustainable Public Transport by Metrobus then this would represent Economic, Social and Environmental gains to Sustainability in Johannesburg.

6.4.4 Carbon Tax leveraging Sustainability

According to my research findings on Carbon Tax, Emissions Tax as well as the new Income Tax act, using alternative fuels which make large Carbon Emission reductions in our Public Transport Industry would represent extremely significant savings. Moreover, when the Carbon Tax and other associated legislations take hold, the consequences of not using the greenest fuels possible will be an extremely negative economic penalty to incur. Therefore if NGVs and more specifically our Metrobus fleet can maximise its environmental Sustainability, then this will also contribute to the overall Sustainability of the country Economically and Socially.

6.4.5 Other feasible RE Sources

In order for the Metrobus NGV fleet to become more Sustainable, they would ideally seek to access the Biogenic gas wells which have been acquired by Renergen, through a pipeline which they would then compress close to their Bus depots in Johannesburg. If the infrastructure were to be made available over time then this endeavour would represent an improvement of Environmental and Economic Sustainability. Due to the fact that the Biogenic gas is Renewable and can achieve up to 200% carbon emission reduction due to its carbon neutrality (a concept clarified in the LR), Metrobus would be massively contributing to the Sustainability of Johannesburg.



Chapter Seven – Conclusion - Figure 24: Climate Change Solutions. Information Is Beautiful (2016)

Chapter Seven – Conclusion

7.1 Overview

In this report I followed a logical progression of ideas, where I nailed down a research question and title after making and observation which I wanted to understand. I then articulated my question in the correct manner with specific attention to the words I was using in order to sharpen my focus. Once my research question had been elucidated I then introduced the context in which my observations and questions came from. This was the warm up to my first chapter and set the tone for my research report.

7.2 Executive Summary

This section will serve as a concise summary which details the journey of my Research Report from start to finish and will succinctly highlight the path which I have taken in answering my RQ and SQ's

7.2.1 Chapter One - Introduction

This Chapter is where I located my RQ in its context and what kind of challenges and complexities surrounded it, moreover I elucidated why I chose this question and the origins of my observation. I situated my RQ and SQ's in the paradigm of a Town Planner and clarified why this endeavor would be of use to the discipline. The distillation of my RQ and SQ's can be traced from the journey of research which is explained by my introduction. Some of the highlights were the grey literature which my case study known as the NBM were born out of and what the agenda of that policy was intended to do. The main argument of the NBM was to us e alternative green fuels in order to fulfill the pledge which was made by Johannesburg at the C40 Cities Summit.

7.2.2 Chapter Two - Literature Review & Conceptual Framework

The second chapter is an intensive summation of all the knowledge which applies to CNG, NGVs, Sustainability and anything which pertains to the case study. The point of this chapter was to understand how technical the question was and

order to find answers to it, technical information needed to be known so as to give a technical answer. This chapter understands that the only way to solve a problem is to understand it, where understanding the technical nature of the case study and RQ was the only way to answer the question and go further recommend ideas on solving the problem. All the Information would then be grouped in to concepts for which the concluding insight as they pertain to my RQ would be succinctly outlined.

7.2.3 Chapter Three - Research Methodology and Methods

Chapter 3 describes the way in which I would go out into the field and attempt to gain new knowledge, which could be added to the current knowledge on the concepts in which my RQ is situated in. The method of how I would approach retrieving this knowledge was defined with ethical considerations also framing their agenda. Additionally the science behind my method by which I would retrieve knowledge would be understood and adhered to in order to make sure that I would get the kind of findings which would help me to answer my RQ. The science of my method would be a case study and the method itself would be underpinned by semi-structured interviews which had been purposefully sampled in order to give me the information I needed to answer my RQ.

7.2.4 Chapter Four - Point of departure for the 'New beginning of Metrobus'

In chapter four I outlined the case study through which I would be answering my RQ and where the case study originated from. What is more I located the case study and explained its qualitative nature where it was explained that my case study was issues based. The NBM is the name of my case study and it describes a situation where the CoJ procured and restocked their vehicle fleet with dual fuel buses which use more alternative fuels. The NBM as a case study was to be explored so as to find out how it was unique from similar projects around the world and what this means for the Sustainability of Johannesburg.

7.2.5 Chapter Five - Findings

In my findings I synthesised information which I extracted from my purposefully sampled, semi-structured interviews and grouped them under similar themes in order to succinctly make

sense of the information which I had received. While synthesising information from interviews, I managed to keep in mind how this information related to my RQ and how it could help me answer it.

7.2.6 Chapter Six - Analysis of findings

Once I had distilled the information from my interviews while being cognizant of the technical information which I had learnt in the LR, I began interrogating that information with regards to what it meant for my RQ. Information which I had collected allowed me to answer my research question but also made me think further as to recommend what more could be done to fulfill the pursuit of my RQ. After I had managed to use the distilled information to answer my RQ and SQs, I followed the secondary information which gave me the insight as to how I could recommend.

7.3 Conclusion - Answering of the RQ and SQ

In order to summarise I will highlight the main points of my research and clarify how they have allowed me to answer the questions which I posed at the beginning of my report**.** This will serve as qualitative insight as to how Sustainable the NBM programme has been for Johannesburg according to the information I have synthesised from my interviewees. In order to build up to the answering of my RQ, I will start with the SQ's as they inform how the main RQ is answered.

7.3.1 What led to Metrobus using CNG in NGVs?

The municipal entity Metrobus, decided to refleet their bus fleet with dual fuel buses because of the Mayor at the time, Parks Tau's mandate to reduce carbon emissions. Parks Tau's mandate arose from his pledge to the C40 Cities Climate Leadership group which is a global association of cities and their mayors whom are dedicated to reducing climate change. What is more, the procurement and use of these dual fuel buses was labelled as the NBM programme, which was a strategy rolled out under the GDS 2040 and Metrobus Operational Plan. Some of the goals which Metrobus was trying to achieve under these policies and plans were: consumption savings; carbon emission reduction; and job creation in the alternative fuel market.

7.3.2 What is CNG and NGVs about?

CNG's and NGV's refer to Compressed Natural Gas and Natural Gas Vehicles which were clarified in detail in the LR. The dual fuel buses which Metrobus are using are a type of NGV and the fuel which the run on is CNG and Diesel. There are multiple complexities with using CNG and NGVs some are advantageous and others, a challenge. Using CNG is a cheaper and cleaner fuel than Diesel; depending on its origin it can reduce carbon emissions from 20-200% in relation to Diesel. NGVs however, are a lot more expensive than conventional vehicles and the process of converting conventional vehicles to NGVs can be very costly. What is more, CNG is safer to use than Diesel but is more problematic to store in quantity as it is less dense. There are tradeoffs when considering the correct alternative fuel, but if done appropriately, the savings in terms of Sustainability by NGVs outweigh that of conventional vehicles.

7.3.3 What are the costs and benefits of using dual fuel Metrobuses?

The benefits of using dual fuel Metrobuses is the savings made on the CNG which it runs on as this is cheaper, however due to the mechanical features of the dual fuel engine, savings on carbon emissions are negated. This would not be the case if the dual fuel buses were either used on long distance trips or were dedicated, meaning that they run on only CNG. The reasons for these choices were justified by the facts that there is not sufficient Natural Gas or Infrastructure to support the use of dedicated buses. The costs of dual fuel buses are the cost of converting them and or purchasing them which will cost about R200 000 and R2 000 000 respectively.

7.3.4 How do dual fuel Metrobuses contribute to the Sustainable City?

At this current moment, dual-fuel buses do not contribute to Sustainability in Johannesburg, the reason being is because the savings that they make on fuel does not outweigh the cost of procuring them in the short run. What is more, the dual fuel buses do not produce less carbon emissions than the diesel

buses which they are replacing but have similar emission results. Furthermore, the jobs which dual fuel buses create in the short term are not penetrating deeply enough to offset the cost of their maintenance. When looking at the criteria of Sustainability, dual fuel buses do not make significant gains to Environmental, Economic or Social Sustainability and therefore cannot be considered as Sustainable as of yet.

7.3.5 What lessons can be taken from the case study, to increase the usefulness of NGV transport?

When looking at the NBM programme as a case study, there are clear lessons which can be taken into account in order to increase the extent to which the dual fuel buses are Sustainable. Assuming that Natural Gas supply is increased with the onshore discoveries by the company Renergen, as well as the development of Natural Gas and CNG infrastructure then the reality of NGV transport can be realised.

7.3.6 How useful are dual fuel Metrobuses for Sustainability in Johannesburg?

In order to answer this RQ, I have used the SQs to set up my argument and elucidate the extent to which dual fuel Metrobuses are Sustainable. The research in this report shows that dual fuel Metrobuses are not Sustainable and do not add to the city's Sustainability. Although they do have some benefits, they are not Sustainable overall because the positives of one sphere of Sustainability negatively impacts on another. In order for an endeavor to be Sustainable it has to add positively to each sphere and not negatively impact on another.

7.4 Concluding Opinions & Recommendations

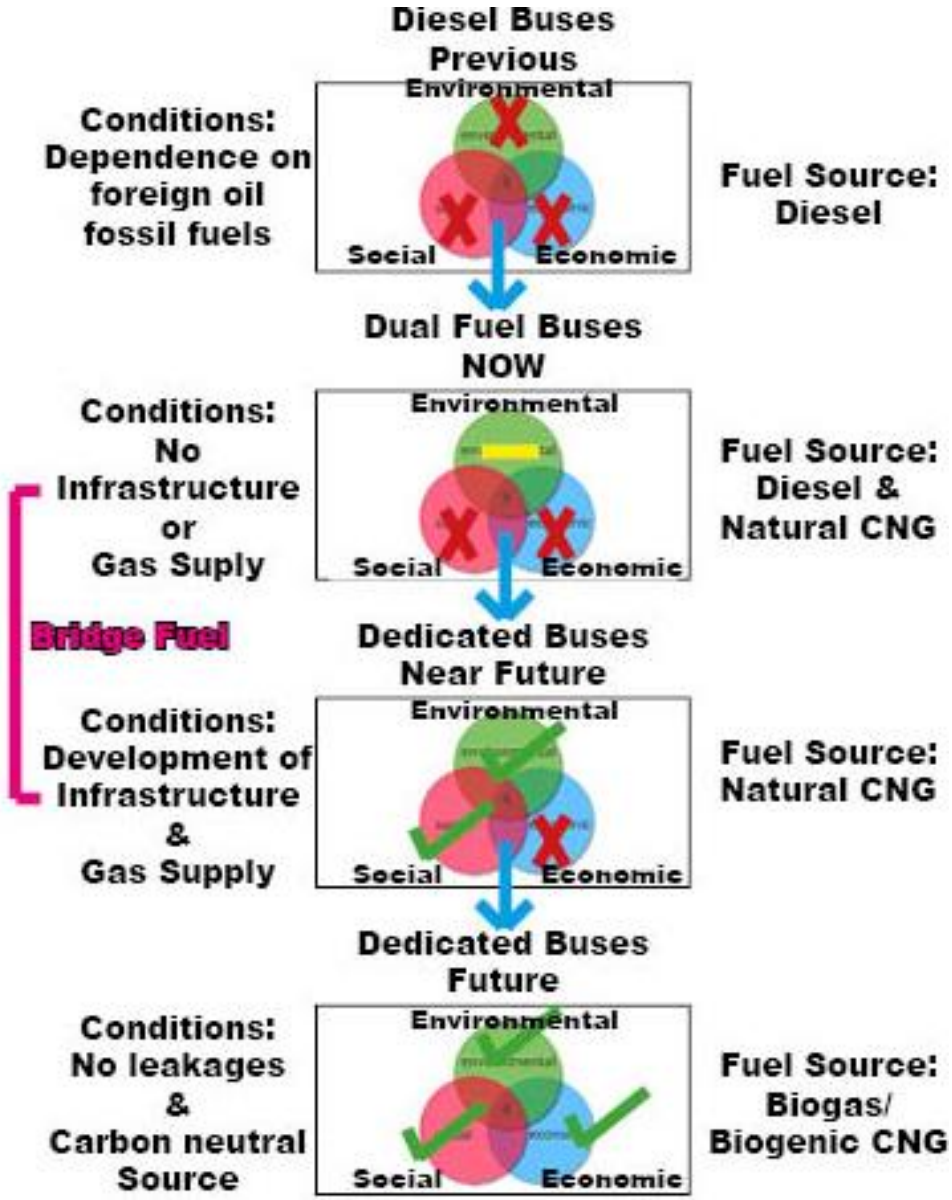
The information which I have learned through this research report has allowed me to answer my RQ, but has also given me extended insight which relates to the future endeavors of Sustainability for Metrobus and the CoJ. Although dual fuel Metrobuses are not currently adding to the Sustainability of Johannesburg, they can however become Sustainable and positively add to the overall Sustainability of Johannesburg. My research shows that a few recommendations for Metrobus can be considered in order to drastically increase the extent to which its buses contribute to Sustainability.

My first recommendation is that Metrobus switch to dedicated buses which use only CNG in order to get the full emissions, range and consumptions savings of this kind of technology. In order to switch to dedicated CNG buses Metrobus will first have to use dual fuel while the infrastructure and gas supply from available sources is made available. Additionally, Metrobus should begin using CNG which is made from Biomethane or alternatively they can exploit the Biogenic Source which Reneregen have commercialized which would be equally as good and more convenient.

By switching to these sources and compressing them into CNG, the carbon emissions savings would be up to 200%. What is more, if Metrobus utilize Biogas sources then they will be able to stimulate jobs in this regard as well. Furthermore, if Metrobus is able to achieve the carbon emissions reductions from the sources mentioned above, then they will benefit proportionately in savings on carbon tax, emissions tax and the new income tax act. If Metrobus' NGVs are able to achieve all of these recommendations together with the stimulation of the CNG and NGV market, then the endeavor of CNG Bus technology would positively add to the overall Sustainability of Johannesburg.

Figure 25 on the next page, illustrates a horizontal succession of the 3 spheres of Sustainability. The diagram shows how Metrobus can become more Sustainable in their transport agenda by choosing the correct fuel source; NGV type and conditions by which to achieve overall Sustainability. The concept of: 'Natural Gas as a bridge fuel', is illustrated here and shows how a fuel like Natural Gas is necessary to get to Renewable Energy through reducing our dependence on fossil fuels like Diesel.

Figure 25: 'Potential Sustainability trajectory for Metrobus in Johannesburg'.



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Appendix

Pro forma - Consent Form

FORMAL (SIGNED) CONSENT FORM

Investigating 'CNG' technology: An Interview survey

I hereby confirm that I have been informed by the student researcher of the purpose, procedures, and my rights as a participant.

I have received, read and understand the written participant information sheet.

I have also been informed of:

□ the nature of my participation in the form of an interview
□ the fact that the interview will take place at my premises for no more than
1 hour
□ the reasons why I was selected to participate in the study
□ the voluntary nature of the interview
□ the fact that I reserve the right to refuse to answer if I choose to
□ the fact that I may choose to withdraw from the study at any time
□ the fact that no payment or incentives will be given
□ the fact that there is no loss of benefits or risks involved
□ the fact that anonymity is assured
□ the fact that confidentiality is assured
□ how the research findings will be disseminated
I therefore agree to participate in this study, in the form of an interview, to the extent that I am comfortable with.

I AGREE / DO NOT AGREE to audio-recording during interviews.

I AGREE / DO NOT AGREE to notes being taken during interviews.

PARTICIPANT:

_____

Printed name

Signature Date

_____ _____

Pro forma - Participant Information Sheet

PARTICIPANT INFORMATION SHEET

Investigating the usefulness of dual fuel for Sustainability in Johannesburg, through the 'New Beginnings' programme.

Greetings

My name is Daniel Brink and I am currently a full time student studying towards a BSc (URP) with Honours in the School of Architecture and Planning at the University of the Witwatersrand.

I am currently investigating the extent to which compressed natural gas (CNG) technology is being used successfully in Johannesburg.

I am inviting you to be a part of the study through a semi-structured interview, which will take place at the location of your business for no more than one hour.

The interview will be recorded using an audio recorder and hand written notes, unless you do not agree to one, in which case I will use which ever one is preferred by you, the interviewee.

You have been selected to participate in this study due to your involvement and knowledge around CNG and renewable energy (RE).

Your participation is voluntary, you may refuse to answer any questions that make you uncomfortable, and you may withdraw from the interview at any time without any penalty or loss.
You will receive no payment or other incentives for your participation. Your participation will be completely anonymous and you will not be personally identified in the final report.

You will be referred to as a CNG enthusiast; however your organization may be identified. Any information that you share will be kept confidential and can only be accessed by me on a password protected computer.

There are no foreseeable risks associated with your participation. The research undertaken is solely for academic purposes and once completed will be available electronically and can be accessed publicly.

If you have any questions, concerns, or comments or if you would like a copy of the final report, please feel free to contact me at 381157@students.wits.ac.za or my supervisor at brian.boshoff@wits.ac.za

Signature

Daniel Brink

Ethics Clearance Certificate

[redacted]

SCHOOL OF ARCHITECTURE AND PLANNING
HUMAN RESERCH ETHICS COMMITTEE

SCHOOL of ARCHITECTURE PLANNING

CLEARANCE CERTIFICATE
PROTOCOL NUMBER: SOAP66/24/06/2016

PROJECT TITLE:	Investigating the usefulness of CNG Metrobuses for Sustainability in Johannesburg, through the 'New Beginnings' Programme
INVESTIGATOR/S:	Daniel Brink (Student No. 381157)
SCHOOL:	Architecture and Planning
DEGREE PROGRAMME:	BSc Honours Urban and Regional Planning
DATE CONSIDERED:	18 July 2016
DECISION OF THE COMMITTEE:	APPROVED
EXPIRY DATE:	18 July 2017

CHAIRPERSON
(Professor Daniel Irurah)

DATE: [illegible] 2016

cc: Supervisor/s: Brian Boshoff

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 ensure 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.

Signature **Date** 28/07/16

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