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Envisioning adaptations towards a zero-carbon well-integrated urban transport network for Johannesburg communities: The case study of Orange Grove.

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

University of Witwatersrand

Johannesburg

01 February 2019

Declaration

I, Lawrence Chetty declare that this research report is my own unaided work except where otherwise acknowledged. It is submitted for the degree of Master of Architecture at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any University.

_____

Signature of Candidate

On the 1 day of February year 2019

Abstract

Since the dawn of the industrial revolution, intensive use of fossil fuels has caused high levels of greenhouse gases to build up in earth's atmosphere; this in turn has triggered global warming and changing climatic patterns. Scientists have linked climate change to adverse weather patterns like unpredictable rainfall, drought, rising global temperatures, melting glaciers, and changes in ocean salinity. South Africa has experienced severe droughts in different parts of the country in recent times where it has been speculated that climate change could be the cause. South Africa is also experiencing other issues like rapid urbanization, poverty, unemployment, food and energy insecurity, and inequality. In recent post-apartheid years, South Africa has aimed to address these issues and reconnect previously disadvantaged areas to better economic and social opportunities. The Corridors of Freedom is one such initiative which has taken up the task of re-imagining the City of Johannesburg through spatial transformation and transit-oriented development. The intention of the initiative was to be inherently sustainable, aiming to reduce urban sprawl through densification, promotion of public transport, cycling and walking and reduction of private vehicle use. However, being largely fossil fuel dependent, the current and planned transit systems are unsustainable both in terms of climate change impacts and the depletion of fossil fuel resources.

This study investigates the potential of suburban neighborhoods to be transformed through retrofitting with interventions that mitigate climate change. The purpose of such transformation would be to create Eco-Cities and reduce fossil fuel dependency. At a social level, this explorative study examines the benefits and challenges of effecting transitions towards sustainable human behavior and lifestyles including racial and economic integration. At an environmental and economic level, the requirements of retrofitting a suburban neighborhood for such a change is provided. As part of the research strategy, scenario planning is used to envision a zero carbon, well-integrated transit lifestyle by 2050. Global zero carbon transport interventions were explored and through a process of elimination the most appropriate interventions were selected for Orange Grove. This process was assisted through site observations, secondary data analysis and semi structured interviews. This report informs the interested reader, City of Johannesburg municipal officials and Orange Grove residents on alternative energy options for providing clean and efficient transport. It is hoped that insights gathered from this study can contribute not only to the adaptation towards zero-carbon and well-integrated lifestyles in suburban Orange Grove but could be applied to similar communities in Johannesburg and beyond.

Dedication

This research is dedicated first to my Saviour Jesus Christ, thank you for second chances.

To my dad, Mr. Balen Chetty, I miss you dearly, thank you for guiding me.

To my mum, Mrs. Angie Chetty, thank you for unconditional love.

To my beautiful wife Jessica, and children Brandon, and Annabella, you mean the world to me, thank you for putting up with me and not kicking me out of the house.

To my sister Lorraine, brother Gregory and your families Louis, Lorrissa, Karishma and Ephryn thank you for your love and support.

I love all of you.

Acknowledgements

Thank you to my supervisor Dr Gerald Chungu and Professor Daniel Irurah for teaching and challenging me for which I am eternally indebted to them.

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List of Abbreviations

AC	Alternating current
ASI	Avoid-Shift-Improve
BEV	Battery Electric Vehicle
BRT	Bus Rapid Transit
CBD	Central Business District
CO_2	Carbon dioxide
CNG	Compressed Natural Gas
COP	Conference of the Parties
COF	Corridors of Freedom
CoJ	City of Johannesburg
DC	Direct Current
DOT	Department of Transport
EDGAR	Emission Database for Global Atmospheric Research
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
GHG	Greenhouse Gas
GtC	Gigatonne of carbon
ICT	Information and communications technology
ICE	Internal combustion engine
IEA	International Energy Agency
IOT	Internet of things
IPCC	Intergovernmental Panel on Climate Change
ITS	Intelligent transport system
JDA	Johannesburg Development Agency
JRA	Johannesburg Roads Agency
KW	Kilowatt
KWh	kilowatt hour
$MtCO_2$	Metric tons of Carbon dioxide

NDC	Nationally Determined Contribution
NERSA	National Energy Regulator of South Africa
NMT	Non-motorised transport
Ppm	Parts per million
PV	Photovoltaic
RCPs	Representative Concentration Pathways
SABS	South African Bureau of Standards
SANS	South African National Standards
SDGs	Sustainable Development Goals
SDZ	Special development Zone
TDM	Traffic demand management
TOD	Transit oriented development
ULCV	Ultra-low-carbon vehicle
UNFCCC	United Nations Framework Convention on Climate Change
V	Volt
ZCW-ITN	Zero-carbon well-integrated transport network

1 Chapter 1

1.1 Introduction: Climate Change

The natural greenhouse effect is an integral requirement for planet earth to sustain life (Wuebbles and Jain, 2001). However, over the past two centuries this process has been disrupted due to the steady increase of greenhouse gas (GHG) concentrations in the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC) the increase in GHG emissions has coincided with increased global surface temperatures, sea levels rising and increased atmospheric carbon dioxide (CO_2) levels, quantified in Table 1.1 below [IPPC, The Fifth Assessment Report (AR5), 2014]. Notably all the above coincides with the start of the Industrial Revolution which saw the beginning of aggressive fossil fuel combustion (ibid). In 2013, the CO_2 concentrations were 396 parts per million in volume (ppmv) which made them 40% higher than they were during the mid-19th century (IEA, 2014)

Table 1. 1: Effects of CO_2 emissions between 1850 and 2010 (Source: IPPC AR5, 2014)

Year	CO_2 concentrations increase (ppmv)	Surface and ocean temperature increase (°C)	Sea levels rising (m)	Anthropogenic CO_2 emission increase ($GtCO_2$)
1850-2010	+/- 110	+/- 0.85		31.7
1900-2010			+/- 0.2	

An article by Paul Crutzen and Eugene Stoermer in May 2000 suggested that anthropogenic activity is the main cause of increasing atmospheric CO_2 levels (Kim and Carver, 2015). Should CO_2 emissions continue on the current trajectory this will result in a multitude of negative effects for the planet. According to the IPCC, four representative concentration pathways (RCPs) are anticipated for climate change scenarios and are represented as: RCP2.6; RCP4.5; RCP6; and RCP8.5, (IPPC, AR5, 2014). In the best-case scenario, RCP2.6, an aggressive number of interventions are implemented, which results in a 2.6 °C increase by the end of the twenty first century (ibid). In a worst-case scenario, RCP8.5, a continued trajectory of current CO_2 emissions with no interventions will result in global temperatures increasing by up to 4.8 °C (ibid). Extreme weather events such as hurricanes, droughts, tropical cyclones, flooding and irregular precipitation patterns would become the norm (ibid). Water shortages, soil erosion caused by flooding and irregular crop cycles caused by temperature fluctuations would decrease

food security and negatively impact on human health (ibid). Furthermore, ecosystems would be disrupted which in turn would negatively impact biodiversity (ibid). Impacts of this temperature rise would cause glaciers to melt resulting in sea levels rising by 0, 59 m by the turn of the century, affecting low lying global cities (ibid).

1.2 Background and Context

In this section the backgrounds to two aspects are investigated, firstly, the effects of fossil fuel combustion, road transport, and its contributions to CO_2 emissions and climate change is provided. Secondly, historical apartheid city spatial planning is discussed and its contribution to current day economic, social and environmental problems is reviewed.

Total global anthropogenic CO2 emissions were close to zero in the mid nineteenth century but alarmingly, by 2016 this had increased to about 36 000 Mt CO_2 (Globalcarbonatlas.org, 2018). According to the Emissions Database for Global Atmospheric Research (EDGAR), the 1990 world population was approximately 5.3 billion with a total emission level of around 22450 $MtCO_2$/yr. In the same year South Africa's population was approximately 37.5 million and a total emission of around 268 $MtCO_2$/yr. In 2016 the world population had increased to 7.5 billion with a total emission of 35753 $MtCO_2$/yr. In the same year South Africa's population was 56 million with a total emission of 390 $MtCO_2$/yr. This implies a 1.5-fold increase in emissions, compared to a 1.6-fold increase globally. The human population is expected to rise to 9.7 billion by 2050. From the above, three assumptions were derived: firstly, that there is a direct relationship between human populations and CO_2 emissions; secondly human populations and CO_2 emissions are increasing at a rate far greater than in the past; and thirdly South Africa is contributing to global CO_2 emissions and is the number 1 contributor in Africa (ibid), and the 14^{th} largest contributor in the world (Van Zyl et al., 2018).

At the third United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP3), the Kyoto Protocol was introduced which aimed to reduce GHG levels by 5% compared to 1990 levels between 2008 and 2012 (UNFCCC, 2011). However, it was calculated that this target was inadequate, therefore in 2015 at COP21 Paris, leaders from around the world agreed to keep the increase in global temperatures to 1.5–2 °C above pre-industrial levels in varying conditions (United Nations, 2015). This would require the business as usual (BAU) fossil fuel usage to be reduced dramatically. According to the 2012 International Energy Agency (IEA) report (IEA, 2014), there are three primary energy fuels used by humans which contribute to CO_2 emissions, namely: coal (44%); oil (35%);

and gas (20%). One percent comes from other energy sources comprising wind, nuclear, biofuels, waste, solar, hydro- and tide-generated energy (ibid). Fossil fuels are used in applications including heating, electricity, vehicle mobility, manufacturing and industry. These applications are related to three primary sectors: buildings; transport and industry contributing 42%, 23% and 20% respectively (see Figure 1.1) (IEA, 2014).

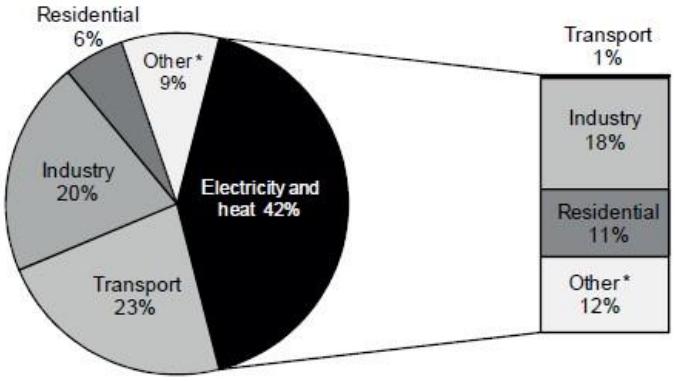


Figure 1. 1: World CO_2 emissions by sector in 2012 (Source: IEA, 2014)

In 2009, South African road transport contributed 43 million tons of CO_2 emissions (Tongwani et.al, 2015). Indicative of its high contribution to CO_2 emissions, the private car was identified as one of the highest used modes of transport in the country. This finding was revealed by both the National House Travel Survey 2013 [Statistics South Africa (Stats SA); Department of Transport (DOT), 2014], as well as a combined study by the University of Witwatersrand and Gauteng City-Region Observatory (Weakly and Bickford, 2015). The Electric Vehicle Industry Association (EVIA) confirmed that the car is the highest producers of GHG emissions in Gauteng (see Figure 1.2 below) (EVIA, 2016). It is of concern that continued dependence on fossil fuels in the transport sector will exacerbate climate change due to the ongoing CO_2 emissions. This will also mean that South Africa will find it difficult to reduce CO_2 emissions after 2035 as per National Determined Contributions (NDC) requirements set out (Van Zyl et al., 2018). The NDC was recognized in the 2015 Paris agreement which aimed at calculating GHG reducing pathways for individual countries (ibid). This meant that countries had to take action to reduce emissions and for each country there was a prescribed 'fair share' determined (Van Zyl et al., 2018: 1).

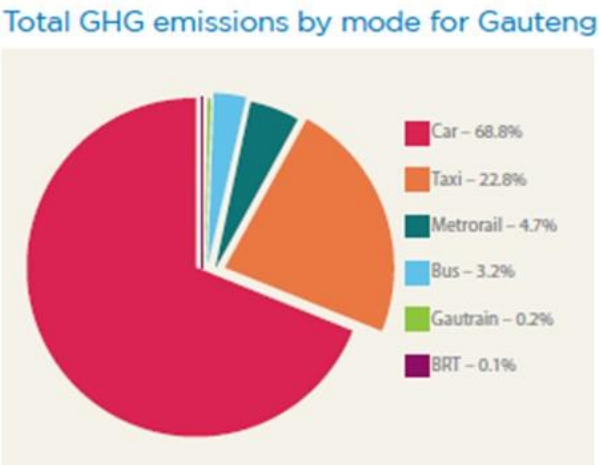


Figure 1. 2: GHG emissions in Gauteng (Source: EVIA, 2016)

1.2.1 **The Apartheid City**

In addition to current day fossil fuel transport problems, discriminatory and impractical urban design decisions made during the Apartheid era have left their challenging legacy in South Africa. The apartheid ideology was based on racial segregation and became part of South African legislation when the National Party (NP) took power in 1948 (Mhlauli et.al. 2015). The segregated city integral to Apartheid operated at 3 levels. Firstly, social segregation saw a separation between white and non-white which was driven by the 1950 Population Registration Act. Secondly, urban segregation was driven by the 1950 Group Areas Act; this saw race groups being placed in different business and residential areas. Thirdly, the removal of black people from areas that were designated white areas was tied to the creation of black homelands (ibid).

This type of spatial planning meant that the central business district (CBD) comprised mostly middle to upper class or [‘high class’ as termed by Du Plessis and Landman, 2002 in Du Plessis et al. (2010)] white areas. Thus, white people had direct access to the CBD (see Figure 1.3). White districts took up about half of the total city footprint and extended uninterrupted to the periphery of the district boundary. The other half of the city footprint was occupied by lower- and middle-class white areas directly next to the CBD. A buffer strip was used to separate these areas from Black African, Indian and Colored townships as indicated in Figure 1.3 below. At the periphery of this half of the city, a combination of Black African townships and unregulated informal settlements was established.

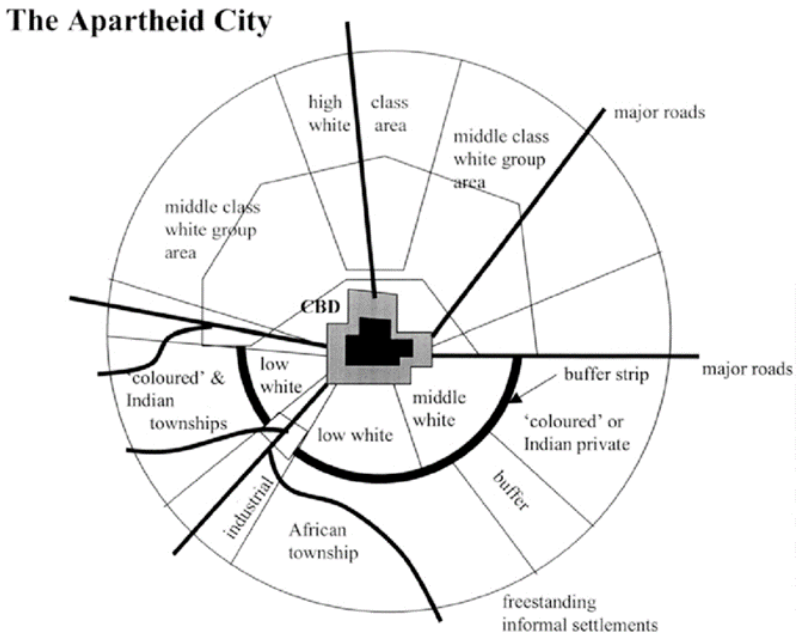


Figure 1. 3: The Apartheid City (Source: Du Plessis and Landman, 2002 in Du Plessis et al., 2010)

This meant that the poorest members of society are therefore often located the furthest from employment and such sprawl and those who live on the outskirts of cities are forced to make long journeys such as to places of work and to go shopping. The travel commences during the early hours of the morning and concludes late at night (SACN, 2016). As a result, large sums of money (a high proportion of impoverished people's income) must be spent on transportation, and results in a poor quality of life. These long-distance fossil fueled trips also contribute to CO_2 emissions and climate change. This type of planning has contributed to the urban sprawl we find today in South Africa, and is responsible for some social, economic and environmental problems (ibid).

Launched in 2013, the Corridors of Freedom (COF) initiative aims to undo past transgressions by redesigning and retrofitting transit corridors in the City of Johannesburg (SACN, 2016). Three corridors have been identified with Special Development Zone (SDZ) opportunities, namely: Turffontein; Empire-Perth and Louis Botha Avenue. Special Area Frameworks (SAFs) have been developed for the latter two. This vision was designed to create better economic opportunities, social inclusivity and environmental protection [City of Johannesburg (CoJ), 2017]. In this report the focus will be on the Louis Botha Avenue Corridor.

1.2.2 **Louis Botha Avenue Corridor**

Louis Botha Avenue was established in 1917 and acted as a main transit arterial connector between Johannesburg and Pretoria [CoJ and Johannesburg Development Agency (JDA), 2016]. During the apartheid era, it was also used by nonwhite residents of Alexandra to commute to the Johannesburg CBD to access economic opportunities (CoJ and JDA, 2016a). In its current function, the corridor forms a link between residential, commercial and light industrial components (CoJ and JDA, 2016). The Rea Vaya Bus Rapid Transit (BRT) System is currently being developed for the Louis Botha Avenue Corridor. This will connect Sandton, Alexandra and the CBD (see Figure 1.4). Supporting public transport structures are the: Metro bus; Non-motorized transport (NMT); Minibus taxis and Gautrain feeder services (ibid). Orange Grove has been identified as one of three SDZs for the COF transit-oriented development (TOD) initiative.



Figure 1. 4: BRT route for Johannesburg CBD, Alexandra, and Sandton (Source: Google Maps)

1.2.3 Orange Grove

Orange Grove is a suburban neighborhood located in the City of Johannesburg along the Louis Botha Avenue Corridor. It is predominantly a residential neighborhood with commercial activity happening along Louis Botha Avenue. It was established in 1904 and it was originally known as Lemoen Plaas (CoJ, and JDA, 2016a). During the first half of the twentieth century, Jewish immigrants escaped to South Africa and took up residence in Orange Grove avoiding the upheavals of Europe (ibid). The Second World War also saw the arrival of Italian immigrants and by 1950 Orange Grove was nicknamed 'Little Italy' (ibid). Orange Grove has a rich history including having briefly housed iconic individuals like Mahatma Gandhi and anti-apartheid activists (ibid). It was only during the latter part of the 1980's that saw nonwhite populations increase in Orange Grove as Apartheid began to fall. Orange Grove is 1.37 km^2 with a population of 7751 and 2789 households (Census, 2011). In 2013 the demographic make-up consisted of 4268 Black African, 2801 white, 326 Indian or Asians and 76 undefined individuals and has a density of 5657 people per km^2 (CoJ, 2013). The area has three fundamental urban typologies, namely streetscapes, green spaces and buildings. The buildings of Orange Grove comprise commercial, residential and institutional structures including churches, synagogues and schools (CoJ and JDA, 2016a).

1.3 Motivation

According to Vallack et al. (2015), transportation of the future has three fundamental criteria: firstly, it must be accessible to all; secondly it must be economically viable; and thirdly it must be powered by a clean source of energy. A zero-carbon well-integrated transport network (ZCW-ITN) would ensure that these three criteria are met. In the present study the key meaning of well-integrated refers to a smooth transition between transport modes. However, integration also happens at technological and social platforms. The interventions suggested in this study for the ZCW-ITN vision have zero or low-carbon emitting properties. Nine fundamental interventions defined later in chapter 2 have been selected and are seen as crucial components of the ZCW-ITN model. Two of the latter are considered primary interventions which are crucial for this transportation transformation to occur, namely ecomobility and e-mobility. Ecomobility, an urban form transformation intervention, will focus on public transport modes and non-motorized transport modes. E-mobility, on the other hand, is a human behavioral transformation intervention which will focus on electric vehicles propelled by a clean energy power source. The clean energy source which is readily available in Orange Grove, and almost everywhere on this planet is the sun; as such this forms the main energy focus of this study. The end goal of the ZCW-

ITN interventions is to ensure an inclusive transport system for all, which is economically affordable and contributes to climate change mitigation.

1.4 Problem Statement

The City of Johannesburg urban transport systems can be defined by two key historical factors, namely apartheid city design and dependence on fossil fuels. These factors have resulted in poor transport service and continues to contribute to the deterioration of the environment including through climate change. Even though the Corridors of Freedom intervention has aimed to reconnect previously disadvantaged areas through transit-oriented development, the 1996 White Paper on National transport policy or the Draft revised White Paper on National Transport Policy (WPNTP) (DOT, 2017) has not confirmed that South Africa will not be dependent on fossil fuel by 2050. Such continued use of fossil fuels will contribute to greenhouse gas emissions which in turn would exacerbate the effects of climate change. This would also mean that South Africa might not be able to meet its NDC by 2035. Even if South Africa does meet its NDC by 2035, it must continue reducing its CO_2 emissions. Failure of South Africa and other countries to do this will contribute to the risk of global warming increasing by more than 2 °C. The multitude of adverse effects which could transpire through such temperature increase are discussed in Chapter 2.

1.5 Rationale of the Study

There are two main aims of this report; firstly, to deal with the global issue of climate change, and secondly to understand the potential for new means of urbanized movement in the City of Johannesburg that address the historical legacy. Climate change is global problem which has become a major concern for humanity since it jeopardizes mankind's very existence. The severity of this problem was prioritized at the UNFCCC in 2015 where 192 countries met to ensure the global temperature increase does not exceed 2 °C. While it is essential in Africa that climate change adaptation is implemented to avoid and minimize food shortages, droughts and premature death, it is also essential that countries on the continent must mitigate the effects of climate change. It is also critical for the people of the City of Johannesburg to have access to affordable, equitable and efficient transport systems, thereby creating new ways of urban movement that does not depend on fossil fuel. This will be one part of transforming the City of Johannesburg into an Eco-City and responding appropriately to climate change imperatives.

1.6 Main Research Question and Sub questions

The research report was guided by a main research question as follows: -

What role can the implementation of ecomobility, e-mobility and associated low-carbon related trends play in mitigating climate change, and how effective would this approach be?

Four Sub-questions are listed below: -

- What is the transformation potential to a zero-carbon well-integrated transportation system in Orange Grove?
- What ZCW-ITN vision is possible in Orange Grove, and how can this be implemented?
- How could insights gained from the pilot study in Orange Grove inform future retrofits of similar existing suburban neighborhoods in Johannesburg and other comparable locations?
- What are the barriers when transforming from a fossil-fueled transport system to a zero-carbon well-integrated transport system in Orange Grove?

1.7 Working Hypothesis

The global trend towards zero- or low-carbon technologies is a global paradigm shift in response to climate change (Broto and Bulkeley, 2012). The working hypothesis for this study is that a zero or low-carbon transport network can be implemented in the Orange Grove precinct, which can be replicated elsewhere in Johannesburg and beyond. This would be in line with global case studies in China and the UK (Joss, 2010) that have demonstrated zero or low-carbon transport networks can be achieved. The research is founded on the assumption that the three key aspects to attain/ implement are ecomobility, e-mobility and renewable energy. When combined with other zero- or low-carbon related technologies and practices such as car-sharing, car-free streets, smart grids (SGs), information and communications technology (ICT) would significantly contribute towards creating zero- or low-carbon transport networks.

1.8 Research Approach

The pilot study ZCW-ITN vision developed for Orange Grove responds to the main research question and is answered through understanding the following: the urban transformational potential in Orange Grove; what kind of vision could be created; the limitations when implementing the vision; and the adaptability of the vision to other suburban neighborhoods. The approach that was taken in order to adequately answer these questions is detailed Chapter 3.

1.9 Chapter outline

1.9.1 Chapter one: Introduction

In this chapter, the reader is introduced to the themes which motivate the research. The chapter includes a contextual description of the site, problem statement and rationale for the study. The main research question together with Sub-questions and a working hypothesis then follow.

1.9.2 Chapter two: Literature Review

The literature review focuses on fundamental concepts which drive and motivate a ZCW-ITN. The review *inter alia* explores the key issues related to climate change including responses both internationally and in South Africa. Alternate urban futures, including the possibility of zero marginal costs are examined with respect to energy, communication and logistics. Eco-Cities are evaluated for their ability to contribute to zero-carbon societies. ICT and its relevance to a ZCW-ITN is examined, and low-carbon transport (LCT) and sustainable urban transformation are analyzed to understand what is required to change from the current high carbon transport network.

1.9.3 Chapter 3: Research Method

In this chapter the research approach and design are discussed and evaluated, and the relevance of the adopted approach is demonstrated. The research tool of 'scenario planning' is also briefly examined.

1.9.4 Chapter 4: The urban transport status quo in Orange Grove

This chapter, guided by Sub-questions 1, describes how a status quo base model was developed for the existing urban form in Orange Grove.

1.9.5 Chapter 5: The ZCW-ITN vision

This chapter, guided by Sub-questions 2 and 3, which describes the vision of a ZCW-ITN and is then imagined using the scenario planning tool from which the conceptual model was developed. The characteristics of the ZCW-ITN model are then analyzed to understand infrastructure, vehicles and sources of energy. This chapter then goes on to describes how the Orange Grove ZCW-ITN is implemented in a comparable neighborhood elsewhere in Johannesburg to establish the adaptability of the conceptual model. A base model is then created and analyzed to understand infrastructure and urban form of the Balfour Park neighborhood.

1.9.6 Chapter 6: Barriers of the ZCW-ITN vision

Chapter six is guided by Sub-question four. It describes how primary data collected from interviews based on a preliminary ZCW-ITN for Orange Grove are used to create a framework of limitations of the conceptual model.

1.9.7 Chapter 7: Conclusion and recommendations

The final chapter, Chapter 7, examines the key findings from Chapters 4, 5 and 6 and findings in response to the research -questions are consolidated. A report summary and conclusions are also provided in this chapter.

2 Literature Review

2.1 Introduction:

The literature review contained in the chapter provides a synthesis of the global and national trends, theory and practice relevant to the development of the ZCW-ITN vision, the subject of this study. The literature as relevant to the study methodology is further drawn in as relevant in Chapter 3. According to the United Nations (2007), more than 50% of the world's population are currently living in urban areas. This number is expected to rise to 70% by 2050. Increased urban population will result in unsustainable social and environmental cities (Bibri and Krogstie, 2017). Studies also show that urbanization has the ability to put pressure on natural resources such as fossil fuels, land, energy, water, and air (Koch, 2016). The literature also reveal that cities consume 70% of the world's energy resources and therefore contribute significantly to GHG emissions (Bibri and Krogstie, 2017). Due to sustainability challenges including densification in cities, urban systems such human and ecosystem services, infrastructure, built form and administration are under severe threat (ibid). Rapid urbanization also negatively affects economic, social and environmental sustainability in the city (Neirotti et al., 2014).

Designing and retrofitting urban environments through sustainable development is a critical step in mitigating and adapting to climate change (Broto and Bulkeley, 2013). This translates to: conserving natural resources; sustainable land use planning; zero-carbon building and implementation of low-carbon transport (LCT) initiatives. It also involves improving infrastructure and utilities; as well as facilitation of economic development and social justice for all. Of the five GHG emitting sectors, transport is the second highest contributor to GHG emissions (IEA, 2014). CO_2 emissions from the transport sector can be divided into three groups: flight, motor car and freight logistics (Chapman, 2007). By 2004, transport had become responsible for almost 25% of international GHG emissions, with 75% of the transport emissions emanating from road transport (Tongwane et al., 2015). Chapman (2007) notes, that as the second largest contributor to transport CO_2 emissions, it is critical that the road transport contribution is addressed.

Analysis of LCT literature and case studies shows that a number of broad principles are used to reduce CO_2 emissions from transport. Using these principles as a guide, this report aims to create a holistic approach to reducing transport CO_2 emissions and is referred to as a zero-carbon well- integrated transport network (ZCW-ITN). This climate change response is dual-purposed in that it acts both as a

mitigation and adaptation strategy. In understanding the ZCW-ITN and urban transformation potential of Orange Grove, the following topics were reviewed:

- Climate change;
- Sustainable urban transformation;
- Eco-Cities;
- Low-carbon transport;
- Zero-carbon trends;
- Zero cost society;
- Utopia; and
- Case study – BedZED.

2.2 Climate Change

2.2.1 The evidence

Climate change refers to a phenomenon where the global temperature is rising due to greenhouse gases being emitted into the atmosphere; as a result, there are changes in climatic patterns. Researchers have concluded that since 1900 the earth's surface temperature has increased by 0.8°C (The Royal Society, 2014). According to Schleussner et al. (2016), global impacts are currently underway and increased warming will result in irreversible impacts. Historic records show that CO_2 concentrations in 1750 measured approximately 277ppm (Le Quere et al., 2016) and this had increased by 122ppm by 2015 (ibid).

2.2.2 Causes

Scientists have confirmed that anthropogenic CO_2 emissions and global warming are the primary reason for climate change impacts (Schleussner et al., 2016). Surveys such as that conducted by Le Quere et al. (2016) show that between 1870 and 2015, the total CO_2 emissions from fossil fuel and industry and emissions from land-use change are approximately 555 gigatons of carbon (GtC). In 2014, South Africa had recorded the highest metric tons per capita CO_2 emissions from all Sub Saharan countries (The World Bank, 2018). Van Zyl et al. (2018) state that South Africa's continued high dependence on coal and oil has contributed 8.09 tCO_2 per capita emissions. From 185 countries South Africa is the 14th largest contributor of CO_2 emissions (Van Zyl et al., 2018).

2.2.3 **Concerns**

The various global impacts being observed include sea level rise, extreme and unpredictable weather events, changes in water availability, poor agricultural yields and loss of coral reefs (Schleussner et al., 2016). According to the 2015 Paris Agreement (article 2), two global average temperature limits were established: 2°C well below pre-industrial levels and 1.5°C above pre-industrial level (The Paris Agreement Summary, 2015).

It is now widely accepted that climate change is a problem that was mainly created by developed countries; however, Africa will experience the brunt of climate change effects (Collier et al., 2008) even though Africa's CO_2 contributions as a whole are relatively low. As urban populations grow in African cities; negative impacts on the well-being of citizens will be exacerbated by reduced crop yields caused by rising temperatures (ibid). Collier et al. (2008) confirm that Africa will experience severe direct effects including a decline in food security. Water shortages may result in political instability in African and Levant countries in the Mediterranean area, even potentially resulting in wars (ibid).

According to Ziervogel et al. (2014), climate change in South Africa will negatively impact food security, health, water, ecosystems, biodiversity and infrastructure. Climate change impacts are also likely to exacerbate high levels of inequality and poverty.

Studies have shown that the CoJ will experience environmental risks such as high precipitation levels associated with floods (Hetz, 2016). Floods will affect human safety and result in damage to property and infrastructure (ibid). The effects of climate change poses a threat to survival of the human race and proactive sustainable strategies need to be implemented. The concept of sustainability became an international turning point in 1987 when the Brundtland report 'Our Common Future' was released which focused on addressing number issues faced in the developing world and environment (Choy, 2015). A subsequent defining moment was the Rio Earth summit of 1992. At the summit it was revealed that immediate action was required to reduce CO2 emission which had accumulated to 22.7 billion tons globally (Afan, 2017). A UNFCCC treaty was created which set targets to reduce emissions by the parties present. Later in 2009 South Africa made a pledge to reduce GHG emissions by 34% and 42% by 2020 and 2025 respectively (DOT, 2017) (EVIA, 2016)

2.3 Responses to climate change

2.3.1 Mitigation and adaptation

Responding to climate change falls into two categories, namely mitigation and adaption. Mitigation responds to climate change causes, whereas adaption responds to climate change impacts (Broto and Bulkeley, 2012). Broto and Bulkeley (2012) have concluded that most interventions carried out at a global scale are done incrementally; however further investigation is needed into interventions that lead to a complete change of systems. It is therefore of vital importance that an accurate account of carbon emissions be kept so that we know when emissions have increased or decreased. This is done through the global carbon budget which assesses anthropogenic CO_2 emissions and their redistribution via land, sea and atmosphere (Le Quere et al., 2016). It is imperative that governments in both the developed and developing world keep up to date with climate change impacts, mitigation and adaptation so that this knowledge can be disseminated (Collier et al., 2008).

Van Zyl et al. (2018) also points out that developed countries should support zero-carbon initiatives in developing countries. Benefits from this would be symbiotic where developing countries would have sustainable interventions implemented at zero or low cost and developed countries could be achieving their National Determined Contributions (NDC) indirectly. Achieving South Africa's fair share of NDC by 2030 is possible however, the challenge lies in ensuring emissions continue to decline after 2035, and this would require renewed effort and revised strategic planning (Van Zyl et al., 2018).

Van Zyl et al. (2018) also state that for South Africa to achieve its NDC target, there needs to be an ongoing push towards renewable energy implementation. This will lower the cost of energy and reduce CO_2 emissions. Ziervogel et al. (2014) advise that there are three critical knowledge gaps that would enhance climate change adaptation in South Africa. It is necessary to: firstly, develop and test adaptation strategies that are flexible and can easily be integrated; secondly, gain an understanding of enablers and barriers with regards to financial, political, authorities and social structures; and thirdly, implement climate change adaptation strategies that support development and reduce inequality and poverty. A large amount of anthropogenic human activity occurs in cities through the use of buildings and transport. In recent years, a key research area responding to climate change impacts is the sustainable city concept, which is also referred to as the Eco-City. Eco-Cities could be a response to the world's leading challenges, namely climate change, growing populations and socio-economic factors (Joss, 2010), and resource depletion [The EcoDistricts Protocol (TEP), 2014]. However, this would require

an understanding of existing urban, social, economic and environmental conditions. There also needs to be an understanding of interventions that eliminate CO_2 emissions, and how it can be best used for sustainable city transformation.

2.3.2 Sustainable Urban Transformation

According to the Rio Declaration on Environment and Development (1992), principle 8 states that: 'To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies '. Sustainable urban transformation is a responsive concept to this principle and aims at converting existing carbon-intensive urban neighborhoods into sustainable environments which responds to climate goals (McCormick et al., 2013). Adaptation and mitigation of climate change is essential and needs to be linked to aspects including transport innovations and intelligent spatial planning in buildings and urban spaces (ibid). This can be achieved through implementing radical changes at a structural level and in a way that is multidimensional (ibid). These dimensions address the following key issues: pollution; poverty; inadequate water quality; over-population; hygiene; inadequate housing; and poor infrastructure (Ernst et al., 2016). Koch (2016) confirm that through the alteration of existing forms and new urban development, cities have the potential to reduce CO_2 emissions significantly. McCormick et al. (2013) adds that sustainable urban transformation is a multi-level and radical transformation process that will lead to achieving the United Nations' Sustainable Development Goals (SDGs). For sustainable urban transformation to occur, Koch (2016) points out the critical importance of SDG number 11: Make cities and human settlements inclusive, safe, resilient and sustainable. Cities have evolved into high carbon unsustainable spaces and require transformation. Transformation requires finances, policy changes, infrastructural changes, and participation at multiple level from the top and bottom.

According to McCormick et al. (2013) issues in urban cities can be the fault of governments who fail to implement planning that will ensure sustainability. This mismanagement has contributed to CO_2 emissions, land consumption, and air pollution Koch (2016). According to Ernst et al. (2016) cities are inherently complicated due to differences between individuals as well as groupings; these differences cover socio-cultural, political, environmental, economic, and institutional aspects and exacerbate challenges faced in the city. A transparent government which puts the needs of the people first will succeed at transforming to low-carbon sustainable cities. In 1971 Curitiba, the capital city of Brazil,

appointed Mayor Jaime Lerner, who strived for good transparent governance which saw positive changes during his tenure.

According to McCormick et.al. (2013), urban areas and cities have been acknowledged as crucial zones for sustainable development and climate change action. Ernst et al. (2016) goes a step further in acknowledging that the transformation needs to be driven by culture; practices and structures; and the understanding of the relationship that exists between society and sustainable transitions. There are multiple level impacts when transformation occurs. There needs to be an overall understanding of knock on effects and must be thoroughly analyzed. Ernst et al. (2016) has identified the systems in urban societies relevant to transformation which include: legal and financial arrangements; education systems; ecological systems; energy systems; agriculture; transport systems; social security and healthcare. Such systems need to be integral to transformation since they respond to essential social functions like food supply, housing, transportation, communication and energy supply (ibid).

According to McCormick et al. (2013), four aspects must be considered for sustainable urban transformation: firstly, possibilities for change need to be embodied; secondly, the importance of creating opportunities for collaboration amongst varied stakeholders; thirdly, stimulating integration of information and expertise; and fourthly, encouraging experimenting with diverse methods and solutions. He also expresses that the need for the transformation to be attractive and exciting and must create opportunities for lifestyle improvement both in the present day and the future (ibid). However, through this transformation process, it is important to remember that water, transport, non-renewables, food, housing, and water are inherently constrained services (Ernst et al., 2016). The use and production of these resources must be kept within limits (ibid).

The inability to ensure sustainability in urban environments is a tremendous problem. The challenge is made more difficult because of the long time it takes for urban environments to transform (McCormick et al., 2013; Ernst et al., 2016). Therefore, there is little room for error when implementing a change that has not been carefully researched through a learning process (Koch, 2016). There are challenges to applying learning, and the process is also hampered by inadequate funding for solutions (ibid). Koch (2016) et al. agree that in order to create resilient and efficient cities with a high quality of life, buy-in is required from societal, financial and political sectors. For the law makers the challenge lies with creating policies which are ambitious but simultaneously realistic and flexible. They need to respond to rapid urban changes, but without causing disruption to the existing functioning of the city environment. If there are disruptions it must be kept down to a minimum and does not cause a failure for people to

function in everyday life. It is also essential that policies that are contradictory must be eliminated (McCormick et al., 2013). McCormick et al., (2013) notes that municipalities play a critical role in acting as a catalyst for transformation (ibid). Partnerships and alliances are also be pivotal to this transformation. An example of a global partnership is the International Council for Local Environmental Initiatives (ICLEI) and the UN-Habitat (2010) which aims to connect local governments and promote sustainable development.

McCormick et al. (2013) conclude that it is evident that the shift towards low-carbon, resilient and sustainable societies is slow even though people are aware of the importance of climate change action and sustainable development. Reasons that McCormick et al. give for this include a misalignment between science and practice; poor support from social, business and political arenas; disintegration in urban planning and research; and lack of co-ordination at varying geographic scales (ibid). They call for a holistic view of issues, understanding of who and what is affected by this status quo, as well as ensuring that a long-term view is taken. It is equally important to manage short and medium term which ensures the continued functioning of overall systems while transformation is taking place.

2.3.3 Eco-Cities

As sustainable urban environments, eco-cities provide means of mitigating against and adapting to climate change (Joss, 2010). According to Joss (2010) planners and designers of the early 19th and 20th century was always aware of the challenges faced in cities and they contemplated how such obstacles could be overcome. Examples of proposed solutions can be seen in the Techno-City, The Garden City and New Town (Joss, 2010). Later on, during the 1980s, attention was being drawn to the ecological environment and cities which was showing signs of deterioration. It was through this predicament the concept of 'Eco-City' was created. The term 'Eco-City' first appeared in Richard Register's book 'Eco-City Berkley' which is defined as a city that is ecologically healthy (ibid). During the 1980's and 1990's the Eco-City was considered an alternative to traditional urban planning where sustainability was becoming an urban response in terms of planning, housing, transportation, public participation and social inclusivity (ibid). Since 2006, there has been an international effort to redefine cities so that they are more efficient, resilient and sustainable (Holden et al., 2015). Eco development in urban areas can happen at 2 geographical scales: city or neighborhood.

Eco-urbanism focuses on projects at neighborhood level and aims at creating green urban environments where healthy living can be sustained (Holden et al., 2015). Holden et al. (2015) define Eco-urbanism to

encompass seven fundamental principles comprising: Econ-urban; Ecol-urban; Living-urban; Local-urban; Democ-urban; Diverse-urban; and Equi-urban. Econ-urban focuses on economic development that promotes green products and capital generated from green initiatives (Holden et al., 2015). Ecol-urban focuses on technological and design efficiency in materials and energy with a strong interest in the environment (ibid). Living-urban embraces healthy community living that can sustain itself even through difficult periods (ibid). Local-urban pushes participation at all levels within a suburban neighborhood (ibid). Democ-urban promotes decision making at a local level which affects value systems and moving towards a single vision (ibid). Diverse-urban draws gains generated from combining varied economic, social and cultural urban backgrounds (ibid). Equi-urban focus on injustices and inequalities and ensures all citizens have equal rights to the city (ibid). Eco urbanism is a design concept that embraces innovations and interventions found in the latest technologies, new design concepts in architecture and urban planning (ibid).

According to McCormick et al. (2013), a city district is ideal for urban transformation. Firstly, this is the appropriate (reduced) scale which allows for sustainable urban transformation and the ability to innovate and create with more than just buildings. Secondly, districts (like full-scale cities) consist of buildings, transport systems, infrastructure, and public space but due to their smaller size are more manageable. Finally, engagement with communities is also more manageable at this scale.

TEP (2014) states that there is a set of fundamental indicators that represent sustainability in city district projects covering: reduction in utility bills, kilometers travelled and GHG emissions; integrated transport; production of local food; quality of storm water; creating jobs and ensuring that all have access to services to name a few. Strategies include: green streets; management demand of transport; car-sharing and bike-sharing; cycle lanes; multimodal transport; improved sidewalks; urban farming; water and energy management; safe routes; planting of trees; composting; harvesting of rainwater; smart grids; distributed generation; waste to energy; and cultural art to name a few (TEP, 2014).

Examples of Eco-Cities or districts are: Beddington Zero Energy Development (BedZED) in the United Kingdom (UK)completed in 2002; Sino Singapore Tianjin Eco-City in China completed in 2008; and Masdar Eco-City in the United Arab Emirates completed in 2010 (Joss, 2010) (Sustainability Institute, 2009). Completed in 2004, South Africa also boasts its own Eco-City in the form of Lynedoch eco-village situated near Stellenbosch in the Western Cape. In each of these examples, transport and energy plays a crucial role in CO_2 emission reductions which is the focal point in this report.

2.3.4 **Low-carbon Urban Transport Strategies**

A low-carbon urban transport strategy is based on low or zero-carbon interventions that would contribute to low-carbon cities (Nakamura and Hayashi, 2012). A key starting point for the LCT concept was the 2003 Comparative study on Urban Transport and Environment (CUTE). CUTE focused on five strategies: reduced transport demand; reduced car usage; alternate transport mode improvements; road network improvements; and vehicle technology improvements (ibid). This later evolved to the Avoid-Shift-Improve (ASI) framework, driven by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in 2007 (ibid):

- Avoid - refers to strategies that reduce future travel demand;
- Shift - refers to introducing more economical and environmentally-friendly modes of transport; and
- Improve – aims at using technological measures to improve vehicle fleet emissions and fuels (Nakamura and Hayashi, 2012).

It applies to ensuring that cities move towards more sustainable models for their design and operation. In the section that follows low or zero-carbon studies and academic articles are analyzed relative to the ASI principles.

Philip and Taylor (2017) used a similar concept to the ASI framework when transitioning to LCT, through appropriate research programs. They established 4 avenues of research: land use combined with transport integration which relates to the Avoid strategy; policy that affect behavior change in mobility which relates to the Shift strategy; new technologies which relates to Improve strategy; and tools used for decision making namely data, integration and evaluation. In a separate study on understanding policy pathways towards zero-carbon transport in the UK, we find the ASI framework being adopted through the following aspects: behavioural changes; fiscal; spatial planning; and technology. Hussaini and Scholtz (2017) on the other hand see transitioning to LCT in the UK as a dynamic pathway which happens via a multi-level perspective (MLP) framework with the main focus on the Shift strategy related to low energy fuels and low emission vehicle technology. They see the pressure from oil depletion, combined with environmental imperatives will be a catalyst for transition. This transition can occur in four different ways: transformation in LCT, reconfiguration in LCT, substitution in LCT, and de-alignment or re-alignment in LCT (Hussaini and Scholtz, 2017). This means that the transition will only occur as scenarios become worse, therefore making it a reactive solution and not a preventative solution. In South Africa the Draft Green Transport Strategy 2017-2050 (DGTS) also echoes the ASI principles such

as: transit-oriented development (TOD) which is an Avoid strategy, bus rapid transit (BRT) which is a Shift strategy; and Improve strategies which are discussed in the document. The DGTS report also aims to create opportunities for employment; use of recycled materials; manufacturing of motor vehicles in SA to reduce embodied energy CO_2 emissions; (DOT, 2017a). Suleman et al. (2015) states that green transport would comprise non-motorized transport (NMT), green urban design, modal shifts, public transport and alternate fuel sources which are related to the ASI principles. In this study, Suleman et al. (2015) focus on understanding implementation of battery electric vehicles (BEVs) and low-carbon fuels: biofuels (ethanol), biogas, compressed natural gas, and the BEV (Suleman et al., 2015).

2.3.4.1 'Avoid' Strategies

Nakamura and Hayashi (2012) provides several examples of the 'avoid' strategy being implemented in the last century around the globe. It was first identified to be applied in 1958 in Singapore where greenbelts were introduced so as to avoid urban sprawl and keep cities compact. Then during the 1960s railway companies in Japan developed towns around railway lines to ensure high usage and to avoid the need for large numbers of cars (ibid). As a means of preventing urban sprawl, high density zones were introduced following the construction of the BRT developed in Curitiba in 1974. This trend continued in the 1980s when 'new urbanism' became popular as a novel way to address urban sprawl in America (ibid). This concept was then enhanced by Caltorpe's 1993 transit-oriented development (TOD) which promoted high density development around transit stations. The aim of the 'Avoid' strategy is to find ways to get people closer to work, stay and play as described in the COF strategy (DOT, 2016). This strategy is very closely related to the 'Shift' strategy.

2.3.4.2 'Shift' strategy

Mass transit 'shift' strategies began in Europe thirty years ago where ageing trams were replaced with improved light rail transit (LRT) systems which reconnected the city (ibid). In Bangkok mass transit systems were introduced in the form of the sky train, the underground, and the airport rail in 1999, 2004 and 2010 respectively. The BRT became popular in Bangkok and Jakarta after being introduced in Curitiba (ibid). An important component for public transport systems is having a clean energy source. However, costs might be a crucial factor when choosing the most effective (DOT, 2017a). Philip and Taylor (2017) suggest it is important to understand travel patterns and the reason why people travel; this information is crucial for applying the most effective low carbon transport (LCT) interventions. Behavioural changes can significantly contribute to CO_2 reduction — what is referred to as 'smarter choices' (Vallack et al., 2015: 32). Awareness by commuters of the imperatives for CO_2 reduction is

essential for implementing changes in behavior (Vallack et al., 2015). Relevant interventions to promote behavioural changes include review of work and personal plans, working from home or teleworking (ibid). Associated with mass transit are feeder systems where bicycles proved to be most popular in Paris, London and China, with Bogota developing 300 km of cycle lanes (ibid). A key aim for the Draft Green Transport Strategy 2017-2050 (DGTS) (DOT, 2017a) is to move passengers away from private transport to public transport and NMT. However, integration between modal shifts will play a key role. Philip and Taylor (2017) argue that integration can happen at multiple levels where there needs to be conscious choice in how interventions are integrated into the systems underpinning the operation of cities. Congestion charging system introduced in 1975 in Singapore, resulted in radically increased use of public transport (Lah et al. (2015). This contributed to a 45% traffic reduction and 25% accident reduction (ibid). Fiscal measures will further encourage behavioural change comprise : road user charges; workplace and non-commuting car parking charges; fuel price increases; car purchase tax; and public fare reduction (Vallack et al., 2015).

2.3.4.3 'Improve' strategy

Emissions standards introduced in Europe and Japan in 1999 and 2000 respectively became an effective 'improve' strategy (ibid). During the 1970s Americas CO_2 emissions were reduced due to fuel economy requirements following the oil crisis in 1973 (ibid). The transformation pathway adopted in the UK include strategies such as making internal combustion engine (ICE) vehicles more efficient using start-stop technology, the use of biofuels, and the introduction of ultra-low-carbon vehicles (ULCV) (Hussaini and Scholtz,2017). Carbon costs were introduced in Australia where businesses were obligated to comply with penalties (ibid). According to the DGTS (DOT, 2017a), the South African government will also use a carbon tax which will aim to create a level playing between renewable energy companies and carbon-intensive companies. The high rate of EV adoption in the USA, China and Europe since 2010 can also be ascribed to 'improve' strategy (IEA, 2018). EV uptake in South Africa has not been on par and is considerably slow due to factors including their high cost (DOT, 2017a).

2.3.5 **Requirements for responses**

South Africa's national policies, strategies and plans is required to be aligned to the country's Constitution which sets out to ensure sustainable development contributes to human dignity social equity and equality. It further enshrines the right to an environment that is not harmful to health and well-being (DOT, 2017). South Africa is also required to work towards achieving the 27 Sustainable

Development Goals (SDGs) set by the United Nations via '2030 Agenda' (UN, 2015). Furthermore, as a signatory to the UNFCCC, South Africa is obliged to fulfill certain obligations to address climate change. In 2016 South Africa submitted an intended nationally determined contribution (INDC) which projected a course of action between 2025 - 2050 to reduce GHG emissions through adaptation and mitigation strategies (South Africa First NDC, 2016). Long-term transport planning in South Africa is laid out in the National Development Plan (NDP) (DOT, 2016), as well as the National Transport Master Plan 2050 (NATMAP 2050) (ibid) The Revised Strategic Plan 2015 – 20 for the DOT lays out short term plans for transportation at the national level. The DOT (2016) highlights several transport challenges faced in South Africa; these are further identified in the NATMAP 2050. Many of the challenges are related to underdevelopment of the transport system in South Africa:

1. The shift towards public transport in South Africa as proposed in the 1996 White Paper on National Transport has not transpired due to lack of integration of transport modes, inadequate planning of the BRT, accessibility, reliability, safety, and predictability (DOT, 2016).
2. Passenger and freight road transport remains reliant on petroleum liquids (ibid).
3. Single occupant vehicle trips are still a major concern in urban areas (ibid).
4. Policy on transport management demand (TDM) is lacking in South Africa.

The 1996 White Paper on National Transport Policy was reviewed in 2015 (DOT,1996) so that challenges such as poverty, inequality, unemployment and the newly added environmental matters could be dealt with according to national and international trends. According to the Draft revised White Paper on National Transport Policy (WPNTP) (DOT, 2017), the 1996 White Paper showed limited consideration of sustainable transport. In an attempt to address these issues, the WPNTP uses the Avoid-Shift-Improve (ASI) framework as a guide for future sustainable transport policy-making in South Africa. In order for these interventions to work at an optimal level, there needs to be: a process of data collection to ensure the right interventions are used for specific urban space; an evaluation of cost-related but also social, economic and environmental matters regarding a site; as well as an understanding of the various levels of integration between transport modes and interventions (Philip and Taylor, 2017). Other factors which influence optimization of LCT are behavioural and fiscal changes, but for these to be a success they would need to be supported by adequate policy (Vallack et al., 2015). It is also evident that intervention implementation is time and cost-related which means that the more expensive the intervention, the longer it takes to implement (Bongardt et al., 2010). In order to achieve LCT transformation, interventions need to occur at three different time frames: short term, medium term and long term

(ibid). Behavioural changes require the least funding and can occur in the short term, whereas medium term technological interventions may require more time due to cost, and infrastructural interventions such as changes to road infrastructure are relative to long term time frames (ibid). This is evidenced by the amounts of money incurred in urban infrastructural changes. Thus, it would be prudent to consider behavioural change interventions when implementing interventions especially when funding is low. Compact cities have become a leader in LCT when considering urban design; however, it is still not clear as to what urban layouts best represent LCT (Philip and Taylor, 2017). This is due to the long time it takes for densification to occur where the life cycle emissions (CO_2 emissions which are accrued from each energy source) may outweigh emission reduction benefits from compact cities. An important factor to keep in mind is the safety of pedestrians and cyclists and how this can be carried out with minimal costs. This could be achieved through intelligent design of streetscapes. In developing cities, an added challenge is the inadequacy of organizational and planning skills (DOT, 2017a). Inadequate planning could spell disaster for a project; therefore, it would be beneficial for managers to be involved and management systems to be put in place. CO_2 emissions should be the main reason for creating Eco-Cities, however social and economic benefits such as standard of living, mobility and feasibility for users must also be considered when designing transport systems in urban areas (Philip and Taylor, 2017). Governments might also go for a cheaper and convenient option in implementing an energy source as seen with CNG being used in buses in such cities as Johannesburg and Tshwane where the more effective option is solar and EV buses (Suleman et al. 2015). Other barriers for LCT could be the large amount of time it takes for governments to make decisions since relevant sectors including diverse groups responsible for emissions need to be consulted during decision-making; (Bongardt et al. 2010).

2.4 Zero-carbon Trends

Provided below is a review of the literature on zero-carbon trends as discussed in Section 2.3, which have been identified for implementation in the Orange Grove ZCW-ITN vision. The vision was developed by the researcher and applied further in Chapters four and five.

The zero-carbon trends were established in three phases, initially involving research based on academic papers. This was followed by searches via the internet and newspaper articles. Finally, direct observations were made by undertaking semi-structured interviews and via site visits to Orange Grove. These choices were crucial for development of scenarios for planning of the zero-carbon transport vision envisaged via this study, proposed to be implemented by 2050.

2.4.1 **Car-free Streets ('Shift' strategy)**

Car-free streets are streets which restrict or omit private car from a precinct and relies mainly on public or active modes of transport which relates to the 'Shift' strategy. The advantage of doing this results in reducing GHG emissions (Nobis, 2003). Car-free zones can also act as commercial streets which can contribute to economic growth (TDM Encyclopedia, 2014). According to Nieuwenhuijsen and Khreis (2016), car-free implementation would make a crucial contribution to GHG emission reduction and would also benefit human health by encouraging active modes of transport like walking and cycling. There are also safety benefits due to vehicle exclusion resulting in zero vehicle road accidents (ibid). Several urban areas around the world have moved towards becoming car-free cities such as the European cities of Madrid, Helsinki, Oslo, and Hamburg. Some cities have also taken steps to reduce private vehicle movement by investing in NMT infrastructure and creating car-free days. They have also reduced parking availability while investing in public transport. This is currently occurring in various cities Hyderabad; Chengdu; Masdar; Paris; Milan; Copenhagen; Brussels; Dublin and Bogota (ibid). According to Melia et al., (2011), there are 3 types of car-free developments: the Vauban model; limited access model and pedestrianized centers. In the Vauban model, there is restricted vehicle access on certain streets and limited parking spots (ibid). Those who choose to own a vehicle have to rent parking spots and make use of parking garages at the periphery of the town (ibid). For the limited access option, access onto the site by vehicles (mainly service vehicles) is controlled by bollards (ibid). Most streets within the precinct are pedestrianized with limited parking spaces (ibid). Pedestrianized centers are car-free developments where cars are not allowed (ibid).

2.4.2 **Complete street design (Shift strategy)**

A complete street is an emerging concept where there is equal thought given to all users of the road; this ensures that there is adequate safety for all, with the intention of creating functional public spaces (Hui et al., 2017). The underlying benefits of such a concept ensures improvements to the environment and social integration (Litman, 2015). According to McCann and Rynne (2010), there are 10 principles crucial for complete street design: a community vision for streets; NMT is inclusive of all users; connected streets and networks; the concept applies to all projects, new or retrofit; latest and best design practices should be used; allowances for exceptions where complete street design wont comply ;the complete street should be complimentary to the urban context; policy creation and implementation procedure; and measurable standards need to be applied. There are a number of demonstration

projects in America which are underway, such as in the city of South Bend, where traffic calming techniques are being tested by using chicanes, traffic circles and speed bumps (Zaccaro, 2018). In the city of Lexington, flexible materials and pedestrian crossings have been used to slow down traffic and makes streets more useable for NMT (ibid). In the city of Orlando, a five-lane road has been converted to a 3-lane road which now includes pedestrian and cycle lanes, staggered pedestrian crossings and a pedestrian refuge island. These projects have been implemented using low-cost materials and included consultation with members of the community. When it comes to changing how an existing streetscape functions, there needs to be an understanding of the road users, types of vehicle and traffic volumes. The existing road reserve available needs to be assessed, and the minimum width from roadways, parking lanes, pedestrian lanes, and cycle lanes should be determined (CoJ, 2014). In the following two section there is a brief description of road type classification and NMT infrastructure which assists in understanding the type of complete street that can occur on existing streets. In making the streets equal for all users means reducing the vehicle numbers and sharing it equally other modes of transport namely walking and cycling. This relates to the 'Shift' strategy which aims at promoting environmentally friendly modes of transport.

2.4.2.1 CoJ Road classification

According to the Johannesburg Road Agency (JRA, 2015) there are six road classification types within the CoJ. Class 1, 2 and 3 roads' main function is for mobility with a focus on vehicle activity with high speeds and volumes of traffic. These run through commercial areas (JRA, 2015). A Class 1 road is called a 'principal artery', whilst a Class 2 road is a 'major arterial', and a Class 3 road is a 'minor arterial'. The maximum speeds expected on these roads are: Class 1 road 100-120 km per hour; Class 2 road 80 km per hour; and a Class 3 road is 70km per hour. Classes 4, 5 and 6 main functions are viewed as low-speed community streets to be used for access or mixed use activity, including for pedestrians and vehicles. . Classes 4a and 4b are collector streets are for commercial and residential areas; Classes 5a and 5b are local distributor streets for commercial and residential areas, while Classes 6a and 6b are walkways with NMT. Class 6a allows vehicular movement, although the pedestrian still has main priority, whilst 6b does not allow any vehicular movement. Class 4a maximum speed is 60 km per hour, whilst 4b is 50 km per hour. Classes 5a and 5b have a 40 km per hour maximum speed whilst Class 6a has a 15 km per hour restriction. All classes have a minimum road lane width of 3.3 m except for class 5b which has a minimum width of 3 m.

2.4.2.2 NMT infrastructure

The City of Johannesburg Complete Streets Design Guideline Manual (CoJCSD), introduced in 2013 states that the minimum width of a cycle lane for Classes 3, 4 and 5 roads is 1.5 m (CoJ, 2014). In addition, the minimum width for a pedestrian walkway is noted in Section 4.1.2 of the CoJCSD as being 1.5 m. According to the Johannesburg Road Agency (JRA) parking details contained in the JRA (2015), the minimum width of a perpendicular parking bay is 2.4 m and 2.2 m for a parallel parking bay. The CoJCSD recommends that walkways be positioned on both sides of the road (CoJ, 2014).

2.4.3 **Ecomobility ('Shift' Strategy)**

Ecomobility aims to change the way people move, focusing on public transport, walking and cycling rather than on use of private cars. The concept was introduced by the International Council for Local Environmental Initiatives (ICLEI) in 2011 (Kuttler and Zimmerman, 2015). In order to move away from a car centric living, the city of Johannesburg has adopted 3 key policies: The Managed lanes policy, 2012; complete streets policy 2013 and the non-motorized transport framework (ibid). There are five components to ecomobility: the use of public transport termed 'passenging'; walking, cycling, wheeling and car sharing (Kuttler and Zimmerman, 2015: 8). The definition of ecomobility is still unclear in South Africa (DOT, 2017a; DOT; 2016). In this report ecomobility focuses on public transport and NMT exclusively based on three fundamental reasons: infrastructure is already in place and therefore costs will be minimized; it is low cost for Orange Grove users; and lastly these are potentially zero carbon emitting modes of transport. This relates to the 'Shift 'strategy which are environmentally friendly modes of transport and this contributes lower carbon emissions.

2.4.4 **Car Sharing ('Shift' Strategy)**

Car-sharing can be defined as a single car being owned and shared by many people. It provides the user with greater choice of mode of transport with lower comparative costs and has social and environmental benefits (Huwer, 2004). Car sharing has been a growing alternative to car ownership without actually owning the vehicle (ibid). The concept was formalized in the 1980s in Switzerland and Germany where companies provided car share service (Katzev, 2003). The idea further evolved with Drivenow and Car2go which incorporated the idea of free-floating cars which could be picked up and dropped off anywhere (Giesel and Nobis, 2016). A peer to peer car sharing service was subsequently introduced where groups of individuals owned the vehicle which was called Getaround (Noll, 2017). The concept has further advanced and in its current format companies such as Zipcar own the vehicle which

provide a service to members (Katzev, 2003). Advancement in technology and the need for a cleaner energy efficient fuel as paved the way for companies such as BlueSG in Singapore which are using electric vehicles (Xue and Gwee, 2017). Car sharing is a mindset change and would need to be encouraged in adapted to South African where car ownership still remains aspirational. conditions. Sensitization programs and campaigns together with other interventions can be used to promote car sharing. Similar concept are already being practiced in South Africa like ride sharing or carpooling. One such company is 'Jumpin Rides' in Cape Town which has more than 10 000 users (Lourie, 2018). The way in which this works is based on commuters traveling in the same direction share one vehicle therefore saving on traveling costs and fuel usage (ibid).

2.4.5 E-mobility - Electric Vehicles (Improve Strategy)

E-mobility focuses on replacing the traditional internal combustion engine (ICE) drive train with electrically powered drive trains, with the most common type being electric vehicles (EVs). EVs use electricity for propulsion and as a result have a lower carbon emission rate than vehicles powered by the internal combustion engine. The environmental impact is reduced further when it is combined with a renewable energy source. The leading e-mobility product and which is rapidly growing globally is the electric vehicle (EV). According to the Global EV Outlook (2018) there was a total world-wide stock of 16 810 EVs recorded in 2010 (IEA, 2018). This increased to 1 million by 2015 and had tripled to 3.1 million by 2017 (ibid). Countries with the best accumulative sales since 2005 are Sweden, Germany, France, the UK, Netherlands, Norway, Japan, United States and China (ibid). Relative to the increase of EV stock, public charging facilities have also increased. Between 2007 and 2016, slow charger units increased globally from 333 to 212 394, with fast charger units increasing from 42 to about 110 000. EVs are also becoming narrower and would play an important role in obtaining optimum street widths to achieve complete street design. EV companies are developing a number of these types of 2 to 4-seater models which cost between 2000 and 8000 dollars (see Table 2.1 below).

Table 2. 1: Micro electric vehicle (source: internet)

	Make and Price	Distance per charge	Linear Dimensions (LxWxH)
	2018 Robeta 2- seater mini EV $ 2 000-3 000	80-100 km	2.2 m x 1.5 m x 1.41 m
	2017 TS 4-seater EV $ 5700	130 km-160 km	2.83 m x 1.5 m x 1.56 m
	2018 Baojun E100: 4-seater EV $ 7 200	155 km	2.5 m x 1.5 m x 1.6 m

2.4.5.1 EV charging facilities.

EV charging can be implemented in locations: residential buildings, in the workplace or within commercial buildings. They can also be placed in public locations. The 2014 EV Charging Station Guidebook [Vermont Energy Investment Corporation (VEIC), 2014) points out infrastructure for EV charging varies according to the amount of power fed to a charging point. Level 1 comprises a 120 V alternating current (AC) charging system; one hour of this type of charge gives you a limited range of about 6.5 km (ibid). Level 2 provides better range of about 32 km based on the one hour maximum 240

V AC charging. Level 3 is the most efficient charging system provided by direct current (DC). The rapid charging on such a system means that 1 hour of charging system gives you a range of up to 120 km (ibid). For residential, workplace and commercial buildings, EV charging positions can be adapted within existing or new perpendicular parking bay facilities. The safety standards as they currently stand for charging stations will need to comply with the South African National Standards (SANS) 61851-23 for South Africa. (SABS, 2015). EV charging site criteria need to consider the following as per Figure 2.1-2.3 below

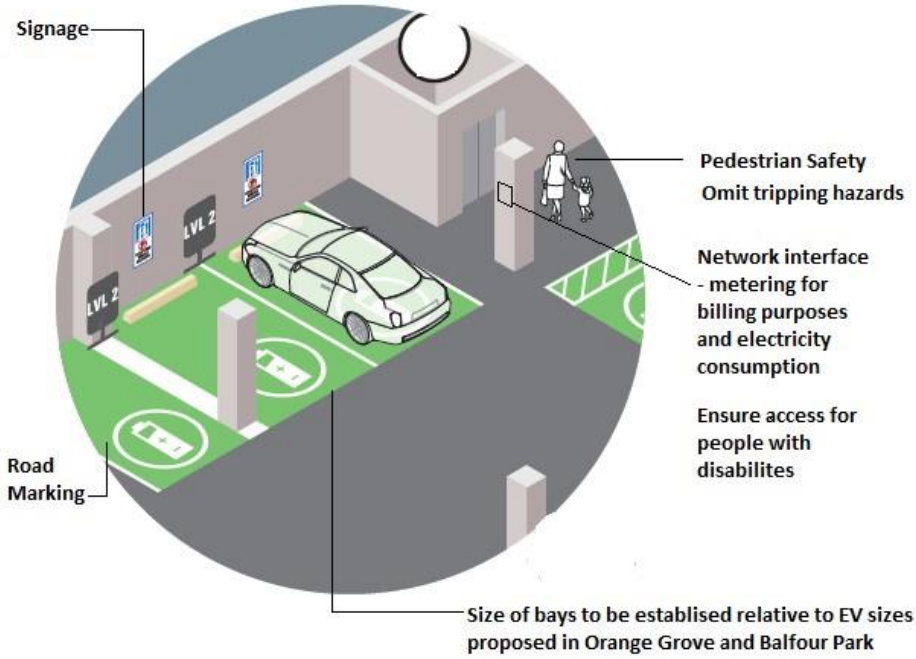


Figure 2. 1: Commercial Parking Garage or Multi unit residential EV charging facility (image adapted from Transportation and Climate initiative, 2012)

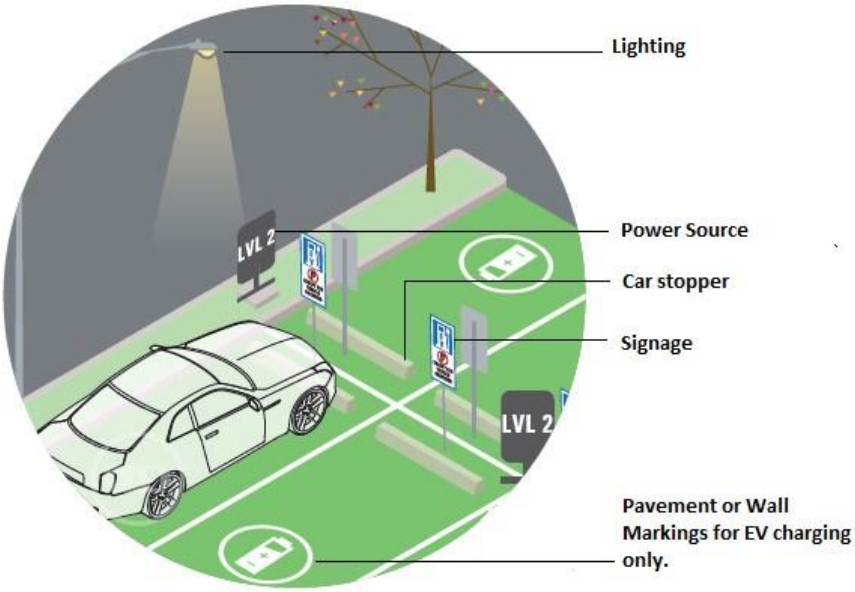


Figure 2. 2: Commercial Parking lot EV charging facility (image adapted from Transportation and Climate initiative, 2012)

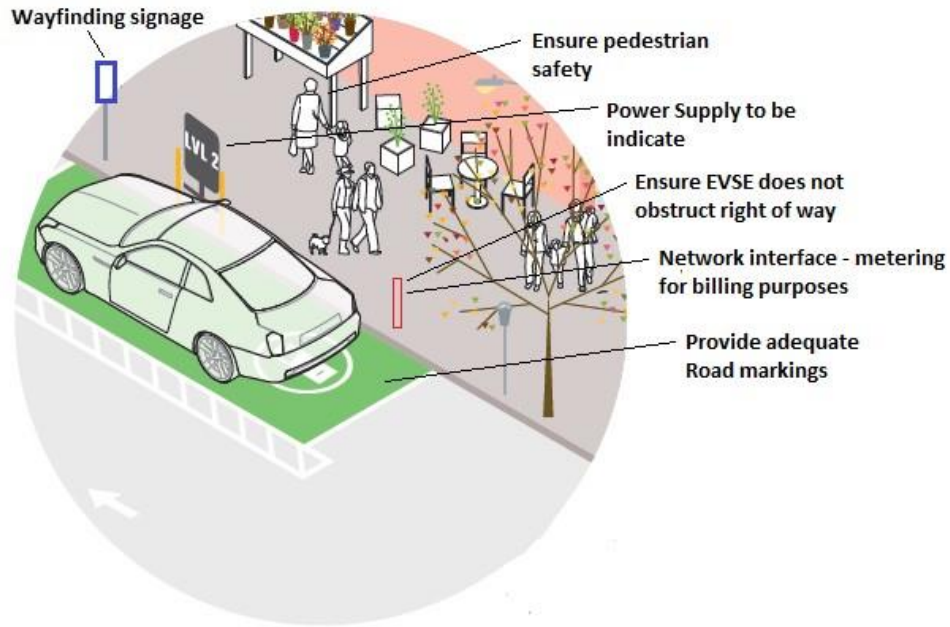


Figure 2. 3: On-street EV charging facility (image adapted from Transportation and Climate initiative, 2012)

2.4.6 Distributed generation: Solar Energy ('Improve' Strategy)

Distributed generation (DG) can be defined as 'electric power production technology that is integrated within distribution systems, close to the point of use' (Angelopoulos, 2004: 10). As opposed to centralized power supply, DG comprises embedded generation like solar; wind; biogas, waste to energy etc. that can be produced and consumed by the user (ibid). This report focuses on solar energy production as a primary power source for LCT for two essential reasons. Firstly, in most parts of South Africa the average sun shine hours per year is 2500 (South Africa's solar resource compared to the rest of the world, 2013), and Johannesburg experienced approximately 3267 hours of sunshine in 2017 (World weather online), which makes it highly favorable for solar energy production. Secondly is the abundant availability of roof space infrastructure that can be used to fit photovoltaic panels that will capture the energy of the sun.

By the end of 2015, the total global installed solar power electricity totaled 227 GWe (World Energy Council, 2016). The leading countries in cumulative PV installation are China (contributing 23% of global installed PV), Germany (13%), Japan (14%), Italy (6%) and USA (14%) with the rest of the world installation amounting to 30% in the last 10 years (ibid). Reasons for this growing interest in PV are the falling costs of PV, free availability of the resource and advancements in technology (ibid). As PV technology becomes more efficient, physical design parameters have evolved as well, and perhaps make it less visually intrusive. Maximum solar energy production is determined by the orientation and the pitch of the PV panel (Matshoge and Sebitosi, 2017). The safety aspects of design and installation of PV panels in South Africa is required to comply with: SANS 959-1: 2016 (SABS, 2016) and SANS 1042 part 1 to part 4 (GreenCape, 2016)

2.4.7 Smart Grids ('Improve' Strategy)

Smart grids (SGs) are electrical grids that act as intelligent management systems designed to ensure that energy usage is efficient and does not go to waste. According to the South African National Energy Development Institute (SANEDI) Smart Grids 2030 Draft Vision (SANEDI, 2013), SG will be crucial for emerging technology requirements like renewable energy, distributed generation and electric vehicles and when combined will reduce CO_2 emissions (ibid). According to the 2017 Smart Grids Innovations Challenge Country Report (MI Smart Grids, 2017), smart grids play a pivotal role in optimizing the use of clean energy. Three components that make this possible are their ability to observe and provide a high level of control; they can also self-diagnose problems backed up with healing solutions (ibid). Fourteen

countries have committed to Smart Grid implementation. Countries which have committed to innovation, funding, demonstration and research are the USA, Australia, Canada; China; Mexico; Italy; Denmark; Norway and Sweden. (ibid). Countries which have implemented functionalities of the smart grid via existing grids are Finland, France, Germany, India, and The Republic of Korea. This trend has started gathering pace in South Africa as well, and according to SANEDI (2013) Converting existing supply grids to smart grids will:

- Improve connectivity and operations management of energy sources;
- Optimize energy usage due to user choice preferences;
- Ensure consumers have access to more information regarding supply choices;
- Reduce environmental impacts; and
- Ensure reliable and secure energy supply.

2.4.8 Smart Urbanism - ICT ('Improve' Strategy)

'Smart cities' and 'smart urbanism' have emerged as new visions of the future, displaying advancements in technology and infrastructure in the form of ICT (Luque-Ayala, 2015). According Bibri and Krogstie, (2017), the 'smart city' originated in the mid-1960s and was referred to as the 'cybernetic planned city'. A smart city is based on planning, design and management (ibid). The single thread that can integrate these interventions is an app-based web platform that would ensure real-time information, which contributes to decision making that is cost- and time-effective. Research shows that in 2007 there were ten million electronic sensors on the planet (Rifkin, 2014). This number increased to 3.5 billion in 2013 and is expected to rise to one hundred trillion by 2030 (ibid). This new intelligent network will connect work, homes, machines and automobiles through an energy internet, communication internet and the logistics internet (ibid). This can be through a combination of smart card systems and intelligent transport systems (ITS) (Thomas, 2005), where information is gathered through geographic positioning systems (GPS), road cameras and the user to inform decisions (Jarašūnienė, 2007).

2.4.9 Zero Cost Society

Rifkin's 2014 book 'Zero Marginal Cost Society' suggests that history proves that costs of technological items decrease with time (Rifkin, 2014). This will eventually lead to a new socio-economic existence, where goods and service will eventually become almost free (ibid). Rifkin (2014) believes that the Internet of Things (IOT) and the Third Industrial Revolution is the catalyst to goods and products being driven to almost zero marginal costs. He refers to this as the 'exponential curve' that calculates cost and

technological advancements, and the rate at which this occurs over a period. He uses the example of the first IBM commercial computer invented in 1959 which was approximately 0.9 m x 1.5 m and cost about$ 30 000 merely to rent. Just 53 years later in 2014, the Raspberry Pi computer cost a mere $ 25 dollars (Rifkin, 2014). He further asserts that this will bring in a new social approach involving harmonious living — the collaborative commons (ibid). Rifkin (2014) highlights the importance of technological advancements that have occurred over the past 25 years. He refers to the current global communication networks where media such as text, audio or video is now being instantly shared globally by billions of people at almost zero cost. These kinds of advancements are crucial for the ZCW-ITN vision where immediate access to real-time information will be crucial for decision-making by users. He also predicts that in the next quarter-century wind and rooftop solar energy will improve efficiency of the global economy, as well as transport costs. He calls these advancements the Energy Internet where green energy will be managed by virtually free information systems, creating a matrix of intelligent energy and communication systems. Rifkin (2014) also highlights the emergence of new modes of transport and how this will result in zero costs due to communications and energy being almost free.

2.5 The ideal – Utopia

Utopia? According to the English Oxford Living Dictionaries, Utopia means 'An imagined place or state of things in which everything is perfect'. This concept was first developed by Sir Thomas More in 1516 due to the social inequalities of the time. From the literature such as 'Utopia' (More, 1515), we find that concern for society and the environment took precedence over wealth and status. In this report the concept of 'Utopia' is crucial — it provides a basis for understanding of zero-carbon transportation needs of the future. Utopia provides a window for the ZCW-ITN vision of the future. This study imagines transport in Orange Grove in 2050.

Wuellner (2011) exposes modernism and the industrial age as main contributors to a tainted utopian image where dystopic images have been created due to climate change and the unsustainable living. However, he also argues that recent images are of positive change where principles of sustainability and resilience are starting to act as turning points. Most opinions on utopianism allude to the fact that the status quo needs to change in one way or another, for a better quality of life, but none are more relevant than Morgan (2015) who suggests sustainability to be a utopian thought. The Brundtland Report, 'Our Common Future', defines sustainable development as "development that meets the needs

of the present without compromising the ability of future generations to meet their own needs." (Brundtland Commission, 1987 in Morgan, 2015: 118). It is a tool which focuses on the needs of the global society and environment (Alhaddi, 2015). This argued that it was time for change involving a collective stance to be taken against global threats and towards protecting mankind's common future through sustainable development (Morgan, 2015). Sustainable living embodies the same characteristics as the Utopia in that it: aims to create integrated social spaces; protects the environment; practices good governance; ensures equality amongst women and men; aims to remove capitalist modes of economics which would eradicate poverty and hunger; and achieve other sustainability development goals.

Participation by communities is key in utopian visions becoming a reality. By way of example, in 1991, the city of Queensland, Australia, approached the community to actively participate in the management of their natural resources in the Mary River catchment (Stevenson, 2009). The government's intention was to build a dam which was not in the community's best interest (ibid). Through a single shared vision and the action learning process, the community made a stand in achieving their goal (ibid). A vision of the future was created in the minds of the Mary River community which was their ideal. Through a combined effort they ensured that this vision became a reality. From this strategy we find that needs of the people became the basis of change, rather than authorities dictating what must happen (ibid). Other lessons from this strategy also highlighted the importance of the coordinator's role or someone who drives and champions projects (ibid). The community had to be engaged on multiple levels before the strategy became a shared vision (ibid). In this we find that it is still important for visioning to take place. The decision made is related to the coming together of people's needs which comes about through a learning process. In this paper the author highlights the importance of visioning and action learning. To implement a vision, co-operation will happen at multiple levels and through numerous channels via a common understanding of the need for reducing CO_2 emissions.

2.6 Case study —Beddington Zero Energy Development

The primary aim of this case study analysis was to understand how CO_2 emissions can be lowered given the mandate of a project. The analysis also revealed two further aspects: it revealed the fundamental aspects of the ASI framework; and it also displayed the social interaction and change that occurs when these kinds of interventions are applied.

The main aim of BedZED was to develop a prosperous community who used their 'fair share of the earth's resources' or less, whilst still maintaining a good quality life (Chance, 2009: 527). The intention was to also ensure that there was zero carbon and zero waste production (BioRegional Development Group, 2004). In order to achieve this BedZED designers and engineers needed to understand the following parameters: required accommodation; waste generation; water usage; and energy requirements. Energy requirement was further divided into electricity usage, hot water usage, space heating and cooling (ibid). The high-density residential development comprising 5000 residents and 2000 houses (ibid), combines work and home spaces (Chance, 2009) which allows residents to walk or cycle to work. The founding principles encompass: protection of natural habitats, wildlife, culture and heritage; zero-carbon and waste; sustainable water, transport and local materials; equity and fair trade; as well as health and happiness (One Planet Living Action Plan, 2015). BedZED has proved that it is possible to reduce world GHG emissions and eco-footprint by focusing on these principles (Chance, 2009). Focus was placed on understanding the needs of the community, which was done through regular consultation (ibid), which is also a key Utopian principle.

The 'Avoid' aspects of the project aimed at creating compact urban living where a density of 50 dwellings per 0.01 km^2 was achieved (Chance, 2009). Beddington Zero Energy Development (BedZED) in Hackbridge on the periphery of London is an urban housing project which focused on low-carbon emissions from buildings and transportation (Chance, 2009). The site selected for this development was a brownfield site.

The first aspect of the 'Shift' strategy saw the site itself as an advantage due to its close proximity to the Hackbridge train station; keeping people close to public transport which also played a key role in preventing sprawl (Chance, 2009). A second aspect of the 'Shift' strategy were concepts such as parking restrictions, car-sharing; and non-motorized transport (NMT) (cycling and walking) have been encouraged (BioRegional Development Group, 2004; Chance, 2009). Social behavior has also improved due to NMT and public transport activity (ibid).

Key aspects of the 'Improve' strategy focused on EVs and cleaner forms of energy production. Due to the high cost of EVs at the time of project commencement, residents focused on other options such as car-sharing. Nevertheless, free EV charging was provided powered by solar energy (Chance, 2009). High on the agenda was renewable energy which comprised combined heat and power (CHP) and solar. 777m2 of PV was installed which was used for powering EVs (BioRegional Development Group, 2004).

The benchmarks that were used to establish sustainable low-carbon living in BedZED were based on the individual's ecological footprint (Chance, 2009). The ecological footprint refers to the biologically productive space that a single human requires to survive on this planet, which is estimated to be 1.7 global hectares (gha) on average (Hudeková et al., 2007). The ecological footprint for people of Sutton at the time was measured at 5.32 gha, meaning they were using more than their budgeted biocapacity (Chance, 2009). As a comparison, South Africa uses 3.3 gha per capita and has a biocapacity of 1.2 gha per capita (National Footprints Account, 2016), Although higher than the BedZED baseline, this nevertheless means that South Africa needs resources from 2.75 planets to keep going as it is. Studies show that residents of BedZED have reduced their footprint to 4.67gha; this constitutes a small reduction which is not ideal considering the interventions implemented (ibid). The unexpectedly high footprint has been ascribed to factors including shared government services which have a fossil fueled energy source and consumer goods acquired outside the BedZED boundary. Chance (2009) also argues that an inadequate understanding of climate change contributed to people not realizing the importance of local sourcing to minimize the ecological footprint.

Despite the lower than hoped for improvements, the BedZED project proves that CO_2 reduction is possible through intelligent design without compromising an individual's quality of life (BioRegional Development Group, 2004). Strong management and effective promotion of renewable energy and green lifestyle have contributed to the success of BedZED (Chance, 2009). Research indicates that if the entire continent of Europe were to adopt the BedZED principles, CO_2 emissions could be reduced by 70% (ibid).

2.7 Conclusion

Climate change is a global phenomenon that affects everyone on this planet due to the primary cause of anthropogenic CO_2 emissions. The evidence of this happening can be seen in sea levels rising, unpredictable weather patterns, coral reefs disappearing, salinity of the sea changing and glaciers melting. Cities are high CO_2 producing zones and this will intensify with rapid urbanization. Climate change impacts at this stage are still manageable and there are opportunities to reduce, stop and reverse them through mitigation and adaptation strategies. In order to achieve this, the following needs to occur:

1) Radical sustainable urban transformation needs to occur through a structural multi-level process where economics, environment and social structures receive equal consideration.

2) Carbon-intensive cities need to become low-carbon emitters through sustainable or Eco-Cities. The Eco-City aims at reducing building- and transport- generated carbon emissions in the cities.
3) A combination of zero-carbon technologies and trends must be implemented which would contribute to reducing CO_2 transport emissions. It is not clear what comprises the ideal combination of trends but there are three key principles: the need to travel; using cleaner modes of transport; and using zero-carbon technologies. This is referred to as the ASI framework. Reducing CO_2 emission from transport using the ASI framework is possible as seen in the BedZED case study.
4) Sustainable transformations to urban systems are disruptive at multiple levels mainly policy, costs to implement, and social behavioural changes. Policy implementation is determined by the will and transparency of governance which aims to understand needs of people and acts accordingly. Costs to implement zero-carbon interventions can be viewed from two standpoints: firstly, there is a return on investment (ROI) for interventions such as EVs and PVs due to the costs being almost zero once these are paid up; and secondly due to theories like the exponential curve cost of interventions such as the EVs and PVs are expected to drop with time. In order for social behavioral change to occur, communities need to understand that there is a vision which benefits all.

3 Chapter 3: Research Method

When defining the main research question, it becomes clear that the nature of this study is exploratory, and the research themes were thus derived from the 4 core Sub-questions:

1. Understanding the extent of urban transformational potential to a zero-carbon well integrated transport network (ZCW-ITN) in Orange Grove;
2. Understanding what kind of a ZCW-ITN vision was possible in Orange Grove and how this goal could be achieved by 2050;
3. Understanding how adaptable the ZCW-ITN is to similar neighbourhoods in Johannesburg and beyond; and
4. Understanding the barriers of the ZCW-ITN vision which was established when analyzing the potential in chapter 4 and 5, and through semi structured feedback interviews with Orange Grove residents, Municipal Officials and professionals.

The approach of this research study was inductive with the research design being qualitative. This qualitative approach was selected in order to provide the following benefits:

1. The data collected in this study would be based on human experience and would contribute to decision making in Orange Grove;
2. The framework parameters are not static, findings would be able to be adjusted when new information and learnings through implementation becomes available; and
3. Findings in Orange Grove would be able to be transferred to similar neighbourhoods in Johannesburg (Anderson, 2010) and elsewhere.

Two research methods were incorporated into the study design, namely direct observation and participant action research (PAR). The latter was carried out through semi-structured interviews (Mouton, 2001). Direct observation had two objectives, firstly to understand the transport challenges faced in Orange Grove, and secondly to document the urban form of Orange Grove. For the first objective, the existing travel patterns were observed during AM peak hour traffic for 5 days. This was analyzed together with the secondary data obtained from the Orange Grove Traffic Impact Assessment (OGTIA) (CoJ, 2017a). The OGTIA highlighted the unsustainable carbon-intensive transport system currently operational in Orange Grove. However, it also assumed that future transport systems in the area will still be carbon-intensive and unsustainable. For the second objective, the physical urban form

was analyzed to understand the urban transformational potential to the ZCW-ITN vision in Orange Grove.

For the semi-structured interviews, the aim was to understand how individuals feel about climate change and to determine people's perception of the importance of a ZCW-ITN transformation. Change can be most effective when there is active participation by the community (Stevenson, 2009). For this reason, people were identified to be interviewed and were selected based on their connection to/ involvement with the community of Orange Grove. A video presentation of a preliminary ZCW-ITN vision was created using an online program. The video was shown to participants during the semi structured interviews. The aim of showing them the video was to inform the interviewees of the alternate future that was possible in Orange Grove and to get feedback regarding the vision. In order to create the final vision of a ZCW-ITN, the research tool 'scenario planning' was used. This assisted in capturing the essence of the main research question which aimed at envisioning an alternate mobility future for Orange Grove.

3.1 Scenario Planning

From the literature review we find that Utopia embodies the importance of imagining alternate futures. In this study one of the main objectives is to envision an alternative existence that will improve quality of life, as well as mitigate and adapt to climate change. The future can be anticipated with the assistance various methods and tools, but its foundation is built on informed conjecture (Ratcliffe, 2002). Validity of this conjecture can be substantiated through interviews and observation to enable valuable data extraction, which is crucial for future scenario development (ibid). Scenario planning (SP) would then systematically use this conjecture to establish different futures through the manipulation of variables. Variable are trends and uncertainties and establishing the impact and predictability of these variables would be used to envision alternate scenario outcomes. The fourth concept from SP, called Deciding, was used to understand how the ZCW-ITN could be strategically implemented in Orange grove.

3.2 Scenario Planning Method

The SP process for this report was guided by Lindgren and Bandhold's book: Scenario Planning *The link between future and strategy* (Lindgren and Bandhold, 2003). Their contention is that the brain is continuously unpacking what it observes, and it recognizes imminent changes in its surroundings. It then investigates different approaches, chooses the appropriate course of action, and finally acts on a decision which averts the danger (Lindgren and Bandhold, 2003).

As a SP framework, Lindgren and Bandhold method is a 5-step process called TAIDA which means: Tracking; Analyzing; Imaging; Deciding; and Acting (ibid). When applying the 5-step method to Orange Grove, the unsustainable high carbon transport network is immediately identified as a current and planned transport problem. This problem however is well documented globally and there are a number of zero carbon transport trends being employed to reduce fossil fuel consumption. Analysis indicates that even though trends have a remarkable potential to reduce CO_2 emissions, barriers such as cost and technological advancements are slowing down the diffusion process, a problem also faced in Orange Grove. Understanding the inherent qualities of a zero-carbon transport system was pivotal in creating the vision for Orange Grove. In do so, it was also important to recognize the barriers of implementing a ZCW-ITN system which is crucial for strategy selection. It is equally important to observe social, political and environmental changes taking place in Orange Grove and to be aware of latest advancements in technology and interventions. Keeping these in ones periphery will contribute to understanding the following: parameters of implementation; and the time it takes for complete ZCW-ITN transformation to take place.

3.2.1 **Step 1: Tracking**

Lindgren and Bandhold (2003) state that as a human being we need to scan our surroundings and be prepared for danger just like how a field mouse looks out for an owl. However, sometimes it might be detrimental if we are unable to determine what we cannot see in our blind spot (Polczynski, 2009). Being able to quickly spot danger in the blind spot will activate intuitive thinking (ibid). What has already been spotted, according to scientists, are the dangers where we are heading with climate change if we do not act to mitigate it. Trends are an important indicator of what is driving change and tracking these would be crucial to developing alternate futures.

3.2.1.1 Trends

According to Lindgren and Bandhold (2003), a trend is not a sudden popular occurrence that loses its importance after a short space of time, but it has a deeper meaning. It can affect the fundamental functioning of normative conditions (Lindgren and Bandhold, 2003). A change in weather patterns is not regarded as a trend due to its inconsistency and low impact, however climate change would be regarded as a trend due to its high impact which has been tracked over a long period of time (Lindgren and Bandhold, 2003). The historical nature of a trend is observed over a period and will determine how it is changing its surrounding environment. An example is the EV which is changing its surrounding

environment at multiple levels: petrol and filling stations could become redundant; new doors are opening for renewable solar energy; new business for EV charging stations are being created; road regulations may be adjusted to suit charging; policies as seen in Norway are introduced to incentivize EV adoption; and the ICE vehicle will becomes redundant. The impact and predictability of such trends are also be affected by drivers such as politics, economics, as well as social, technological and environmental factors (Lindgren and Bandhold, 2003; Polczynski, 2009). It is also important to note that trends are selected based on their relationship to the main research question and the interventions selected for the ZCW-ITN vision.

3.2.1.2 Impacts and predictability of trends

Understanding the impacts and predictability of a trend would involve having a comprehensive understanding of that trend at social, economic, environmental and political levels. The nature and characteristics of ZCW-ITN trends were evaluated in Chapter 2 to understand how potent these might be are on a global scale and how they might be starting to change their surrounding environment. During the process of identifying trends, it may at times become difficult to understand their predictability and how sustained they will be (Lindgren and Bandhold, 2003). It would be left to the scenario planner to fully investigate a trend and make an informed decision based on how quickly or slowly the trend is changing the environment, if at all.

3.2.1.3 The Main Research Question (Focal Question)-

To generate valuable and transparent results in scenario planning, a focal question needs to be selected (Lindgren and Bandhold, 2003). In this research report, the focal question (main research question) aims to answer two issues: first is to stop fossil fueled dependence in the transport sector; and secondly, how can the ZCW-ITN vision contribute towards climate change mitigation and adaptation goals? It is also important to select a suitably long-time horizon so that there is sufficient change in this period (ibid). On the other hand, if this period is too long then this would create uncertainty about the success of a trend (ibid). Based on these considerations, the time horizon for the vision for Orange grove is 2050 which is assumed to be sufficient time for the scenario end goal to be accomplished. This is also approximately a 20-year time horizon which would allow for an acceptable period for knowledge building and forthcoming research (ibid).

3.2.2 Step 2: Analyzing

At this point of the SP process, certain questions can arise regarding these trends such as: How sustained will this trend be? What does it mean for people affected by the trend? Or what are the relationships that will be created or destroyed because of a trend? (Lindgren and Bandhold, 2003). To achieve this understanding, the trend will be analyzed to understand how they have evolved and what this mean for future scenarios.

3.2.3 Step 3: Setting the vision

A vision consists of an ideology and a picture of the future (Lindgren and Bandhold, 2003). A vision needs to be a vivid description of the future and there needs to be a precise description of the desired outcome (ibid). A vision is created through feelings and emotions, to imagine yourself living in the desired future (ibid). A vision needs a reality check for it to be thought of as plausible (ibid). Imaging (or creating the vision) can be carried out without all the steps mentioned above, although using the aforementioned steps allows for a calculated look into the future (ibid). A vision can be described as a positive outlook on the future and should not be 'pie in the sky', but on the other hand should also 'aim for the stars' — a 'Big Hairy Audacious Goal' (BHAG) (Lindgren and Bandhold, 2003: 77). In the case of the current research report, the desired outcome is a ZCW-ITN vision.

3.2.4 Step 4: Deciding

The fourth step in the process involves deciding on strategies that would make the vision become a reality (Lindgren and Bandhold, 2003). Many strategies can become evident and this could cause confusion as to which strategy is the best (ibid). There would need to be sufficient analysis and understanding of the vision in order to apply the most appropriate strategies. The validity of the strategy is crucial and how it relates to the bigger picture which is mitigation and adaptation to climate change. For example, it would counter-intuitive to fly engineers from across the world to South Africa for professional assistance where flying would contribute to greater CO_2 emissions. Therefore, it would best to understand the assets and strengths in the CoJ which can be used with the least amount of life cycle CO_2 emissions (ibid). Finally, does the strategy lead to the ZCW-ITN vision (ibid). These strategies are further discussed in chapter 5 in order to achieve the ZCW-ITN vision.

3.2.5 Step 5: Acting

The final step in the SP process is 'Acting'. Lindgren and Bandhold (2003) advise that Acting has a double meaning, in the first instance involving acting upon strategies that were chosen, and the second meaning has to do with keeping an eye on the scenario planning process to observe changes in the environment that could change the direction of the vision. In understanding the environment, it is important to understand the dynamics of the drivers. In the case of the ZCW-ITN in Orange Grove, the driver is climate change and continued dependence on fossil fuel. Acting needs to start at ground level where a bottom up approach is used, which means getting the people of Orange Grove involved in making change. In the present study initial steps of Acting have begun, through semi structured interviews, by making CoJ citizens aware that a ZCW-ITN is imaginable and through the creation of this report.

3.3 Scenario Planning for the Green Utopia

Scenario planning the ZCW-ITN vision process aimed to understand the current and future transport conditions in Orange Grove. Current conditions were established during the direct observations of traffic and the site analysis while the future conditions were proposed by the CoJ through the COF transit-oriented development plans. An analysis of the COF transit-oriented development plans (CoJ and JDA, 2016; CoJ, 2017; CoJ, 2017a) also revealed that there is no plan which indicates that by 2050 the energy source for transport would be anything but fossil fuel, although the CoJ indicates that this change needs to happen. Should this scenario not be altered, it can be foreseen that the problems currently present in the Orange Grove transport system will be ongoing at 2050 after the COF SDZ implementation. The ZCW-ITN vision aims to change this by making carbon- reducing changes to ensure the COF TOD initiative becomes zero-carbon by 2050.

3.3.1 Creating Scenarios in Orange Grove

In order to build future scenarios, there needs to be an understanding of emerging carbon-reducing trends which have the ability to transform existing urban environments. In Chapter 2, these carbon-reducing trends were analyzed at a global scale. An understanding was established to determine the impact these trends would have on the future transport system of Orange Grove. Two uncertainties were also established that responded to these trends: what would the consequences be if CO_2 emitting trends were not applied in Orange Grove; and the consequence of CO_2 emission targets being met or not. Four scenarios were developed from this as shown in Figure 3.1.

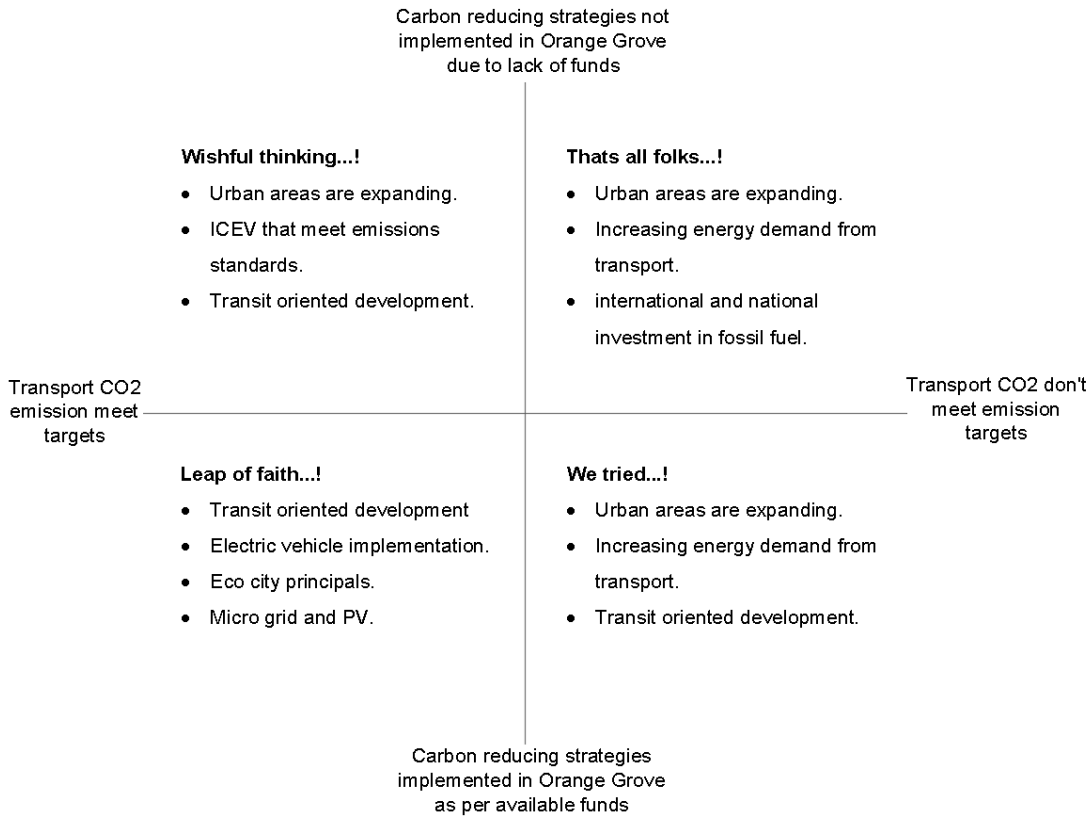


Figure 3. 1: CO_2 emissions and alternate Future Scenarios (Chetty, 2018)

- Scenario 1: 'That's all folks…!' The question that is asked is what happens when carbon-reducing strategies are not implemented, and CO_2 emission targets are not met —, a worst-case scenario. We find that if no interventions are implemented will result in worst case climate change impacts, like sea levels rising, global temperature rising, unpredictable weather patterns, droughts, and food shortages;
- Scenario 2: 'We tried…!' In this scenario CO_2 emission targets are still not met due to a limited number of carbon-reducing strategies being implemented due to reasons such lack funds and lack of belief that climate change is real. In this scenario the impacts of climate change will still occur but at a slower rate, due to NDC targets not being met timeously as proposed in the 2015 Paris Agreement;
- Scenario 3: 'Wishful thinking…!': In the third scenario it is anticipated that CO_2 emissions reductions could be met by assuming that advances in ICE vehicle technology will have low CO_2 emissions. According to studies by the Union of Concerned Scientists (2015) EVs life cycle

emissions are 50% less than ICE vehicles. Therefore, it is likely that CO_2 will continue despite contrary beliefs resulting in the full extent of climate change hitting when least expected;

- Scenario 4: 'Leap of faith…!' In this scenario maximum zero-carbon interventions are implemented but it is done with the intention of answering world urban area issues such as poverty, food security and shelter amongst other things. Therefore, interventions will be based on the environment, society and economy. In this scenario climate change is mitigated and is eventually terminated.

Based on these four scenarios, it becomes easy to understand the importance of applying the full extent of all zero-carbon interventions. Based on Scenario 4, the ZCW-ITN vision in 2050 is developed in chapter five.

3.4 Data Collection

In this study, both primary and secondary data were collected. Primary data is that information collected first-hand, and which acts as evidence and assists in validating a hypothesis or proves otherwise (Polkinghorne, 2005). Primary data is information that is regarded as reliable and valid (Mouton, 2001). However, collecting primary data can be costly and time-consuming; it is furthermore, subject to unforeseen interruptions. Primary data can be collected through interviews, experiments and observations (ibid). In the present study, primary data was collected through interviews and observations.

Secondary data is described as information that has been gathered by other individuals (Polkinghorne, 2005). The advantages of secondary data are that this information can be gathered from a wide range of existing sources and does not have a high cost attached to it (ibid). It can be obtained through sources including statistical service providers, official documents, mass media and the internet. The tables below describe how data was collected and analyzed in this study. Between Tables 3.1 and Table 3.5 below describe how data was collected and analyzed in this study.

Table 3. 1: Data collection – sub question 1

Research Sub-question	Data needed and collection tools and processes	Data analysis processes
Sub-question 1: What is the transformation potential to a zero-carbon well integrated transportation system in Orange grove?	Primary data and secondary data sources: Primary data: ◦ Direct observations of traffic patterns which is partially quantitative ◦ Direct observations of urban form ◦ Desktop study – street-widths measured in Orange Grove using Google Maps, existing building heights Secondary Data: ◦ Louis Botha Spatial Development Framework ◦ Orange Grove SDZ Brochure (2017) ◦ OGTIA (2017) ◦ Orange Grove HIA, 2016 ◦ Secondary data tools: ◦ Electronic published data	Primary data and secondary data analyzed for: ◦ Traffic volumes, speed, pedestrian movement and cycle movement ◦ Urban form, function of buildings, streetscapes and accessories ◦ Understanding existing road reserve Analyzed data was applied to: ◦ Defining and understanding the status quo of traffic and urban form in Orange Grove ◦ Understanding the potential for change in the Orange grove transport

Table 3. 2: Data collection – sub question 2

Research sub-question	Data needed and collection tools and processes	Data analysis processes
Sub question 2 What ZCW-ITN vision is possible in Orange Grove, and how can this be implemented?	Primary data: ◦ Direct observations of traffic patterns, ◦ Direct observations of urban form ◦ Desktop study – street widths measured in Orange Grove using google maps, existing building heights Secondary data source: ◦ Louis Botha Spatial Development Framework ◦ Orange Grove SDZ Brochure (2017) ◦ OGTIA (2017) Academic Journals **Secondary data tools**: Electronic and printed published data-books/journals	Primary data and secondary data to be analyzed to understand: ◦ Urban infrastructural transformation ◦ Defining and developing a ZCW-ITN vision ◦ Requirements to develop strategies that would lead to the ZCW-ITN becoming the end state.

Table 3. 3: Data collection – sub question 3

Research sub-question	Data needed and collection tools and processes	Data analysis processes
Sub-question 3: How could insights gained from the pilot study in Orange Grove, inform future retrofits of similar existing suburban neighborhoods in Johannesburg?	Seconday data sources: qualitative Primary data: ◦ Direct observations of urban form in Balfour Secondary data: ◦ The Louis Botha Spatial Area Framework interrogated (2016). ◦ Balfour Park Precinct Plan & Urban Design Framework (2016) ◦ Traffic Impact Assessment ◦ Balfour Park Precinct Plan & Urban Design Framework (2016) ◦ Desktop study – google maps Academic Journals **Secondary data tools**: Electronic and printed published data-books/journals	Primary and secondary data to be analyzed to understand: ◦ urban form, function of buildings, streetscapes and accessories in Balfour Park ◦ other similar neighborhoods on the Louis Botha corridor that have been selected for transit-oriented development. ◦ Understanding this determine the applicability of the ZCW-ITN vision to another TOD proposed in the CoJ. ◦ Traffic patterns, types of vehicles and road usage.

Table 3. 4: Data collection – sub question 4

Research sub-question	Data needed and collection tools and processes	Data analysis processes
Sub-question 4: What are the barriers when transforming from a fossil fueled transport system to a zero-carbon well integrated transport system in Orange Grove?	Primary data and secondary date sources: qualitative Primary Data: ◦ Direct observations made in the OG study area. ◦ Google desktop study of road reserve. ◦ OGTIA (2017) ◦ semi structured interviews with Orange Grove residents, Municipal officials, traffic engineer, GBCSA representative, and SANEDI representative Academic Journals **Secondary data tools**: Electronic and printed published data-books/journals	primary data to be analyzed to understand: ◦ This sub question determined the barriers the ZCW-ITN vision will experience, which was presented in chapter 5, ◦ Solutions were investigated for overcoming such barriers. ◦ Parameters of the ZCW-ITN vision and assisting the scenario creating process.

Table 3. 5: Main research question data requirements

Main research question	Data needed and collection tools and processes
What role can the implementation of ecomobility, e-mobility and associated low-carbon related trends play in mitigating climate change, and how effective would this approach be?	Data collection and analysis of the sub questions has determined the suitability of the fundamental concepts of envisioning a ZCW-ITN in Orange Grove. ◦ Direct observations of traffic and urban form in Orange Grove; ◦ Traffic impact assessments examined to understand current and future transport in Orange Grove based on the TOD; ◦ Findings from primary and secondary data was used to determine the potential to implement the ZCW-ITN vision in Orange Grove. During this process barriers for the ZCW-ITN vision were also recognized; ◦ Findings from primary and secondary data was used to develop scenarios to understand alternate futures; ◦ Strategy developed to implement the ZCW-ITN model based on primary and secondary data; ◦ Physical characteristics were examined in BPP study area through direct observations and a google maps desktop study. This determined the applicability of the model to other suburban neighborhoods going through a TOD in the CoJ; ◦ Semi structured interviews were carried out to determine barriers of the ZCW-ITN model.

3.5 Primary Data Collection

In this study, primary data was collected through direct observations made in Orange Grove regarding traffic patterns and urban form.

3.5.1 Traffic patterns and urban form observations

According to de Jongh and Bruwer (2017) traffic patterns and volumes vary by day, week, month and by year. Such variations are also be affected by public holidays, school holidays and seasons (ibid) which must be considered in this section. Traffic Patterns in Orange Grove were observed over a period of five days during morning peak traffic between 07h00 and 08h00. The period of observation was approximately 15 minutes on all days. These patterns were being observed to understand the sustainability of the existing transport system in Orange Grove. Aspects observed covered categories of vehicle observed and their transmission type and the number of people occupying privately owned vehicles. Further observations made, related to the number and relative safety of pedestrians and cyclists. The streets selected for observation were the designated high traffic volume streets as per the OGTIA (CoJ, 2017a).

These covered Osborne Avenue, Patterson Road, Louis Road and Hawthorne Street and Dunotter Street. As the highest volume street in the suburb, the northern and southern most points of Louis Botha Avenue falling within the study area were also assessed. The OGTIA (CoJ, 2017a) established that there are high current traffic volumes of ICE vehicles, and it also predicted that as Orange Grove densifies, so will bus and minibus taxi numbers (CoJ, 2017a). A second trip to the site was used to observe streetscapes and buildings.

3.5.2 Semi structured interviews.

A seven-and-a-half-minute video was created to present a preliminary ZCW-ITN model to Orange Grove residents, municipal officials and professionals. Eleven semi-structured interviews were conducted to collect primary data as follows:

1. Three Orange Grove residents were interviewed to determine affordability, comfort and accessibility of the current transport system and their willingness to change behavior to achieve a zero-carbon well-integrated transport system was assessed.
2. Three professionals in the fields of building and transport sustainability, traffic engineering, and an EVs and solar energy were interviewed to gain their input on the ZCW-ITN vision. They were requested to evaluate both the physical and financial aspects of the design. Feedback requested included educated opinions on: ecomobility; building and transport relationship; urban infrastructure; current transport systems; electric vehicle, solar charging facilities, lithium ion batteries, smart grids and distributed generation.

3. Seven municipal officials were interviewed to gather their feedback on their level of concern about climate change. Three were from Johannesburg Roads Agency (JRA) and four were from the CoJ. They were further requested to provide their feedback on the spatial and financial barriers of the ZCW-ITN vision, as well as their opinions on feasible energy sources for transportation. They were also asked to give their opinion on how adequate and comprehensive current transport policies are.

3.6 Secondary Data Collection

Roadway widths, number of lanes and directional flow of traffic were determined through a Google Maps desktop study. A copy of an AutoCAD file indicating the proposed SDZ was obtained from the City of Johannesburg. The CAD file was adapted to create various site maps in Orange Grove. The OGTIA and the Orange Grove SDZ was studied to understand future building types and the proposed densification to be carried out. Site maps were also created for Balfour Park where the applicability study was carried out. A site map was traced in AutoCAD from the existing Balfour Park Precinct Plan and Urban Design Framework. 16 site maps were developed covering 2 aspects: firstly, was the existing land and transport conditions in the Orange grove and Balfour Park Precinct; and secondly were the proposed ZCW-TN interventions:

Site map 1 – Existing Land use (Source: based on google maps and COF SDZ, 2017)

Site Map 2 –SDZ road classification (Source: based on google maps and CoJ, 2017a)

Site Map 3 – SDZ proposed densification (Source: COF SDZ, 2017)

Site Map 4 – SDZ future transport (Source: COF SDZ, 2017)

Site Map 5 –Traffic heat map: Monday to Friday at 8am (Source: based on Google Maps)

Site Map 6 – Existing Street Parking in Orange Grove (Source: based on CoJ, 2017a)

Site Map 7 – Existing gated streets in Orange Grove (Source: Chetty, 2018)

Site Map 8 – Existing streetscape typologies in Orange Grove (Source: Chetty, 2018)

Site map 9 – locations of proposed car-free streets (Source: Chetty, 2018)

Site Map 10 – EV charging station opportunities (Source: Chetty, 2018)

Site Map 11 – roof space identified with potential for PV in Orange Grove (Source: based on the COF SDZ, (CoJ and JDA, 2017)

Site Map 12 – Existing available roof space in Orange Grove (Source: Chetty, 2018)

Site Map 13- Road allocations and density proposals in Balfour Park (based on BPPPUDF, 2016)

Site map 14 streetscape interventions types 1–5 for BPP study area based on OG study area (Source: Chetty, 2018)

Site map 15 - EV charging potential in BPP study area (Source: based on BPPUDF, 2016)

Site Map 16 - RSPP in the BPP study area (Source: based on BPPUDF, 2016)

The following documents were used to collect secondary data:

- Louis Botha Avenue Development Corridor Strategic Area Framework (CoJ and JDA, 2016);
- Louis Botha Corridor Local Area 3 Orange Grove Special Development Zone (COF SDZ) (CoJ, 2017);
- Orange Grove Traffic Impact assessment (OGTIA) (CoJ, 2017a);
- Draft Green Transport Strategy: (2017 – 2050) (DOT, 2017a);
- Orange Grove Precinct Heritage Impact Assessment & Conservation Management Plan Report (CoJ and JDA, 2016a);
- Balfour Park Precinct Plan and Urban Design Framework (CoJ, 2015); and
- Balfour Park Traffic Impact assessment (CoJ, 2015a).

3.7 Assumptions and Limitations

The scope of this report is limited to a pilot study intended to contribute to mitigating climate change in the City of Johannesburg. The researcher had to deal with the following limitations during the research process:

3.7.1 Assumptions:

- Due to the embryonic status of the topic and the limited number of recorded successful case studies, there was limited understanding of the exact parameters of a ZCW-ITN vision. This meant that the researcher needed to make assumptions about the combination of interventions used. Interventions were selected according to three criteria: firstly, it had to be related to the ASI framework; secondly direct site observations determined the type of infrastructural changes possible; and thirdly according to what was established from semi structured interviews. According to Vallack et al. (2015) it is unclear what combination of interventions would result in the most potent ZCW-ITN conditions; and

- The ZCW-ITN model was also created from secondary data, assumptions needed to be made regarding behavioural changes. This implies that there could be limitations when adapting the model to other neighborhoods.

3.7.2 The limitations associated with the research report is the following:

- The scenario planning tool is most successful when there is more than one scenario planner participating thereby producing a range of diverse objective opinions. This would make for a thorough analysis of future scenarios. Aspects of the City of Johannesburg's Corridors of Freedom formed the foundation of the ZCW-ITN vision and played a crucial role in the scenario planning process. In this report the researcher worked as the sole scenario planner which made the process subjective and unchallenged. This means that the researcher's bias may have hindered the process and skewed future scenarios. This was mitigated through the researcher being constantly aware of this challenge and evaluating decision-making from different viewpoints. The researcher might have been biased; and although the researcher endeavored to identify and prevent this, bias may have been applied to aspects of the SP;
- The scenario planning process was time dependent which means that the more time dedicated to observations made in the surroundings, the stronger the analysis. However due to time constraints the SP had to be completed within a short space of time;
- The scenario planning process can be carried out in one of three ways, namely expert model, participation model or organization model (Lindgren and Bandhold, 2003). For this report the expert model was used which required the input of just the researcher. This reduced the number of viewpoints and again might have resulted in bias;
- Due to time constraints only thirteen interviewees participated in the semi-structured interview and ideally, more people would have been interviewed. However, the main aim of the semi structured interviews was to: firstly, assist in the scenario planning process, and secondly to understand the barriers when implementing the vision which was sufficiently achieved;
- In the present study certain issues cannot be addressed in-depth such as socio-political will, unions and other worker's organizations which are linked to sustainability transitions due to them being beyond the scope of this study; and
- Even though the video presentation of the ZCW-ITN model presented during the semi structure feedback interview seemed to provide adequate information, most interviewees were unable to

respond adequately to interview questions. This implies that the interviewees generally had limited knowledge of the topic.

4 Chapter 4: The ZCW-ITN vision in Orange Grove

This chapter outlines a utopian vision of transport in Orange grove (OG) study area set in 2050. To develop this vision the current transport system in Orange grove is examined and analyzed to be used as a basis for the development of the utopian vision. This is guided by Sub-questions 1

- Sub-question 1: What is the transformation potential to a zero-carbon well integrated transportation system in the OG study area?

To realize the potential of transforming the OG study area into a ZCW-ITN, it is necessary to understand the nature and state of the current transport infrastructure. This can enable the development of strategies to transform infrastructure to accommodate green transport technologies. Necessary information includes direct observations made in the OG study area. This was divided into 2 categories: first was to understand the type of traffic and how people used the roads in the OG study area (see section 4.2); and second was to understand existing street typologies (see section 4.3).
It is anticipated that the adaptive nature of the ZCW-ITN will allow it to complement the status quo and the future transit-oriented developments proposed in the OG study area.

4.1 Overview of the Study Area

The OG study area falls under the City of Johannesburg municipality. It is located in the eastern part of Johannesburg and is primarily a residential area with supporting socioeconomic functions. Orange Grove has a population density of about 5647 people/km^2 (Census, 2011). The area has been identified for compact city development as per the Louis Botha Corridor Local Area 3 Orange Grove Special Development Zone (COF SDZ). This is proposed to increase the population density to around 44515 people/km^2. The Special Development Area (SDA) of Orange Grove is about 8.5 km from the City of Johannesburg central business district (CBD) (CoJ, 2017a) and bounded by Oaklands Road on the north, Osborne Road on the south, 9th Road on the east and the sub urban neighbourhood Norwood and the M1 freeway on the west (see Figure 4.1 and 4.2). Orange Grove falls within the Gauteng Province which is the economic hub of the country. There is a considerable amount of economic activity that happens within Orange Grove along Louis Botha Avenue. Louis Botha Avenue acts as a connector between the Johannesburg CBD and the densely populated residential area of Alexander. Also, of major importance is the link to, the national capital of the country Tshwane (previously known as Pretoria) and Midrand en route to Tshwane. This has been one of the reasons why Orange Grove has been identified for TOD.

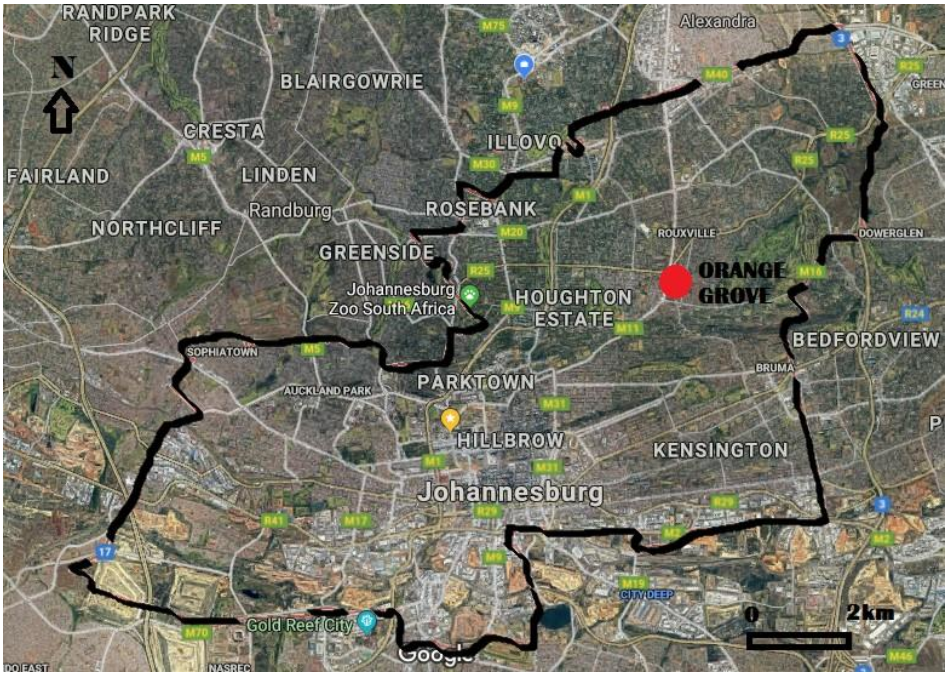


Figure 4. 1: Site Locality Map – Johannesburg (Source: Google Maps)



Figure 4. 2: Site Locality Map – Orange Grove (Source: Google earth)

4.1.1 **Land Use**

Land use in Orange Grove is dominated by residential development with the majority comprising single storey units on typical sites of 450 m^2. Other residential types include walk-up flats as well as mixed use areas. Economic activity within the study area occurs mostly on Louis Botha Avenue and it comprises of commercial, retail and office functions (ibid). Commercial functions are also dispersed around the suburb (see the existing land use in Figure 4.3 below.)

4.1.2 **Economic Profile**

According to the OGTIA (CoJ, 2017a) majority of the residents in Orange Grove are low- and medium-income earners (ibid). Low income residents do not earn more than R3500 per month whilst middle income earners earn between R3500 and R11000 per month (ibid). Altogether there are 2792 households in Orange Grove with the majority being middle-income earners and low-income earners also (CoJ, 2017a; Appelbaum, 2016). Also, within the study area exists a small number of high-income earners. Poverty and inequality is a common socio-economic disparity that exists in South Africa.



Figure 4. 3: Site map 1 – Existing Land use (Source: based on google maps and COF SDZ, 2017)

4.1.3 Transportation

There are four distinct arterial roads in Orange Grove as follows: the M1 freeway which is a Class 1 road with 3 lanes per direction; Louis Botha Avenue which is a Class 2 major arterial road with 2 lanes per direction; Louis Road which is a Class 3 minor arterial with one lane per direction; and two Class 4 local distributor roads (Osborne and Patterson Roads) (CoJ, 2017a). These road classifications and functions are expected to change with densification once the SDZ is complete by 2040 (see Figure 4.5, Figure 4.6 and Figure 4.7 below) The peak morning traffic survey undertaken for the present study confirmed a high volume of vehicles travel through the Louis Botha Avenue (future class 3) and Osborne Road intersection (future class 3) (southern extent of the study area). Similar findings were made for the northerly sampling point on Louis Botha at the intersection of Dunotter and Louis Botha Avenue.

4.1.4 Mobility in Orange Grove

Traffic surveys show that 900 vehicles / hour pass through Orange Grove during peak hour traffic (CoJ, 2017a). Another Surveys showed that 48% of business owners in Orange Grove use their cars to work, whilst 41% walk to work (Appelbaum, 2016). Public transport includes privately operated mini-bus taxis and bus services operated by Metro-Bus and Putco buses. Most who work in Orange Grove live in Orange Grove or Norwood with 40% of them walking to work (Appelbaum, 2016). 28% of people who work in Orange Grove rely on mini bus taxis for transportation (CoJ, 2017a). The mini bus taxi plays a crucial role in transporting many low-income earners in South Africa. There is also high contingent of public transport service running along Osborne, Patterson, Goodman terrace and 10th Street (ibid). The Rea Vaya bus rapid transit (BRT) system is currently under construction and it is anticipated this will form part of the public transport services by 2019 (ibid) (see Figure 4.4 below). There is no rail network within a wide radius of Orange Grove, with the closest rail systems being the Gautrain located in the CBD and the closest Metro rail station is located in Doornfontein, 6.2 km away.

4.1.5 Energy Sources

Orange Grove is dominated by motorized transport system based on fossil fuels; thus, the area is contributing to the carbon foot print and consequently climate change. The new transport upgrades outlined in the Orange Grove traffic impact assessment and planned to be implemented by 2040 (CoJ, 2017a) are also reliant on the same technologies and do little to move to transport systems that are based on cleaner energy. To achieve ZCW-ITN, there is a need to rethink the transport system towards cleaner transport systems which rely on renewable energy sources.

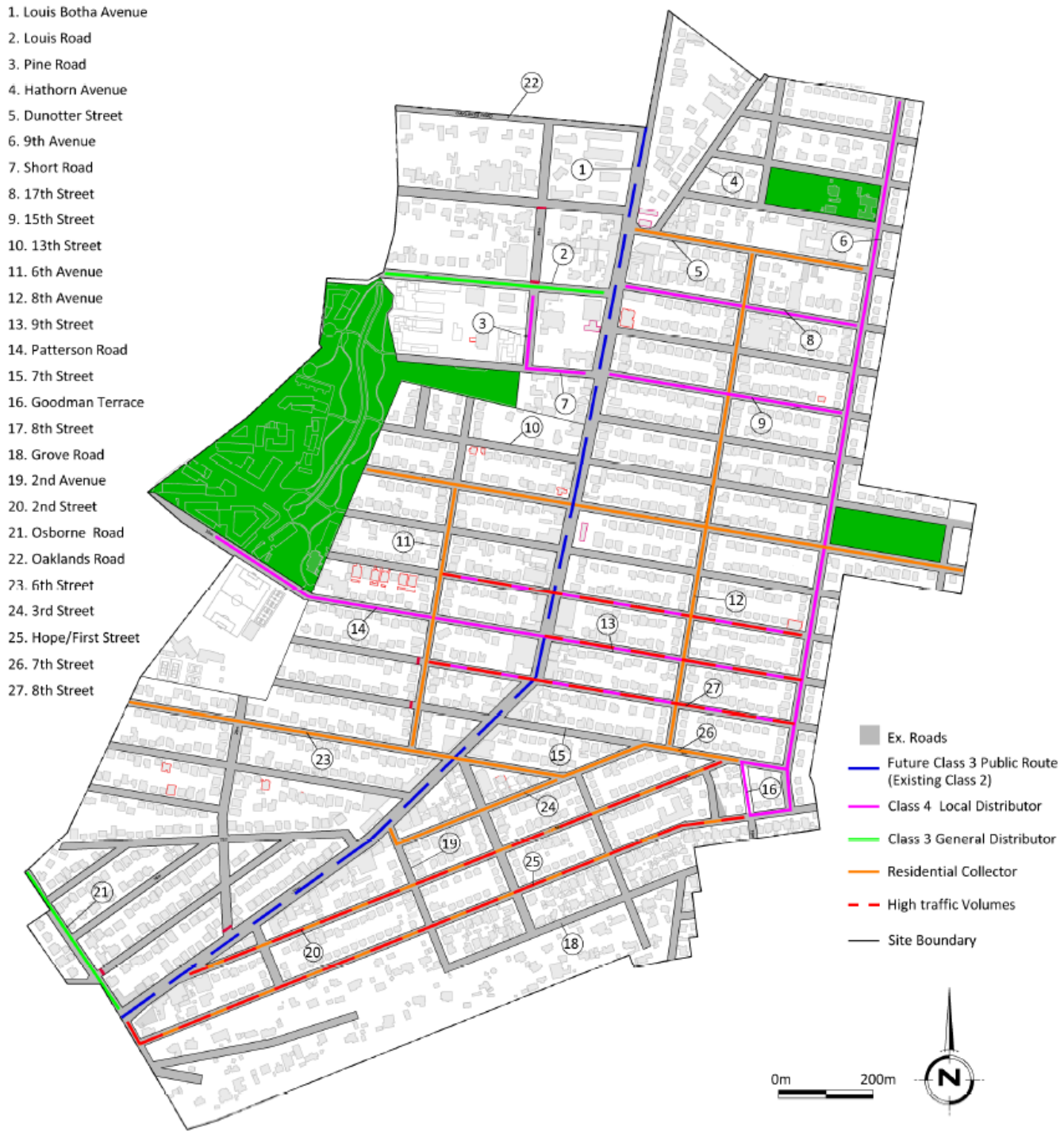


Figure 4. 4: Site Map 2 –SDZ road classification (Source: based on google maps and CoJ, 2017a)



Figure 4. 5: Site Map 3 – SDZ proposed densification (Source: COF SDZ, 2017)

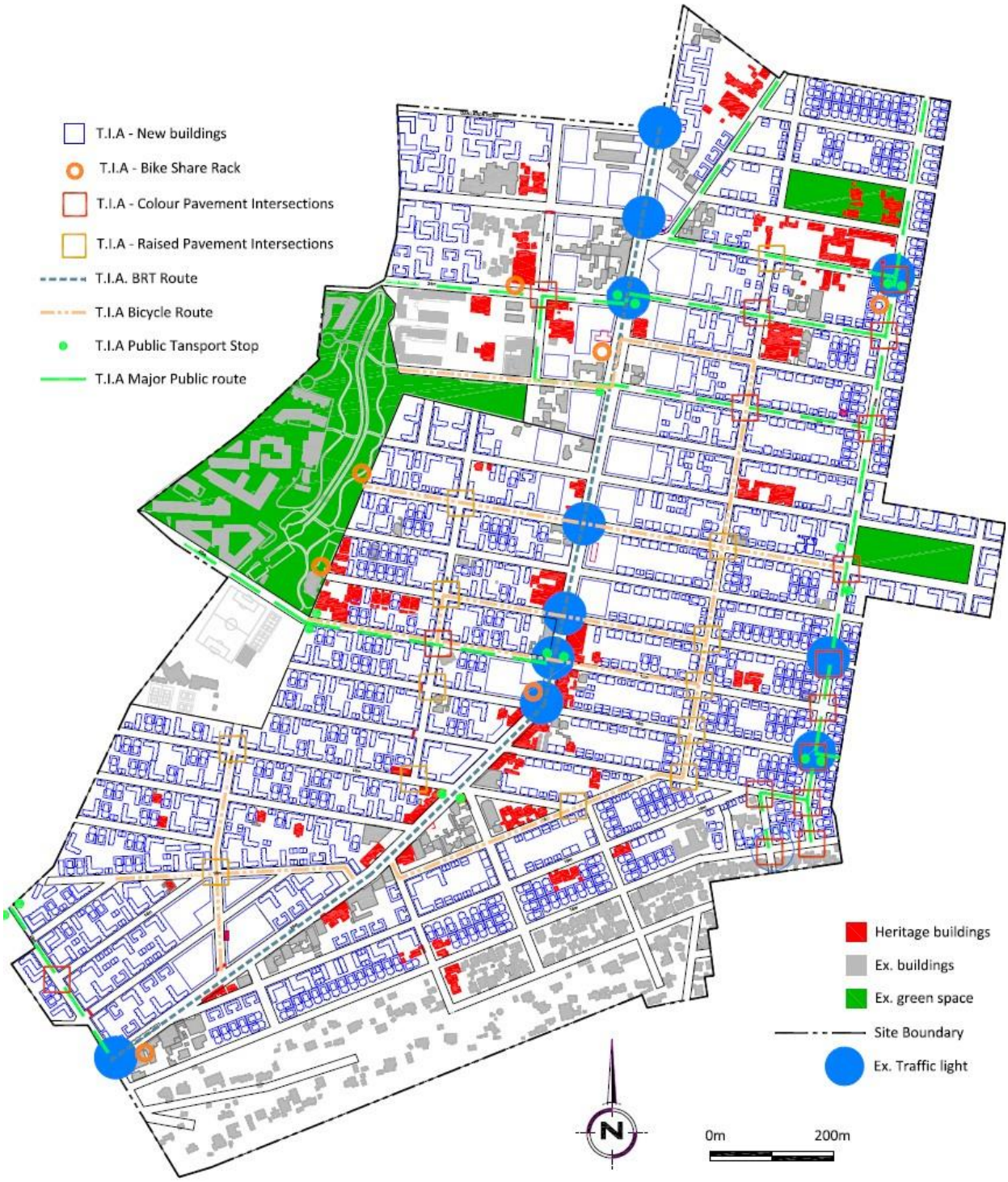


Figure 4. 6: Site Map 4 – SDZ future transport (Source: COF SDZ, 2017)

4.2 Peak Traffic Flows

A number of vehicles were observed turning into Osborne Road (class 3) from Louis Botha Avenue, with traffic flowing at approximately 10 vehicles per minute. Louis Botha Avenue (existing class 2) itself was found to be congested, with a high volume of vehicles moving in both directions. Approximately 28 vehicles per minute were observed at approximately 8am, to be travelling away from the Johannesburg CBD, with fewer vehicles (approximately 17 vehicles per minute) travelling towards the Johannesburg CBD.

Patterson Road (Class 4) is relatively busy with medium flowing traffic during peak times. It was observed during the peak morning survey for the present study that traffic predominantly was moving away from Orange Grove towards the western part of Johannesburg. Vehicle types using this road consisted mainly of passenger cars and mini bus taxis. There were about 18 vehicles per minute travelling on this route at about 8.15 AM. Although only a Class 4 Road, Patterson Road (based on the observations in this study) appears to experience slightly higher traffic volumes than Louis Road (Class 3). The latter road was observed to have 14 vehicles moving from a westerly direction and 9 vehicles moved in easterly direction per minute in peak morning traffic.

As with the other roads observed, there is a three-way intersection of Dunotter and Hathorne (Class 4) with vehicles travelling from Dunotter Road into Louis Botha Avenue, from Louis Botha Avenue into Dunotter and into and away from Hathorne Avenue. This kind of vehicular activity makes this a relatively busy intersection. Approximately 16 vehicles were observed to travel through the intersection per minute. The cause of this congestion was due to a high volume of vehicles using this route to access and move away from the N3 freeway which is approximately 5 km east of Orange Grove.

On Louis Botha Avenue there were approximately 14 vehicles per minute moving towards the CBD. This road features 2 lanes in each direction with wide (approximately 3.5 m) sidewalks on either side. Based on the observations made, the sidewalks are intensively used by pedestrians either being dropped by taxis, or pedestrians travelling in a northerly and southerly direction (see Figure 4.7 below). The pattern of pedestrian movement on the other roads surveyed revealed that there were not as many as observed on Louis Botha Avenue. This suggests that people used the route as a walk path, or they were being dropped off by public transport at various points on Louis Botha Avenue. Most vehicles were travelling in a southerly and westerly directions which suggests movement towards economic hubs such as the CBD or Sandton.



Figure 4. 7: Louis Botha Avenue – Northern End (Photo by Chetty, L., 2017)

In order to get a better understanding of traffic in the study area, a traffic heat map was generated based on information extracted from Google Traffic (see Figure 4.8). Traffic is generated using GPS coordinates obtained from cell phone users where speeds are analyzed, thus understand speed of traffic on a specific length of road. Due to the traffic results being based on real time information accuracy levels are quite high. The heat map revealed that besides the busy routes noted above, the following roads, numerous other roads are also congested during peak morning traffic. 2nd street, 2nd avenue, Grove Street, 7th street, 8th street, 9th street, 9th avenue, 6th avenue, 13th street, 15th street, 17th street, short road, pine road.

This exercise was aimed at understanding the current situation and this in turn helped informed the kind on interventions that were required to transform the area into a ZCW-ITN.

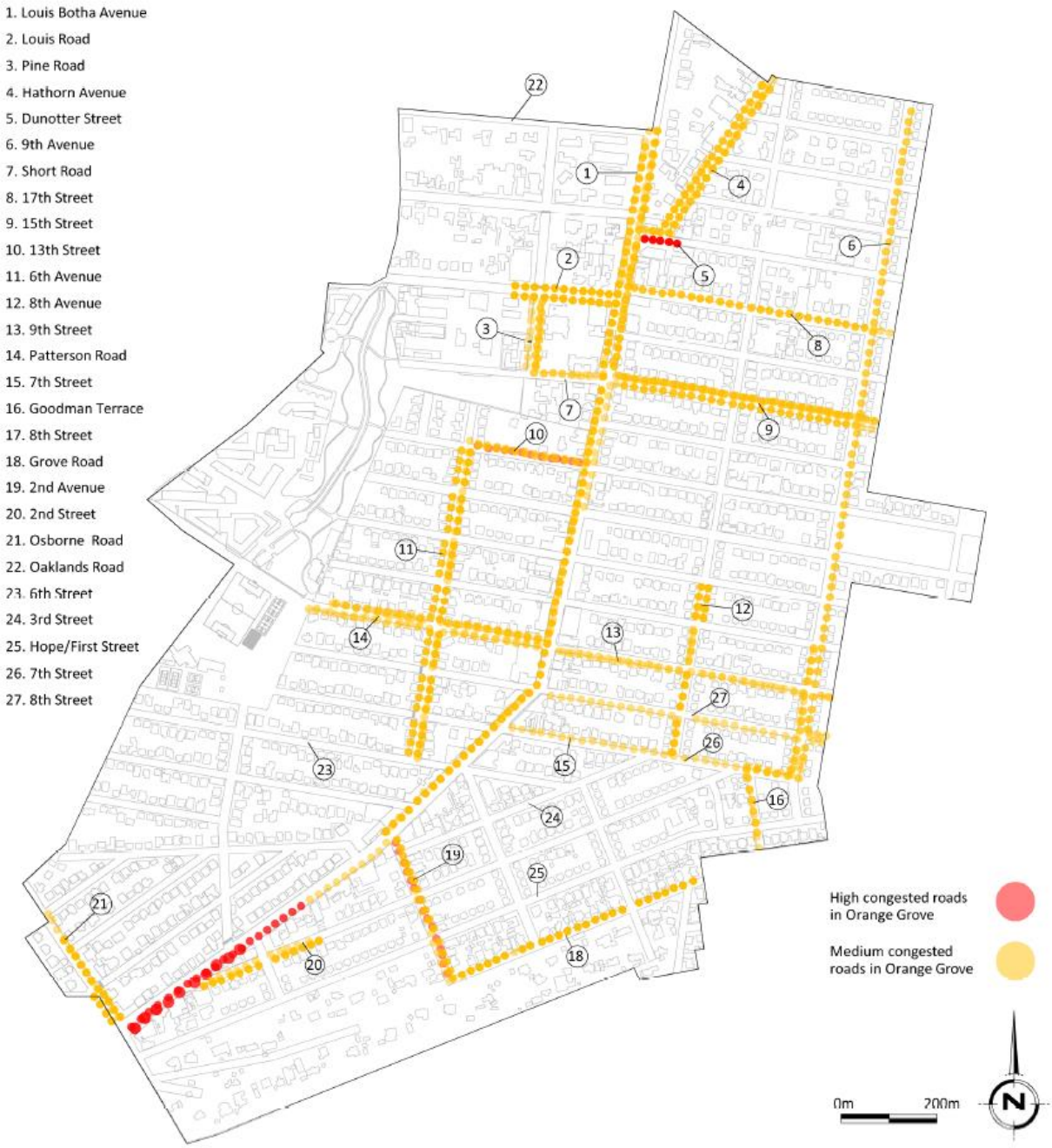


Figure 4. 8: Site Map 5 –Traffic heat map: Monday to Friday at 8am (Source: based on Google Maps)

4.2.1 **Typical Mobility Behavior**

More than 95% of private vehicles observed on Louis Botha Avenue were occupied by a single person, when an average private vehicle can carry 4 passengers excluding the driver. This was also observed on Patterson, Louis, Dunotter and Hathorne Roads. This low seating capacity rate means that there are more vehicles on the road than they need to be, leading to greater CO_2 emissions. Mini bus taxis were observed to stop at inconvenient points on the road to drop off passengers (see figure 4.9). This creates bottlenecks, which in turn holds up traffic. Based on observations, vehicles seemed to be moving faster than the legal speed limit in the area and this creates a dangerous situation on the roads. According to the Road Traffic Management Corporation, most road fatalities in 2016 and 2017 in South Africa involved pedestrians, with speeding being the main cause (DOT, 2017b).

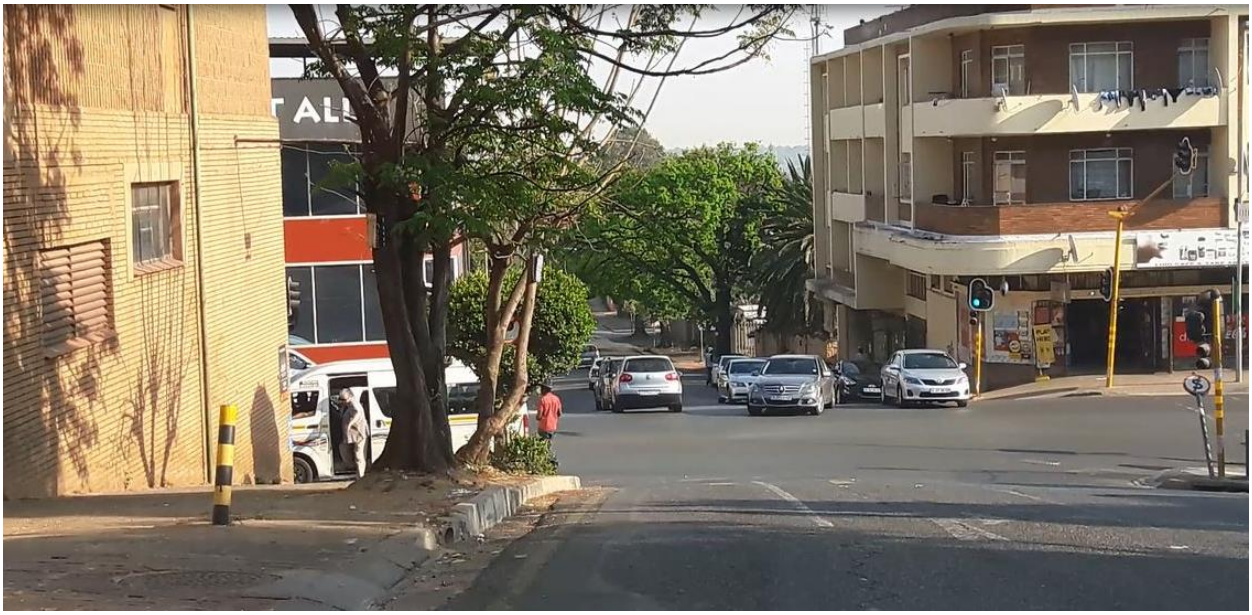


Figure 4. 9: intersection at Osborne and Louis Botha Avenue (Photo by Chetty, 2017)

On all of the busy roads, pedestrians/joggers were found using the road due to the poor condition of walkways. This is due to the placement of obstacles such as light poles, water meters and road signs on the pedestrian walkways. Patterson road was measured through google maps, with an overall width of 9m. Being a class 4 road it only requires a total road width 6.6 m as per JRA requirements, meaning that there is wasted road reserve which could have been used to widen the pavement (See Figure 4.10 below).



Figure 4. 10 Patterson Road (Photo by Chetty, 2017)

School children were observed crossing the road between stationary vehicles on Dunotter Road, a hazardous situation (see Figure 4.11 below). At the northern end of Louis Botha Avenue, pedestrians were observed crossing at any point on the street below, even though they could have crossed at the traffic light which was just a few meters away, but which pedestrians chose to ignore. Again, this created situations that could be hazardous or fatal.



Figure 4. 11: Dunotter Road (Photo by Chetty, 2017)

4.2.2 **Parking Situation**

Parking availability in Orange Grove was inadequate. In the case of Louis Botha Avenue, this forces vehicles to stop in the left lane. This effectively changes a two-lane road into a single lane, therefore exacerbating the congestion, as seen in Figure 4.12.

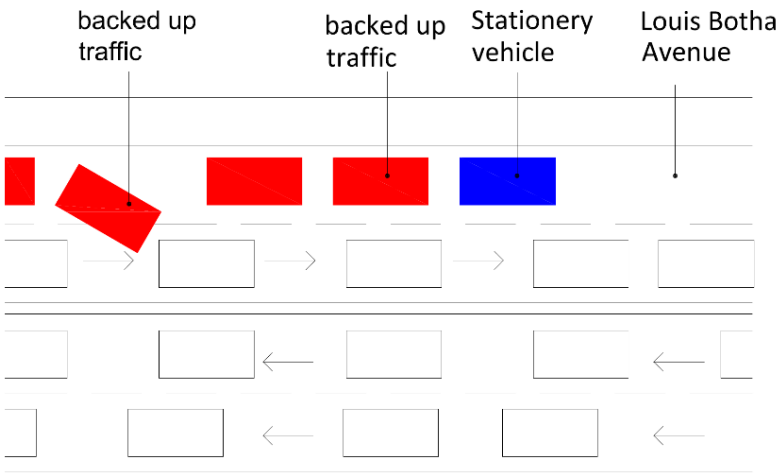


Figure 4. 12: Congestion on Louis Botha Avenue (Source: Chetty, 2018)

According to the OGTIA (2017), there 97 parking spots located on the following streets: Louis Botha Avenue with 27 parking bays; 2nd Street with 19 parking bays; 6th Street with 10 parking bays; Louis Road with 10 parking bays; Garden Road with 13 parking bays; and Dunottar Street with 18 parking bays. See Figure 4.13 below.



Figure 4. 13: Site Map 6 – Existing Street Parking in Orange Grove (Source: based on CoJ, 2017a)

4.2.3 **Impact of gated roads**

A number of gated roads were identified within the study area. In some instances, these were boom gates manned by a security guard, who granted access into streets, but still slowed down traffic. These come about when residents on a street set these up to prevent access aimed at improving their security (see Figures 4.14 and 4.15). They have the unfortunate consequence of interrupting the flow of traffic. They also force vehicles to particular roads which increases traffic on those roads; creating concentrations in some parts. Furthermore, gated communities reduce integration of different modes of transport and would need to be removed. Gated roads were observed on Forbes road, Walter Street, Castle Street, 7th street, 8th street and Davidson Street. The two streets which are affected the most is Osborne and Louis Botha Avenue. This is due to these roads carrying large volumes of traffic during peak times. People who are not familiar with the area using and trying to find their way around Orange Grove will be inconvenienced when arriving at these gated intersections. Finding alternate routes also means spending more time on the road therefore contributing to greater CO_2 emissions.



Figure 4. 14: Gating and booming of public roads impact on traffic flow – Osborne Road (Photo by Chetty, 2017)

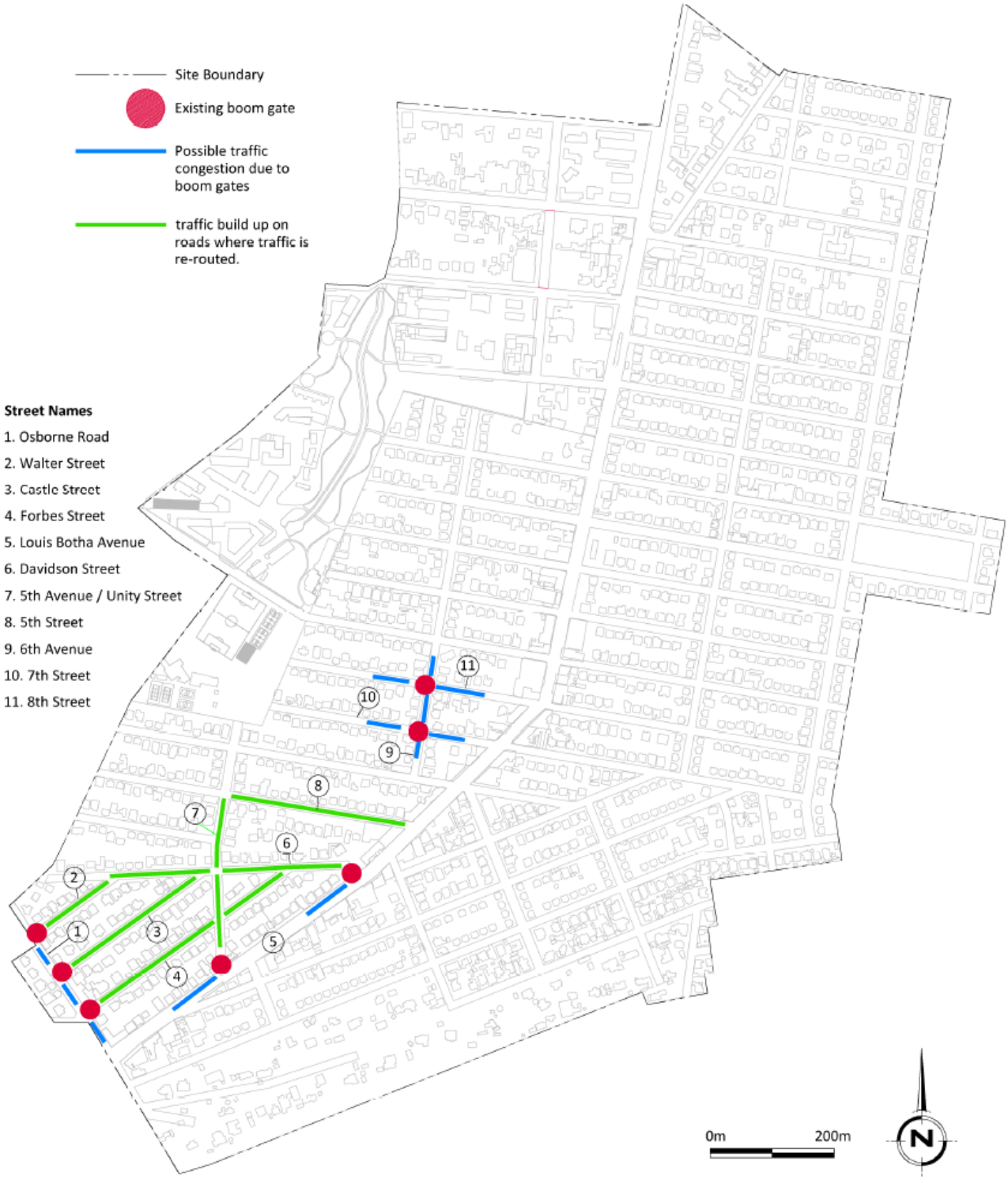


Figure 4. 15: Site Map 7 – Existing gated streets in Orange Grove (Source: Chetty, 2018)

4.2.4 **Road infrastructure**

Orange Grove consists of 54 streets, approximately 82% of which are primarily residential as indicated in Figure 4.16. The residential streets are very similar in nature comprising an 8 m wide road with approximately 1.3–2.0 m wide pavements on either side. Patterson and Osborne Roads are slightly wider at 9.5 m, with wide pavements of about 1.5 m on either side. Louis Botha Avenue streetscape width is approximately 22 m, and the road width relative to the pedestrian walkways varies. The distance between cadastral boundaries is approximately 12–15 m. This corresponds with the Orange Grove Traffic Impact Assessment where existing road reserves measuring between 12.6m and 15.8m (CoJ, 2017a). Road reserves are expected to increase as per OGTIA (DOT,2017a) requirements are reflected in Appendix A.

4.3 Existing Street Typologies

Existing roads were analyzed in the Orange Grove Traffic Impact Assessment (OGTIA) document for the type of road it could be converted to by 2040 (CoJ, 2017a). For this to happen, the CoJ proposes that road reserves need to widen (ibid). The proposed CoJ typologies show minimal thought towards NMT and the OGTIA makes no mention of infrastructural changes that will accommodate electric vehicles (ibid). Drawing from these findings, streets in Orange Grove were observed and new typologies were developed for the present study which were analyzed for transformational potential for the ZCW-ITN vision. Roads were analyzed to understand: existing pavement design; interface between private property and road; buildings adjacent to streets; and road reserve widths. Analysis of existing roads in Orange Grove reflected five street typology types which are indicated in figure 4.16.



Figure 4. 16: Site Map 8 – Existing streetscape typologies in Orange Grove (Source: Chetty, 2018)

4.3.1 **Typology 1**

Typology 1 comprised one-way streets with pedestrian pavements on either side. The roadway and pedestrian walkway of this typology has a tarred surface. Within the pedestrian walkway, there is a green patch which separates the pedestrian path from the road. Light poles and existing trees are positioned within the green barriers, which don't obstruct pedestrians. Boundary walls are constructed from brick and plaster and are approximately 1.5 to 2.5 m high and separated private properties from the street. Single- and double-storey residential buildings were found on either side of street. This typology occurs on 1st Avenue, Hope Road, Grove Road, 3rd Avenue, a part of 2nd Avenue, as well as sections of 9th, and 10th Streets (see Figure 4.17 and 4.18).



Figure 4. 17: Typical Street Typology 1 (Photo by Chetty, 2017)

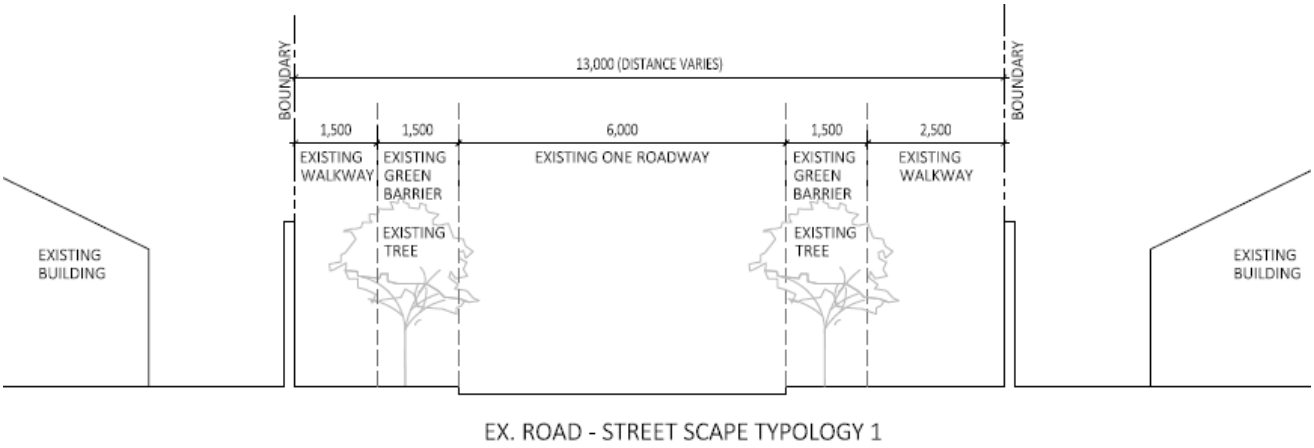


Figure 4. 18: Typical section – Ex. street Typology 1 (Source: Chetty, 2018)

4.3.2 **Typology 2**

This typology was defined to be very similar to Typology 1 with the main difference being that this is a two-way, rather than a one-way street. Due to the lack of maintenance, some parts of the green barrier comprised exposed eroded soil. It appeared that over the years the trees had grown so big that they have become obstructions on the sidewalk. This typology occurs on part of Unity, 12th, 13th and 15thStreets, as well as on portions of 5th and 8th Avenues, and Gardener and Oaklands Roads (see Figure 4.19 and 4.20).



Figure 4. 19: Typical street Typology 2 (Photo by Chetty, 2017)

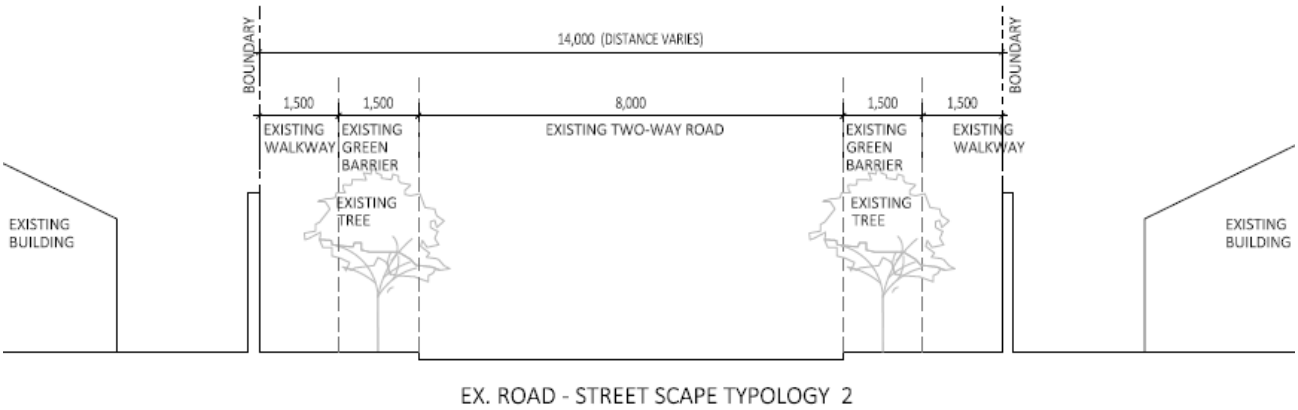


Figure 4. 20: Typical section – Ex. street Typology 2 (Source: Chetty, 2018)

4.3.3 **Typology 3**

This street typology was very similar to street Typology 2 but with no green barrier consisting of a roadway with pedestrian pavements on either side. Streetscape. Instead these pedestrian walkways surfaces were either tarred, grassed or paved with a paved roadway. Light poles and water meters positioned on pedestrian walkways. This typology occurs on part of 15th Street, Roslin Road, Raglan Street, Pembroke Street, Hawthorne, Dunottar Street, 17th Street, 16th Street, 14th Street, part of 13th Street, 11th Street, 10th Street, 9th Street, 7th Street, 3rd Street, 4th Avenue, 4th Street, 5th Street, 6th Street, 6th Avenue, Davidson Street, Walter Street, Castle Street, Forbes Street, Osborne Road, Short Road, Pine Road, and Louis Road. See figure 4.21 and 4.22 below.



Figure 4. 21: Typical street Typology 3 (Photo by Chetty, 2017)

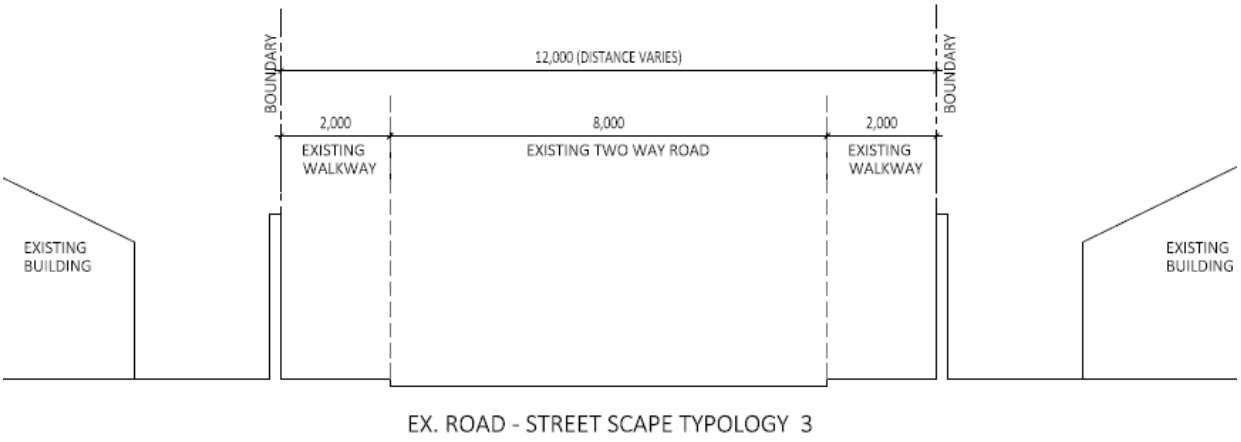


Figure 4. 22: Typical section – Ex. street Typology 3 (Source: Chetty, 2018)

4.3.4 **Typology 4**

This street typology is similar to street Typology 1 which consists of one-way street with pedestrian pavements on either side. However, like street Typology 3, there is no green barrier within the

pedestrian walkway. This typology occurs on part of 1st Street, part of 2nd Street, part of 3rd Street, part of 9th Street, and part of 2nd Avenue. See Figure 4.23 and 4.24 below.



Figure 4. 23: Typical street Typology 4 (Photo by Chetty, 2017)

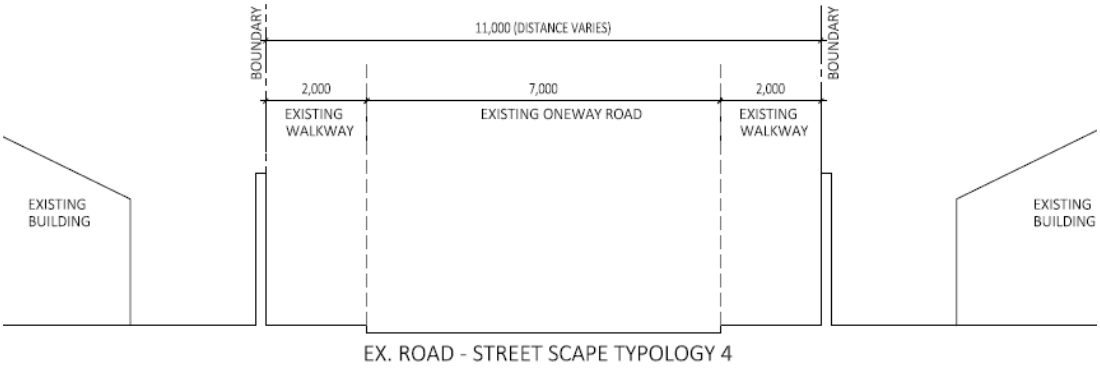


Figure 4. 24: Typical section – Ex. streetscape Typology 4 (Source: Chetty, 2018)

4.3.5 **Typology 5**

Within the study areas, Louis Botha Avenue consisted of a two-way tarred roadway which was double lane each way, with tarred pedestrian pavements on either side. Central islands separates moving vehicles travelling in opposite direction. Buildings on this street sometime went up to 4 storeys and were mostly used for commercial activity. Building columns encroached onto pedestrian walkways and formed colonnades which had a visually pleasing aesthetic quality (see Figure 4.25 and 4.26 below). A BRT station was being constructed at Short Road and Louis Botha intersection. This will also occur at the northern end of Louis Botha near the Victory theatre, should the second BRT get the approval from the City of Johannesburg. This typology occurs only on Louis Botha Avenue.



Figure 4. 25: Typical street Typology 5 (Photo by Chetty, 2017)

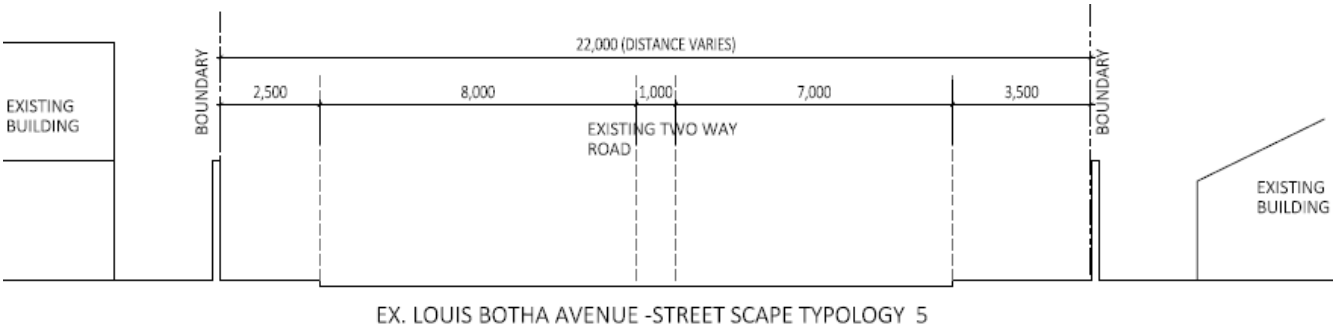


Figure 4. 26: Typical section – Ex. street Typology 5 (Source: Chetty, 2018)

4.4 Key findings on the Status Quo

The key findings based on five days of observations, supplemented by the Orange Grove Traffic Impact Assessment regarding the status quo of the Orange Grove transport system in:

1) All motorized vehicles observed during peak hour traffic were either diesel or petrol transmissions. EVs were not observed in the study area;
2) Roads are congested at peak traffic hours within the study area, due to high rates of single seating capacity of vehicles; with more than 95% of passenger vehicles were found to have a single occupant, indicating a poor level of efficiency is being achieved;
3) The public transport services in the City of Johannesburg is currently inadequate due to the large volume of private vehicles that were observed during peak hour traffic;
4) Unsafe driving practices of the mini bus taxis further add to the congestion on the roads;
5) Roadworks underway in the area were also a likely contributor the congestion levels observed;

6) A single cyclist was observed on 2 different occasions in Orange Grove during peak hour traffic, indicating that bicycle use appears to be very limited. Furthermore, there are no dedicated lanes for cyclists;
7) Besides motor vehicles, there is a high volume of pedestrian traffic within the study area. Some infrastructure for the pedestrian's inadequate. The width of pedestrian walkways is inconsistent and are too narrow and in a poor condition in many places. Furthermore, the walkways have obstructions such as light poles and other utilities positioned in the middle of the walkway resulting in numerous pedestrians walking on the roadway which makes these situations hazardous;
8) There is an unequal sharing of the streets in Orange Grove, with the road hierarchy showing that it is dominated by motor vehicles, followed by pedestrians and then cyclists. The observations suggest that the current transport system in Orange Grove is extremely reliant on ICE vehicles and does not have enough different options for cleaner modes of transport. This status quo is enabled by design which is not user-friendly for other modes such as cycling and walking. This over-reliance on ICE consequently translates into high carbon emissions which in turn contribute to climate change;
9) The physical make-up of the most streets in Orange Grove were similar where they comprised of raised tarred pedestrian walkways found on either side of a single lane one-way, single lane two-way or double lane two-way road. From these permutations, 5 streetscape typologies were defined in Orange seen in Figure 4.18. Streetscape Typology 3 was the most common type that was observed, with Typologies streetscape 2, 4, 1 and 5 following respectively. Unfortunately, it quickly became apparent there were physical problem with these streets. Pavement widths were inconsistent. In addition to this problem light poles, traffic signs, water meters, fire hydrants, and other utilities irrationally positioned on this narrow walkway. In some instances, pedestrian walkways were quite wide which were raised and incorporated a green barrier. These green barriers consisted of strategically positioned trees, light poles and other street elements. This existing green barrier feature is in line with the ZCW-ITN model and was incorporated into the new ZCW-ITN streetscapes by the researcher. However, it is anticipated that all existing streets in Orange Grove needs some kind of adjustment and intervention;
10) For most part of the study area, excluding Louis Botha Avenue, single or double storey buildings were positioned on either side of the road but lacked a direct relationship with the road due to

high boundary walls. A sense of social integration is lost due to this separation and will be omitted as per the COF and ZCW-ITN models. It cannot be ignored that the question of security may be an issue once boundary walls are omitted. This vision however is set in the future and it is imagined that socio-economic issues like crime, poverty and equality will also be eradicated through relative initiatives and interventions. This is beyond the scope of this study;

11) Existing gated streets interrupted the continuity of streets and disconnected the flow of traffic. All gated streets in the study area must be omitted due to its negative significance which aims to separate and congest. Again, it is not ignored that this is a security issue, but it is hoped that this will be dealt with by the relative authorities to ensure safer streets in the future. This too is beyond the scope of this study; and
12) Most buildings in Orange Grove were double pitched with fewer single pitched roofs with roof tiles or roof sheeting.

4.5 Conclusion

The status quo of the site indicates that there is potential for this neighbourhood to implement low or zero-carbon interventions. This can happen in the following ways:

1) Public and private ICE vehicles can be converted to EVs;
2) Existing streets can be converted into low or zero-carbon streets so that active modes of transport like walking and cycling becomes key features;
3) New management systems to be introduced which can then integrate public transport, private vehicle usage and NMT to allow for efficient transition points;
4) Reduce speed limits so that road hierarchy shifts, and usage become equally distributed;
5) All gated and boomed gates to be omitted which allows for greater accessibility, efficiency and integration between all road users;
6) Existing roofs can be used for PV installation for solar energy production.

5 Chapter 5 – The Green Utopia

In this chapter a revolutionary 2050 vision is created of a 'Green Utopia' where zero carbon transport systems and net zero energy systems are now intrinsic features of a sustainable neighbourhood. This futuristic innovative compact neighbourhood of Orange Grove will comprise a network of pedestrian and cycle lanes. In certain parts of the neighbourhood, residents will have the choice to live on car free streets where a variety of shops, parks and social gathering spaces occur. Public transport nodes will be closely positioned to these streets for easy access, where car share clubs and NMT are also alternate modes of transport. The working class who were once proud owners of high emitting CO_2 ICE vehicles, will now belong to car share clubs. They will only use the car share facility when they need to, but for most part they will use the well-integrated electric public transport networks. This will be complimented by a real time web service which provides times of departure and arrivals for all modes of public transport. Owing to public transport being powered by zero carbon renewable energy systems, fares and tariffs will be almost zero. For a few it will be imperative for them to own private EVs. But even in these cases there are no cost implications due to the private PV energy systems and EVs being fully paid off. This highly efficient transport systems has created a place where there is no traffic congestion, accidents, crime, or noise pollution. Parents are home early from work and in this future they lead a high quality family life.

In the previous chapter it was established that the Orange Grove transport system can be transformed into a ZCW-ITN through various interventions. This possibility and potential is used to create a 2050 vision for ZCW-ITN in the OG study area. The COF TOD that sets the blueprint for the development of transport infrastructure in Orange Grove has been evaluated with respect to its carbon efficiency. Recommendations are made for improving outputs towards a more utopian vision, however the proposed changes by the CoJ are still based on fossil fueled transport systems by 2040 which is when the COF TOD is expected to be completed. In this Chapter a proposed means of converting Orange Grove into a ZCW-ITN by 2050, are provided. Also included in this chapter is the adaptability of the ZCW-ITN vision which will be tested in Balfour Park. This chapter will be guided by Sub-question 2 and 3:

- Sub-question 2: What ZCW-ITN vision is possible in Orange Grove, and how can this be implemented? The range of interventions and infrastructure transformations proposed are encompassed in the concepts of ecomobility, e-mobility and sustainable energy; and

- Sub-question 3: How could insights gained from the pilot study in Orange Grove, inform future retrofits of similar existing suburban neighborhoods in Johannesburg?

In this report the main focus is to reduce CO_2 emissions from road transport in urban areas by encouraging a move to LCT. LCT is based on three ASI principles: reduce the need to travel, provide environmentally friendly modes of transport, and the use of technology to reduce CO_2 emissions. It is on these three principles that zero-carbon trends and the future imagined transport system in Orange Grove will be based. Elements of a LCT transport systems were also assessed in the BedZED case study. Other important aspects of the vision are to create a new collaborative way of existence where the cost of transport becomes almost zero.

Developing the ZCW-ITN vision was based on gaining a broad perspective of carbon emitting interventions trending globally which was subsequently followed by process of elimination which determined interventions appropriate in OG. In chapter 6, a video was developed by the researcher which was used as an education tool during interview sessions. This video introduced three primary concepts comprising: ecomobility; electric vehicles and associated technologies and complete street design. 17 secondary interventions were then derived from this comprising: reduction of road speed; cycle and pedestrian lanes on all streets; green barriers with limited parking; bike hire station not more than 300m apart with the option of electric bicycles; additional public transport stops to be in a radius of not more that 500m; PV; EV's; urban roof farms; all public transport to be EV powered by solar; electric sky tram; car share vehicles; self-driving vehicles; smart grids; car free commercial streets; teleworking; and ITC.

Two factors assisted the process of eliminating interventions that weren't conducive to the ZCW-ITN in Orange Grove: firstly, understanding the physical properties of the study area which was done through site investigations, review of secondary data reports and google map studies; and secondly gathering data during semi structured interviews. Site investigations and secondary data from the OGTIA (CoJ, 2017a) revealed interventions that are favorable in Orange Grove: reduced road speeds; cycle and pedestrian lanes; green barrier comprising EV charge points, parking and bike kiosks; PV installations; car free commercial streets; smart grids; and ITC infrastructure. Additional public transport with 500m radius were omitted due to the potential addition of the second BRT station (ibid), which met the 1 km radius standard from the complete street design guide. The option for the electric bike was omitted due to the OG site being fairly flat with non-motorized bicycles showing added health benefits. Data from interviews also indicated a preference for non-motorized bicycles. The urban roof farm was omitted due

to the uncertainty of future roof design intentions. Some interviewees also felt it was not a priority for them, but this will require further research. The electric sky tram was omitted due to it being an unnecessary cost and will be futile without fully understanding the transport demand in OG. This will require further study. During interviews nearly, all respondents showed an approval of the car sharing concept and appreciated the economic benefit from this. Even though the self-driving car was omitted from the intervention list due to the lack of successful case studies, it is anticipated that this will play a key role in future transport systems. Teleworking was also excluded due to most respondents feeling that most business models in CoJ are not set up to function in this manner.

Using these deductions, interventions for Orange Grove were confirmed based on the GIZ (2007) ASI framework as discussed in chapter 2:

- Avoid
    i. Compact city and TOD (as per COF SDZ proposals);
- Shift
    ii. BRT (based on COJ initiative which is currently under construction in Orange Grove).
    iii. Car-free streets
    iv. Complete street design (ecomobility: cycle and pedestrian lanes)
    v. Car Sharing
    vi. Cleaner energy generation: rooftop solar photovoltaic production (RSPP) These cover changes including a shift to electricity for powering transportation and solar energy as the source of power for buildings and other installations. A further key aspect is in changes to infrastructure to support green solutions; and
- Improve
    vii. E-mobility
    viii. Smart grids
    ix. Urban management through ICT.

There are 3 defining concepts that sets the ZCW-ITN vision apart from current LCT systems. Firstly, the transport system in the OG study area aims to be zero-carbon by 2050. Secondly the transport system in the OG study area aims to be nearly zero cost where the long-term goal of the vision is to ensure that transportation would be free or become nearly free by 2050. Thirdly, by 2050 the OG study are will be

transformed to new utopian ways of existence where sustainability, collaboration and efficiency become the guiding principles.

5.1 Proposed Model – ZCW-ITN 2050

There are aspects of the ZCW-ITN model which could be tested, aspect that could not be tested, and aspects that did not need testing:

a) Compact city and BRT was not tested in present study. The reason why the compact city and BRT was not be tested is due to the fact that studies have already been prepared by the CoJ as a response to rectifying the injustices of apartheid urban planning. COF SDZ proposed in the OG study area proposes an increase in urban population densification from 5647 people/km^2 to 44515 people/km^2 by 2040. Construction of the first BRT station is underway in the OG study area, and there a possibility of a second station being built.

b) Car sharing, smart grids and ICT are beyond the scope of this study and was not tested in present study. The reason why it was not tested is due to the fact that these interventions have the potential to reduce CO_2 emissions or is an associated technology that can reduce CO_2 emissions, which was already established in the literature review. Further studies would be required pertaining to these fields where an understanding of technical, economic and other aspects of retrofitting urban areas with these interventions are determined.

c) However, car-free streets, complete streets, e-mobility (including charging station potential), and rooftop solar are physical properties of an urban environment and was tested in the present study.

5.2 Car-free streets

The car-free commercial street is predominantly a street intervention and it tests the possibility of car-free streets with the intention of incrementally converting streets into car-free zones. To reduce vehicle trips, car-free commercial streets are proposed which would drive economic and environmental revitalization. Car-free commercial streets would incorporate: small businesses like cafes, vendors and shops; open green spaces; and dedicated cycle and pedestrian lanes that would connect to areas outside the car-free commercial zones (see figure 5.1). The car-free zones would also act as areas of social activity, where children would play, friends meet, and would provide a space to unwind, therefore creating opportunities for social integration to take place.



Figure 5. 1: ZCW-ITN Vision: Car-Free commercial streets (Source: Chetty, 2017)

To transform the OG study area to a ZCW-ITN by 2050, car fee streets are proposed on the following streets as see in Figure 5.2 below. Three criteria were considered during selection of car-free streets in OG study area:

1) They were not identified as high traffic zones as per traffic heat map analysis. This meant that these streets are not used by Orange Grove residents regularly, therefore this change will not affect the functioning of the regular transport routes;

2) Streets were not identified as Class 3, 4 or 4a as per OGTIA (CoJ, 2017a). This meant that these streets did not form part of a public transport service route and therefore has little or no implications for service providers or local authority management;

3) Streets were in a 500 m radius of a BRT station. This meant that residents who lived in car free street zones had easy access to public transport which is crucial for them because they do not own private vehicles.



Figure 5. 2: Site map 9 – locations of proposed car-free streets (Source: Chetty, 2018)

5.3 Transformation of Streetscape Infrastructure

Pedestrian and cycle networks should be built into all streetscapes in Orange Grove. This would ensure that all residents in Orange Grove could safely travel either on foot or bicycle to schools, shops and places of work (see Figure 5.3). Integrated with this is public transport and accessibility to this will play a

crucial role which should also ensure that people do not have to walk more than 1 km to a public transport node. It would be ideal if commuters in Orange Grove are within 500 m of a public transport node. There are 2 BRT station which ensures that individuals within the study are within 1 km walking distance which is suitable for pedestrians.



Figure 5. 3: Vision: cycle; pedestrian networks; charging stations; bike racks (Source: Chetty, 2017)

To achieve the ZCW-ITN in the OG study area the following infrastructural changes and adaptations are proposed in accordance with the CoJCSD (CoJ, 2014), and compares favorably to good practices internationally:

- 1.5 m wide pedestrian lanes will be introduced on all roads. This will be achieved by taking 1.5 m on both sides of all roads;
- Roads will be redesigned to include cycle lanes. Cycles lanes a minimum of 1.5 m wide positioned between green barrier and pedestrian walkway on both or one side of the road to reduce risk of cyclist and motor vehicle crashes;
- Green barrier of 2.4 m wide to incorporate EV charging stations, parking bays, municipal utilities such as light poles, and public transport pick-up and drop-off stops;
- Roadways as follows:
    - Residential Class 3 and 4 streets would have a 3 m wide vehicle lane;
    - Louis Botha Avenue to become a Class 3 road rather than its current Class 2 status, would incorporate a 3.3m wide vehicle lane;
- Pedestrian walkways and crossings should, as a minimum and in line with the CoJCSD have the following features:
    - Universal design which caters for all disabled, young, aged or pregnant people with a minimum 1.5 m wide sidewalk. Kerb ramps for prams or wheelchair access; reduced

kerb radii which shortens pedestrian crossing and lowers vehicle speed; kerb extensions to reduce speed; mid-block pedestrian crossing; refuge islands; and split pedestrian crossovers (CoJ, 2014);

- Walkways to be porous and streetscapes to be adequately designed for stormwater runoff;
- Adequate lighting for walkways. Light poles and other utilities to be positioned within green the barrier;
- Ensure that no utilities are located on walkways; and

- In order to differentiate between the pedestrian and cycle lane surfaces, the pedestrian walkway to be brick paved whilst the cycle lane to be a solid surface with skid resistant highly visible paint (CoJ, 2014).

To achieve complete street design in Orange Grove, there need to be five typical streetscape interventions as outlined in Figures 5.4 to Figure 5.8. These involve the following permutations:

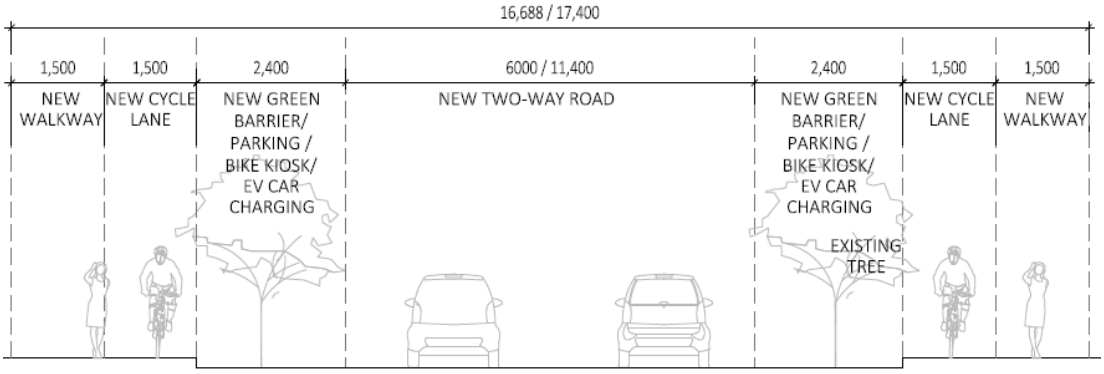


Figure 5. 4: (Source: Chetty, 2018)

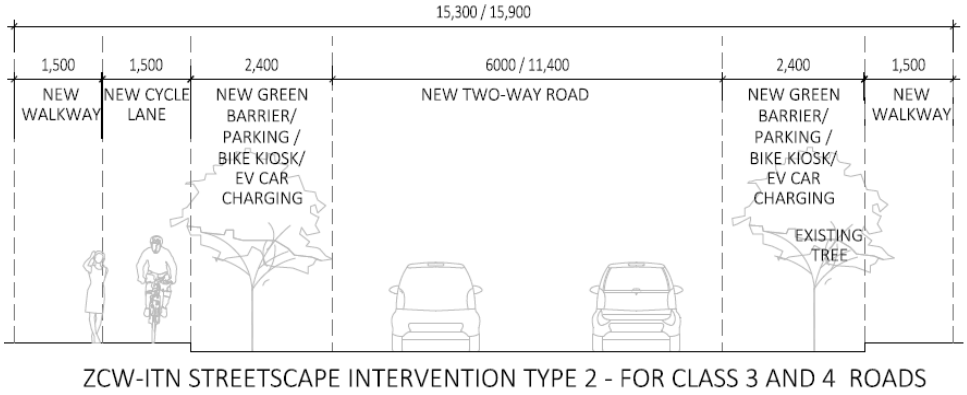


Figure 5. 5: (Source: Chetty, 2018)

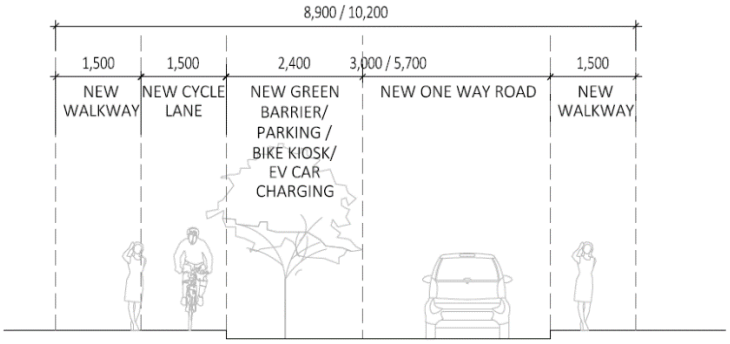


Figure 5. 6: (Source: Chetty, 2018)

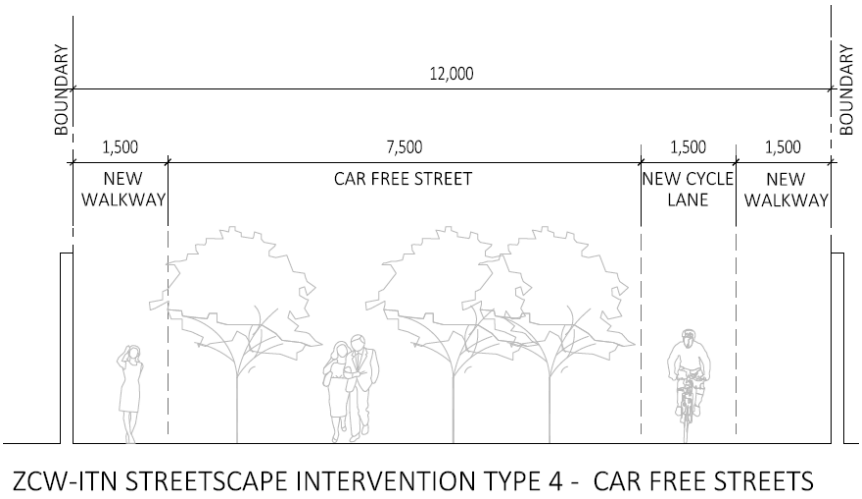


Figure 5. 7: (Source: Chetty, 2018)

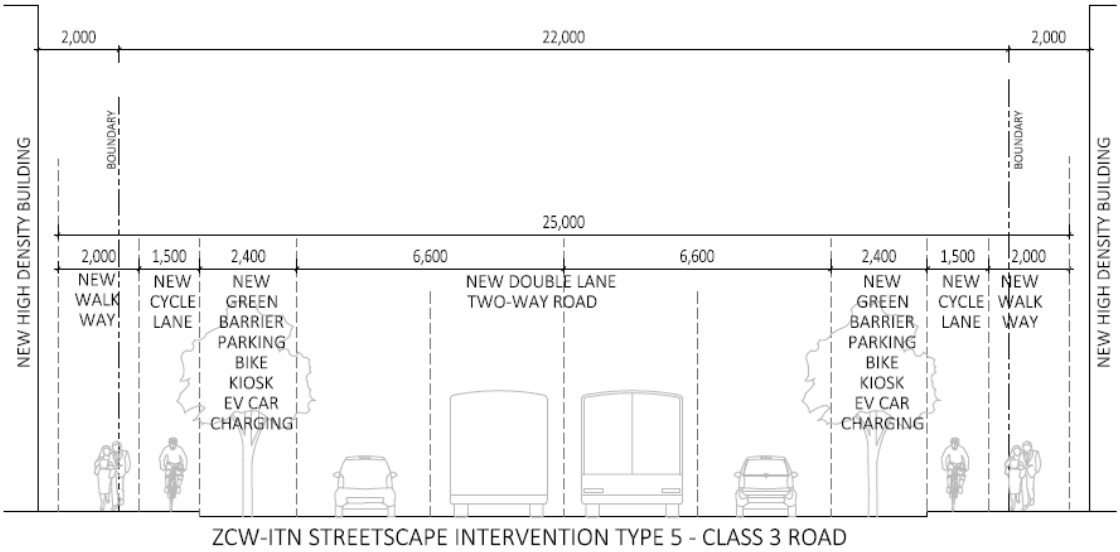


Figure 5. 8: (Source: Chetty, 2018)

5.3.1 ZCW-ITN streetscape transformation potential

Cross analysis between 44 existing streetscapes in Orange Grove in relation to proposed COF SDZ road widenings, and the ZCW-ITN streetscape interventions proposed in this research report revealed the types of streetscape infrastructure changes that could occur in Orange Grove. It was determined that 87% of all the Orange Grove streets could be converted to ZCW-ITN streetscapes, with 31% of the streets potentially being ideal streetscapes (see streetscape intervention 1, 3 and 5 in Figure 5.3, 5.5 and 5.7). Note that streetscape intervention type 3 is for single lane road. In the case of emergencies the green barrier may be used to pull over and allow emergency vehicles to pass. 36% of all streets would accommodate all ZCW-ITN requirements with only one cycle lane (see streetscape 2 in Figure 5.4). See Appendix A for intervention allocation relative to streets in the OG study area.

5.4 Replacement of ICE vehicles with EV

The model proposes that over time ICE vehicle be replaced by EVs to a point that in 2050 95% of vehicles in Orange Grove will be EVs. This can be achieved by making them more affordable and ensuring they suit the needs of those who use them.

5.4.1 Private EVs

Electric vehicles are one of the main components of the ZCW-ITN interventions due to its potential of being zero-carbon emitting during its operational phase. For this to occur it must use a clean energy source. In order for EVs to operate at optimum levels it needs to be complimented by smart grids, home battery system and rooftop solar photovoltaics. A home battery system enables EVs to be charged at night during off peak times and leftover energy from the EV can be used for building operations during peak times (see figure 5.9 indicating PV on flat roofs, EV, charging station and home battery mounted on wall).



Figure 5. 9: Vision: electric vehicles, residential charging stations; Photovoltaics, battery storage (Source: Chetty, 2017)

An analysis of the micro EV showed that it was a good option for short distance travel in Orange Grove and was based on two fundamental criteria, namely affordability, and reduced linear width compared to a standard ICE vehicle. For the first criteria, the micro EV seats 2 to 4 people and currently costs between $2000 and $7000 (Alibaba.com, 2018). This price compares favorably with current ICE vehicle prices in South Africa which converts to R30 000.00 and R105 000.00 respectively. Regarding the second criteria, having a narrower vehicle means that the road lane can be narrower which would then allow for wider cycle and pedestrian lanes. The width of a micro EV is markedly narrower at approximately 1.5 m wide. According to the Roads: Geometric design and layout planning a vehicle needs 0.25 m on either side of a single lane, therefore the micro EV would require a single lane width of 2 m (CSIR, 2005). Even though a 2 m lane is a practical solution for a micro EV, it might not be reasonable for service vehicles, therefore for the present study the regulatory requirements as stipulated by the Johannesburg Roads Agency (JRA) will be used for a single lane width depending on road classification. Current requirements for a class 5 residential collector are 3 m as per the (JRA) for the CoJ (JRA,2015).

5.4.2 Public transport – BRT conversion to electricity

All public transport fleets in Orange Grove will be electric vehicles which are charged at multiple points along their trips. Roofs of BRT stations to be fitted with PV panels for solar created electricity. Even though this may not be enough power for charging an entire fleet, but every opportunity to install PV panels must be taken in Orange Grove. An efficient EV BRT system will also aim for fast charging opportunities to happen at BRT stations. (See figure 5.10)



Figure 5. 10: Vision: electric bus- BRT with solar energy power source (Source: Chetty, 2017)

The vehicle proposed to replace the current diesel-driven Rea Vaya BRT buses are the electric buses already being used in Cape Town. These buses seat 34 people and have a low entry point accessible for people with disabilities. It has a range of 250 km and need 5 hours for a full charge.

5.4.3 **Public transport – mini bus taxi's**

The ICE mini bus taxi's currently in operation can seat between 10 and 14 people depending on make and model. An electric mini bus seats between 11 and 20 people with a range of up to 260km. It is fitted for DC fast charging technology; therefore, charging can occur at mini bus taxi ranks, or emergency charging can occur public charging points provide costing and metering facilities are in place. The cost of a single unit is currently between $10 000 and $20 000 (Alibaba.com, 2018). Linear width dimensions match ICE vehicles and for these EVs, road widths cannot be adjusted. Another mode of feeder public transport that could supplement the mini bus taxi is the electric tuk tuk which is already operational in Johannesburg.

5.4.4 **EV charging**

In order to service EVs in Orange Grove, charging stations would need to be provided in various areas. The 2014 Guidebook (VEIC, 2014) identifies generic locations for recharging as falling into residential, workplace/ commercial buildings and public locations. The locations for charging stations in Orange Grove proposed in 2050 are shown in Figure 5.11. For residential buildings, a Level 1 charging system would be recommended for those existing buildings that remain single family home by 2050. For existing residential buildings, a power outlet already exists, so it would be a matter of finding a

convenient spot in an existing garage or driveway to install the charger (ibid). For multi units, charging units may need to be installed in parking areas, and a metering system would also need to be installed in order to charge the respective EV owners. Charging systems recommended for workplace and commercial buildings by 2050 would generally be Levels 1 and 2, but Level 3 could also be considered where large numbers of vehicles need charging (ibid). Charging equipment would be installed in parking areas. This charging system will apply for both existing buildings which remain unchanged by 2050 and new buildings. Charging systems for public locations are proposed to be Level 3 DC rapid-charging systems. Unlike workplace or commercial buildings, public locations do not have activities that would keep an EV user busy whilst waiting for their vehicle to charge. Therefore, charging may need to happen quickly. For the OG study area, public charging EVSE will be positioned within the ZCW-ITN green barrier. It would also be of vital importance that adequate signage be provided that can direct EV users to these charging points.

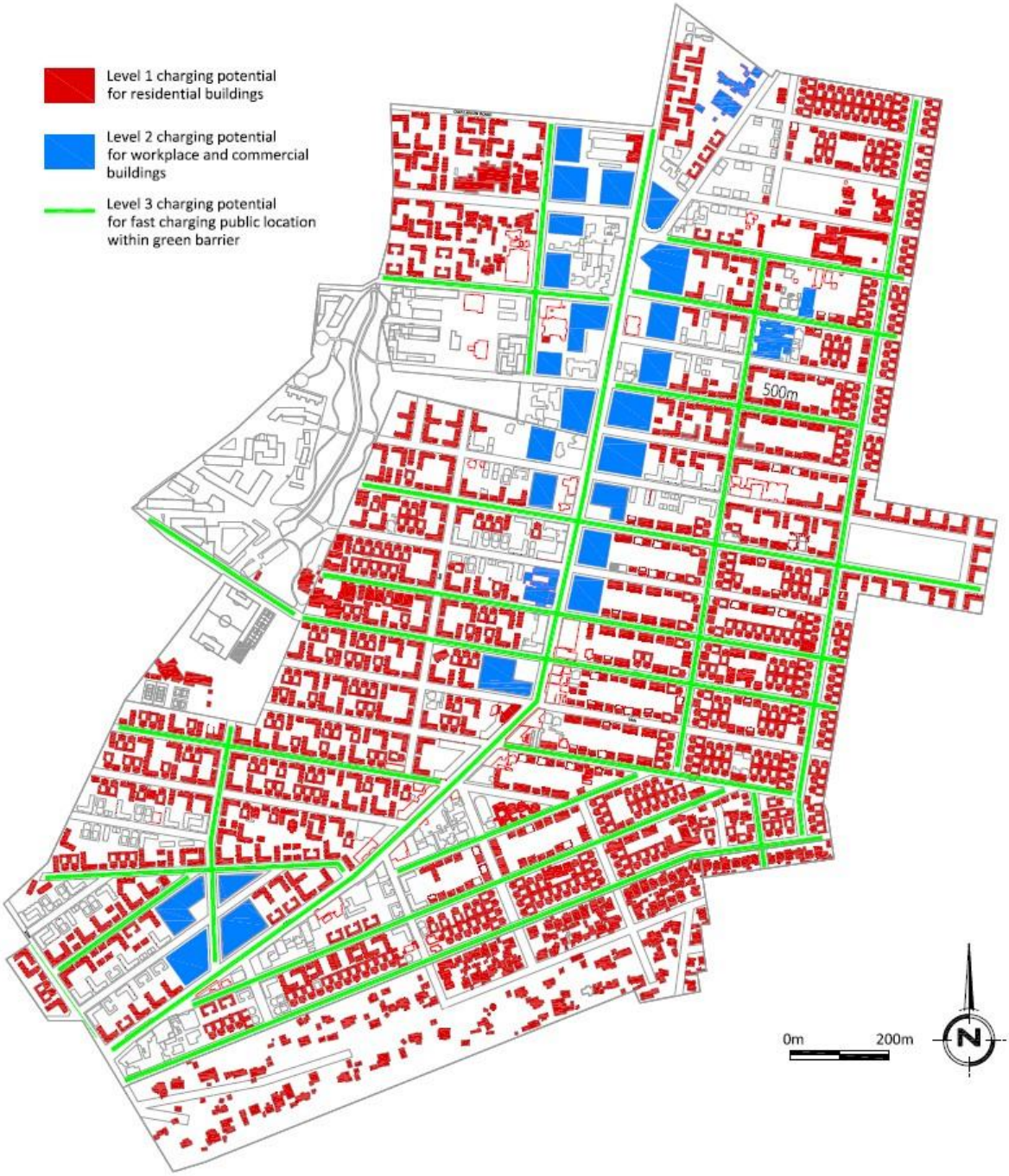


Figure 5. 11: Site Map 10 – EV charging station opportunities (Source: Chetty, 2018)

5.4.5 Car Share Electric vehicles

In a future zero-carbon transport system where EVs are the dominant mode of transport, petrol stations as an infrastructure would become redundant. In Orange Grove, this infrastructure could be converted into car-share vehicle businesses (see Figure 5.12). For every car-sharing vehicle introduced to the road, 10-15 privately owned vehicles would be made redundant (Katzev, 2003). The idea of the car sharing vehicle is further advanced if it is an electric vehicle. This infrastructure could also act as an integration point for car share vehicles, pedestrian, commuter, cyclists or electric mini bus taxi's where a modal split could occur. Charging stations fitted with solar PV panels therefore providing a clean zero-carbon energy source.

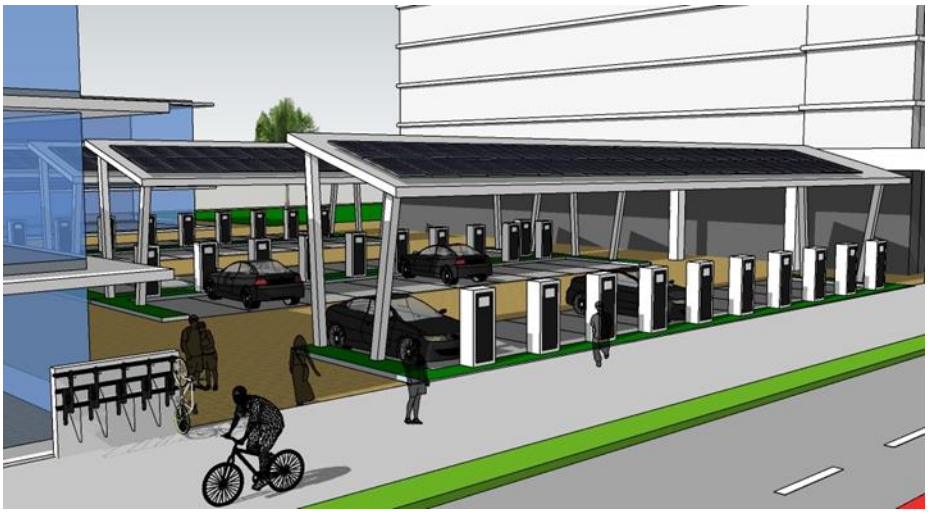


Figure 5. 12: Vision: Petrol Station converted to car-Share business; EVs; PV's; battery storage; EV charging (Source: Chetty, 2017)

5.5 Energy to power the ZCW-ITN

To transform the OG study area into a ZCW-ITN, there will be a need to change to a clean energy source for providing power to the proposed transport model. Clean energy is readily available in the form of solar energy and the availability of roof space to install photovoltaic panels. Solar energy will be used for e-mobility and for building operations. Smart grids will ensure that power is efficiently supplied. Actions required to achieve this are outlined below.

5.5.1 Rooftop Photovoltaics

Rooftop photovoltaic solar installation will be used as the power source of all electric vehicles on the site. Ideally roofs proposed in Orange Grove should be flat which would allow for maximum solar energy

production. However existing roofs are pitched but must also be used for calculating total roof area potential. Other possibilities for solar energy production could obtained from PV panels being placed on building awnings and on building facades. However, when calculating roof area availability for PV installation for the present study 2 calculations were considered, the existing roof space availability and the future availability after the SDZ is completed in 2040.

5.5.2 Future roofs

The SDZ provides a proposal of how future buildings will be constructed in Orange Grove by 2040. Using this information an analysis was carried out to calculate the approximate new roof areas. According to the SDZ, not all buildings will be transformed with several structures including heritage buildings to be left in their current state due to reasons stated above. The total area that was calculated for new roofs was 328 790 m^2 whilst the total area calculated for existing roofs was 80 698 m^2. Therefore, a total of 409 488 m^2 would be available for solar energy production. Solar panels can be installed in various scenarios covering double or mono pitched roofs; atop awnings, along building façades or else placed and flat (Othman and Rushdi, 2014). For façade and awning type positions, maximum solar potential cannot be achieved as per Figure5.13 below. The double pitched roof will lose maximum PV potential on one side, whereas a mono pitched roof could obtain maximum potential provided that it is orientated correctly towards the sun; however, this might have cost, design and aesthetic implications. Thus, a flat roof could be the most feasible option for maximizing solar energy production. For future scenarios PV installation must not be restricted just to roof applications but every opportunity should be taken including façade and awnings.

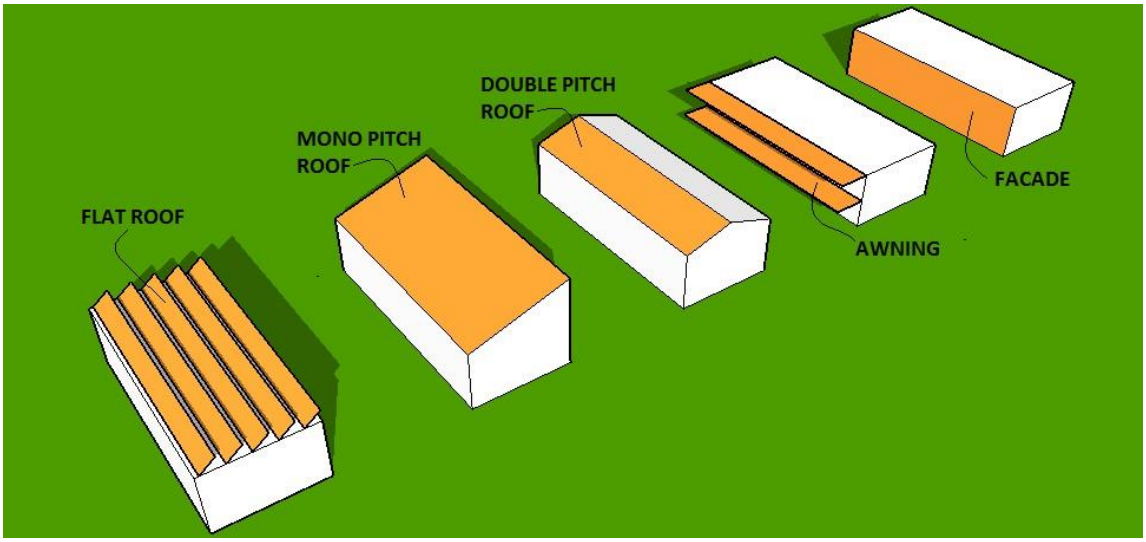


Figure 5. 13: Proposed optimal rooftop solar production in Orange Grove (Source: based on Othman and Rushdi, 2014)



Figure 5. 14: Site Map 11 – roof space identified with potential for PV in Orange Grove (Source: based on the COF SDZ, 2017)

5.5.3 Existing roof installation

The area of all existing roofs was calculated by using the footprint of each building on the Orange Grove site. The calculation excluded all heritage buildings. According to section 34 the National Heritage Resource Act 25 of 1999, no part of a heritage building can be altered without special consent. Therefore, the total of potential existing roof area for rooftop solar energy was determined to be approximately 334 946 m^2 (see Figure 5.15).



Figure 5. 15: Site Map 12 – Existing available roof space in Orange Grove (Source: Chetty, 2018)

5.6 Infrastructural Transformation

This ZCW-ITN vision for Orange Grove is made up of both streetscape and building interventions and the following infrastructural permutations will occur:

- Existing streetscapes will be redesigned so that they are conducive to pedestrian walkways, cycling lanes, and green barrier;
    - Green barrier to contain public EV charging, landscaping, public transport nodes, bike kiosks, municipal utilities;
- Existing roofs will now accommodate PV panels;
- New COF SDZ roofs will be flat and accommodate PV panels;
- Existing buildings to accommodate charging stations which need to be installed in private homes, workplace and commercial buildings; and
- Existing streets to be transformed to car-free streets.

The ZCW-ITN vision would involve significant building and street infrastructural changes anticipated to progress according to the COF SDZ vision, as seen in Figures 5.17 to 5.22 (read in conjunction with figure 5.16).

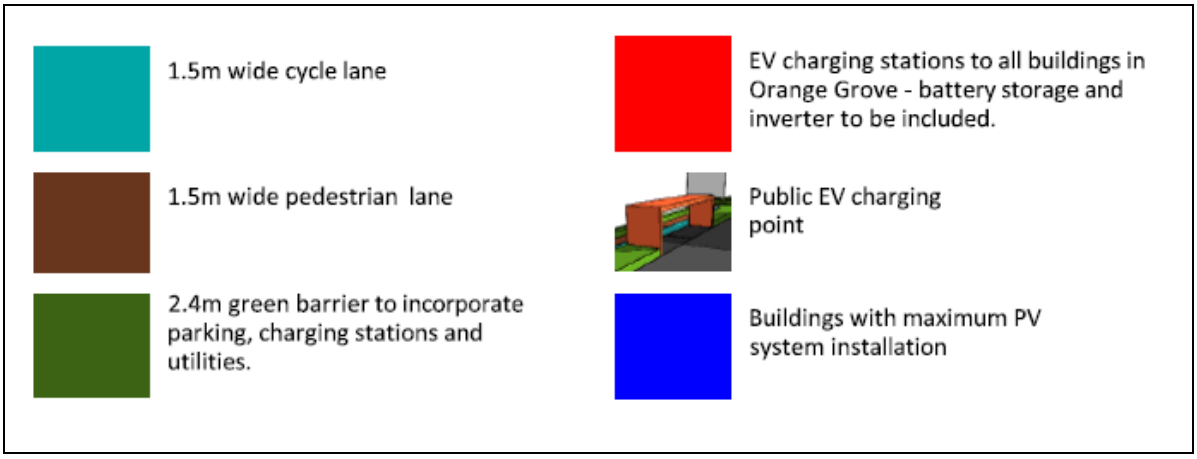


Figure 5. 16: ZCW-ITN interventions. To be read in conjunction with Figure 5.17 – Figure 5.22 (Source: Chetty, 2018)

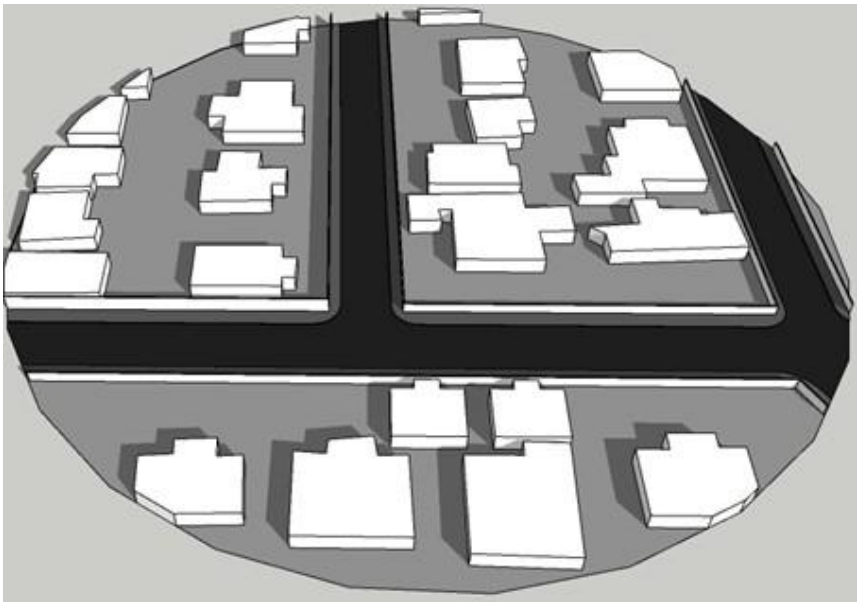


Figure 5. 17: Before ZCW-ITN infrastructural intervention on Orange Grove residential street (Source: Chetty, 2018)

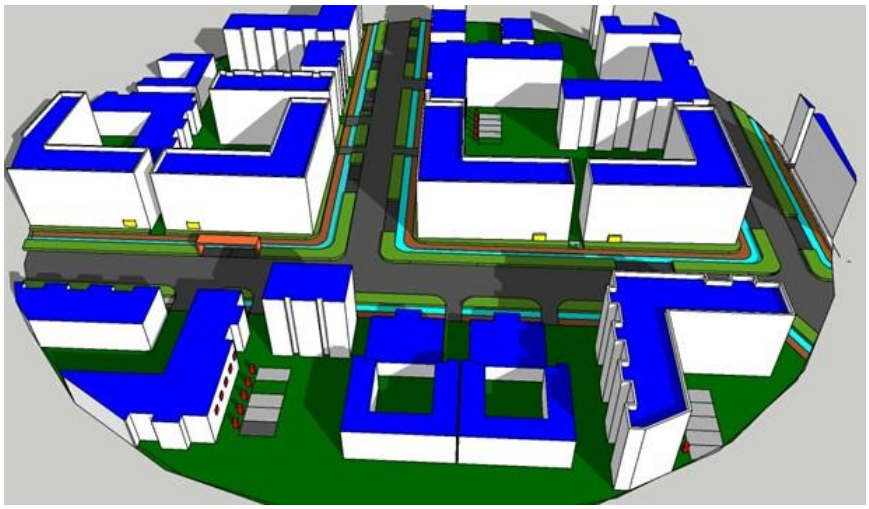


Figure 5. 18: After ZCW-ITN infrastructural intervention on Orange Grove residential street (Source: Chetty, 2018)

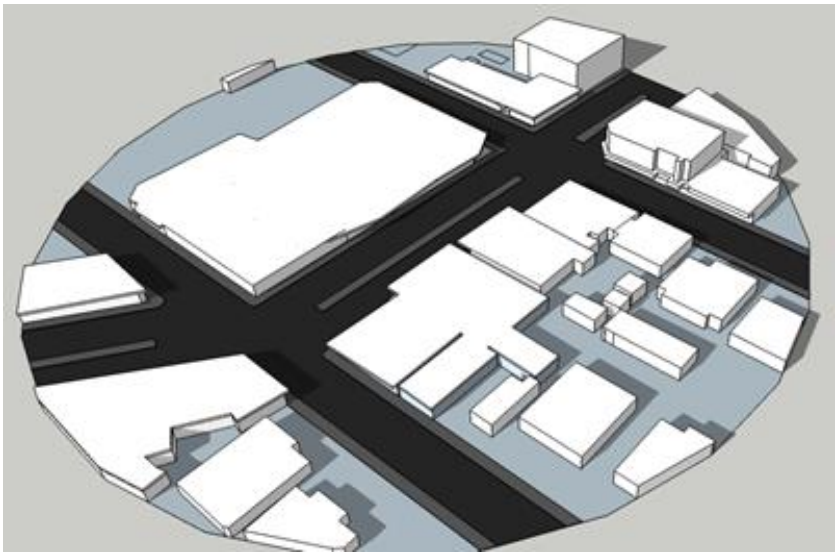


Figure 5. 19: Before ZCW-ITN infrastructural intervention on Louis Botha Avenue (Source: Chetty, 2018)

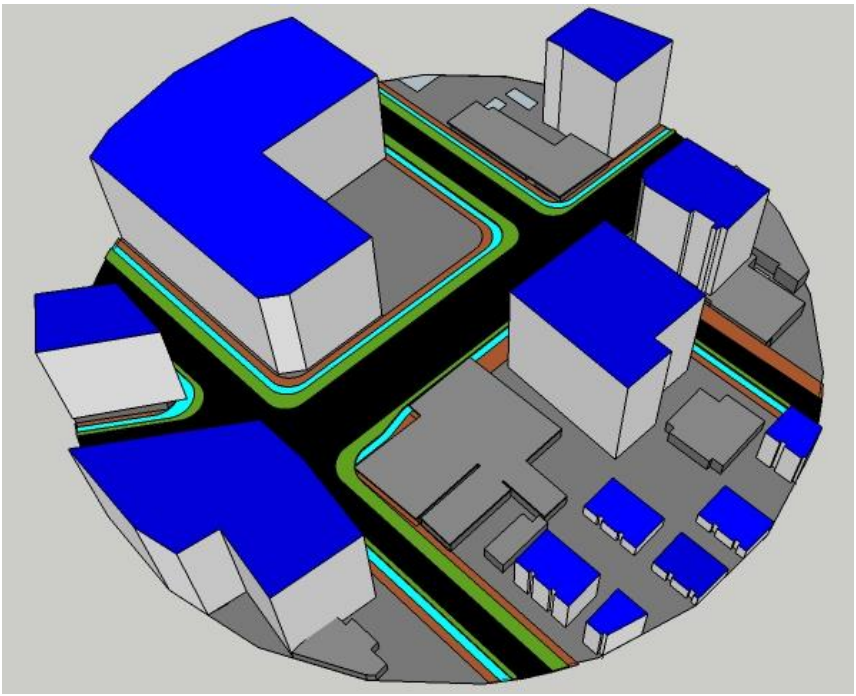


Figure 5. 20: After ZCW-ITN infrastructural intervention on Louis Botha Avenue (Source: Chetty, 2018)

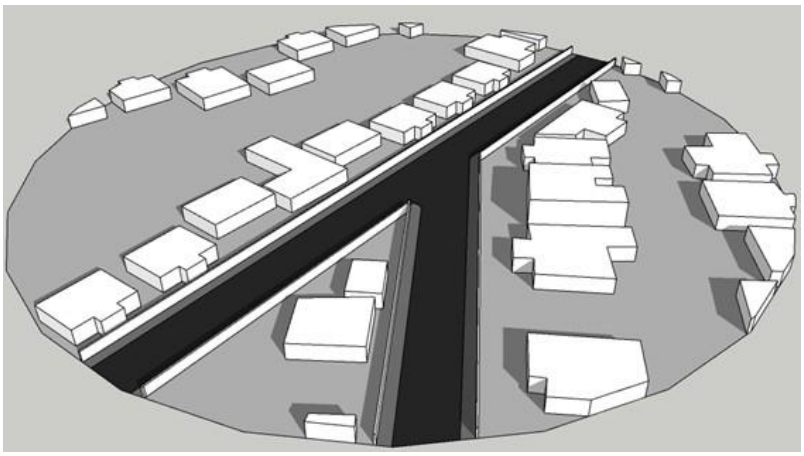


Figure 5. 21 : Before ZCW-ITN car-free street infrastructural intervention (Source: Chetty, 2018)

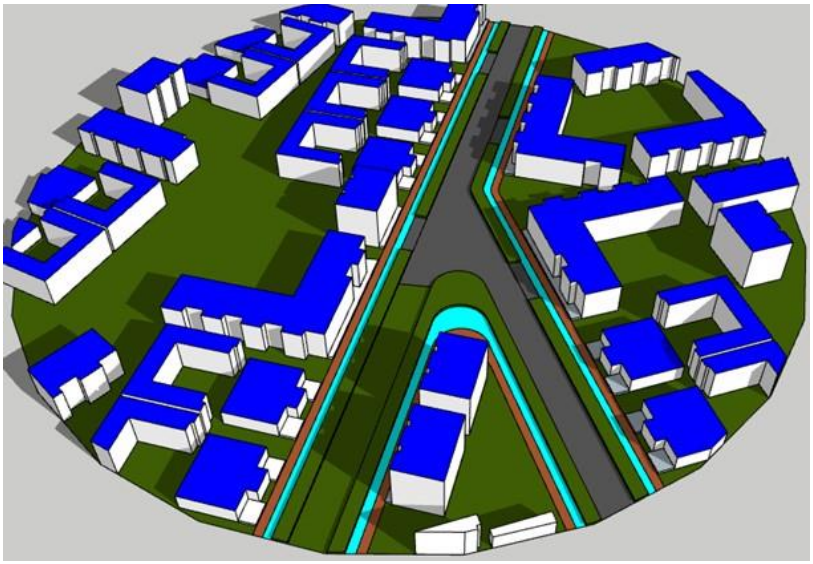


Figure 5. 22: After ZCW-ITN car-free street infrastructural intervention (Source: Chetty, 2018)

5.7 Implementation of the ZCW-ITN vision

In order to implement the ZCW-ITN vision, policy, legislation and regulations will have to be adapted that lead to a successful spatial and behavioral transformation. The kind of policies and legislation that that would be required are:

- Streets which are not high priority traffic lanes to be considered for car-free street retrofitting;
- All future streets be designed to accommodate pedestrian and cycling lanes wherever possible;
- Incentives to be allocated for all new EV owners;

- Incentive to be allocated for new PV installations; and
- All new and existing buildings to be fitted with required level power for EV charging.

As discussed in chapter 2 policy makers are quite aware of climate change issues and are also aware of South Africa's NDC commitments. There are acts such as the IPP Procurement Programme 2012, but there are no incentives for rooftop solar production in urban areas. According to EVIA, the electric vehicles carries a 25% import tax duty (EVIA, 2016). Further to this there are no policies which make cycle lanes a compulsory part of street design in urban areas. A crucial component of the ZCW-ITN is converting the fossil fuel energy source in Orange Grove to a clean energy source however right now these are too expensive. Capital investment by stakeholders, investors, developers, private companies, individuals, and government will be a crucial part of making the ZCW-ITN vision possible. One of the most crucial elements of creating the vision would be having the appropriate knowledge and expertise to construct and co-ordinate the vision. It is worth noting that the construction phase is beyond the scope of this study, and even though there is an awareness of relative challenges there would not be time to address such issues in the same study.

5.7.1 Existing Buildings

It is proposed that an incentive is set in place which encourages owners of existing residences and commercial buildings to install photovoltaic panels on all existing roofs. Means of encouraging installation of PVs could include rebates on taxes or through net metering. Exclusions would need to be made for buildings (notably heritage structures) which are prevented from doing so by the COF SDZ. Governing body's equivalent to the National Energy Regulator of South Africa (NERSA) would need to ensure that the latest technical information is available. Standards to be put in place would need to cover such aspects as safe installation practices and ensuring public safety during the operational period. The likely body to be in charge of such standards would be the City of Johannesburg where health and safety requirements as currently determined by the municipality would need to be modified accordingly and applied. The CoJ would also need to oversee compliance during implementation at the local level. It would need to be ensured that the specifications of installed PV infrastructure are appropriate, and technicians with applicable qualifications carry out the installation of PVs and EV charging systems. Aspects to be addressed will include ensuring existing grids are not compromised. It is further proposed that a net metering system be put in place where by an owner generating more than

required for their own usage feeds this into the grid. The user would get credited for this energy by the municipality.

5.7.2 New Buildings

The construction of new buildings would be on-going, dependent on involvement of developers and investors. Guidelines for new buildings would need to be developed and made available to developers and investors; such guidelines should include requirements for implementation of smart meters, PVs, EV charging stations and home battery systems. The same policies and legislation that would apply to existing buildings for EV charging and solar panel installation will apply to new buildings. However, it will be compulsory for new buildings to install PV systems. Most COF SDZ new buildings are expected to be multi units; therefore, PV energy would be shared amongst users. Standards should be set which specify how the solar energy is used, such as for EV charging and other purposes within a building. For new buildings there needs to be an understanding of who owns the solar panel, who owns the roof, who uses and owns the electricity, and how people get charged for using it. The same would apply to EV charging equipment. This would apply to residential, commercial, mixed use, educational, religious and civic buildings. In order to maximize solar energy capture, all new roofs be flat as explained earlier in this chapter. To ensure that all future roofs are flat, standards in the following documents must be adjusted: SANS 204, SANS 10400XA, and SANS 10400. It would also be prudent to investigate the existing site to ensure there are no obstructions which could interfere with sunlight; obstruction of sunlight to surrounding buildings could also be amongst the considerations in building standards.

5.7.3 Non-compliant ZCW-ITN streets

It was not possible to convert 6 streets in Orange Grove for zero-carbon strategies. For these streets, reduction in road-width should be considered since EVs are narrow than the current ICE. According to the OGTIA (CoJ, 2017a), the existing road reserves for these streets are 12.6 m. If a single vehicle lane is reduced to 2 m as calculated for the micro EV, then this 2-way street would also accommodate pedestrian and cycle lanes on both sides, with a green barrier on one side.

5.7.4 Redesign of the streets

Existing streets which can be redesigned for the ZCW-ITN must be guided by regulations and standards for the construction of infrastructure including pedestrian and cycle lanes, charging stations, as well as below-ground cabling for ICT, smart grid and PV. Proposed locations for public EV charging stations were

provided in Figure 5.11; however, it is recommended that guidelines for ideal locations for charging should be developed. These should incorporate the need for EV charging facilities should be confined to the extent of the 2.4 m wide green barrier. This should similarly be applied to infrastructure and facilities such as bike kiosks, municipal utilities, public pick and drop off zone, parking and landscaping.

5.7.5 Incentives and Disincentives

New policies would be crucial to facilitate the implementation of the ZCW-ITN interventions. These could be in the form of disincentives such as congestion charging during peak hour traffic, or the use of incentives in the workplace for using public transport rather than using private vehicles. Municipalities should also encourage the creation of incentive programs for car-sharing organizations/clubs. Other incentive programs could include allowing private vehicle owners options to replace their ICE vehicles with EVs.

5.7.6 Spatial Transformation

As proposed in the ZCW-ITN, new COF buildings should be positioned to ensure that there is enough space on streetscape to accommodate pedestrian lanes, cycle lanes, green barriers and roadways. These need to comply with the complete street design guide standards. Design and construction of these items must be holistic, and their planning should incorporate consultation at multiple levels. For example, it would be important for a civil engineer to design the pedestrian, cycle and green barriers to ensure efficient and reusable storm water drainage. Current drainage systems in CoJ are inadequate and it will be crucial for permeable surfaces and adequate drainage systems be put in place in order to deal with any additional stresses on infrastructure. This conversation must occur between engineers, designers, planners and the municipality. This requires further research and is beyond the scope of this study. A return on investment (ROI) should be anticipated for reduced marginal costs for energy, logistics and communications (Rifkin, 2014). Monetary savings accrued should be used for further development of the site until 2050.

5.7.7 Energy Sources

The main source of renewable energy in Orange Grove is proposed to be solar power; policies and regulation as discussed above will need to be rolled out to ensure maximum solar energy production. There are, however, at least two other energy opportunities in Orange Grove, namely: waste-to-energy and natural gas. Currently there is an existing gas line which runs below Orange Grove. The HP and LP

gas currently feed the homes and businesses in Orange Grove. This is supplied by gas manufactured by Egoli Gas. According to the Louis Botha Avenue Development Corridor Strategic Area Framework, it is hoped that this existing infrastructure can rather be used for natural gas sourced from Egoli Gas (CoJ and JDA, 2016). Also, within the Orange Grove study area, there is the waste removal service provider, Pikitup Norwood garden refuse site. It is proposed that waste at this site be used for waste-to-energy production. In order to ensure efficiency in energy distribution in Orange Grove, there needs to be a smart grid that will control supply and demand. Requirements for implementing smart grids successfully include: ensuring smart meter targets are met; pricing of energy based on demand, real time and peak; and ensuring data security (SANEDI, 2013).

5.7.8 Capital Investment

All interventions will require capital investment with varied respective costs. As discussed in chapter 2 such costs and the ease of implementing interventions are related to three-time frames: short term; medium term and long term. In the present study a short-term period will fall between 5 and 10 years (CoJ, 2015) which will comprise the following interventions: conversion of BRT buses to EV; introduction of feeder transport modes like electric tuk tuks; and promotion of active modes of transport. A medium-term period will fall between 10 and 15 years (Bongardt et al., 2010). This period will comprise the following interventions: public charging facilities; residential and commercial investments in EVs and PVs; conversion of all ICE public transport to EV; and the conversion of existing petrol stations to car share business. A long-term will fall between 15 and 30 years which ends in the year 2050 and this falls in line with the CoJ aims to transform transport in South Africa (DOT, 2017a). Interventions during this period will be as follows: compact city developments; all streets to have cycle and pedestrian lanes which are compliant with complete street design guide manual; permanent EV charging facilities; car free zones complete; and fully functional ICT and smart grids. A cost analysis would be beneficial in understanding the strengths and weaknesses of interventions. The analysis will also help understand where it would best to start. Capital investment will be required for the following:

1) Ecomobility infrastructure;
2) E-mobility infrastructure;
3) Smart grid infrastructure;
4) ICT infrastructure; and
5) Solar energy infrastructure.

ZCW-ITN interventions which are expected to have cost implications are outlined in Appendix B

5.8 Transferability of the Vision

In this part of the chapter, we will attempt to understand the applicability of the ZCW-ITN model to a different suburban context. In doing so, this section addresses sub question 3.

- How could insights gained from the pilot study in Orange Grove, inform future retrofits of similar existing suburban neighborhoods in Johannesburg?

Balfour Park (BPP) study area was chosen to test the adaptability of the Utopian model since it is comparable to OG study area (see Figure 5.23). The reason Balfour Park precinct was selected for the transferability test is to highlight the importance of Compact City and BRT which are TOD aspects. These are also fundamental aspects of low-carbon transport strategies which are the 'Avoid' and 'Shift 'strategies respectively. Having these 2 components inherently built into the study areas makes the task a bit simpler to achieve a ZCW-ITN neighbourhood. The CoJ has proposed TOD in three corridors to date: Turffontein, Empire-Perth and Louis Botha (CoJ and JDA, 2016) and ensuring transferability of the ZCW-ITN vision will play a key role in reducing CO_2 emissions in Johannesburg. The limitation however is that not all neighbourhoods in CoJ are going through TOD.

Balfour Park and Orange Grove in terms of its socio-economic characteristics are similar where disparities occur between rich and poor. Like the OG study area, the BPP study is also one of the eight transit-orientated development precincts that will be constructed on Louis Botha Avenue as part of the CoF strategy being implemented by City of Johannesburg.

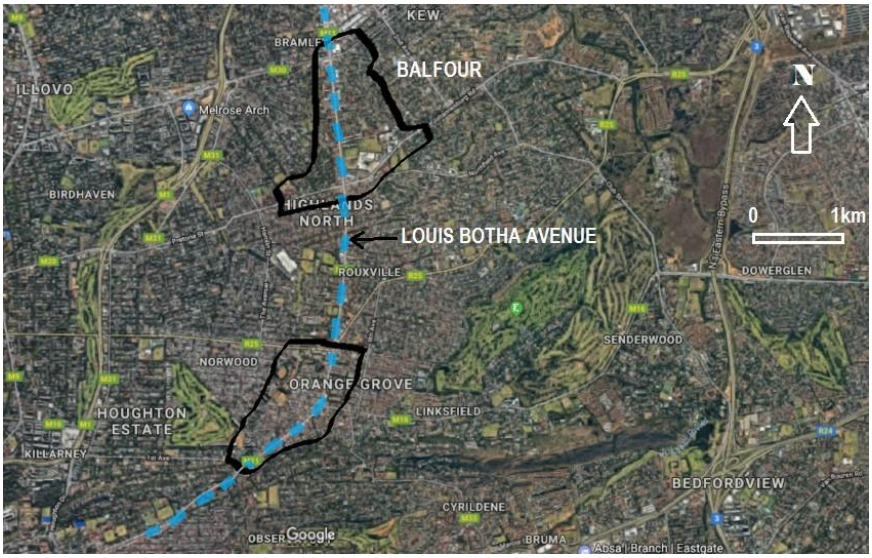


Figure 5. 23: Locality Map – Balfour Park (Source: Google Maps)

5.8.1 **Balfour Park Status Quo**

The Balfour Park Precinct (BPP) study area lies 3.1 km to the north of Orange Grove According to the Balfour Park Contextual Market Analysis (BPCMA) (CoJ, 2015b) the BPP study area is made of Bramley, Waverly, Highlands North, Savoy Estate, Kew, Glenhazel and Gresswold. The population size of the precinct is approximately 25 779. The existing population in the Orange Grove is 7751. As with Orange Grove, the area benefits from a high level of employment and many individuals with post graduate qualifications (ibid). However, the OG study area is made up of mostly middle-income earners. There are approximately 11 000 existing dwelling units in the precinct (ibid). As with Orange Grove, its urban form consists mostly of single and double storey buildings, with a few triple storey building sporadically spread across the area (see Figure 5.30 for existing site conditions).

The south-eastern part of the study area is poorly maintained with very little greenery and is not conducive to pedestrian activity due to the lack off or poor quality of pedestrian lanes (CoJ, 2015). There are a number of triple storey residential buildings. See Figure 5.24 below.



Figure 5. 24: Balfour Park – (Photo by Chetty, 2018)

The north-western corner of the BPP study area is a relatively well-developed residential space, how much of the residential zoning is now used for commercial activity. (CoJ, 2015). See Figure 5.25 below.



Figure 5. 25: Balfour Park – (Photo by Chetty, 2018)

The eastern side of the study area is dilapidated with gated streets which reduce circulation in the BPP study area. See Figure 5.26 below.



Figure 5. 26: Balfour Park – (Photo by Chetty, 2018)

The western side of the study area is relatively well-maintained with high boundary walls. See Figure 5.27 below.



Figure 5. 27: Balfour Park – (Photo by Chetty, 2018)

In central eastern position of the site there seems to be poorly managed area with inadequate pedestrian walkways with informal trading (ibid). See Figure 5.28 below.



Figure 5. 28: Balfour Park – (Photo by Chetty, 2018)

The north-eastern corner of the study area seems to be a well-kept, but with limited greenery (ibid). There were also a number of boom gates in this zone which impacts on traffic circulation. See Figure 5.29 below.



Figure 5. 29: Balfour Park – (Photo by Chetty, 2018)

Besides four schools, the buildings are predominantly residential and commercial as seen in the OG study area. Balfour Park, like Orange Grove, straddles Louis Botha Avenue (see Figure 5.30 for existing land use below). As described in Chapter 2 this is a Class 2 public route road originating in the outskirts of the Johannesburg CBD and connects to Tshwane. However, the OGTIA proposes to convert the stretch of Louis Botha Avenue that falls within the OG study area to a class 3 road. Balfour Park is bounded by Athol Street to the north and Corlett Drive so the south which are Class 3 general distributor roads with high traffic volumes during peak times. The Class 4 roads in the precinct, namely Grenville Road, High Street and Waverly Road are also busy roads during peak time's mainly serving traffic within Balfour Park. The rest of roads in Balfour Park is made of residential connectors with low traffic volumes. Transit oriented development is also being planned for the precinct together with a new BRT line which is also currently under construction. It is evident that there are many similarities between the OG study area and the BPP study area with the only major difference being the population size.

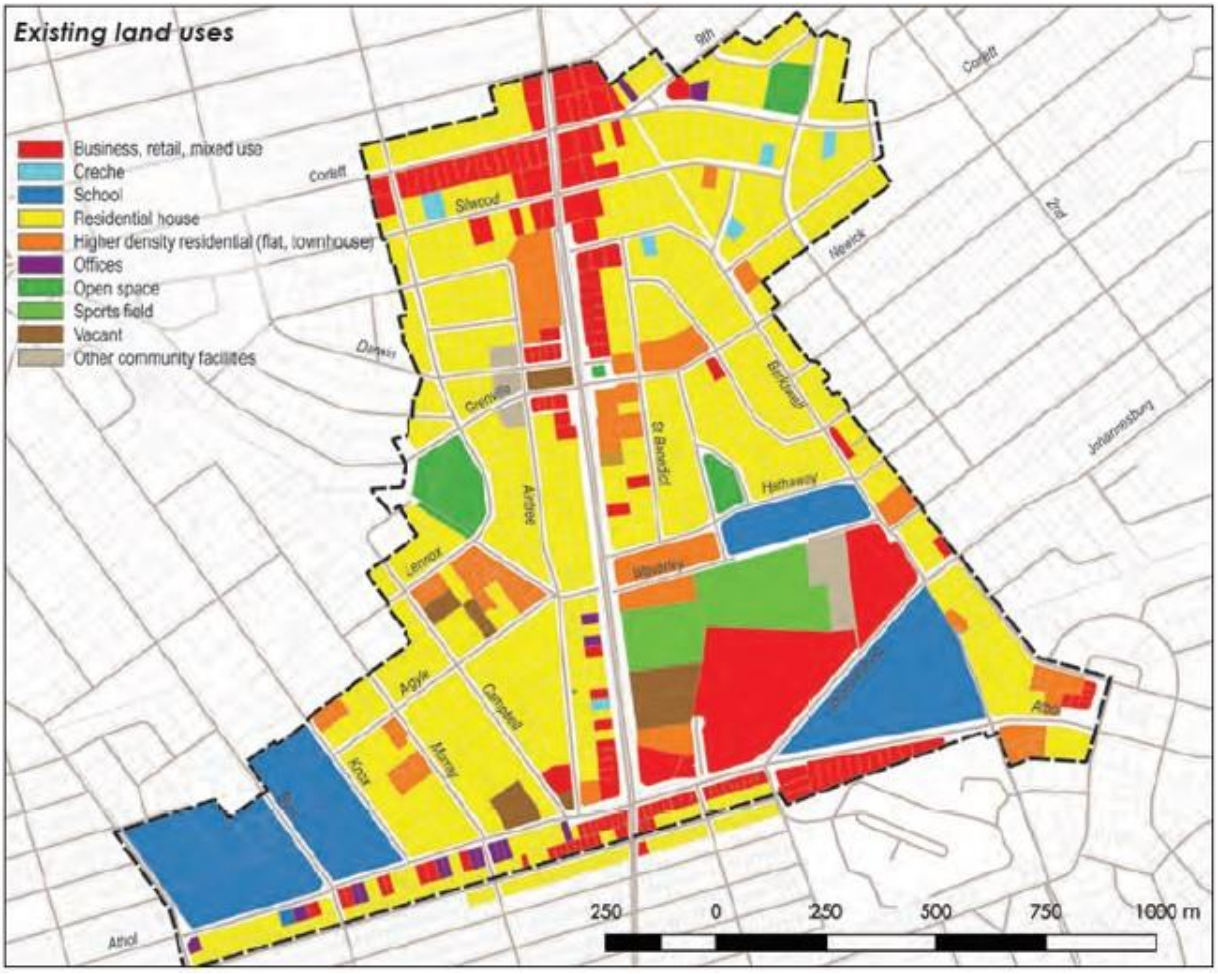


Figure 5. 30: Existing Land use in Balfour Park – Source (CoJ, 2015).

5.8.2 **Transit oriented development in Balfour Park**

The study area is 2.3 km^2 and currently has a low density of 46 dwelling units per hectare (du/ha) (CoJ, 2015). According to the BPPPUDF (CoJ, 2015) the City of Johannesburg proposes that a minimum to medium density of 80 du/ha be accepted in some zones whilst a density as high as 200 du/ha would be the target for the entire study area. This would mean that there would be an increase from 11 000 units to 46 000 units and a population increase from 25 779 to 146 000 people (CoJ, 2015) (CoJ, 2015b). An additional combined maximum area of 63 874 m^2 is expected to be added for retail, offices and urban manufacturing (CoJ, 2015) (see Figure 5.31 for road class allocations and density proposals in Balfour Park). The population density planned for the OG study area is a lot higher than the BPP study area. As with OG, the vision to densify the Balfour Park precinct aims to create a compact mixed-use node that incorporates an economic hub intertwined with civic spaces along Louis Botha Avenue. The BPPPUDF

(CoJ, 2015) aims to implement cycling and pedestrian lanes on all roads that fall within the BPP study area. To improve the public transport system in Balfour park, two BRT stations have been proposed and fall within a 1 km walking radius in the study area (CoJ, 2015a).

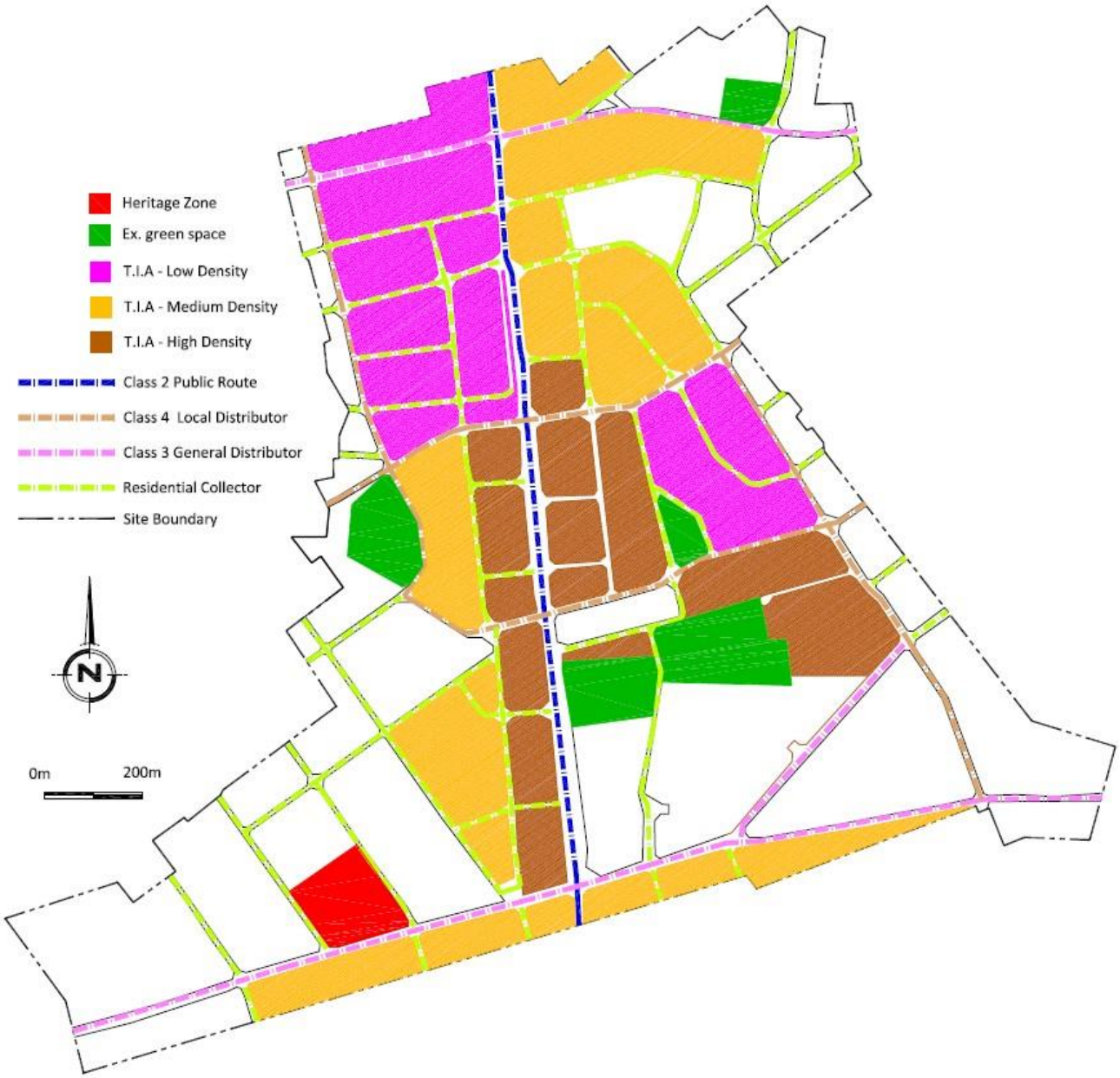


Figure 5. 31: Site Map 13: Road allocations and density proposals in Balfour Park (based on BPPPUDF, 2016)

5.8.3 Transferability of the ZCW-ITN interventions in Balfour Park

When applying the ASI framework in Balfour Park, the following approach was taken when testing for applicability:

Shift

- Car-free streets (based on the three criteria developed for the OG study area. This is tested for applicability in present study);
- Complete street design (This is tested in the present study for applicability based on ex. road reserve available to accommodate pedestrian, cycle lanes, minimum vehicle lane requirements);
- Car Sharing – as noted in the OG study, this is beyond the scope of this study, however a petrol station was identified on the corner of Corlett Drive and 9th Street.

Improve

- E-mobility – For the BPP study area, electric vehicle recommendations for the OG study area for private and public EVs would be the same namely the micro EV, minibus EV, and the Bus EV. Availability of charging station positions is tested for applicability in the present study; and
- Solar Energy Production - existing and new roofs were investigated for solar PV adaptability is tested in the present study.

Therefore, as in the OG study, conversion of existing streetscapes to car-free streets, conversion of existing streetscapes to complete streets, potential for EV charging points, and solar energy production potential has been tested in the BPP study area.

5.8.4 Existing Street Scape Observations and site analysis in Balfour Park

There is total of 29 streets within the Balfour Park study area, although Blyton Road and Aintree Avenue become one street, as do High Street and Hastings Street. Thus 27 streets that were analyzed was done via a site visit and a google maps desktop study of the BPP study area. The analysis revealed that most streetscapes in BPP were similar to those found in OG. Three street typologies were observed which were similar to the OG study area, namely street typologies 2, 3 and 5. Just over 50% of the resembled typology 2, about 33.3% resembled typology 3, and the remaining 15% of streets were similar to typology 5. See Figure 5.32-5.37 below.



Figure 5. 32: Balfour Park – Streetscape 2 – (Photo by Chetty, 2018)

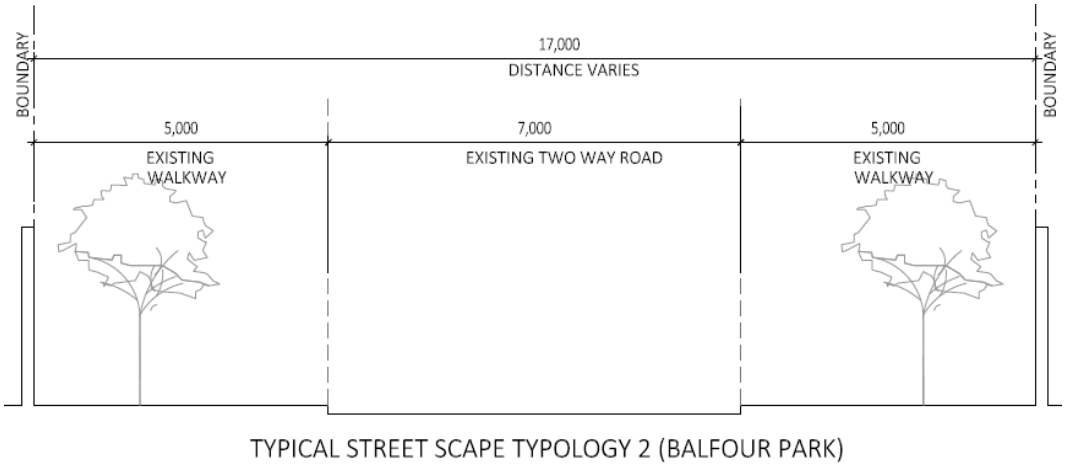


Figure 5. 33: (Source: Chetty, 2018)



Figure 5. 34: Balfour Park – Streetscape 3 (Photo by Chetty, 2018)

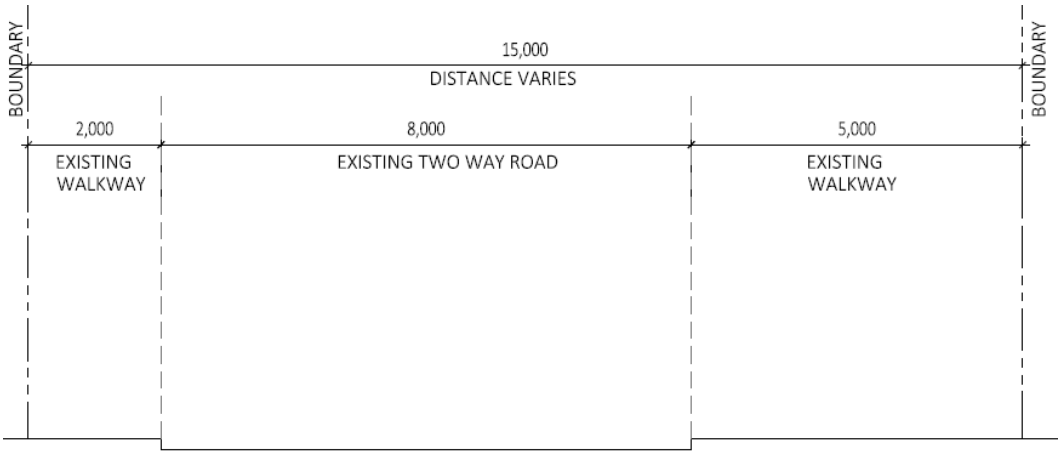


Figure 5. 35: (Source: Chetty, 2018)



Figure 5. 36: Balfour Park – streetscape 5– (Photo by Chetty, 2018)

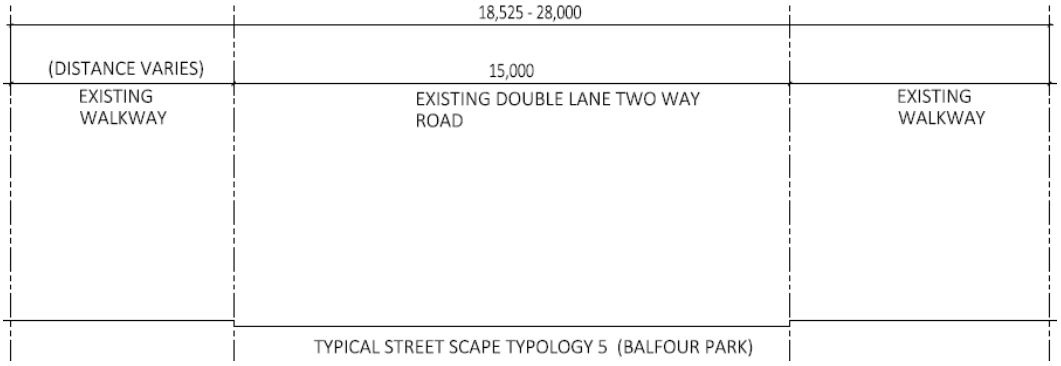


Figure 5. 37: (Source: Chetty, 2018)

Part of Louis Botha Avenue has an additional two-way side street on either side situated between Sillwood Road and Athol Streets; these are known as the Louis Botha Service Avenues. The service avenues have the advantage of maintaining smooth traffic flow; their disadvantage, however, is that

they prevents any access from Louis Botha Avenue on to private properties (CoJ,2015a). All properties within the BP study area have a boundary wall or a palisade fence as road frontages, except for a few commercial properties located on the Louis Botha Service Avenue. Most of the existing residential buildings are single storey with tiled heaped or double pitched rooves. There were a few double or triple storey building found along Louis Botha Avenue with single low-pitched roofs.

An analysis of street typologies revealed that streetscape intervention 1, 2, 4, and 5 that were used in the OG study area were also applicable in BPP study area. See Figure 5.38 below and See Appendix C.



Figure 5. 38: Site map 14- streetscape interventions types 1–5 for BPP study area based on OG study area (Source: Chetty, 2018)

5.8.5 E-mobility applicability – EV charging potential in the BPP study area

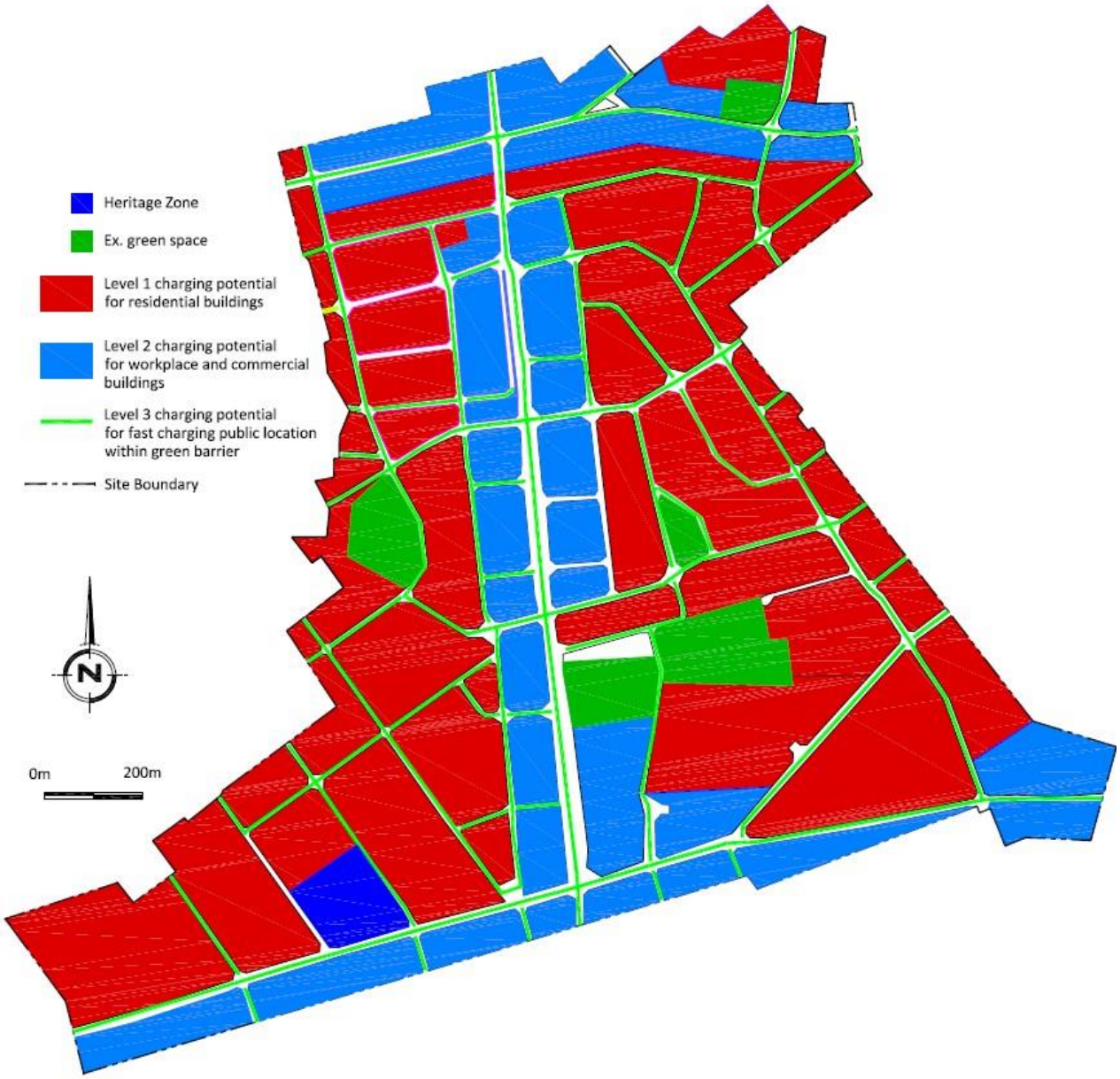


Figure 5. 39: Site map 15 - EV charging potential in BPP study area (Source: based on BPPUDF, 2016)

5.8.6 **Solar Energy Production potential in the BPP study area**

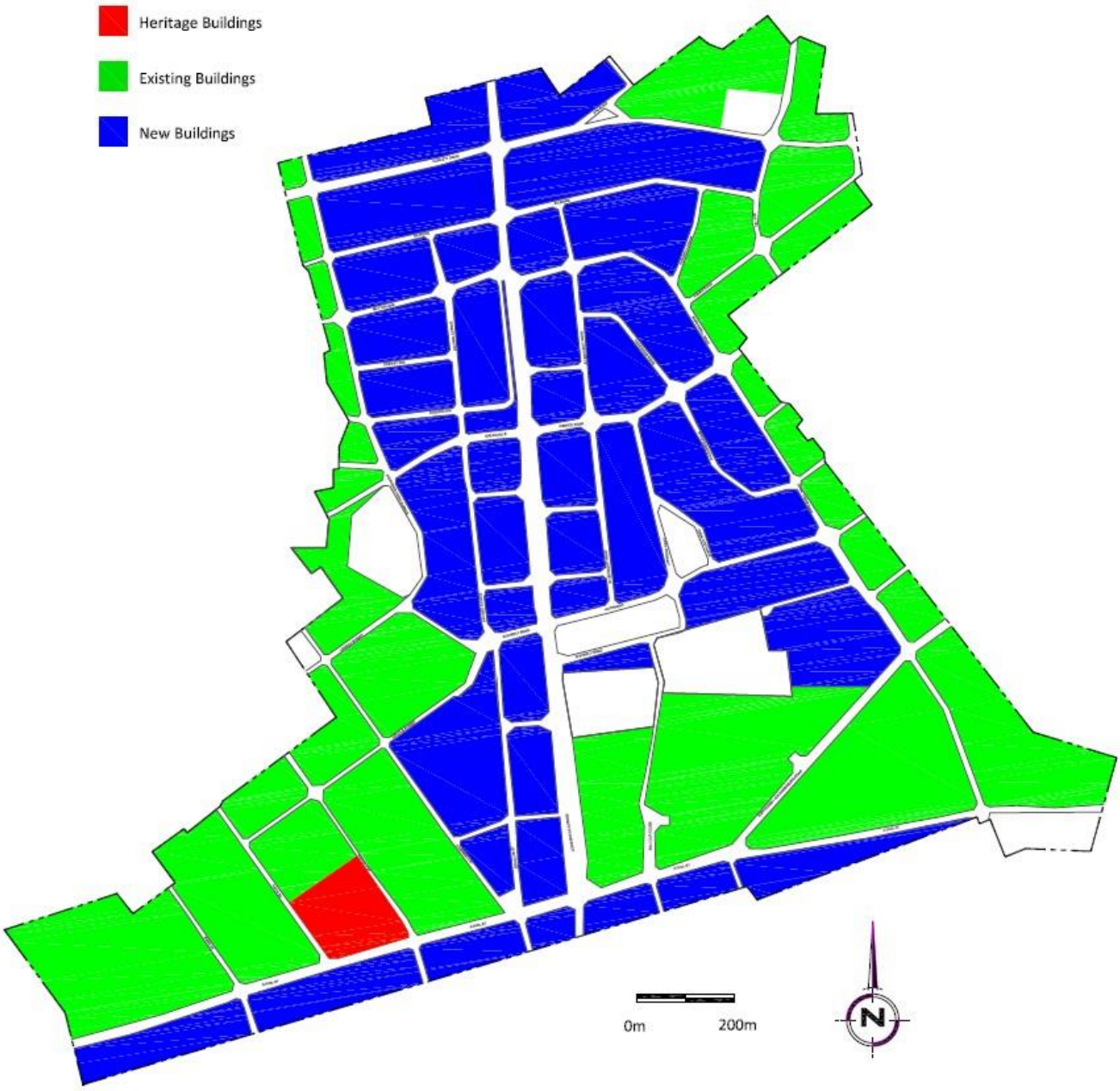


Figure 5. 40: Site map 16- RSPP in the BPP study area (Source: based on BPPUDF, 2016)

5.8.7 Key Findings – applicability of the ZCW-ITN visions in the BPP study area

There are 2 options to adapt existing streets for low- or zero-carbon mobility: car-free streets and complete streets (namely pedestrian lanes and cycle lanes). Streetscape Intervention 4, which is the car-free street option, was selected using the same criteria proposed in OG study area. Three streets in BPP study area were identified to be suitable for car-free adaptation, namely Blyton Avenue, Cheney Avenue and Murray Street. Analysis of the existing streetscapes in Balfour Park demonstrate it is possible to adapt nearly all streets to the ZCW-ITN interventions 1, 2 and 5 covering ecomobility, complete street design and EV charging facilities. The most important requirement for complete street design based on the ZCW-ITN is a sufficiently wide road reserve. The reserve was found to be inadequate on two streets, namely Corlett Drive and Northview Road. The class of street relates to the width of road lane and determines the ability to accommodate public transport vehicles such as buses. A Class 3 street, for example, would require a 3.3 m lane as opposed to a Class 4 or 5 street which would only require a 3 m wide lane. The final analysis indicates that almost all (92.6%) of the existing roads can be converted to ZCW-ITN streetscapes. Just under half (46.1%) of these suitable roads could be transformed into Intervention Type 1, the ideal for ZCW-ITN streetscapes.

An analysis of roofs revealed that all new and existing roofs in Balfour Park could be used for photovoltaic installation due to them being either pitched or flat and there are no obstructions from the sun's rays. According to the BPPPUDF (CoJ, 2015) 55.3% of the site will be targeted for TOD densification. Therefore, it can be anticipated there will be 55.3% new roofs. In chapter 2 it was suggested that a flat roof could get maximum solar energy production. There it can be concluded that 55.3% of the BPP study area roofs will produce maximum energy from solar. The other 43.4% of the BPP study area comprise of existing roofs and will produce less than maximum solar energy due to their mostly being double pitch, as per google map survey. 1.3% will not be available for solar energy production due to their being of heritage significance.

As in OG study area, assessment of adaptability for installation of EV charging infrastructure the residential, workplace, commercial and public locations was carried out. Therefore, the same approach will be used in the BPP study area which is made of the same types of buildings. A google map site analysis revealed that existing residential buildings have abundant space within the respective properties for charging facilities to be installed. The facilities could be installed inside existing garages or driveways. Important considerations for feasibility of installation include the size requirements of EVSE equipment (VEIC, 2014). As found in OG study area, the potential of planned multi storey buildings to

form part of a mixed-use component would need to consider EV charging in parking lots or within parking garages. More than 95% of the site can be used to install either level 1, 2 or 3 EV charging stations. Based on these findings reveal that it is highly possible to adapt Balfour to a ZCW-ITN.

6 Chapter 6: Barriers to the ZCW-ITN vision

6.1 Introduction

In line with this report's aim investigating the potential to transform from an unsustainable fossil fuel transport system to a ZCW-ITN in an urban neighborhood, chapter 4 and 5 demonstrated the ability that it is possible. Specifically, it was found that such transformation is feasible for Orange Grove, as well as Balfour Park where the ZCW-ITN model was replicated. In Chapter 4, it was proposed that this be achieved in accordance with the COF SDZ (CoJ, 2017) and compact city initiative. Furthermore, it also aims to have a transport system that is almost zero carbon, zero cost, and has created a new state of collaborative, sustainable and efficient living by 2050. However, barriers to implementation of the ZCW-ITN model were identified during the research process, in answer to Sub-question 4:

- What are the barriers to transforming from a fossil-fueled transport system to a zero-carbon well integrated transport system in Orange Grove?

Barriers were identified both in terms of the ZCW-ITN model itself (i.e. limitations to the how applicable and feasible the model is), and in terms of attitudes towards its implementation. Gathering of information on barriers to implementation was through:

- Applying the model to the comparable area, namely the OG and BPP study areas (already outlined in Chapter 5); and
- Through semi-structured interviews with 13 people regarding the proposed ZCW-ITN model. Orange Grove residents were interviewed, as well as experts in the areas of sustainability, climate change adaptation and mitigation. They included a traffic engineer, as well as officials from the CoJ, JRA, GBCSA and SANEDI. See Appendix D – H for typical questions used during semi structured interviews.

As outlined in Chapter 3, the proposed 2050 utopian model (ZCW-ITN) was presented to different stakeholders in the form of a video; this was done to test how such a model would be received by end-users. The video was also aimed at addressing a concern that interviewees would not be able to respond adequately to questions due to their lack of knowledge or understanding the ZCW-ITN vision. This video describes what a ZCW-ITN vision could look like in 2050. Interviewees were informed on key aspects such as ecomobility, e-mobility, renewable energy, low-carbon technologies and interventions trending internationally and nationally, and complete street design. The content provided to the interviewees is provided in the CD contained in Appendix I.

The potential barriers to, and limitations of the ZCW-ITN model identified through analysis of interviewee responses are set out in the sections below.

6.2 Knowledge of and attitudes to climate change

Although climate change is a well-documented concern in academic research, selected industries, government, and municipal arenas, there are not as yet sufficient 'in-your-face' warnings of the consequences for South Africa. Insufficient knowledge about climate change can be a barrier to implementation of climate change adaptation and mitigation measures. During the course of the interviews, it became clear that some of the interviewees have only minimal knowledge around climate change and the need for preventative zero-carbon measures such as ecomobility, e-mobility and renewable energy. Feedback gathered during the interviews on climate change revealed the following:

1) Acceptance but lack of climate change knowledge: two respondents accepted that climate change was an issue, and that the video had important elements that would fight climate change. These interviewees felt that climate change is an unknown space and they did not understand mitigate or adaptive approaches.
2) Indifference: four respondents accepted that climate change was an issue, and that the video displayed positive action against climate change. However, there wasn't a clear understanding of climate change and they were not experts in the field. Therefore, they felt that this is not an issue that they needed to deal with.
3) Acceptance but the earth will heal itself: one respondent accepted that climate change was an issue, and the interventions from the video will help, however it would only be to an extent. The respondent believed that the planet will naturally return to a balanced state.
4) Acceptance and understanding: five respondents understood the issue of climate change. They also had a clear understanding of what needed to be done in their respective fields in order to mitigate and adapt to climate change. They also believed that a zero-carbon transport system would be a way in lowering CO emissions and fighting climate change. They also believed the interventions proposed in the ZCW-ITN were part of the solution, and that should be implemented.
5) Denial: one respondent felt that public debate on the topic made it difficult to accept that climate change is a reality. The environment was also not a big concern for them. Therefore, the video had no impact other than if there was economic gain.

6.3 Attitudes to the ZCW-ITN model

Insufficient positive reaction to the proposed model would constitute a barrier to its being implemented. Those respondents with knowledge of sustainability and climate change adaptation/mitigation embraced the importance of the types of interventions envisaged. They agreed in principal to the kind of change that needs to happen, and which was represented in the video. Those with limited knowledge on the topics nevertheless saw the benefits of economic, social and environmental gain; they in fact became intrigued and wished to learn more. It can be inferred that these respondents did not object to the utopian vision to becoming a reality.

Responses from the participants ranged across being positive (7 respondents); positive only once they had been able to provide constructive advice on the model (5 respondents) and finally, negative (1 respondent). In the first category, interviewees who were positive were ready for this vision to become a reality immediately. In the second category, respondents offered expert advice on areas where the model could be improved, and they valued the vision. In the third category, the respondent felt it was too expensive, there were not enough resources to support it coming to fruition, and they were further not convinced about climate change being a reality. Overall, it can be inferred that the majority of people want to see change in the current transport system in Johannesburg towards a utopian future.

6.4 Economic feasibility

Insufficient funding presents an economic barrier that would need to be overcome to make the ZCW-ITN vision become a reality. According to Stats SA (2018) a 0, 7% downturn was recorded for the second quarter of 2018 in South Africa. In 2017 the CoJ borrowed 3 billion rand from the Development Bank of South Africa (DBSA) due to City Power, Johannesburg Development Agency (JDA), Metro Bus and JRA, operating of overdrafts (African Times, 2017). According to the CoJ Integrated Development Plan (IDP) (2018/2019) job creation has been low due to the decline in the mining and manufacturing industries. Matters are not helped by 3000 people migrating to the CoJ per month, which aggravates rapid urbanization and put pressure on existing infrastructure (CoJ, 2018/2019). So, there is little doubt there are financial challenges in the CoJ, but climate change is still an issue and needs to be addressed. Funding would need to be identified from two sources, namely Public investment by the CoJ to implement and operate the new infrastructure, as well as purchases/investment by private individuals in technologies like the EV and photovoltaic panels.

6.4.1 Public investment

Public investment in the ZCW-ITN will go to infrastructure that will facilitate the implementation of ecomobility; e-mobility; solar energy; and ICT. In the previous chapter, the ZCW-ITN vision was shown to have high transformational socio-economic and environmental benefits. This would be considered a profitable business opportunity for the City of Johannesburg, especially if initiated with solar energy, EVs and EV charging stations to start. The sun's rays are free of charge and funding would be required for PV panels. The aim of this would be to reduce the energy bill from the oil and coal sectors. A comparative cost analysis between coal, petrol and solar in Table 6.1 below shows that solar is by far the cheapest. Note that petrol and diesel prices are for October 2018.

Table 6. 1: Comparative cost analysis of solar, coal, petrol and diesel in South Africa (Source: Business Tech, 2018; Eskom schedule of Fees 2018/2019, 2018; DeepResource, 2012; Ireland and Burton, 2018)

Energy type	Rand/litre	kWh/litre	kWh/Rand
Solar			R0.62
Eskom coal			R1.04
Electricity from Eskom with coal energy source (Block 1)			R 1.35
95 Petrol	R17.08	9.7	R1.76
93 Petrol	R16.86	9.7	R1.74
diesel	R15.65	10.7	R1.46

As profits are gained from this system, the rest of the ZCW-ITN vision can be implemented.

6.4.2 Service costs for construction

A fundamental limitation that might affect the ZCW-ITN at the initial stage of the project is upgrading of existing services such as power and water, required for the construction phase to be kick started. There are high costs which are associated with this. Ways in which this could be approached is for the municipality to install solar power on all existing roofs in the OG study area, with the permission of residents which could be then used for construction. Costs for the PV panels would be recovered from developers who want to invest in the study area. In order to deal with the water issue, rainwater harvesting, reducing water consumption in Orange Grove, and greywater harvesting could be sustainable means to improve water services during the construction phase. Creating this culture of water sustainability would also be good practice to follow through into the ZCW-ITN vision.

6.4.3 Private investment

Individuals in Orange Grove would have to purchase ZCW-ITN technologies, namely EVs and PV panels which are 'Shift' strategies for LCT. For electric vehicles investment would have to be made by 2 groups: residents and minibus taxi owners. All interviewees believed that the electric vehicle is too expensive in South Africa. In South Africa a plug-in electric vehicle (PEV) currently costs R500 000–R 650 000. The monthly installment for a R500 000 vehicle over 72 months at a 10% interest rate is about R 9 355 per month. The majority of the people in Orange Grove are middle-income earning approximately R11 000 per month (CoJ, 2017a). Clearly, the majority of the people cannot afford to buy an EV. Under such circumstances it is unlikely that many will convert to EVs. However, the cost of the EV is expected to decrease by 2050. Other evidence that shows EV costs are decreasing is the falling cost of the lithium ion batteries which has decreased from $1000 per kWh in 2010 to $227 per kWh in 2016 (Mckinsey and Company,2017). Other popular smaller four-seater EVs cost about $8000 after government subsidies (Oak Ridge National Laboratory, 2017). According to Bloomberg Electric Vehicle Outlook (2018), EV prices are expected to become competitive by 2024 at a global scale. The pricing will be competitive even without subsidies and will be cheaper to make than ICE vehicles by 2030 (ibid).

In the ZCW-ITN utopia, the most feasible source of energy for EVs and the home is solar as noted in Table 6.1. This scenario would require Orange Grove residents to purchase/invest in them. When looking at monetary costs, most interviewees felt that this technology was too expensive. The cost to convert an average home in South Africa to solar is approximately R215 000 to R295 000 (Business Tech, 2018a). Middle income earners cannot afford this technology. However, due to PV technology advancements, costs are expected to decline. For instance, in 2008 the installed costs in South Africa for a one-kilowatt (kW) PV system costed approximately R80 000, which has since decreased to almost R20 000 in 2016 (Green Energy Solutions, 2016). The first sign of PV prices falling started in 2008 with bulk supply of low-cost PV panels by China and silicone prices falling by 80% were the main reasons for a decline in PV panel costs (WWF Technical Report, 2014). From 2010 onwards saw inverter prices decline by 66% (ibid). This resulted in the cost of PV systems being reduced by 52% in America by 2013 (ibid). As these technological advancements continue, is likely that relative PV system costs will continue to drop significantly by 2050.

A further outlay for private EV owners would be the need to invest in EV charging stations. According to Business Tech (2017), a 'wallbox' charging station will cost approximately R22 000. For middle-income earners, this is also a costly item to purchase without finance arrangements. However, BMW have

included the EV charger as an accessory when purchasing the vehicle; therefore, if other companies selling EVs could adopt the same business model then the EV charger will become cheaper to afford. Thus, to own an EV currently incurs high costs if you want to acquire your own PV system together with a charging unit. Factors that will drop these costs by 2050 include advancements in technology, government subsidies, and favorable business models. Investigation during the present study revealed that there is just one existing public EV charging station installed by the CoJ municipality. The present paucity of access to charging facilities is an obstacle for the private EV owner who must rely on home-charging and 27 other public-access charging stations in Gauteng exclusively. The number of EVs in South Africa is currently still low, with about 300 EVs in the country (Global EV Outlook, 2018). This number would need to rise significantly in order for municipalities to believe that there is a need for installing more charging points. There could be a 'Catch-22' type situation, where because there are few electric cars, the number on EV charging points will remain low. However, because there is limited access to EV charging points, people will be discouraged from purchasing EVs.

6.5 Design limitations

There were a number of design limitations identified during the observation and interview process. 38% of all interviewees raised potential problems that would affect the ZCW-ITN implementation covering technology, existing street infrastructure and urban function.

6.5.1 Climatic and weather conditions

The interviews revealed that people are concerned about the effects of weather on the energy output of solar (PV) panels. Cloud cover has the most impact on PV panels (Pillay et al., 2016), although according to Suri et al. (2014), South Africa is dominated by sunny regions. On average 225 days of the year experiencing sunshine (ibid). Less than 25 days of the year are typically cloudy, with about 120 days with inconstant cloudy conditions (ibid). Johannesburg experiences longitudinal and latitudinal are co-ordinates are -26.2041° S, 28.0473° E respectively (Latlong.net, 2018). Johannesburg is in South Africa's climatic zone one which is referred to being cold interior, with low humidity, hot summers and cold winters (Architective, 2013) with sunny winters and stormy summers. To accommodate cloudy day's battery storage systems will play key role (Sustainable Energy Africa, 2017).

6.5.2 Battery capacity

One of the fundamental technological issues with the EV is the battery which has a limited distance range. According to findings all Orange Grove interviewees were uncomfortable with the EVs range; this is commonly referred to as range anxiety (IEA, 2018). According to the Global EV outlook (IEA, 2018) the minimum range for a battery electric vehicle (BEV) is 100 km. This means that people in Orange Grove can typically only make a 50 km trip in one direction. However, people make different kinds of trips and understanding where they travel to on a regular basis would require a separate study. To reduce range anxiety by 2050 it is hoped that more midway charging facilities are installed in public charging zones, commercial buildings and the workplace. It is also likely that range will increase as battery technology improves. In recent years there has been a great improvement in the battery power technology, both in terms of their reduced size and amount of energy they can store. The lithium ion battery was first conceptualized in the 1950's and was first commercialized by Exxon in 1977, only to fail due to a technical miscalculation (Material Research Society, 2015) The first breakthrough came in 1991 when Sony commercialized the first successful lithium ion battery which has be steadily improving since (ibid).

6.5.3 Existing Streetscapes

Findings indicated that from 54 streets tested for zero or low-carbon streetscape interventions, there were 6 streets in the OG study area that could not be converted. This was due to limited street reserve, and neither was it feasible to convert car-free street due not meeting the required criteria stated in Section 5.2. The aim of this report is to reduce CO_2 emissions in all suburban neighborhoods in Johannesburg and the transferability of the model is crucial to meet this aim. Therefore, it would be important to understand in the context of built road widths in Johannesburg. According to the OGTIA (CoJ, 2017a), no buildings are expected to be affected by the road widenings proposed in Orange Grove. This methodology to widen roads in Orange Grove must be appropriately considered and discussed so that the same can be applied elsewhere in Johannesburg in order to implement ZCW-ITN streetscapes. This is discussed further in Section 6.7 dealing with the regulatory environment.

Municipal officials also became concerned that if certain existing streets were converted to car free zones, then this will change how the existing transport routes function. During the design phase of the ZCW-ITN, selection of car free streets had to comply with 3 fundamental criteria as discussed in chapter 5. Two of these criteria stipulated that streets identified for car free street conversion must have low

traffic volumes and must not form part of public transport service route, therefore aiming to cause minimal disruption to traffic flow and service providers.

6.6 Barriers to behavioural change

The feedback from the interviews carried out revealed behavioral challenges that will limit the implementation of the ZCW-ITN vision. Just over half of all respondents felt that they chose not to alter their mindsets with regards to their current beliefs. Several aspects were identified by the research can be considered behavioral barriers to implementation of the ZCW-ITN vision as outlined below.

6.6.1 Ecomobility

Ecomobility requires behavioral change by Orange Grove residents. Public transport, walking, cycling and trip planning are behavioral change items. Almost half of all respondents confirmed that they would cycle, while the remainder indicated they believe that it is not safe to cycle in Johannesburg. If implemented, the ZCW-ITN vision would offer four solutions to promote cycling safety: the right infrastructure would be in place for cycling; secondly, road speeds in residential areas would be reduced to 30km/h; raised intersections would reduce speed; and the green barrier would be installed to separate NMT lanes from the roadway.

6.6.2 Car-Sharing

Even though most respondents were in favor of car sharing, feedback also revealed that not everyone might want to share a vehicle due to a sense of privacy being lost. In order to cater for this condition, a number of mobility options are available in the OG study area; and all zero-carbon modes would need to be explored by users as to what suits them best. The main principle of the idealized transport system would be integration. This means that at any point in the network, a change to a different transport mode could be made. The other predominant principle of the ZCW-ITN is to challenge the misplaced acceptance of the current transport mode hierarchy.

6.6.3 ICT

People have varying opinions on whether ICT should be allowed to play an increasingly leading role in society. Feedback implied that if technology was allowed to take over, the role humans play in society would come into question. It was also implied that perhaps the socio-economic disparity the CoJ finds itself in where 21% of people were living below the poverty line in 2013 (SACN, 2016). Those who are at the lower end of the economic scale must earn enough money to survive and cannot afford for

computers and technology to be taking away their jobs. But the ICT system proposed for the ZCW-ITN vision intends on making transport more efficient so that low income earner can reach their destinations quickly and at a low cost by 2050.

6.6.4 Climate change denial

A small number of respondents felt that the environment was not a concern and did not believe that climate change was an issue. Although this is now less common, even amongst the scientific community there are climate change denialists. However, the reality is that climate change is already happening, as discussed in detail in Chapters 1 and 2. A crucial piece of evidence which supports climate change is that since 1950, the atmospheric CO_2 level has been steadily climbing and currently sits at 400 ppm. Before 1950, this number was never higher than 300ppm (IEA, 2014).

6.6.5 The fragmented CoJ

Well over half of all respondents advised that they cannot do without their cars. One particular reason that stood out is the fragmented nature of the city that we live in. The apartheid city was discussed in Chapter 1; this historical design legacy still impacts on how people travel in Johannesburg today. This pattern is furthermore exacerbated by urban sprawl. The City of Johannesburg is working tirelessly to overcome this through initiatives like the Corridors of Freedom project (CoJ and JDA, 2016). There are two main reasons why this fragmentation needs to be overcome; firstly, to undo past transgressions, and to ensure that previously disadvantaged people have s equal rights to the city. It is also necessary to actively manage fragmentation that can be entrenched through rapid urbanization.

6.7 Regulatory barriers

6.7.1 Road design regulations

Current regulation does not require complete street design compliance, even though it is promoted by the CoJ. It is also not mandatory for roads to include cycle and pedestrian lanes, even where the road reserve is wide enough to include these elements. This is a barrier to the implementation for the ZCW-ITN utopian model. To make the regulatory environment conducive to realizing the ZCW-ITN vision, it would be prudent to make it mandatory for all roads to be based on Complete Street Design Principles (CoJ, 2014) which prioritize NMT over Motorized Transport.

6.7.2 Existing road regulations

Currently, roads in Classes 4a and 4b have 60 km/hr and 50 km/hr respectively. If such speed limits were to remain in place, they would constitute a barrier to implementing the ZCW-ITN vision. In order to create safer, more 'walkable' spaces, residential road speeds would need to be reduced. The ZCW-ITN model has proposed that all residential road speed be changed to 30 km/hr. If these road speeds were reduced, it would encourage people to walk and cycle and would create a greater sense of safety.

It was not possible to convert five of the Orange Grove streets into 'complete streets 'due to existing road reserves being limited to between 12 m (google maps) and 12.6 m (CoJ, 2017a). According to the JRA, the standard width of an ICE car is 1.8 m and a minimum road width of 3 m has been provided in the Complete Street Design Guidelines (CoJ, 2014). This is a limitation to the realization of the ZCW-ITN vision. As shown in chapter 5, a street could be as narrow as 2m due to the 1.5m wide micro EV. However, this will not be feasible until service or emergency vehicles to reduce accordingly.

6.8 Management limitations

Multiple actors need to pull in the same direction to achieve the successful implementation of the ZCW-ITN vision in order for maximum benefits to the community and climate goals to be reached.

A small proportion of individuals were concerned with missing buses, and they felt that a backup system would be required. It would be imperative for the public transport managers to know exactly where public transport vehicles are on the circuit, at any one time. This could be done through web-based apps which would also be available for a user to see. If the bus is broken down, users at the BRT station would be informed through information screens installed at the BRT station or via cell phone web apps. In terms of backup systems, bus frequency is currently based on a bus every 5 minutes during peak times and every 15minutes during off peak times. If these times are too long to wait, there would still be other modes of transport like EV mini bus taxis or EV car-share vehicles.

The ZCW-ITN model represents a major potential change to the community of OG which comprise urban infrastructural, behavioral, and technological. Change management will play a crucial role during this process. This involves the management of change and development by the CoJ, within OG during the implementation of the ZCW-ITN vision. If not carried effectively, this would compromise the vision. There would need to be integrated involvement of various stakeholder at different levels such as Government authorities, academic and technological institutions, and residents. Agencies responsible for resourcing the transformation would also be a key stakeholder grouping. This is important for

ensuring a common understanding of what needs to be done. Therefore, accurate and timeous information to all parties representing their range of interests and concerns would be crucial.

6.9 Conclusion

Majority of all respondents' attitudes towards the ZCW-ITN vision felt that it was a good idea which answered social, economic and environmental issues. More than half of all respondents felt that the ZCW-ITN vision should be implemented immediately, whilst just under half offered constructive advice which would improve the ZCW-ITN vision. One respondent however disagreed with the model due to there being a lack of evidence on climate change. It also became evident that even though respondents were aware of climate change, more than half of them were not sure of its severity or what needed to be done to mitigate or adapt to the effects.

When looking closer through the design process and interviews, five fundamental barriers to implementation became evident: economic; design, regulatory, management behavior change limitations. Funding from a public or private point of view would be crucial to the progress of the vision. This may require incentives which would encourage people to change to adopting ecomobility, e-mobility or solar energy technologies. No significant design limitations were identified; rapid technological advances in EVs, PVs and battery technology are improving efficiency and affordability. However existing road reserves will be an important item to consider when applying the ZCW-ITN vision to the rest of Johannesburg. One way to address this issue would be by regulating new road width by investigating possibilities for increasing road reserves. It is of extreme importance for people to be made aware of the social, economic and environmental benefits of the low-carbon interventions. If people do not 'buy into' this change, they will find no need to change their behavior; behavior change will thus need to be encouraged through education, as well as provision of benefits/incentives. Disincentives such as taxes will also play a vital role in bringing about change. Ensuring resourcing of the ZCW-ITN vision will need to be carefully managed Interventions will also need to be carried out in an integrated and coordinated manner, so that maximum CO_2 reductions can be achieved through the ZCW-ITN. Appropriate addressing of the barriers to implementation of the ZCW-ITN vision will be a useful in assisting the transitioning process from planning, through to construction and completion.

7 Chapter 7 - Conclusion and recommendations

7.1 Introduction

Climate change is a silent but severe problem that has been steadily changing the course of humankind's existence. Impacts of rising global temperatures, rising sea levels, droughts, and unpredictable weather patterns are becoming more evident. If not properly addressed through mitigation and adaptation measures, the future of humankind's existence is in jeopardy. This report has shown that through an envisioning study in Orange Grove, that it is possible to mitigate climate change by adapting and retrofitting existing neighbourhoods in the City of Johannesburg into a ZCW-ITN. The vision encompassing ensuring zero-carbon emissions from transport by 2050, nearly zero cost for energy and transport and achieving a new state of social urban existence can be attained. Achieving the vision needs to be guided by the principles of collaboration, efficiency and sustainability. The process of development of the ZCW-ITN undertaken in this report has been guided by the ASI Framework created in 2007 by the GIZ. Their framework has provided a useful basis for the ZCW-ITN, since it envisions outcomes that are key to implementing a holistic understanding of sustainability. These encompass reducing travel through compact city development and car-free streets. It also sets out to use economical and environmentally friendly modes of transport through the BRT, NMT and car-sharing. Finally, the ASI Framework aims to introduce low emission technology such as e-mobility, solar energy, smart grids, and ICT. These same interventions were incorporated into the ZCW-ITN vision for OG developed for this report. Selection of interventions for the ZCW-ITN was also guided through a scenario-planning process involving gathering of observations through semi structured interviews and site investigations. In this report there were certain aspects of the ZCW-ITN that could be tested, some that could not be tested, and some that did not need testing. Aspects that were tested were: potential for car-free streets implementation; complete street design that included cycle and pedestrian lanes; e-mobility potential; and RSPP. Aspects that could not be tested were smart grids, ICT, and car sharing potential which was beyond the scope of the present study. Aspects that did not need testing was: TOD or compact city design which is in the initial proposal phases for OG study area and the BPP study area; and BRT which is under construction in both study areas. In order to make this vision a success the following actors would play a key role: government at national, provincial and regional levels; town and urban planners; engineers; architects; suppliers of solar and e-mobility products; sustainability experts;

JRA; CoJ municipality; and the citizens of Johannesburg. In writing this document it was hoped that these actors could be sufficiently convinced that such a vision can one day become a reality.

7.2 Findings

The intention of this study was to answer the main research question:

- What role can the implementation of ecomobility, e-mobility and associated low-carbon related trends play in mitigating climate change, and how effective would this approach be?

The sub questions created focused on the potential for the ZCW-ITN to bring about transformation in OG and the sort of changes which would be possible. The transferability of the ZCW-ITN interventions, and the barriers that would potentially prevent implementation the ZCW-ITN interventions were also explored.

To test for the possibility of transformation from a fossil fuel transport system to a ZCW-ITN in OG, the following was considered: feasibility from a spatial transformation perspective; the potential for behavioural change necessary for implementing the transformation; as well as viability from a financial point of view. This was done in line with the work of BedZED who were identified having undertaken similar work to achieve transformation towards sustainability in 2002. The assessment potential for spatial transformation, aspects of technological retrofit and implementation was successfully tested in Orange Grove through a Utopian Model located in an imagined future set in 2050. The 2050 ZCW-ITN model was designed in such a way that the COF transit-oriented development plans already partially being implemented through the BRT by the CoJ became part of the ZCW-ITN transformation process as depicted in the ASI framework. In order to achieve this, the model was anchored in following primary aspects which directly address transport CO_2 emissions in Orange Grove:

- Compact city development — this initiative has been proposed by the CoJ to densify Orange Grove as described in the COF SDZ document (CoJ, 2017);
- BRT – this is currently under construction in Orange Grove as a CoJ initiative;
- Ecomobility – a bottom-up approach to setting a priority order for the individual choice of transport modes as well as for urban planning and investment. 1 - Walking. 2 - Cycling and wheeling. This was guided by complete street design. 3 – encouraged use of public transport modes;
- E-mobility - a general term for the development of electric-powered drivetrains designed to shift vehicle design away from the use of fossil fuels and carbon gas emissions; and

- Car-free streets – conversion of streets to predominantly rely on pedestrian movement.

The main aspect of ecomobility explored in the present study was the use of public transport, and non-motorized transport, namely walking and cycling. The investigation of transformation potential was guided by the process of complete street design; this involved understanding minimum widths of roads, cycle and pedestrian lanes. The process of exploring ecomobility itself assisted in achieving one of the fundamental aims of this report, namely is to introduce ZCW-ITN streetscape in Johannesburg. Safety of pedestrians and cyclists was another factor that was taken into consideration when the ZCW-ITN streetscape was being designed. A proposal that was considered was for speed limits to be reduced; however, this would require policy and regulations review and while this should still be considered, fell outside the scope of the present study. The second intervention suggested was the introduction of raised intersections as per the COF SDZ proposal. And third measure proposed was for physical separation which is the green barrier that was created between the NMT lanes and roadway.

E-mobility investigated in the present study focused on the use of electric vehicles and targeted two main transport modes, namely private vehicles and public transport. The micro electric vehicle was considered for private use in OG which has a maximum range of 80km, and seats up to 4 people. Supporting this consideration, is that the EV will become a more affordable option by 2050 for low- and middle-income earners due to falling prices of EVs. It will be important to ensure that new EVs replacing mini-bus taxis have a similar seating capacity to accommodate similar passenger numbers; this would help to ensure the financial feasibility for the owner should the transformation take place in current day settings. However, as public transport demand evolves by 2050, it would be recommended that vehicle sizes be adjusted accordingly. In identifying suitable EV replacement for diesel-powered Rea Vaya buses, is the 34-seater electric bus being used in Cape Town, which has a range of 250km. Charging facilities were proposed at the following locations in OG: homes; commercial districts or workplaces; and public spaces. A level 1 power source was allocated for residential locations, while levels 2 or 3 for workplace and commercial locations respectively. A Level 3 power source was allocated for charging points in public locations. Other notable requirements for EVSE must consider spatial and safety requirements, metering, universal design and directional signage.

It can be expected that the adoption EVs and greater use of public transport systems will impact on the ICE vehicle and fossil fuel industries which will affect existing policies and foreign investment. This will require further research and is beyond the scope of this report.

A clean renewable source of energy is crucial for powering the private and public sector EV. From a design and efficiency perspective, it would be beneficial to have all future roofs in OG to be constructed as flat roofs. This will allow for maximizing orientation of PV panels, since orientation of the panels for optimal insolation will not be dictated by pitched roofs facing in various directions. Flat roofs will also be safer for installation and maintenance of the PV panels. As the solar technology evolves it would also be important to consider façade solar panels which would further enhance power.

ICT will be imperative in providing information to the public and would include real-time arrivals and departures; travel fares; identification of congestion points and ensuring all public transport service providers maintain proper conduct and do not break the rules of the road. ICT will also play a crucial role in understanding CO_2 emissions and ensuring optimal decrease occurs.

Transferability tests carried out in Balfour Park demonstrated that the ZCW-ITN model is replicable in suburban areas that is going through TOD transformation when using the ASI principles established in OG. Tests in Orange Grove and Balfour Park revealed that more than 90% of all streets can be transformed for NMT and car-free streets. Other results in both study areas revealed that more than 90% of existing urban space has the potential to be transformed to install EV charging points. More than 95% of roofs in Orange Grove and Balfour Park were found to be suitable for adaptation for PV installation. Currently the CoJ has identified and planned the following corridors that will be undergoing TOD: Empire-Perth; Louis Botha Avenue; and Turffontein (CoJ and JDA, 2016). Even though the test to show transferability in BPP study area was successful, the transferability to CoJ neighbourhoods not going through TOD still needs to be tested, and the ZCW-ITN vision should be updated and refined in response to learnings from other urban settings.

Semi structured interviews highlighted attitudes towards climate change and the ZCW-ITN model. All respondents were aware of climate change, but most were unsure of appropriate adaptive or mitigative measures. A small number of respondents believed that climate change was not an issue due to unresolved public debates. Nearly all respondents felt that the ZCW-ITN model was a solution to climate change and transport issues experienced in the CoJ. During the process of developing the ZCW-ITN model and semi structured interviews, five fundamental barriers were identified: economic feasibility; design limitations; behavioural change; regulatory barriers; and management limitations.

Implementation of ecomobility, e-mobility and associated technologies require capital costs which posed to be a crucial economic barrier. For private residents, the main concern was affordability of EVs, solar PV installation, battery storage and charging facilities. Early adoption of these technologies will

guarantee monetary savings by the private and public sector where it is anticipated that once capital costs are settled for EVs and PVs, then transport and energy have almost zero cost implications. There will also be further savings when smart grids are implemented as a result of efficient use of energy. Proceeds from this can be used for further development of the ZCW-ITN vision.

A concern regarding PV panels however is understanding climatic conditions in Johannesburg, particularly during the summer months when there is a relatively high incidence of cloud cover. It is estimated that cloud cover is experienced at least one day per month (Sustainable Energy Africa, 2017). This can be addressed using battery storage but due to high costs batteries it might not be a favorable solution. An alternative solution to battery storage could be switching to low-carbon energy sources such as biogas or CNG. These two alternatives are not zero-carbon unfortunately, however biogas would be the better option due to it being renewable and contributes less to GHG emissions than CNG (Suleman, 2015).

Range anxiety is term commonly used for individuals who do not feel comfortable about owning an EV due to the lack of charging facilities. In order to deal with this in OG, charging stations were proposed at residential, workplace, commercial and public locations. It is anticipated though that by 2050 advances in battery technology will require less frequent charging and will supply power for longer distances before recharging is required.

Road reserves in Johannesburg will need to be investigated to understand what kind of ZCW-ITN streetscape interventions can be implemented. Where it is not possible to introduce ZCW-ITN streetscapes, then it is recommended that road reserve expansion should be considered.

Municipal officials expressed concern about the function of the roads being lost in OG if streets become car-free. However, the streets selected were screened to ensure that they were close to transport nodes and had zero or very limited traffic during the day. In order for individuals to consider living on a car-free street, they would need to feel comfortable with no longer depending on their car.

Unfortunately, the CoJ is still fragmented with respect to transport connections; public transport system is not where it should be in terms of functionality. It is anticipated that individuals will only start feeling comfortable being ‘carless’ when the city has been re-stitched through TOD.

Facilitating implementation of the vision and associated new technologies will require a policy and regulatory framework including appropriate incentives and disincentives. Having the adequate policy and regulation in place will allow for proper co-ordination and management by professionals, business owners, Orange Grove residents, and the municipality during the design, construction and operational

phases. Management during the operational phase will be assisted by use of ICT where monitoring and integration of public and private transport will be crucial.

Three different time frames were proposed when attempting to transform to a ZCW-ITN model: short-term (between 5 and 10 years) (CoJ, 2015), medium term (between 10 and 15 years) Bongardt et al., 2010) and long term (between 15 and 30 years); These time frames are proposed in order to align with other planning initiatives underway. It will also allow sufficient time for budgeting to be carried out and for the regulatory environment to be updated so as to be conducive for the transformation.

In the short-term residents can be encouraged to use:

- the BRT buses to be changed to electric with a solar power source;
- introduce feeder transport modes like electric tuk tuks;
- active transport modes such as walking. This will also bring about health benefits for commuters.

In the medium term, municipalities should be encouraged to install public charging facilities and residential and commercial owners can be encouraged to:

- purchase EVs, install solar panels, battery storage devices and charging stations;
- convert buses to EVs;
- convert mini bus taxis to EVs; and
- introduce car-share businesses.

In the long term it is proposed that there be:

- conversion of roads to include cycle and pedestrian lanes;
- permanent public charging facilities and bike hire kiosks to be installed within green barrier;
- compact city development;
- car-free street development;
- smart grids; and
- relevant ICT upgrades and installation.

Limitations to the study included the fact that assessments for the potential for required behavioural changes by residents in OG for low or zero-carbon emissions could not be determined. Limited time and resources meant that a broad survey of residents was beyond the scope of the study. This was owing to the length of time that was allocated for the completion of the report. However, the semi structure interviews had the following two aims: firstly, to assist in the scenario creation process; and secondly to

gain a broad understanding of barriers that would hinder the ZCW-ITN transformation. Fiscal measures normally implemented through policies and regulations for incentives and restrictions were also not included in the study since they fell beyond the study scope.

7.3 Recommendations for the ZCW-ITN

The ZCW-ITN vision would be a crucial step in countering climate change. Added to this, the ZCW-ITN vision would also become an important component of creating Eco-Cities being driven by organizations such as The World Bank. These will assist South Africa in achieving its targets for CO_2 emission reduction required according the UN NDC. South Africa is also required to start reducing CO_2 emissions from 2035 onward. Should the ZCW-ITN be implemented at national level, there would be social, environmental and economic benefits accruing across the country. At the local level, activities such as cycling, walking, making use of public transport and car-sharing would create greater social interaction amongst users. There would also be health benefits for those who choose active modes of transport. CO_2 emissions reductions would be a key environmental benefit contributing to global efforts at emission reduction. Introducing multiple modes of transport would reduce pressure for constructing of additional roads for passenger cars. The quality of life for many would also improve should the anticipated almost zero cost for transport come about. Quality of life would also be improved due to less time being spent in traffic and more time spent with families.

The potential to implement the ZCW-ITN in a suburban neighbourhood that is going through densification and TOD transformation within the CoJ is possible. However, in order for this to happen, the limitations of the ZCW-ITN model must be first addressed. To achieve this the following recommendations are proposed:

1) Awareness of the various benefits of the ZCW-ITN vision must be promoted, which should be aimed at residents; municipalities; and other professionals.
2) Incentives and policies need to be structured in such a way that they promote ZCW-ITN interventions, namely ecomobility, e-mobility and associated technologies.
3) Business models should be implemented that form new relationships between municipalities, business owners and residents creating an environment which enables implementation of sustainable technologies.
4) Regulations for buildings and roads should be re-examined. Revisions to regulations should aim at incentivizing the ZCW-ITN and encouraging a move away from ICE transportation.

5) Management systems should be developed that efficiently and accurately monitor ZCW-ITN interventions and CO_2 emissions.

7.3.1 Lessons for the implementation of the utopian model

If residents, stakeholders, municipalities or financial institutions are not aware of the effects of climate change, then this would compromise the implementation of the vision. This means that communities need to be adequately informed about the issue of climate change. Furthermore, in order for change to take place, coordinated community action and public participation will be a crucial step to the success of the vision. Participants will need to be involved in the process of change, which will need to include dissemination of relevant information, consultation with interested parties to get their feedback on the changes thus empowering individuals to decide on their futures (IAP2, 2006). It is also essential to grow collaborative relationships between different role-players and sectors.

7.4 Further research recommendations

In order to gain a better understand of the ZCW-ITN concept, the following area of research is recommended:

- Policy that would incentivize electric vehicle adoption in South Africa.

7.5 Contribution to knowledge

In this study the ZCW-ITN interventions potential in Orange Grove was able to contribute to the body of knowledge in the following ways:

- It is possible to transform the suburban neighborhood of Orange Grove into a ZCW-ITN;
- In order to implement a ZCW-ITN streetscape, adequate road reserve is essential on existing roads;
- Due to the reduced physical properties of electric vehicles, it is anticipated that future roads will become relatively narrower; and
- The ZCW-ITN model could be applied to other neighborhoods similar to the OG study area. Key similarities needed for replication of the model are stated in the ASI frameworks for the OG study area.

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List of Appendices

Appendix A

Table 9. 1: Street Interventions analysis for the OG study area

Road name	Ex. Road reserve as per google maps	Proposed SDZ road reserve widening	SDZ road classification	Street scape typology	ZCW-ITN Streetscape intervention
1st street / Hope Road	13 m	16m	4	1	TYPE 3
2nd street	12 m	16m	4a	4	TYPE 3
3rd street	12 m	16m	4a	3	TYPE 2
4th street	12 m			3	TYPE 4
5th street	12 m		4a	3	TYPE 4
6th street	12 m	16m	4a	3 & 4	TYPE 2 & 3
7th street	12 m	16m	4 & 4a	3	TYPE 2
8th street	13 m	20m	4	4	TYPE 3
9th street	12 m	20m	4	1 & 3	TYPE 1 & 3
10th street	12 m	20m	4	1, 3 &4	TYPE 1 & 3
11th street	12 m			3	TYPE 4
12th street	15 m	16m	4a	2	TYPE 2
13th street	12 m			2 & 3	TYPE 4
14th street	12 m			3	NONE
15th street	13 m	16m & 20m	4	2 & 3	TYPE 2
16th street	12 m			3	TYPE 4
17th street	13 m	16m	4	3	TYPE 2
1st avenue	14 m			2 & 3	TYPE 4
2nd avenue	12 m			3 & 4	NONE
3rd avenue	16 m			1 & 2	TYPE 2 & 3
4th avenue	12 m			2 & 3	NONE

5th avenue / Unity street	12 m	20 m	4a	3	TYPE 1
6th avenue	12 m	16 m	4a	3	TYPE 2
8th avenue	12 m	16 m	4a	2 & 3	TYPE 2
9th avenue	15 m	20 m	4	2 & 3	TYPE 1
Osborne Road	15 m	25 m	3	2	TYPE 1
Walter Street	12 m			3	TYPE 4
Castle Street	12 m	16 m	4a	3	TYPE 2
Forbes Street	12 m			3	TYPE 4
Grove Road	12 m			3	NONE
Davidson Street	12 m	16 m	4a	3	TYPE 2
Princess May street	12 m			3	NONE
Goodman Terrace	12 m	20 m	4	3	TYPE 1
Short Road	13 m	20 m	4	3	TYPE 1
Pine Road	17 m	20 m	4	3	TYPE 1
Louis Road (R25)	15 m	25 m	3	3	TYPE 1
Garden Road	15 m			2	TYPE 2
Oakland Road	15 m			2	TYPE 2
Dunotter Street	12 m	16 m	4a	3	TYPE 2
Hathorn Avenue (R25)	13 m			3	NONE
Pembroke Street	13 m			3	TYPE 4
Raglan street	12 m			3	TYPE 4
Roslin Street	12 m			3	TYPE 4
Louis Botha Avenue	22-25 m		3	5	TYPE 5

Appendix B

Table 9. 2: Itemized list ZCW-ITN interventions that would require capital costs

1. Ecomobility
1.1. Widening of road reserve (as per COF SDZ recommendations)
1.2. 1.5m wide cycle lane infrastructure (as per complete street design guidelines)
1.3. 1.5m wide pedestrian walkway infrastructure (as per complete street design guidelines)
1.4. Raised table intersections (as per COF SDZ recommendations)
1.5. 2.4m green barrier
1.5.1. New parking bays (as per COF SDZ recommendations)
1.5.2 Public EV charging stations infrastructure
1.5.3. Public transport pick-up and drop off zones
1.5.4. Municipal services – light fittings, metering devices
1.5.5. Landscape elements – greenery and street furniture
1.5.6. Bike Kiosks as per SDZ COF requirements and additional 3 as per ZCW-ITN
1.6. Optimization of road widths to suit EV design.
2. E-Mobility
2.1. Electric vehicle purchase: private owners; businesses; and public transport.
2.2. EV charging stations – workplace and commercial: Level 1 or 2 power supply
2.3. EV charging station – residential: Level 1 power supply
2.4. BRT EV charging – level 3 power supply
2.5. Conversion of existing garage to Car share business
2.5.1. Purchase of EV fleet
2.5.2. Charging facilities: Level 1 or 2 power supply
2.6. Public location charging facilities in green barrier
2.6.1. Level 3 power supply (DC fast charging)
2.6.2. Directional signage
2.7. Charging facilities for e-bike at bicycle kiosks. – level 1 power supply
3. Energy
3.1. Photovoltaic panel purchase and installation on new and existing roofs

3.1.2. Battery storage
3.1.3. Inverters
3.2. Natural gas implementation
3.3. Waste to energy infrastructure
3.4. Smart Grid implementation
3.4.1. Smart meters
3.4.2. Conversion of substations
4. ICT
4.1. Intelligent management systems – oversees all interventions
4.2. Intelligent monitoring systems – for ZCW-ITN optimization and CO_2 emissions
4.3. Intelligent integration systems – smart cards; provision of real time information for all transport modes

Appendix C

Table 9. 3: Street Interventions analysis for the BPP study area

Street name	Street Typology based on the OG study area	Ex. Road reserve as per google maps	Road classification	ZCW-ITN intervention based on the OG study area.
Argyle	2	18.654 m	5	1
Athol	5	25.255 m	3	5
Berkswell	3	15.33 m	5	2
Blyton/Aintree avenue	3	15,5 m	5	4
Burn	2	19.690 m	5	1
Campbell	3	18.7 m	5	1
Cheney	3	15.77 m	5	4
Corlett	5	21.020 m	3	NONE
Darwin	2	15.48 m	5	2
Douglas	2	17.440 m	5	1
Grenville	2	18.270 m	4	1
Hathaway	2	15.960 m	5	2
Helen Road	3	15.35 m	5	2
Howard Avenue	2	15.4 m	5	2
High / Hastings	2	16.265 m	4	2
Knox	2	17.935 m	5	1
Lapwood	2	15.505 m	5	2
Lennox	2	18.740 m	5	1
Louis Botha Avenue	5	28 m	2	5
Murray	2	18.360 m	5	4
Newick	2	15.325 m	4	2

Northview	5	18.525 m	3	NONE
Packwood	3	15.400 m	5	2
Portlock	3	15.840 m	5	2
Silwood	2	15.4 m	5	2
St Benedict	3	15.480 m	5	2
Waverly	3	19.625 m	4	1

Appendix D: List of interview questions for Respondents (Type A)

1. How were you involved in the Eco mobility festival in Sandton, 2015?
2. What is your stance on climate change?
3. Are there any case studies where transport systems have transformed to Eco mobility, subsequent to an Eco mobility festival, how was this transformation achieved? What were the limitations/challenges?
4. Was there any positive user behavioral changes that has been documented since the Sandton 2015 festival?
5. What do you think were limitations/challenges during the festivity? And is there anything that could have been done differently?
6. What are your thoughts on the current transport system in Johannesburg?
7. What do you think is preventing people from transforming to Eco mobility?
8. How would you introduce Eco mobility to sub-urban neighborhoods?
9. How will this relate to the larger transit networks?
10. What policies will you like to see being introduced to encourage Eco mobility?
11. What are the challenges /limitations of making an entire neighborhood cycle and pedestrian friendly?
12. Where do you see the transit systems in 10 years from now…and 30 years from now?
13. Where do you see electric vehicles fitting into an Eco mobility future?
14. Has the concept of car sharing been adopted in South Africa as yet? Where? Cost? Infrastructure?
15. Is a car free future possible? Can you explain how this will happen?

Appendix E: List of interview questions for Respondents (Type B)

1. What is your stance on climate change?
2. How have you been involved in promoting electric vehicles and renewable energy?
3. How are we monitoring CO2 emission for ICE vehicles?
4. Do you believe that electric vehicles are the future answer to fossil fuel scarcity and environmental problems?
5. Why haven't EV's not caught on yet?
6. What are the major issues of electric vehicles implementation in South Africa?
7. Where do we need electric vehicle charging infrastructure? What effort has been offered by government to incentives charging infrastructure? Can you think of a case study business model where this has been most successful?
8. Is there a reason why governments don't invest in charging stations?
9. Have you investigated electric sky trains in South Africa or internationally?
10. Where is the battery technology at with regards to electric vehicles?
11. Have we forecasted how many EV's we expect to see on the roads by 2030 / 2050 in SA?
12. What is the progress of E-mobility in other countries and which country has made the best progress?
13. What is the state of electric buses, and has this been introduced in South Africa yet?
14. How do you feel about car sharing electric vehicles? How will this change transport infrastructure?
15. When do you think the EV will be cheaper than an ICE vehicle?
16. Aside from the infrastructural costs required for Electric Vehicles charging point, are there any costs that needs to be considered during the lifecycle of an EV.
17. What is the range of an electric vehicle?
18. How narrow can one make an electric vehicle?
19. Where do you see the electric car in 2050?
20. Where do you see the ICE vehicle in 2050?

Appendix F: List of interview questions for Respondents (Type C)

1. What is the municipality's stance on climate change?
2. From a transport perspective, what is being done to fight climate change?
3. How are we monitoring CO2 emissions?
4. Are you involved with the Corridors of Freedom initiative (Orange Grove)? Do you think the current transportation system in Johannesburg works? Future OG?
5. Pursuing a fossil fuel transport system is making the same mistake that developed countries have already made, how is the COJ doing it differently?
6. What efforts are being made to improve this type transport system to decrease congestion; noise pollution, accidents, and making streets safer for NMT?
7. Has anything been done to promote a culture of NMT? What are the challenges?
8. With regards to the Ecomobility festival in 2015 in Sandton, what positive changes have come out of this? Is this being documented?
9. Is our current transport system socially and economically inclusive? Gautrain, metro trail brt private car etc.? What is being done to improve this?
10. Is the BRT working in Johannesburg? Have there been complaints? Road widths?
11. Has there been an effort to integrate different modes of transport so that there are no overlaps?
12. What kind of incentives could be introduced to reduce private car use and encourage public transport system?
13. Has the municipality investigated the advent of the electric vehicle at large scale in the future? What kind of policies will be introduced to support this?
14. Are you aware of what the EV sales been like in South Africa?
15. Have there been any business models developed for public charging stations?
16. Has there been any thoughts as to how we handle conversion of public transport to electric?
17. Has there been any thoughts with regards to these charging stations and its energy source with regards to renewable energy and smart grids?
18. Has the municipality investigated the advent of electric vehicle car sharing organizations?
19. Has the municipality investigated the advent of self-driving cars?
20. Almost on a daily basis we hear of technological advancements with transport like electric sky trains etc., does the municipality investigate this for adoption in Johannesburg?

Appendix G: List of interview questions for Respondents (Type D)

1. Is there any about the video that you would like me to explain before I start the interview?
2. Have you heard of climate change, and do you believe that it is a problem?
3. How do you travel to work, and how long does it take you to get there? Do you enjoy the trip? What would you change about it?
4. Do you mind planning daily trips to work if it saves you money?
5. What are your concerns when you or your family are travelling in Orange Grove?
6. How do your children go to school? Would you allow your children to walk or cycle to school?
7. Will you allow your children to play outside out of your property?
8. Do you own a car, and are you be willing to get rid of it to use the public transport only?
9. Will you walk to a bus stop or to the shop from your house?
10. How far are you willing to walk from your house to a public transition point or the shop to buy bread / milk?
11. Do you cycle? Will you cycle in Orange Grove?
12. What are your thoughts regarding the electric vehicle?
13. What do you know about PV? Will you invest in them?
14. How do you feel if cars were not allowed on certain streets on a permanent basis, similar to the Grant avenue concept?
15. If you could find everything you want just down the road in the form of small businesses or informal traders, will you still go to the mall?
16. A car share vehicle is where you pay to hire it for a short period of time without actually owning a vehicle, do you think your lifestyle allows you to do this?
17. Would you get involved in a community urban farming group in Orange Grove?
18. What kind of work do you do? Given the type of job, will you be able to work from home?
19. What mode of transport do you use when making long distance trips? What would you change about that?
20. What would you change or add to this conceptual model?

Appendix H: List of Interview questions for Respondents (Type E)

1. How have you been involved with the Corridors of Freedom?
2. What is your stance on climate change?
3. What are our current land use and transport issues?
4. In terms of the vision in Louis Botha Avenue, how far are we? Challenges?
5. What kind of investments are expected to be made in order for the Orange grove to go from its current state to the envisioned state in 2040 with regards to BRT and NMT?
6. What kind of interest has been shown by private developers? What kind of partnerships are looking to be made?
7. In terms of movement transformation, increased density will increase transport use, what has been done to accommodate this increase in order to respond to congestion, noise and air pollution and road accidents?
8. Has a sky train ever been considered to alleviate congestion?
9. What has been done to make public transport efficient and user friendly?
10. What are challenges and implications of making the entire neighbourhood of Orange Grove cycle and pedestrian friendly?
11. Will buses and cars still be dependent on petrol and diesel in 2040?
12. What efforts have been made to reduce carbon emissions and ensure that it is in line with 2015 Paris climate agreement?
13. Has the corridors of freedom intervention factored in the advent of electric vehicles?
14. Do you think the electric vehicle will be a concern by 2040? Infrastructure? Charging facilities?
15. In terms of social and economic transformation what is the COF vision?
16. Has the COF considered car free commercial streets? From a town planning perspective what are we basically looking to expect?
17. In terms of economic transformation, has there any thought been given to energy security in the COF? Smart grids / solar?
18. In terms of economic transformation, has the COF considered the informal trader?
19. In the event that interventions like the COF take longer to get going, how will the city manage urban population growth? How will transport be re-imagined coping with this?