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Renewable Energy Transitions in Cape Town

Opportunities for Cape Town to Become a Pioneer City for Renewable Energy Transitions in South Africa

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Dedicated to my parents, for their continuous support in every way

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LIST OF ABBREVIATIONS

ANC *– African National Congress*

BoP *- Balance of Payment*

CDM *– Clean Development Mechanism*

CSP *– Concentrated Solar Power*

DA *– Democratic Alliance*

EMNE*- Emerging Markets Multinational Enterprises*

FBE *– Free Basic Electricity*

FIT *– Feed In Tariff*

GDP *- Gross Domestic Product*

IMEP *- Integrated Metropolitan Environmental Policy*

IPP *– Independent Power Producer*

IRENA *- International Renewable Energy Agency*

IRT *- Integrated Rapid Transit*

LTMS *– Long Term Mitigation Scenario*

MW *- Megawatt*

NERSA *- National Energy Regulator of South Africa*

NGO *– Non-Governmental Organisation*

PCP *- Power Conservation Program*

PPA *– Power Purchase Agreement*

PV *- Photovoltaic*

RDP *– Reconstruction and Development Program*

REFITs *- Renewable Energy Feed in Tariffs*

REIPPPP *- Renewable Energy Independent Power Producer Procurement Program*

SANEDI *- South African National Energy Development Institute*

SDG *– Sustainable Development Goal*

SOE *– State Owned Enterprise*

UNFCCC *– United Nations Framework Convention on Climate Change*

USD *– United States Dollar*

WEC *– World Energy Council*

YES *- Youth Environmental Schools Program*

INTRODUCTION

Just as fossil fuels sculpted the geopolitical map, the new positioning of renewable energy technology has initiated a global energy transformation which is affecting the geopolitical positioning of countries. The geographical location of fossil fuel reserves has had a profound influence on wealth distribution across nations, whereby countries with rich coal reserves maintained the majority of energy related political power and leverage.[1] New renewable energy trends pose a unique opportunity for countries (developing and developed) to reposition themselves on the geopolitical map and increase their energy independence. Whereas coal reserves are typically abundant in specific locations and regions whilst completely devoid in others, renewable energy is available in abundance in many more locations. Variable renewable sources such as solar and wind power are available almost everywhere, however, are dependent on weather conditions and the time of day. The main renewable energy sources include solar power, biogas, geothermal, hydropower and ocean swell power, and are all found in abundance in the Southern African region.[2]

Our planet is facing dramatic environmental and climate challenges, with global temperatures reaching unrivalled highs and increasing with time. Although we have been aware of these changes for some time, it was not until the *Paris Climate Change Agreement* in 2015 where close to every developed and developing country committed to decreasing their effects on

[1] Irena, 2019, p.15.
[2] Ibid., p.15.

global warming in the most widely accepted globally binding climate agreement to date.

Over the past century, human consumption, including deforestation and land clearing, agricultural activities, industrial expansion and other anthropogenic activities, have dramatically increased the burning of various fossil fuels. These fuels include coal and oil, which play a major role in increasing the concentration of carbon dioxide (Co2) in the global atmosphere.[3] Although carbon dioxide is released through both natural processes as well as man-made activities, this anthropogenic activity has increased the carbon dioxide concentration from 280 parts per million to over 400 parts per million in the short 150 years since the dawn of the industrial revolution.[4] The effects that these gasses have on the environment have been heavily researched. The main consequence shows how such emissions are quickly increasing the atmospheric temperature of the global greenhouse, creating a butterfly effect of change which is difficult to measure. Simply put, increased temperatures inevitably lead to increased evaporation of water, precipitation and decreased ocean acidification, which in response is responsible for melting glaciers and sea ice and increasing ocean levels. Such effects have influenced natural disasters such as floods and famines, extreme weather conditions and even the extinction of certain fauna and flora biodiversity.

The *United Nations Framework Convention on Climate Change (UNFCCC)* at the *2015 Paris Climate Change Conference* brought immense attention to issues relating to carbon emissions in the modern world. The conference

[3] NASA, 2019.
[4] Ibid., 2019.

fostered the creation of a global agreement regarding the reduction of global atmospheric temperatures. At present, 196 member states, who collectively represent over 87% of global greenhouse gas emissions, are in the process of adopting different measures to ensure that the global warming temperature is limited to well below 2 degrees Celsius compared to pre-industrial revolution levels by the year 2030. Anything above this will increase damage to the global ecosystem and increase the risk of sudden large-scale climate disasters, exposing particularly the developing world to water stress, hunger, biodiversity loss and extreme weather events. This is the first time in history that a universally binding agreement on climate change has been reached between all seven continental areas. The agreement has been structured in a bottom up manner, contrary to other environmental treaties such as the *Kyoto Protocol*, which includes the force of the law, allows for specific nations to determine their own national targets and mechanisms for change, guided by 17 general *Sustainable Development Goals (SDGs).* The hope is to encourage political climate change action rather than legally forcing it upon the signatories by law.[5]

This thesis will center around the importance of energy security and sustainability within Cape Town, South Africa. *SDG* number 7 emphasises the importance of providing clean and affordable energy to everyone worldwide:

"At the current time, there are approximately 3 billion people who lack access to clean-cooking solutions and are exposed to dangerous levels of air

[5] UNFCCC, 2018.

pollution. Additionally, slightly less than 1 billion people are functioning without electricity and 50% of them are found in Sub-Saharan Africa alone." [6]

Energy is the most influential contributor to climate change, contributing about 60% to global greenhouse gas emissions worldwide. The transition to renewable energy has so far been relatively slow in Sub-Saharan Africa. This can be attributed to various factors including the management of different political, social and environmental situations within the area. This thesis will focus on the effect that geopolitical, environmental and geographical, political, socio-economic and social factors have on energy transitions within Cape Town, showcasing how the city has the potential to become a pioneer city for Sub-Saharan Africa and the rest of the continent to look up to regarding its transition towards renewable forms of energy.

Cape Town was chosen as the focal city for this research for three reasons. Firstly, due to the fact that this is the home town of the author, secondly, in light of the recent Eskom energy crisis which is causing much dismay within the city, and finally, due to the fact that although South Africa is labeled as a developing, non-annex one country by the UNFCCC, many parts of the city are in fact highly developed, industrialised and clearly contributing to global warming equally, if not more, than many developed countries. In 2005, South Africa was responsible for 1.1% of the total global emissions and 40% of emissions in Sub-Saharan Africa.[7] The country's average contribution is almost double what industrialised country's contribute at present, with

[6] UN.org, 2019.
[7] Pegels, 2009.

carbon dioxide (mainly from the energy sector) constituting the largest portion of total greenhouse gas emissions at around 80%. [8]

The scope of the research focuses on the effect that the various socio-political situations within Cape Town have on the city's transition towards renewable energy. This thesis is geared towards provoking thought on specific opportunities for management which could reduce social exclusion and increase energy equity, energy security and environmental sustainability in the transition towards renewable energy in South Africa. Social planning and efficient management is identified as the grounding element which needs to be well understood before the country finds a renewable energy supply opportunity for areas where social inclusion is limited. The research will demonstrate how renewable energy can offer a sustainable security solution to citizens within Cape Town, focusing on socially disadvantaged communities who do not have access to enough electricity supply from Eskom. The limits of the research paper include the limited quantitative analysis of data. Although statistical data has been used to supplement the World Economic Council (WEC) Trilemma Index, the paper has focused solely on qualitative research and has omitted quantitative data. Through focusing on the improvement of energy equity, energy security and environmental sustainability within Cape Town, one reaches a conclusion which portrays the city as an ideal example for a developing city as a renewable energy pioneer.

[8] Pegels, 2009.

LITERATURE REVIEW

'Social Planning in Energy Transitions' Miller & Richter - 2014

Social planning in energy transition is defined as the required research and knowledge of various social outcomes, dynamics and ramifications that may accompany energy transitions and policies. Social planning includes developing and supervising certain strategies that allow us to include societal thought into energy policy and planning when designing new energy systems.[9] In the modern world, societal considerations regarding energy transitions are mainly economic, centering around pricing and societal job access. It is essential to understand how these social and technological elements in energy transition are highly integrated.

The social dimensions of energy transitions in Cape Town are expanding as the city moves away from traditional coal burning towards renewable energy. First, social planning requires research and documentation on what effects energy transitions have on social systems and vice versa. Once this information is understood and correctly interpreted, new strategies need to be developed to ensure societal success in the new transition towards renewable energy. Creating useful and meaningful partnerships within different public spheres, societal groups and the energy sector is important to help encourage dialogue and decision making in energy transition. Finally, it is important to have effective management and governing institutions in place to manage such transition processes within the separate social systems.[10]

[9] Miller & Richter, 2014. p.77.
[10] Ibid., p.78.

Energy technologies such as electricity, heating and transportation are interlaced with a diverse range of social and political phenomena. These include regulatory frameworks, urban planning, social movements and gender politics. In a world where energy systems are in fact socio-energy systems, it is clear that energy transitions can have a knock-on effect on social affairs in terms of skill requirements and job replacements. Energy transitions have the power to restructure social, environmental, economic, political and geopolitical landscapes of a region, both positively and negatively.[11]

Miller and Richter talk about four characteristics of social change that frequently accompany energy transitions. These elements include movements surrounding redistribution, reorganisation, reauthorisation and reimagination.

Firstly, the redistribution of both wealth and financial risk across communities are common outcomes of energy transitions, influencing an increase in societal risks across communities. Secondly, reorganisation refers to the social and environmental structural changes that are caused by the above-mentioned redistribution. Thirdly, reauthorisation shows how political power and energy transitions are inextricably intertwined. Energy transitions have the power to influence social mobilisation, political struggles and resistance over new forms of energy.[12] Finally, reimagination refers to the way in which societies imagine their communities in the future, including the changes in technological and energy usage. Reimagination of communities usually

[11] Miller & Richter, 2014. p.78.
[12] Ibid., p.79.

occurs during large scale transitions, where possible local or regional livelihoods are changed for the better or for the worse.

It is essential to develop certain strategies for understanding such socio-energy relations, as well as governance strategies to manage the unique challenges posed by these changes. Documenting, researching and mapping existing socio-energy relationships is necessary to pave the way for further research. This information should include research into the way that people live, work and play, where this occurs and when. This can help one to identify different methods of management for the individual and for society as a whole. Insight into the communities that surround a new project is useful in identifying and managing potential resistance that may arise from the community regarding the transition.[13]

Envisioning socio-energy futures is essential for social planning for energy transitions. Possible implications of future energy changes, as well as different mixes of energy sources are necessary for achieving diversified societal values throughout an energy transition. In addition to this, designing energy systems for a just socio-energy transition is essential to a avoid following past mistakes. By designing and using just socio-energy transitions, we are able to incorporate human wellbeing, equity and energy security into new energy systems and transitions. Various concerns about socio-energy justice include the manner in which risks, benefits and costs are distributed across a community and what this means for minority social groups in the region. This also includes the idea that the relationship of power between those who

[13] Miller & Richter, 2014. p.80.

implement the energy changes and those who inhabit the areas in question needs to be supervised and fair.[14]

Social planning for energy transitions requires building socio-energy partnerships. This refers to the introduction of new forms of governance that involve the public society in the decision-making process through increased participation and deliberation processes. Social considerations are better understood when there is a meaningful collaboration between the energy sector implementing the change and the public who will inevitably feel the effects of such a change. This sort of citizen engagement, like any modern democracy, makes it possible for the energy industry to involve minority populations who may otherwise be marginalised in society.

Governing socio-energy transitions is the final step to help manage tradeoffs between different societal groupings through increasing trust in the transition, by addressing social confusions common to energy transitions. Finally, such governance is necessary to organise and effectively manage across different levels of governance as well as communicating different goals across these societal levels.[15]

Most renewable projects require a reorganisation and integration of these complex factors, as acceptance and participation at local and national levels are essential for successful energy transitions. In the case of Cape Town, this is made more interesting by various past and present social, cultural and racial inequalities as well as the interesting relationships between past

[14] Miller & Richter, 2014. p.81.
[15] Ibid., p.81.

colonial powers and local populations. Every form of energy transition and production today is contingent on social or political contestation.[16] It is therefore essential that modern energy policy and renewable transition planning encompasses a new scope for assessing, managing and governing such social dimensions.

[16] Miller & Richter, 2014. p.81.

CHAPTER 1

1. The Current Position of Cape Town's Energy Sector

1.1. Overview of Cape Town's Energy Sector

In order to understand Cape Town's energy sector clearly, it is necessary to understand the socio-political situation of South Africa as a whole. One immediately encounters a multilayered energy sector in the country, which should be seen as a crucial dimension for the policy analysis in Cape Town. In this sense it is necessary to understand the distinction between Cape Town and South Africa in the study. Although the focus is on the city of Cape Town in particular, we need to understand that the structure of the energy sector is not local to the city and is in fact highly influenced by the socio-political state of the country. The layers of the energy sector include regional and national layers, accounting for energy resources, infrastructure and government. In addition to this, regulations, and institutions function at a national level. In building new local energy policies, one will need to consider both local and national data availability.

Since South Africa's first democratic elections held in 1994, the country has experienced massive shifts in both social and governmental policy. The new government quickly emphasised the importance of tackling various environmental issues, such as access to affordable and clean energy, as well as increasing sustainable development efforts across urban and rural sectors.[17] At this time, South Africa's development aims were ambitious for a

[17] Mwakasonda, 2004. p.41.

new government facing inevitable economic and infrastructural challenges from its troubled past. These aims included increasing racial equality, poverty alleviation, job creation and fostering economic prosperity whilst simultaneously decreasing negative environmental impacts. Simply put, increasing economic prosperity whilst minimising environmental consequences was a difficult task for a new government emerging from a period of racial segregation and social inequality.

Since before the apartheid era, South Africa's energy market has been characterised by excessive burning of poor-quality coal, which has proven to release high intensity carbon emissions into the global greenhouse.[18] These high emission rates contrast the Sub-Saharan African regions emission rates which are relatively low in comparison to developed parts of the globe. However, South Africa continues to release similar amounts of carbon emission as fully developed countries. This will be explored further in chapter two.

The *1998 South African White Paper* document laid out a modernised renewable energy policy which provided energy services according to racial status. The main aims of this document were to increase citizen access to affordable energy as well as to improve energy governance through increased transparency, broad membership and accountability amongst members. Other objectives included increasing economic development by introducing and encouraging energy market competition, managing environmental and health effects of energy use and ensuring adequate supply of energy through increasing opportunities for energy trade across

[18] Mwakasonda, 2004. p.41.

the Southern African region. [19]These policies have since influenced the creation of various programs and targets which have influenced increased supply and access to energy services within the country.

The implementation of renewable energy programs was included at this stage, and the government allocated national resources towards the production of renewable technologies and power plants. Public resources such as monetary incentives for new renewable based jobs, and the creation of a new investment climate was directed towards the renewable energy sector.[20] Regarding legal instruments, the *White Paper* document mentioned the development of a legal and regulatory framework for pricing and taxation, which could be used to support the transition towards renewable energy through the incorporation of independent power producers (IPPs). Education and awareness-raising was added as a way to increase capacity building, communication and interaction throughout South African society. This was included to promote an increased flow of knowledge of renewable energy and the benefits it would have on the economic, social, environmental and trade sectors of the country and region.[21]

Currently, South Africa's total domestic electricity generation capacity is 51309 MW, including coal, oil and renewable sectors. Roughly 91.2% (46776 MW) is generated by coal powered stations whilst only 8.8% (4533 MW) is generated from renewable sources. Within the renewable sector hydroelectric power accounts for 661 MW whilst all other renewables, including solar, biogas and wind account for only 3872 MW. With a

[19] Mwakasonda, 2004. p.42.
[20] Ibid.,
[21] Ibid.,

population of 54.8 million people, the current connection access rate in South Africa is 86%, with 93% access in urban sectors and only 66% in rural sectors. 2.2 million households do not have access to power.[22]

The *World Energy Council (WEC)* has created a *Trilemma* index tool for the purpose of measuring and ranking countries based on their ability to provide clean and sustainable energy to their citizens.[23] The *Trilemma* ranks countries according to three main dimensions; energy security, energy equity and environmental sustainability. The use of this framework allows one the opportunity to analyse the principles of a specific energy system in its current form and compare it with other developing and developed countries worldwide. The index focuses on the performance of these three core dimensions by looking at the relationship and links between the public sector, private sector and governmental regulatory sector, regarding various economic and social factors, natural and national resources, environmental concerns and social behaviors.[24]

The *World Energy Council* gives a general overview of the current energy situation within the Sub-Saharan African region and then moves more specifically into the South African country profile. Within Sub-Saharan Africa, the *Trilemma* emphasises continuous energy related challenges for the 46 countries with a population reaching almost one billion people. The most common challenges experienced within this area are inefficiencies in energy stock, as well as failing electrical infrastructure and a resulting decreasing

[22] Power Africa, 2018.
[23] World Energy Council Trilemma, 2018.
[24] Ibid.,

quality of energy supply failing to meet a growing energy demand.[25] The *World Energy Council* states that to unbundle the regions energy potential and ensure further energy security, equity and environmental sustainability, strong collaboration and joint efforts are required to attract domestic and international investment. This should be done by improving energy policies and local energy governance, increasing institutional capacity building and making on-grid and off-grid energy supply more reliable. By diversifying and decentralising the renewable energy market, one increases cross border infrastructure and therefore the flow of regional resources.[26] According to the *Trilemma*, South Africa currently ranks at 85 with a score of B for energy security, C for energy equity and D for environmental sustainability (BCD). Whilst the country has seen a stable increase in its scores over the past few years, South Africa has dropped three places from 2017 to 2018 due to relative improvements of other nations.[27]

It should be emphasised that although each dimension is as important as the next, and that there is no priority amongst them, each dimension plays out in very different ways and in different moments in time amongst different regions. We will be using this *Trilemma* framework to analyse the current energy sector position in Cape Town.

[25] World Energy Council Trilemma, 2018.
[26] Ibid.,
[27] Ibid.,

TRILEMMA INDEX RANKINGS AND BALANCE SCORE

RANK

85

SCORE

BCD

	2016	2017	2018	Trend	Score
Overall rank and balance score	**84**	**82**	**85**	▶	**BCD**
Energy performance					
Energy security	66	47	37	▶	B
Energy equity	82	87	85	▶	C
Environmental sustainability	105	109	118	▶	D
Contextual performance	47	46	48	▶	

i. South Africa Trilemma Score 2018. Available at: https://www.worldenergy.org/data/trilemma-index/country/south-africa/

1.1.1. Energy Security

Energy security is the biggest concern for the city of Cape Town. The ongoing energy crisis and its resulting rollout of blackouts and load shedding has sent shockwaves throughout the economic and social stability of the city. It is estimated that the power outages in 2008 cost the country about 280 million USD in economic impact.[28] Whilst according to the *Trilemma* index, the country's energy security trends have gradually improved due to new recent improvements and investments in the renewable energy market, various complications exist which lower this grade.[29] Eskom, South Africa's sole electrical public utility, was first established in 1922 by the government and plays the role of South Africa's representative in the global power pool. As a state-owned enterprise, Eskom manages and controls 95% of all electricity across the country and a further 45% within Africa in 2010.[30] Although the company does not have exclusive energy production rights, economic

[28] Pegels, 2009.
[29] World Energy Council Trilemma, 2018.
[30] Ward & Walsh, 2010. p.4.

circumstances and history have created a scenario in which Eskom has a monopoly on energy production in the country.

As most electricity is produced and controlled solely by Eskom in the north of South Africa, Cape Town receives its share of power through extensive transmission lines, spanning up to 1600km across the country. These electrical lines require massive maintenance costs and highly specialised technical work. With a struggling economic sector and an increasing population and energy demands, such resources are hard to come by, and have resulted in Cape Town experiencing long periods of load shedding over the past 10 years. Such load shedding has a massive impact on the social and economic sector of the city and will be discussed further in chapter two. With ageing infrastructure and inefficient management, the electricity provider has been unable to supply and accommodate the demands of its customers.[31]

As a response to these threats of energy security, Eskom has responded by increasing tariffs and building two new coal power plants, namely '*Medupi*' and '*Kusile*'.[32] Research shows how these power plants cost three times their original budget, were inadequately designed, and are as a result performing up to only 40% of their expected performance. *Medupi* alone produces 32 million tons of carbon dioxide emissions every year.[33] The construction of such powerplants at a time when the country should be focused on transitioning towards renewable forms of energy is a debate in itself. Eskom's argument for building these power plants included proof that the plants would increase energy security for citizens as well as provide more jobs to

[31] Ward & Walsh, 2010. p.4.
[32] Deign, 2009.
[33] McNulty, 2019.

local communities. However, in reality, payment failure and project debt has caused a large increase in state tax and failure to pay employee salaries.[34]

The *2018 South African National Budget Speech* announced that due to financial complications, Eskom would remain state owned enterprise (SOE), yet be split into three separate sectors, namely 'generation', 'distribution' and 'transmission'. This decision came as a response to the entity facing an enormous debt of 31 billion USD and was reached in an attempt to separate responsibility and allow for more efficient management for each sector. The separation will also allow for independent power producers (IPPs) more autonomy within the field with which they sell their renewable energy supplies. Regardless, with inadequate infrastructure, corrupt management and aging coal reserves, it is difficult to foresee whether Eskom's new business design will help the state utility get back on its feet.[35]

In addition to the new coal power plants, plans to increase nuclear power production have been initiated by Eskom. The idea behind this is to increase the energy provision mix in an attempt to stabilise energy security levels as well as boost economic and technological development.[36] However, concerns from the private sector with knowledge of nuclear unpredictability are warning against these projects. South Africa's energy mix includes the use of oil, which is mainly imported from the Middle East and North Africa. This dependence on importing fuel used mainly for petroleum to fulfil transport

[34] McNulty, 2019.
[35] Deign, 2009.
[36] Ward & Walsh, 2010. p.4.

requirements, makes the country susceptible to global market shocks and economic fluctuations.[37]

Another conflict of interest is that although South Africa's economy is highly energy intensive, indicative of the mining sector in the central and northern parts of the country, the economy in Cape Town is far less energy intensive and uses only 5% of South Africa's total energy in daily operations.[38] Due to the fact that at present, the city of Cape Town produces very little of its own energy, the majority of this energy is purchased from Eskom, reinforcing the notion that Cape Town is heavily dependent on electrical supply and national production at state level.

It is clear that there has been a vast failure of security of supply for energy in Cape Town, as a result of poor planning, inefficient management and limited resources. The effects this has had on the political, social and environmental spheres of the city are numerous, with present failures influencing new business models and ways of living country wide.

1.1.2. Energy Equity

With this knowledge of security of supply failure, the inequality of energy equity can be set in an entirely different light. Cape Town has the opportunity to localise its infrastructure for renewable energy and increase the level of service it provides, making it available in areas where it is currently not.

[37] Ward & Walsh, 2010. p.5.
[38] Ibid., p.6.

Energy equity refers to the equal distribution of both the positive and negative outcomes from energy production and consumption. South Africa's energy equity statistics have changed drastically since the dawn of democracy, where in 1994 only 37% of households had access to the national electrical grid, by 2018 this number had increased to 91%. It is important to understand that energy equity is not simply defined by grid accessibility. Energy equity is measured by how much a household spends on electricity in relation to their income. Using this measurement, families who spend over 10% of their household income on energy are considered 'energy poor', as this is the threshold percentage whereby families make tradeoffs between their energy demands and other essential living needs.[39] Households who reside in informal settlements across the greater Cape Town region typically spend about 27% of their total monthly income on electricity, whereby the wealthy spend only 6% of their monthly income on this expense.[40]

Currently, previous political instability including institutional racism and social inequalities introduced by colonialism and the apartheid regime, have left a long-lasting scar on South Africa's energy equity. During these periods, politics, economics, natural resources, labour and the energy market were under full control of white colonial minorities. In light of this the country faces increasing energy poverty, which refers to the inadequate availability of electricity for cooking, heating and lighting for certain socially disadvantaged households and communities.[41] South Africa's historical apartheid regime increased inequality between races both during and after the first democratic elections, with a legacy of unequal social constructs remaining years after the

[39] Joubert, 2016.
[40] Ibid.,
[41] Ryan, 2016.

abolition of institutionalised racism. This inequity, along with a lack of reliable energy security on Eskom's behalf, has created consequential inequalities in wealth, and in response, has created difficult energy availability circumstances.

In terms of Eskom's performance and electrical grid access, informal settlements and townships typically receive the least distribution of electrical supply. This is partly because of a lack of payment and taxes coming from this area, as houses are often temporary and built without internal wiring and partly because these areas use much less energy as the citizens own less energy intensive technologies.[42] This is a cycle of injustice in itself, as the lack of supply in these areas decreases living standards further. Informal settlements, which are make shift dwellings not approved by a local authority, comprised of many small houses made from scrap metal in close proximity to one another, are known to have poor air circulation and are thermally inefficient due to inferior building materials, lack of insulation and size. Low cost building materials, together with burning paraffin and wood for heating and cooking create a deadly combination.

Energy poverty stems from a geographical network of infrastructure which is unequally distributed, whereby energy resources bypass specific social groups. The most obvious example of this is the difference in energy distribution between privileged suburbs and underprivileged and overpopulated informal settlements. Due to the low availability of energy in these areas, citizens are forced to use alternative energy sources such as paraffin and wood burning to produce heat and cook. In other cases, citizens

[42] Ryan, 2016.

in these areas are often forced to siphon electricity supply through illegal connections. Such alternatives have massive environmental and health consequences on these communities.[43] Paraffin is highly prone to explosions, is highly flammable and is composed of chemical components that cause negative environmental and health effects. Today, 43% of the South African population is considered 'energy poor', with around 2 million households lacking access to basic electricity.[44] Various projects have been put into place to decrease this inequity, however, there has been strong evidence that these projects have not been making the change that they intend to. This will be discussed at a later stage in chapter three.

The effects of climate change, including the increasing risks for both natural and social systems are unequally distributed, with impoverished groups and communities feeling the effects the most.[45] An absence of communication between the Eskom state utility, employees and workers unions has fostered an undemocratic system whereby workers are not properly informed about the changing forms of Eskom's coal mines and power plants, all of which impact their job security and livelihoods.[46]

Workers unions such as *Numsa* have been fighting for a clean transition towards renewable energy, and a socially owned national energy grid since 2011. However, their argument has been tainted due to the fact that coal workers are portrayed as being against transitions, prioritising protecting their jobs. Workers unions define a socially owned energy sector as a way in

[43] Ryan, 2016.
[44] Ibid.,
[45] McNulty, 2019.
[46] Ibid.,

which the city can resist multinational corporations who control and distribute the country's energy. It is clear that a change in management as well as the formation of a nationally integrated energy policy could assist in achieving energy equity across the country.[47] High quality engagement between government stakeholders and the public and private sector is necessary to enforce educational programs about energy usage and opportunities to reduce energy poverty.[48]

1.1.3. Environmental Sustainability

Environmental sustainability remains South Africa's lowest grade point in the *Trilemma* Index. This is due to the fact that the country is still heavily reliant on poor quality coal reserves for energy production. Whilst renewable energy contributions are increasing, this sector still occupies less than 10% of the total energy market, and coal powered energy is expected to remain dominant even as renewable transitions speed up.[49] Whilst the country looks to find ways in which it can diversify its energy sources, and reduce its heavy dependence on coal powered energy, interim measures may need to be employed to allow the country to meet its commitments to the *2015 Paris Agreement* and the Sustainable Development Goals. Natural gas seems to be a good alternative to coal, but as South Africa does not have much natural gas reserves within its boundaries, the country will need to consider importing such reserves from regional neighbors in Sub-Saharan Africa as well as using nuclear power as another alternative to coal.[50]

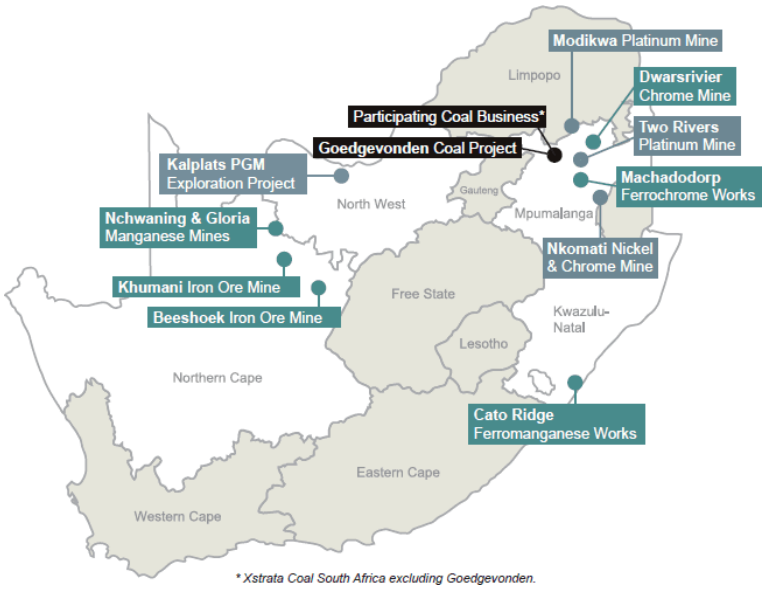
[47] McNulty, 2019.
[48] Joubert, 2016.
[49] World Energy Council Trilemma, 2018.
[50] Ibid.,

Coal power plants pose an obvious environmental threat for South Africa, impacting air quality as well as water and land pollution. Conveniently for Cape Town, the majority of the country's coal reserves, mines and power stations are situated in the north of the province, in the Northern Cape, Mpumalanga and Kwazulu Natal provinces. This is shown in more detail on a map below. A 2018 report by Alfreds, found that the province of Mpumalanga has the worst air quality in South Africa and is one of the worst contributors to nitrogen dioxide (No2) in the world.[51] These areas suffer from more air pollution due to their close proximity to coal plants as well as coal waste deposit sites. This research confirms that the country is home to the most polluting coal-fired power fleet in the world. The environmental effects have large social impacts. The *World Health Organisation* (WHO) calculated that outdoor air pollution is responsible for 4.2 million premature deaths per year, whilst air pollution in general accounts for 7.6% of the country's total death count. Although these coal belts lie out of the public eye, Cape Town should not ignore these statistics and the disastrous impacts that coal power has on the environment as well as human health.[52]

In addition to Cape Town's fortunate geographical positioning, the city experiences a forceful wind which blows from the South East, allowing for any air pollution to be dispersed away from the city. The most immediate environmental threat for the citizens of Cape Town are the emissions released from the burning of oil and kerosene by local populations to heat homes and cook food. This will be discussed further in chapter three. Regarding nuclear power, the unclear and unpredictable nature of this source of energy, due to

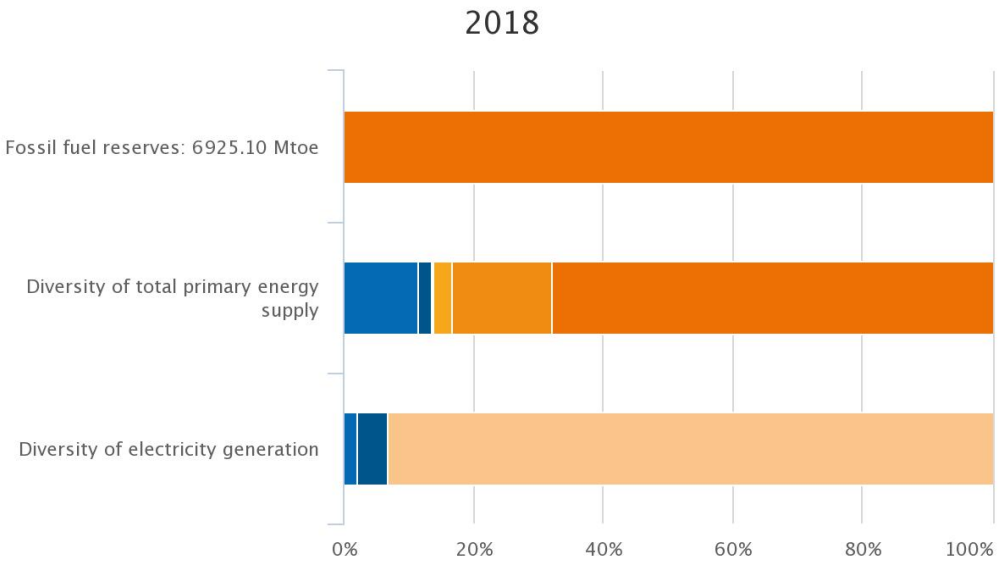
[51] Alfreds, 2018.
[52] Ibid.,

the newness of such technologies and lack of understanding of how to act in case of a nuclear disaster make this source of energy one that lacks security as well as environmental sustainability. Whilst such air pollution issues are mild in Cape Town, there is cause for concern as plans for coal and nuclear power plants increase across the country.



ii. South Africa Coal and Metal Mines Map. Available at: https://www.arm.co.za/b/sa_africa.php

With a low energy generation diversity and a supply composition dominated by coal power, South Africa continues to lack environmental sustainability within its energy sector, and it is unclear at what stage the country may begin to rely less on coal and more on renewable energy sources. Linking the issues related to energy security and environmental sustainability allows one to clearly distinguish the dilemma that Cape Town faces; the city needs to increase its supply and coverage of electricity access whilst taking into consideration Eskom's internal deficiencies.



iii. South Africa Energy Distribution Graph 2018. Available at: https://www.worldenergy.org/data/trilemma-index/country/south-africa/

1.2. South Africa's Commitments to the 2015 *Paris Climate Change Agreement* and *Sustainable Development Goals*

The Cape Town municipality has made many commitments in supporting international climate change reduction efforts since the origination of the *UNFCCC*, its *Kyoto Protocol* and the more recent *2015 Paris Agreement of COP21*. The city claims to understand that a sustainable future requires a clear set of policies and strategies conducive for sustainable development fostering the transition towards renewable energy. This section will reference the country's sustainable policy aligned with the Paris Agreement. This reference should act as a useful adoption of the globally recognisable sustainable policy vocabulary, whilst maintaining the emphasis on the South African dimension to policies and goals. This section will also be split up into the efforts and action of South African and local Cape Town regulatory regimes and the private sector within the city.

The 17 *Sustainable Development Goals* were developed by the *United Nations* and first publicised at the 21st Conference of the Parties in 2015 in *the 2030 Agenda for Sustainable Development*. The goals laid out a blueprint for present and future peace and prosperity for the planet. The agenda was adopted by over 178 countries worldwide, reaffirming the global commitment to sustainable development, reduction of poverty and economic prosperity.[53] As a member of the party nations, South Africa's *SDG Hub* has committed to supporting and reaching the goals by providing access to important information, providing policy advice, encouraging dialogue and building capacity between stakeholders. The aim is to create effective partnerships between all stakeholders in academic, private and public sectors and civil society by encouraging knowledge and expertise sharing.[54]

Sustainable Development Goal number 7 relates most to this thesis. The goal is to achieve affordable and clean energy world-wide by the year 2030. Ensuring this provision of energy requires heavy investments of time and finances into clean energy sources whilst increasing cost-effective technologies that could reduce energy usage and demand of industries and buildings. This expansion of technology and infrastructural upgrades are essential for developing countries to leapfrog certain energy insecure developments and arrive at a cleaner and more efficient future, faster. Technological leapfrogging refers to the ability of a country to avoid investing in old and inefficient technologies and arrive at the most recent and advanced technologies and developments.[55] The reduced adoption time period has allowed for developing countries such as South Africa to arrive at

[53] UN.org, 2019.
[54] Ibid.,
[55] Amankwah-Amoah, 2015.

technological expertise faster than otherwise expected. However, such advancement of technologies requires a relatively highly productive human capital force to function and manage developments. In this case, Cape Town needs to invest heavily in education and training programs to increase the local ability of human capital to facilitate this technological leapfrogging within the city. Due to past effort and investment being placed on fossil fuel energy research, renewable energies have been left out, leaving the industry with a lack of innovative capacity and education.[56] One needs to recognise that developing countries will not necessarily follow the lead of developed countries success, and that such countries are expected to follow their own path in establishing competence in new industries. This is true for South Africa, where past political traumas have left a lasting scar on civil society, influencing their acceptance of Western ideas.

1.2.1. The Public Sector

The Cape Town Energy and Climate Change Strategy document was published in 2006 and lays out strategic visions and goals for increasing sustainability of the energy sector at the time. This document states how Cape Town was the first city on the African continent to lay out a clear and comprehensive climate change strategy which was labeled the *Integrated Metropolitan Environmental Policy* (IMEP). IMEP was fully adopted in 2001 and is still in use in 2019. The policy identifies the necessity for citizens to shift from a business-as-usual lifestyle to one driven and inspired by sustainable development. IMEP defines the environment in a broad manner, inclusive of the physical, built, cultural and socio-economic sphere of the city. Under the

[56] Pegels, 2009.

IMEP heading, different projects and programs have been developed, including a *Biodiversity Management Strategy, Air Quality Management* and a *Climate Change Strategy,* which each set out their own visions, objectives and measures to enforce sustainable development. The overall aims of the IMEP was to reduce anthropogenic causes of climate change through increasing energy efficiency and sustainable energy use, whilst protecting communities and ecosystems that are under direct threat of climate change impacts. In 2006, energy production was 95% dominated by coal generation, with the remaining 5% being generated by nuclear power at the *Koeberg* nuclear power plant.[57] With an inefficient transport sector and a resulting vehicle dominated transport system, transportation accounted for more than 50% of the city's energy use, followed by industrial and commercial activity, and households. In the year of 2000, Cape Town was responsible for 26% of South Africa's renewable energy production, making it an area of energy expertise in the country. However, in relative terms, the city was still not investing or producing nearly enough renewable energy to be sustainable on a global level. In 2006, the national renewable energy target was to reach 10 000 GWh per year by 2013, accounting for only 4% of the total energy consumption in the country.

Regarding air quality, Cape Town initiated the *Air Quality Management Plan* to be adopted in 2005, with a vision of reducing the health effects of pollution through enforcing legislations and establishing education and training programs.[58] At this time, the main threats of energy related decisions included increasing climate change risks, rising populations, housing

[57] City of Cape Town, 2006. p.8.
[58] Ibid., p.12.

demands, transport systems and air pollution, whilst trying to increase economic growth, energy equity, energy security and an affordable and convenient transportation system for all. Ways in which to reach these goals included reducing energy dependence on fossil fuels, increasing the use of more renewable energy, and introducing oil and natural gas as cleaner fuel alternatives to fossil fuel during the inevitable renewable transition phase.[59]

Cape Town introduced its *Clean Development Mechanism* (CDM) under the *Kyoto Protocol*. CDM refers to the mechanism employed to allow developed countries to invest financial resources in sustainable projects that reduce greenhouse gasses in developing countries, with the aim of providing local citizens resources to promote further sustainable development in their communities. One example of a CDM employed in Cape Town is the provision of energy security and equity of social housing projects in the low-income informal settlement of *Kuyasa*, *Khayalitsha*. Whilst this project aimed to help one section of the large informal settlement, many more areas require the same assistance.

IMEP has five specific strategic visions. The first is to create a city where everyone has complete access to affordable, safe and healthy energy services. The second is for Cape Town to lead Africa in meeting its energy demands in a sustainable manner. The third is to manage energy use in commercial, residential and industrial sectors efficiently. The fourth goal is to create a city whereby citizens have access to an efficient public transportation

[59] City of Cape Town, 2006. p.14.

system, and the fifth goal is to be able to enforce goals 1 to 4 by increasing economic competitiveness and employment.[60]

At this early stage, Cape Town was planning to build the *Darling Wind Farm*, the first fully renewable energy project in South Africa. The farm would operate on 10 wind turbines with a total output of 13MW operating at a capacity of 25% due to variable wind expectations. The wind farm began construction in 2005, only 75km north of the city. In addition to this, Eskom planned to implement a series of *Pebble Bed Modular Reactors* at *Koeberg* nuclear power plant. Whilst the national government supported this project, local populations were unsure about its negative consequences as well as its feasibility. Until this day, citizens in Cape Town remain uncomfortable about nuclear power development occurring on their shores.

Whilst in 2001 the city of Cape Town committed to achieving 10% renewable energy by the year 2020, a separate document published four years later stipulated how the broader South African country was committed to 10% renewable energy by the year 2030. This is due to the fact that the country consumes 55% of its energy on mining and industrial activities whilst these activities only account for 14% of Cape Town's consumption. Regardless, there is a major gap between these goals, with Cape Town being presented with a unique set of challenges and opportunities in comparison to the rest of the country.[61]

[60] City of Cape Town, 2006. p.20.
[61] Moving Mountains, 2011. p.9.

Three of the objectives included in the 2001 *Action Plan for Cape Town* look at reducing energy consumption and attaining a more localised, low carbon energy supply. However, the country's electricity generation plan published in 2010 does not include much investment or effort into the renewable energy industry, showing how only 9% of electricity on the national grid would realistically be generated from renewables by 2030. This implies that the expected energy supply would remain carbon intensive.

The first major objective of the *Action Plan for Cape Town* was to induce a 10% reduction in energy use by 2012 in residential and council sectors, through implementing solar water heating projects, as well as residential, commercial and industrial campaigns. Another major energy related objective was to meet new energy demand growth with renewable energy supply as well as other alternative sources. This was to be done by incorporating large-scale and embedded small-scale renewable energy projects in the country's energy mix.[62] Regarding transport, the city formulated a goal to develop a more sustainable transport system. They intended to do this by implementing an *Integrated Rapid Transit* (IRT) program, including a non-motorised transportation program to encourage cycling and walking.[63] A final essential energy related objective was to enable local economic development within the energy sector, through the installation of solar water heaters and through the establishment of a *Renewable Energy Development Agency*. This agency is now referred to as *Green Cape*, which was established in 2010 in an attempt to showcase the local employment opportunities introduced by the renewable energy

[62] Moving Mountains, 2011. p.22.
[63] Ibid., p.29.

economy. Multiple educational programs and campaigns were added to the agenda with a goal of spreading awareness and transparency about the necessity to transfer to a sustainable lifestyle.

The IMEP document concludes by thanking internal and external funders and partners, including the *Royal Danish Government, the Department of Provincial Government of Western Cape* and the *British High Commission* for their participation and dedication in the sector. This shows the necessity of external funding.[64]

The benefits and potential of the IMEP project were clear, however, the project seemed over ambitious at a time where political and social inequalities were so present. The document emphasised the need for active support from all stakeholders, international and domestic, in order to achieve the goals set out by the city of Cape Town.[65] It has become clear that maintaining low carbon emissions whilst simultaneously increasing one's economic development becomes troublesome in a developing country with many demands and few resources. Cape Town requires a more integrated approach able to tackle climate change issues from all angles, including top-down and bottom-up. This needs to be done using local generation of renewable energy and electricity as well as through lowering demand and increasing energy supply and diversity through the perseverance of renewable energy transitions. In this ideal situation, structural changes in transport, industrial and residential sectors will be more energy conscious

[64] Moving Mountains, 2011. p.30.
[65] City of Cape Town, 2006. p.7.

and increase social cohesion, local investment, living conditions and improvements in resistance to external environmental climate change shocks.

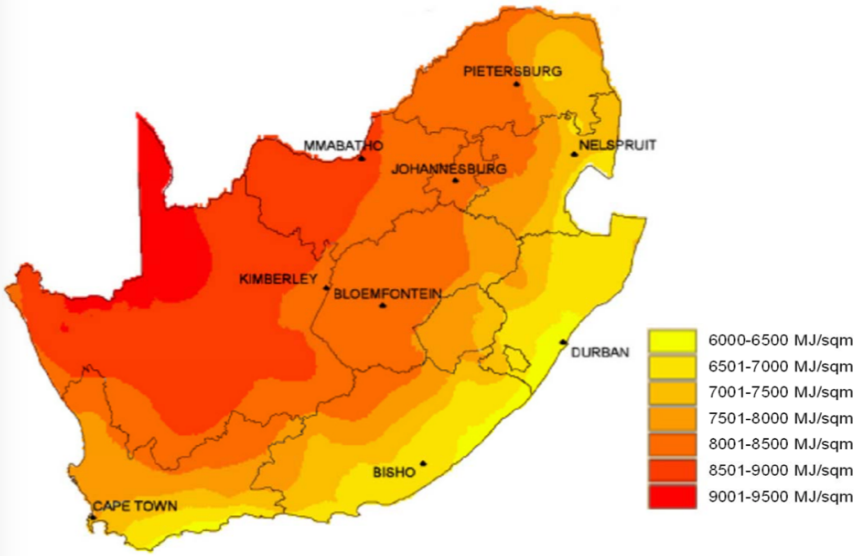
Years later, further information and data emerged showing the progress that South Africa had made on its previous commitments. Whilst global investments in renewable technology are stably increasing, the photovoltaic market (PV) has recently escalated within the African and Sub-Saharan African region. Since the first solar panel was designed, Western and Eastern powers have perfected the science and have moved away from traditional concentrated solar power (CSP) panels (also known as thermal solar energy) towards the photovoltaic sphere. Photovoltaic panels are less prone to defects and are more flexible than past designs.[66] China holds a monopoly on the manufacturing industry due to its low-cost base, its ability to leapfrog technologies developed in the West, its low-cost labour force including engineering and manufacturers as well as their previous experience operating in emerging and developing markets across Asia.[67] Their ability to undercut established firms and provide emerging economies with low-cost renewable technologies allows China to maintain their relative monopoly, with which they sell over 60% of their solar panels to European, American and African markets.

Africa's solar power sector has an intrinsic advantage to become a powerful instrument of economic development for the continent, providing citizens with a cheaper, safer and more efficient source of lighting and heating to currently used kerosene and wood burning.[68] Due to the fact that the most

[66] Amankwah-Amoah, 2015.
[67] Ibid.,
[68] Ibid.,

solar potential lies in the northern regions of the country, long transmission lines will be needed to connect potential solar stations to the national grid. This requires massive initial infrastructural investment and such a comparatively high cost struggle to compete with ultra-cheap coal-fired power stations which currently dominate the market.[69]

Figure 8: Annual Solar Radiation South Africa



Source: CSIR et al. (s.a.)

iv. South Africa Solar Potential Map. Available at: http://oneenergy.co.za/solar-power-photovoltaic-commercial/

1.2.2. The Private Sector

Both civil society and the private sector are equally important players in attaining and reaching such environmental goals, and should be involved in the entire process of environmental protectionism and sustainable development. In order for civil society to respect the environment, there needs to be some sort of ownership or accountability held by the public,

[69] Pegels, 2006.

influencing their personal involvement in the matter.[70] Whereas civil society within developing countries are often untrusting of governmental organisations and regulatory regimes, the involvement of the private sector should be used as a vehicle for dissemination of information, awareness and knowledge across the sector. The importance of community based natural resource preservation and management is emphasised, especially in fields of wildlife protection, fisheries, farming and forestry management. By allowing civil society to manage their own resources of which their society depends on, they are encouraged to protect their wildlife in effective ways.[71] This should be furthered by increasing connections between women, youth and other underplayed forces. In such situations, journalists and documenters play an important role in identifying environmental issues, causes, alternatives and plans-of-action to reduce the negative effects of such issues through increasing civilian attention.[72]

The national design of the *Renewable Energy Independent Power Producer Procurement Program* (REIPPP) has had a huge impact on South Africa's renewables market since its inception in 2015, giving the country a strong foothold in the renewables market within Africa. The previous South African minister of energy, Jeff Radebe, has committed the country to a further 1800 MW of renewable energy to be provided from local independent power producers (IPPs) under the REIPPPP.[73] As mentioned previously, renewable transitions require the efforts of the public as well as private sectors, showing how a strong policy and transparent evaluation is necessary for the successful

[70] Hassan, 2001.
[71] Ibid.,
[72] Ibid.,
[73] Liedtke, 2018.

transition towards renewable energy. In order for the private sector to participate and thrive in the renewable energy market, the national government needs to decentralise and open up market access in a non-discriminatory manner allowing for private and community-based energy producers to engage in the market freely. This increase in private activity and market share will increase economic growth by providing a supply of competitively priced, locally produced, sustainable and renewable energy.[74]

Nationally Determined Contributions (NDCs) act as an instrument of planning for countries to achieve their Paris Agreement aligned goals. It is essential for South Africa to address its financial requirements as well as loss and damage provisions to be able to manage its transition towards renewable energy, via attracting international and domestic financing in effective ways.[75]

[74] Liedtke, 2018.
[75] Rennkamp, 2018.

CHAPTER 2

2. The Current Socio-Political Situation in Cape Town, South Africa

2.1. Challenges and Opportunities in Cape Town

The geopolitical, social, socio-economic, political and environmental and geographical challenges and opportunities for Cape Town in achieving its renewable energy vision will be discussed below. These socio-political factors are inextricably intertwined with one another as well as with the WEC *Trilemma*'s energy equity, energy security and environmental sustainability. Each influence one other on a constant basis. The relationship between energy security and geopolitical challenges; energy equity and social challenges; and environmental sustainability and environmental and geographical challenges are emphasised.

2.1.1 Geopolitical Challenges and Opportunities

Geopolitics refers to the study of the relationship between the earths physical and human geography and politics. It allows us to interpret and predict international political behavior through understanding geographical variables. A country's position in the geopolitical international system is determined by an array of different characteristics, including gross domestic product (GDP), population size, natural resources and land positioning.[76] Having access and control over important energy resources and markets

[76] IRENA, 2019. p.16.

allows for states to protect their national interests by leveraging economic and political influence abroad. Countries without this access lack leverage and are more economically vulnerable as a response.[77]

In an ideal situation, renewable energy will allow developing economies to reduce their energy security risk and vulnerability to changing market prices. Such countries will be able to leapfrog various fossil fuel technologies and fast track to implementing renewable technologies which have been tried and tested across the developed world. In this sense, the transition towards renewable energy and the changing geopolitical map could be an agent of democracy, allowing citizens and communities to be more economically and socially empowered through the decentralisation of energy supplies.[78]

The advantages of renewable energy are clear. Renewable resources are abundant across the world, unlike fossil fuels, which are concentrated in limited locations. Renewable energy resources 'flow' and cannot be depleted, whilst fossil fuel resources are 'stocked' and can run out. In addition to these obvious advantages, renewable energy resources have close to no marginal costs and some sources of power, such as solar and wind energy enjoy cost reductions of up to 20% for every doubling of capacity.[79] However, whilst these factors increase the capability for renewable transformation in all regions of the world, they require regulatory solutions and guidance to make sure that profits and resources are equally distributed. These resources have the ability to reshape the geopolitical world map, as well as influence equality, urbanisation, technological innovation, environmental sustainability

[77] IRENA, 2019. p.27.
[78] Ibid., p.17.
[79] Ibid., p.23.

and sustainable development, in international as well as domestic politics. As a summary, the growth of renewable energy has the power to change and influence the power dynamics between regions, emphasising how each country's energy transition context depends heavily on their exposure to changing fuel trends.[80]

Sub-Saharan Africa as a whole has an opportunity to benefit greatly from having their own natural and renewable resources to create energy. The benefits of this would include spending less on fossil fuel imports by creating their own energy at home, which has the potential to boost job creation and economic growth. At this stage, only Nigeria and Angola rely on fuel exports and fuel rent and will no doubt be at heavy economic risk once renewables take the front seat. In the long term, however, this area has the potential to leapfrog certain renewable developments.[81] At present, over 80% of the worlds' population reside in countries with no fossil fuel reserves, fully reliant on the importation of oil and gas. Energy security remains a huge problem for these energy importing countries.[82]

IRENA (International Renewable Energy Agency) distinguished four categorical groups to describe the vulnerability or resilience of countries in the fossil fuel industry. These include highly exposed yet low resilience countries, highly exposed yet high resilience countries, moderately exposed and moderately resilient countries and relatively low exposure countries.[83] South Africa would be positioned in the fourth category, as having relatively

[80] IRENA, 2019. p.27.
[81] Ibid., p.30.
[82] Ibid., p.35.
[83] Ibid., p.33.

low exposure to the end of the fossil fuel era. This is because although the country imports fossil fuels, the country does not rely on exporting much of its own fossil fuel reserves and should technically be able to transfer its market and employees from one industry to another. In contrast, the effects of such transitions on highly dependent countries such as Saudi Arabia and Kuwait could be disastrous, however, many alternative strategies could ensure a path towards economic diversification through transformation. This is a topic for another research paper.

2.1.1. Social Challenges and Opportunities

Cape Town's residential sector constitutes only 18% of overall energy consumption in the city, with area specific usage differing drastically depending on the level of household income. Low-income households such as those found in informal settlements and townships spend up to 27% of their monthly household income on their energy needs whilst high-income households in the center of the city or surrounding suburbs spend between 3% to 6% of their income on energy. These high-income households use most of their energy on water heating, whilst the low-income households prioritise cooking for their usage.[84] These social challenges link directly to the issue of energy equity discussed in chapter one.

Research done by IRENA shows how the move towards renewables has the ability to create 11 million new energy sector jobs across the world by 2015. However, with the inevitable phase out of fossil fuel and coal mining sectors, the transition will simultaneously weaken employment in other industries. At

[84] Ward & Walsh, 2010. p.10.

present, the global coal mining industry employs about 9 million people, all of whom face job security threats with the coming transition. Due to the very nature of coal and fossil fuel mining being concentrated in specific areas, the transition towards renewables and resulting shut down of coal mines will no doubt have long lasting social and economic effects on entire local communities and regions who depend heavily on the coal industry, deepening existing political divides worldwide.[85]

It is essential to understand the effects of various transitions on jobs and business sectors across the country. The move towards renewable energy transitions is clearly desirable, however, to avoid an increase in unemployment levels and resulting poverty, Cape Town needs to ensure a socially inclusive growth framework is initiated for such transitions.[86] This refers to the idea that communities and livelihoods built around industries that we want to move away from, are considered and integrated into the new developments.

A different challenge that South Africa faces is its decreased capacity of adaption in comparison to other more developed countries. More than 40% of the country's population live on under 2 USD a day, reside in informal settlements and most often rely on agricultural incomes. Such lifestyles are highly susceptible and impacted by changing weather conditions caused by climate change and lack the financial prowess to be able to prevent or prepare for such climate related events.[87] It is ironic therefore, that this

[85] IRENA, 2019. p.63.
[86] McNulty, 2019.
[87] Pegels, 2009.

population who contributes least to climate change ends up feeling the effects of the phenomenon the most.

In order for there to be a more 'just transition' towards renewable energy use, the city of Cape Town needs to prioritise the rights of its citizens and place climate change avoidance at the forefront of economic and technological growth, avoiding the many short-term, profit-driven priorities common to multinational corporations and large businesses.[88] Policies that aid a 'just transition' have the opportunity to address the crucial socio-economic complications and dilemmas that coal workers and nearby communities face as their work becomes redundant. Policy makers should devise various programs to assist job retention and phase out stages for employees, who should be reintegrated into new, sustainable and renewable energy workforces. This is not expected to occur immediately, however, measures that are currently being developed within South Africa include transitional bodies and funds to assist with job relocation and allocation, including job retention programs, investment into new sustainable infrastructure and programs to develop, share and review skills, knowledge and education country wide.[89]

2.1.2 Socio- Economic Challenges and Opportunities

The social and economic situation of a country is highly influenced by whether social growth is inclusive or not. Tensions are expected to rise in states who employ centralised measures to protect elite ownership over

[88] McNulty, 2019.
[89] IRENA, 2019. p.64.

public interests. From a socio-economic standpoint, development and energy transitions should be socially inclusive and environmentally sustainable in order to be effective.[90]

The transition towards renewable energy can improve human wellbeing through promoting social justice and cohesion, influencing local empowerment and independent financial generation, improving health and influencing educational possibilities. Overall, a 'just transition' to renewable energy has the opportunity to move Cape Town in a direction of sustainable development and assist the city in attaining its sustainable development goals at the global level.[91]

The challenge for South Africa remains whether the country and its civil society can break the mold created by Sub-Saharan Africa and move away from emission intensive technologies and pave the way towards reduced energy inequity, reduced poverty and increased sustainable energy without destroying the country's energy intensive economy.[92] South Africa's economy is highly energy intensive and has historically benefitted from low cost electricity. The country's economy and political system thrives on large centralised coal, oil and gas infrastructure which affirms their power and control further.[93]

[90] IRENA, 2019. p.68.
[91] Ibid., p.69.
[92] Rennkamp, 2018.
[93] Ibid.,

2.1.3 Political Challenges and Opportunities

Energy security plays an important role in the economic, social and environmental wellbeing of any large city. Cape Town is no exception here, and the local municipality understands its responsibility to lead the way towards sustainable development and renewable energy transitions, by protecting vulnerable communities, advancing its infrastructure and economic growth and reducing the effects of climate change through adaptation and transition techniques.[94] This section will address various opportunities and challenges which arise from South Africa's political past, present and future.

South Africa is haunted by a past of institutional racism, colonialism and unequal social policies. The country, which was previously colonised by both the British and the Dutch, has suffered drastic racial institutionalisation, with African citizens historically receiving fewer rights than white colonialists.[95] For example, migrant labour systems were created to limit African land access and ownership by increasing taxes and implementing restrictive bans. African, Indian, mixed race and Asian populations were ranked. Generally, Indians, mixed race and Asian populations would receive 50% of what white citizens would, whilst African citizens would receive only 15% of what the white population would. These restrictive regulations were furthered by the election of the *National Party* (NP) in 1948, whereby the apartheid system was formally established. Apartheid laws increased state oppression against

[94] Ward & Walsh, 2010. p.15.
[95] Leubolt, 2014. p.2.

African populations, redirecting public investment towards white, Afrikaans education to benefit the previous Dutch colonisers.[96]

Towards the end of the Apartheid regime, various liberation movements became more active and gained more leverage over the economy. As technological advancement increased, changes in labour market dynamics assisted citizens in this movement. Such advancement required more skilled labour, whilst the previously exploited unskilled labour group lost 'importance'. Therefore, cheap African labour became dysfunctional for both the industrial and political economy of the country, as demands for skilled labour increased.[97] With these changes, the black middle class emerged and is currently increasing exponentially.

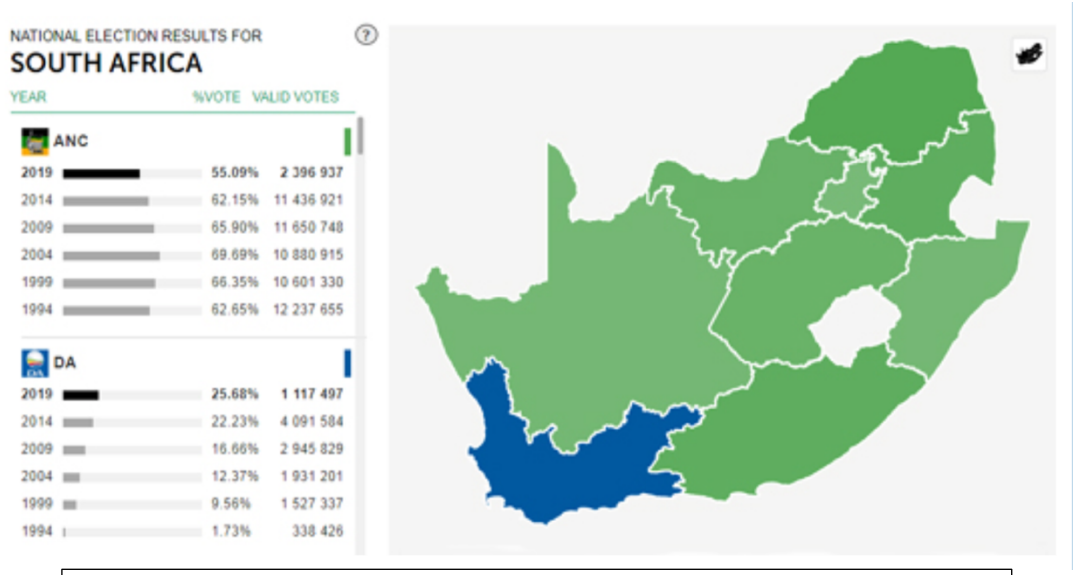
Although institutional racism and inequality vanished in South Africa's democratic rising after the 1994 elections, past racial privileges have secured the white population with a large amount of state money and welfare, leaving many previously marginalised groups in poverty.[98] Racially motivated alliances between the British and Dutch colonisers has also left its mark on the country's social policies. Despite massive liberation efforts and new constitutional equality, statistics have shown that South Africa's poverty and inequality levels have actually increased since the dawn of democracy. This is exacerbated by the fact that there has been a prominent rise in inter-racial inequalities such as xenophobia, which suggests that such inequalities are less racially motivated.[99] These statistics have come as a surprise to a country

[96] Leubolt, 2014. p.2.
[97] Ibid., p.5.
[98] Ibid., p.8.
[99] Ibid., p.1.

who had such high expectations for reduced inequality at the end of apartheid.

In addition to massive inequality between social and racial groups in South Africa, Cape Town is currently facing a unique internal political-party competition. The national government is headed by the African National Congress (ANC) party, who have maintained power since Nelson Mandela was elected as president in first democratic elections in 1994. The ANC's initial objective was to bring all citizens of South Africa together in a united, free and equal society. However, reality shows how the political party has unfortunately been involved in many cases of corruption, fraud and constitutional failures such as insufficient infrastructural spending. The Western Cape, which includes Cape Town as its main municipal city, is the only South African province not run by the ANC and is headed by the *Democratic Alliance* (DA), who despite other controversies has managed to successfully transform the province into a better run, efficient location. This region experiences record low corruption levels and an increased infrastructural sector compared to the rest of the country. Due to the fact that the DA and the ANC are each-others main political competitors at the national level, it has been difficult for the DA to gather the funding and support it needs from the national government to implement its sustainable development plans for renewable energy transitions. This is because it is not in the interest of the ANC to support the DA in its ventures to improve quality of life in Cape Town, as it is trying to win the city over in a political fight of its own. This is a complex topic which could be discussed in a different research topic.

Due to the disabled political history of the country, South Africa faces interesting social barriers towards politics. These include barriers of political will between different racial groups as well as the ANC and the DA. Since the ANC first came into power in 1994, the party has maintained its power by positioning itself as the representative African political party which brought an end to the apartheid regime that crippled so much of the South African population. In this sense, black South African's have shown tremendous reluctance in voting for other parties.



v. South Africa Political Representation Map. 2019. Available at: http://googlemapsmania.blogspot.com/2019/05/south-africa-election-maps.html

As a leading local municipality, Cape Town will need to understand its responsibility for environmental accountability and the need to devise and implement coordinated approaches to reduce negative climate change effects and enforce positive action. There is a dire need for the city to commit its human resources to natural resource conservation whilst leading the city and its inhabitants towards renewable energy. The *Framework for Adaptation to Climate Change* in the city of Cape Town, as well as the *Climate Change*

Strategy had laid out clear objectives and visions for the city to follow in this journey towards clean energy. However, due to decreased work ethic and inefficient planning during political governmental changeovers, the energy committees working on the projects have so far been unable to make many concrete improvements.[100]

Renewable technologies in South Africa could reduce uncertainties regarding turmoil and conflict, such as wars and terrorism that revolve around competition for oil and gas reserves. It has been noted that oil production within many north African countries has increased internal conflicts, as well as inequalities and poverty due to inefficient government management, corruption and unfair wealth distribution.[101] In this context, cyber security should be recognised as another political threat to renewable energy transitions. Energy transitions are occurring parallel to cyber developments and new information technologies such as 'the internet of things' and 'smart cities' to be discussed in chapter three. Such technologies are at high risk of being breached by criminal groups, terrorist groups or foreign governments if not protected properly.[102]

2.1.4 Environmental and Geographical Challenges and Opportunities

Cape Town lies on a peninsula at the most southern point of Africa. Its vast coastline surrounds the city like an island, resulting in important isolation from external resources. Due to previous economic, political and social inequalities, the cities highest density populations are mainly found in

[100] Ward & Walsh, 2010. p.16.
[101] IRENA, 2019. p.55.
[102] Ibid., p.57.

informal settlements and low-income residential zones within urban areas. Such areas are a result of the apartheid legacy, and often have over 150 people living within one hectare of one another.[103] In contrast to this, the central city is relatively under populated, and is characterised by large homes and spaces occupied by few high-income households.

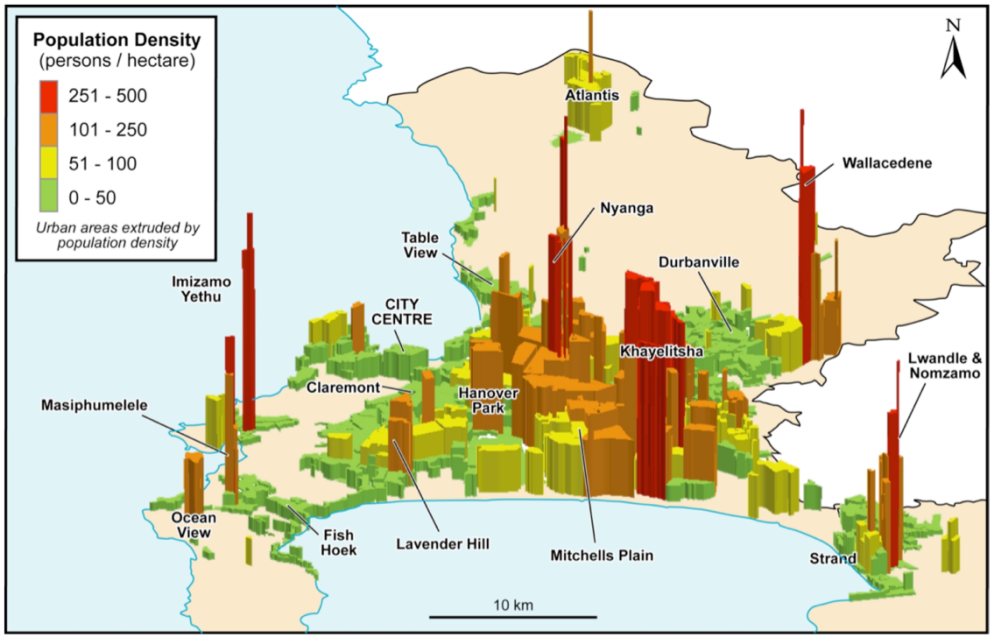


Figure 6. Population density per square kilometre by suburb, Source: Turok & Sinclair-Smith, 2009

vi.	Population Density per Suburb in Cape Town. Available at: https://www.groundup.org.za/article/expropriate-suburbs-say-

South Africa is rich in many mineral resources, fostering massive mining industries in platinum, gold and coal. The abundance of coal in the region has made the country's energy sector heavily dependent on this mineral, with 88% of electrical energy produced through the burning of lower grade coal. This lower grade coal burning has led to inefficient energy production and a disregard for the environmental costs of burning such coal. When burnt, coal emits massive amounts of carbon dioxide and other harmful greenhouse

[103] Ward & Walsh, 2010. p.7.

gasses. The relatively low price of electricity within South Africa and resulting high usage of energy generation means that the country is emitting relatively high carbon dioxide emissions per capita in comparison to other developing and developed countries.[104]

One of Cape Town's most important environmental challenges is simultaneously a political and social opportunity for the region. The *Koeberg* power station is an Eskom built nuclear power plant which was synchronised with the national electrical grid in 1984. The plant lies only 27km outside of the city of Cape Town and is Eskom's most reliable power station working at an 80.4% productivity capacity. It is the country's only nuclear power plant and provides the nation with 5% of its total electricity. In addition to this, the *Darling Wind Farm* lies 70km outside of the city and sells its wind turbine created power to the city of Cape Town, who pays a premium for the renewable energy as a commitment to its renewable targets. It has become clear that in order to transition towards fully renewable energy, a short-term interim energy provider is necessary to keep the city powered.[105]

Because of Cape Town's low energy usage, the city has been presented with the unique opportunity to access and make use of power from this nuclear plant as an important interim measure whilst the region transitions towards renewable energy. Transitioning towards renewable energy is not a simple task, and interim measures are often necessary to bridge the gap between coal power and renewable energy. In this case, *Koeberg* power station could be used to produce enough energy for Cape Town whilst renewable energy

[104] Ward & Walsh, 2010. p.2.
[105] Eskom, 2019.

projects are implemented across the area. Although it has been proven that nuclear waste is a dangerous product that poses threats to our environment and people, it should not be ignored that the modern nature of renewable energy technology means that long term effects of such technologies have not yet been tested and could be equally as harmful.

Whereas fossil fuels are scarcely available in certain countries, renewable energy resources are available in abundance across the globe. In Sub-Saharan Africa, and Cape Town in particular, resources such as wind, hydro power, solar power and biogas are largely available, yet are not being harvested to their full potential. Cape Town is a long peninsula where the warmer waters from the Indian Ocean and the colder Atlantic Ocean intersect, and is the last contact of land before reaching Antarctica. Due to the geographical location of the city, the coast is well known for receiving large ocean swells from both the Indian and Atlantic Oceans, creating especially large waves throughout the winter months. Even in cases where wave movement is scarce on one coast line, there is more often than not swell and wave movement somewhere else along the peninsula. This wave energy could be used to create hydro and wave powered energy to be added to the grid, diversifying it further. In addition to this, long summers and low cloud coverage common to the region allow for solar power to be captured in abundance. This is occurring at present in low cost housing schemes and Reconstruction and Development Programs (RDP) as previously discussed but should logically be extended to use within the industrial sector. For example, solar panels should be deployed across government, private and public building roof surfaces, including factory roofs and high-rise buildings. Although solar photovoltaic panels are relatively cheap and easy to buy and

install, the high price of battery storage systems and connection services are a clear shortcoming for the solar potential of the city. Cape Town could make important use of battery storage systems in which solar power can be stored and used during times of rolling black outs and load shedding, however, until these products have been subsidised or provided by the city, solar capture remains a missed opportunity.

Alongside the transition towards renewable energies, another geographical and environmental opportunity and challenge arises. Renewable technologies, such as solar panels and energy storage batteries require a variety of different minerals and natural resources to function. Necessary resources such as platinum, manganese, bauxite and chromium are highly abundant in the African continent.[106] Whilst it should be expected that the area would benefit from these resources, political powers within the international sphere will inevitably continue to retain power and monopoly over these reserves through the financial support that they provide. Africa should focus on harnessing economic and political power over these resources in the future, reducing the need for international intervention and investment common to African history.

Hydropower refers to the conversion of flowing water movement to electrical energy. This is the worlds' largest source of renewable energy, as rivers, oceans, lakes and other water sources are abundant. River movement in South Africa is limited however, as low rainfall and long summers have forced the region into a 5-year long drought. Low water supplies across the Western Cape region have increased risks of food security for the citizens of Cape

[106] IRENA, 2019. p.59.

Town. The serious drought, which has been publicised worldwide, showcasing how Cape Town could become the first city to run out of water completely, affects energy price fluctuations that therefore influence the availability, affordability and accessibility of energy in the area. An important solution to this could be blending the use of renewable energies in the agricultural sector. This could be done by implementing solar powered water pumps for irrigation systems as well as geothermal energy for food production. This implementation could assist local farmers in increasing their food yields during drought, as well as increasing their food and business security whilst retaining renewable values. Renewable energy has the potential to reduce effects of water shortages, as the functioning of renewable technologies requires up to 200 times less water than conventional oil and fossil fuel energy production does.[107]

[107] IRENA, 2019. p.67

CHAPTER 3

3. Setting the Stage for the Transition Towards Renewable Energy: Opportunities for Cape Town to Become a Pioneer City for South African Transition

3.1. The Opportunity for Cape Town to be a Pioneer City for Renewable Energy Transition

Taking into consideration the socio-economic factors mentioned in chapter two, South Africa and Cape Town in particular have a huge opportunity to lead Africa towards renewable energy and sustainable practices. There is an intrinsic opportunity to use sustainable development and renewable energy to bring energy equity and security to communities where energy is currently unavailable or limited.

Factors that make Cape Town a good example of a potential renewable pioneer city include how the city is small, contained and locally managed by the Democratic Alliance (DA). The small size of the city allows for it to be well managed and for change to be easily measured and used as a test for the broader country as a whole. The cities low energy usage ensures that a transition in Cape Town will not have any immediate negative effects on service provision for the rest of the country. Further opportunity lies in the fact that the city is situated within close proximity to the largest nuclear power plant in Africa, allowing the possibility for nuclear power to be used as an interim transition measure. The city of Cape Town purchases its energy from Eskom and then distributes it to residents, whereas the rest of the country

purchases directly from Eskom. If the city can obtain this energy from renewable sources and deliver it to the population efficiently, this could be tested.

In the ideal situation, Cape Town could find itself as a renewable energy economy in the near future. This would mean that the city would move from a reality of energy dependency to one of independency and energy access. This independence would allow for increased levels of energy security, and therefore greater energy equity and freedom to make decisions that suit the local African market in line with its strategic political and economic goals.[108] Cape Town, and South Africa as a whole would be able to increase their economic base power and attract new investment and industries into the country, whilst simultaneously strengthening the nation's trade balance. At present, South Africa is a fossil fuel importing country and is at risk of supply changes and price volatility that could be caused by any political instability such as war and terrorism occurring in the exporting regions. Such consequences include potential balance of payment (BoP) deficits and inflation and decreasing economic growth, stability and consumer buying power caused by changing fuel prices.[109]

Technically, reaching a 100% renewable energy supply is realistic and feasible in locations where resources are abundant. Cape Town should use its strategic geographical location, political situation and improved economy as an advantage to achieve such levels of electrification. In addition to this, as a location rich in minerals such as gold, diamonds and platinum, the country

[108] IRENA, 2019. p.36.
[109] Ibid., p.37.

could include itself in the international production and value chain which could benefit its further transition towards renewable technologies. Once this perfect scenario has been achieved, it is essential to note that having such independence will not automatically mean that the city is self-sufficient, rather, it will enable the country to choose to include the specific international imports that it requires, allowing Cape Town to benefit from international value exchanges and technological trading as opposed to being subject to whatever changes this international system makes.[110] Energy independence would allow South Africa more power over its domestic governance as opposed to focusing on international security.

As technological innovation and production increases, photovoltaic (PV) energy panels and grid system costs are falling. As a lower cost alternative to nuclear power, this is quickly opening up the renewable energy market for any consumer with rooftop space. The transition towards renewable energy will help achieve a more diverse energy ecosystem in South Africa, whereby local and private energy creation and distribution can allow for households to experience autonomy over their energy use and move away from centralised systems.[111] This process of transition and the formulation of new information technologies such as the 'internet of things' will eventually allow previously passive consumers who are controlled by their energy providers, to be their own private producers of energy. As well as this increased power and autonomy of the private individual, the financial benefits of such transformation will be enormous, through reducing the role of centralised organisations and corporations such as Eskom, who at present hold

[110] IRENA, 2019. p.39.
[111] Ibid., p.42.

considerate power over South Africa's energy pool. The private ownership and decentralisation from such control could give local communities across South Africa in both urban and rural locations more autonomy over their energy use as well as increase their resilience against potential environmental disasters caused by nuclear and coal powered technologies.[112]

As previously mentioned, the transition towards renewable energy in Cape Town and across the world in general, will have strong impact on the geopolitical situation of the country. Renewables harness the power to change and create new relationships between states by reconstructing alliances, communities and trade relations. South Africa should specialise in a renewable energy that it has an abundance of resources in and use that energy as a competitive advantage to leverage its economic benefits with other countries. Regarding trade, renewable technologies will inevitably rearrange dependencies on states by allowing more autonomy within the country producing the specific energies and by blending grids between neighboring countries to form mutually beneficial relations.

This next section will outline various programs and measures that are already in place and advise how with this information, we can improve to make a change towards further renewable energy generation.

[112] IRENA, 2019. p.43.

3.2. Current Measures Employed

3.2.1. Public Sector Effort

The national government as well as the local municipality of Cape Town recognise the effects of climate change on the land and population of the area and claim to be committed to reducing the effects through implementation of various projects and mitigating actions. These include setting targets through the use of *the Long-Term Mitigation Scenarios* (LTMS), which were created to outline ways in which the country could change its national policy in favour of climate change avoidance.[113] The projects that were initiated include the *'start now', 'scale up' and 'use the market'* measures. These national policies aim to highlight ways in which one can reduce emission levels, including how to diversify the energy production market and increase energy security through the transition towards renewable energy. Barriers to these aims include initially high investment costs, difficulties of technological leapfrogging and capacity building. Failure to overcome these barriers thus far has unfortunately played a big role in the slow transition to renewables that South Africa is currently facing. Other projects that have been implemented include the distribution of fluorescent light bulbs, which use less electricity and last longer that common light bulbs. These products have been distributed across the country and city, replacing street lights and governmental buildings in a 250 million ZAR governmental project.[114]

[113] Ward & Walsh, 2010. p.14.
[114] Ibid., p.15.

The most impressive initiative for change thus far has been the *Energy and Climate Action Plan*. This serves as a road map, which includes already existing and newly proposed sustainable energy projects across all municipal departments within Cape Town. This plan is constantly being altered and developed with its progress being monitored and reviewed on a regular basis. The 2010 *Energy and Climate Action Plan* lays out many important objectives and proposals regarding proposed environmental, political and social changes through determining which department is responsible for overseeing the process as well as how the project will be financed.[115]

Within the *Energy and Climate Action Plan*, the *Power Conservation Program* has been written into national legislation and requires that the top 40 energy consumers in the city limit their energy use by 10%. It is believed that this effort will cut Cape Town's electricity consumption by 1%. Along similar lines, a project regarding the mass distribution of solar water heaters implemented in 2011 was successful in saving up to 27% of heating energy. The *Kuyasa Clean Development Mechanism* (CDM) project was implemented to fit houses in informal settlements such as *Khayalitsha* and *Langa* with solar water heaters, energy saving lighting and lightbulbs and efficient ceilings.[116] Different electricity saving campaigns have been initiated to help influence consumer behavior by increasing climate change awareness. The *National Energy Regulator of South Africa* (NERSA) was established in 2004 to assist in overseeing and managing licensing, pricing, tariffs and infrastructural planning and reform for all electrical and piped gas and petroleum industries. NERSA has since introduced the *Power Conservation Program* (PCP) into their

[115] Ward & Walsh, 2010. p.20.
[116] Ibid., p.25.

program, aiming to make the conservation of energy legally compulsory by targeting the top 500 biggest electricity users within the country, by forcing them to reduce their emissions with a penalty threat.[117]

In an attempt to meet new demands with renewable technologies and energy, *Renewable Energy Feed in Tariffs* (REFITs) were introduced to help increase independent power producers (IPPs) influence within the energy market at a time when they were not yet able to feed energy directly into Eskom built grids. The hope for these REFITs as instruments of market creation, are to make renewable energy easily accessible and more affordable for the average citizen.[118] The plans objectives are to build city wide resilience and ability to adapt to the impacts and effects of climate change, emphasising the importance of increasing resilience of low income and vulnerable communities within the region. Low income households typically exist in settlement type areas. In these areas, where living conditions are compromised by limited space, citizens are highly prone to the effects of water and electricity shortages as well as climate change disasters such as floods and fires. Adaptation strategies here include implementing stable water restrictions, energy tariffs, and multiple awareness projects and campaigns.[119] The *Free Basic Electricity Policy' (FBE)* provides a baseline of 50kWh free electricity to consumers using less that 450kWh per month, with the aim of providing low income households with a relative advantage for their low usage. FBE is funded by the national government through a local governmental grant which is an unconditional grant given to different municipalities for the provision of basic needs and services using subsidies

[117] Ward & Walsh, 2010. p.15.
[118] Ibid., p.25.
[119] Ibid., p.27.

from large scale users and wealthy residential customers.[120] In reality, this grant is not yet reaching its intended target, and different departments mention different statistics regarding its impact. For example, the *Department of Energy* calculates that the efforts are reaching 59% of informal households, whilst the *National Treasury* states that they are benefitting only 30% and Statistics SA believes that these FBEs are reaching 51% of intended poor households.[121] It is clear that this data is unreliable, and exceptions apply whereby many households are connected to one meter and therefore do not apply for FBE, or whereby wealthy households who have installed private renewable energy power sources qualify for FBE due to low municipal electricity usage. There is a debate about whether this should serve as an incentive for wealthy households to transition or whether this grant should serve its original purpose.

Alternatively, households without access to electricity continue to use paraffin and gas burning facilities in their homes for cooking and heating.[122] Such gasses are highly flammable and cause regular fires which are easily spread across informal settlements. Paraffin burning also releases dangerous emissions and can cause many respiratory diseases. Another objective looks to improve local economic development within the energy sector through the promotion of renewable energy entrepreneurship and businesses development. To achieve this educational entrepreneurship aim, the city of Cape Town has teamed up with the *South African National Energy Development Institute* (SANEDI), to assist in educating and promoting

[120] Sustainable Energy Africa, 2014.
[121] Ibid.,
[122] Ward & Walsh, 2010. p.25.

economic growth through sustainable development and climate change.[123] The *Youth Environmental Schools Program* (YES) was initiated to help educate the youth about the effects of climate change by teaching them hands-on skills to alleviate certain effects within their local communities. This program was supplemented by *YES EduNet* which was a program designed to empower and educate teachers about such environmental realities and climate change mitigation strategies. The *Smart Living Campaign* was designed to increase interaction between businesses, learners, teachers, the government and the community as a whole, providing a platform for dialogue to initiate change.[124] Overall, these objectives focus on identifying the necessary resources for research, development and monitoring results and future situations.

3.2.2. Private Sector Effort

Private sector effort has also increased dramatically over the past few years. Numerous trends are influencing change and increasing the rate of renewable energy distribution. First, as technological innovation advances and renewable technologies decline in cost, cost competitiveness and investment opportunities are increasing rapidly. As an example, the cost of photovoltaic (PV) and wind power dropped by 73% and 22% between 2010 and 2018 respectively.[125] The cost of lithium-ion batteries for electric vehicles has dropped by 80% since 2010, causing a wave of new affordable investment opportunities and business models. Second, greenhouse gas pollution and the onset of climate change caused by overuse of fossil fuels

[123] Ward & Walsh, 2010. p.26.
[124] Ibid.,
[125] IRENA, 2019. p.18.

has led governments, the public sector, the private sector and investors who are well acquainted to new research and scientific studies, to understand the dire necessity to decarbonise the global economy.[126] It has been proven that two thirds of global greenhouse emissions are caused by the energy sector, and that the transition towards renewable energy is the most cost-effective way to reach global sustainable development goals. With the effect of pollution in mind, achieving renewable energy targets becomes central in our discussion. At this stage, 57 countries have drawn up plans to decrease carbon emissions using government support such as subsidies.

With decreased costs and increased awareness of the problems, technological innovation has accelerated world-wide. If innovation continues at the current rate of growth, second generation renewable energy could soon be used in sectors that are not yet electrified, including aviation, shipping and industrial sectors.[127] New forms of digital innovation and energy storage alternatives are furthering technological innovation and increasing corporate and investor involvement. Large economic players, including public banks such as the *World Bank*, are calling on national governments to stop financing coal powered and energy intensive businesses whilst simultaneously redirecting their supply chains to support and foster renewable sectors.[128]

Public citizen opinion has been another influence for change, by pressurising governments, businesses and local municipalities to reduce their green-house gas emissions. Demonstrations and movements such as the '*Extinction*

[126] IRENA, 2019. p.18.
[127] Ibid., p.20.
[128] Ibid., p.22.

Rebellion' and *'Fridays for Climate Change'* are allowing groups of people to become educated and directly involved in making a positive change in accelerating the move towards renewable transitions.[129]

3.3. New Opportunities for Energy Transitions in Cape Town

Whilst renewable energy offers a broad sector of new, sustainable and climate friendly technologies, it also provides an alternative to the highly centralised fossil fuel system that has failed to ensure security of supply of energy, with an opportunity to restructure and decentralise itself. This can be done in many ways; however, this section will outline the opportunities that such decentralisation can have on new business opportunities and innovation as well as how policy makers have an intrinsic opportunity to accompany these transitions by giving independent power producers as much independence as possible.

Regulatory regimes and policy makers will need to manage key roles in setting the correct incentives for new business ideas and installations empowering communities who are emerging from a past of energy inequality and energy pollution. This new decentralised framework has the potential to overthrow old transition norms and provide South African citizens with the opportunity to take the change into their own hands.

[129] IRENA, 2019. p.23.

3.3.1. Policy Recommendations and Implementation

This research analysis leads one towards two dimensions of policy advice. It seems clear that in order to achieve a successful transition to renewable energy, South Africa needs to over-come different policy challenges regarding urban and rural energy poverty. This section will focus on a desired integrated energy policy framework for both Cape Town and South Africa in the transition to renewable energies.

In short, renewable energies and off-grid renewables constitute a lever to expand coverage of energy access and quality of energy supply in areas where energy access is currently restricted in Cape Town. The incentives that may be created for this investment into renewables are not necessarily competitive towards those industries that are geared towards the traditional mode of energy production. In other words, in the ideal situation where various sectors of the city would leave the national grid, Eskom would not lose much of its market. The question remains which industrial applications and business models we should construct around off-grid renewables, as these renewables can sometimes be introduced too rapidly and end up inefficiently maintained and managed in the long run, downgrading to low usage patterns and even void usage. Taking Cape Town off the national grid in order to expand energy coverage is a powerful policy conclusion.
The second aspect refers to the necessity to completely revamp the central energy policy around Eskom. It is clear that the company has made poor management decisions, implicating generation capabilities as well as transmission and distribution efforts. Cape Town should look to the west for advice to leapfrog certain managerial and technological fields to learn how to

manage and regulate the energy networks in such a way that the network connection quality increases over time. This is most likely to happen when different generation options and energy sources are able to equally compete for space on the energy market. In South Africa, the redundant effect of detrimental management has increased the need to decentralise this market.

After various progressive steps have been taken to reduce the inequity amongst energy provision in the country, demonstrated by the country progressing from 36% electrification in 1994 to 87% in 2014, inequalities and energy poverty still persist. Due to the nature of the country being a generally low income, developing region, South Africa requires a deepening engagement between civil society, public and governmental sectors in the discourse of energy poverty and renewable transitions.[130]

In order for energy poverty to further decrease and for renewable energy transition to receive the effort it requires; governmental plans and policies need a strong alignment of coordination. In modern politics, the national government is responsible for developing various strategies and policies which are presented as guidance for municipal governments to implement. However, a lack of alignment and capabilities between governmental planning, municipal capabilities as well as human, infrastructural and financial resources country wide implicate these intended interventions. In this sense, improving this sense of alignment between national ANC and municipal DA governments is essential.

[130] Sustainable Energy Africa, 2014.

In addition to this, regulatory regimes need to rethink how policies are being implemented. Despite increasing electrical access, various energy patterns remain entrenched among different civil sectors. Households prioritise different electrical requirements differently, whereby high-income households have an opportunity to prioritise renewable and sustainable practices whilst energy poor households prioritise providing their homes with heat or light regardless of the energy source used. Energy price reviews are needed to ensure that poor households do not get further entangled into energy poverty whilst wealthy households are influenced to further maintain their effective practices.

Community engagement and participation is most essential in a developing nation such as South Africa and this participation is a key objective in municipal affairs and decision making. Cape Town's civil society needs to become more actively involved in the energy poverty and transition discourse. There remains a need to strengthen city and municipal level dialogue, information and data systems. At present, data collection is not always accurate or adequate, and retains problematic inconsistencies. South Africa needs to improve its data collection and definition skills to create consistent, accurate and clear data.[131]

Central to this thesis, it is evident that the creation of a new renewable energy industry is central to ensuring security of energy. South Africa needs to ensure that the incremental upfront cost of transitioning to renewables is not unrealistically high in consideration of the wealth distribution of its citizens.[132]

[131] Sustainable Energy Africa, 2014.
[132] Winkler, 2005.

In realising the country's environmental goals, one must not lose sight of the country's social developmental objectives, and in doing so, South Africa needs to turn its natural and technological resources into economic exploitations, advancing both environmental and social objectives at once. New technologies should be economically feasible for all sectors of the country and its economy, addressing constraints on the development of the renewable energy industry.[133]

Studies show that to achieve a successful transition to renewable energy, a combination of policy tools are most likely to be effective in achieving the environmental, social and economic outcomes most desired. As the objective is to promote and influence renewable energy and environmental sustainability, budget constraints need to be prioritised through fixing prices by using a feed-law to help minimise costs. As environmental objectives are equally important in the transition towards renewable energy, portfolio standards should be used to regulate energy quantities. It is argued that a grid-feeder law, which would allow for flexibility and growth in the IPP pool would be effective in South Africa, by providing security for renewable businesses and plants by guaranteeing a market and a price for them. The costs that are likely to incur from this policy decision should be paid for by a cross subsidy between all tax payers. The implementation of *Feed In Tariffs* (FITs) allow for the national government to fix prices to renewable electricity, increasing market security and promoting investment into IPPs. A key limitation is that the government in a developing country will struggle to pay such fees for maintaining a FIT. Such implementation has the potential to

[133] Winkler, 2005.

increase diversity of supply whilst promoting competition amongst new producers.[134]

South Africa's policy context is a unique one, as despite massive efforts towards electrification, a large portion of the country's population remains without access to electricity. Due to the fact that universal access to basic electricity is a global objective, policy makers will need to ensure that policy's recommended take into consideration renewable energy transition as well as governmental budget issues and current electricity prices. The main goal for the nation is to keep electricity prices low and affordable for all. This creates an obvious issue for the case of renewable energy which has inherently high up-front prices. South Africa faces another issue common to developing countries in that the region lacks the institutional capacity to be able to implement such complex policy options. In this sense, if the government sets targets without taking these issues into consideration, industrial professionals will be forced to meet expenses by carrying these extra costs back over to their customers. This model is ineffective in a developing nation where consumers cannot afford to pay for exponential price increases, as raising tariffs would work against the general goal of affordability.[135]

To conclude this section, regardless of the policy option taken, the government will need to ensure that a permissive environment is created to allow for renewable transitions and technologies to be developed and compete on a level playing field with current energy options. This should be done via implementation of Power Purchase Agreements (PPAs), non-

[134] Winkler, 2005.
[135] Ibid.,

discriminatory access to the national electrical grid system and by providing financial assistance for research, development and testing. At present, the opportunities for IPPs to enter the energy market are limited due to Eskom's monopolisation of the energy sector. For emerging IPPs to gather the investment they require, they need to be sure that they will have access to the grid in a manner where their pricing is not tied to the marginal costs of Eskom. South Africa needs to move away from this centralised system by incorporating a regulation system, whereby social and environmental goods and services are protected.[136] An option exists to limit PPAs to small scale renewable projects. The hope here is that the independence and commercialisation of IPPs will allow these businesses to grow at a faster rate.

Renewable Energy Independent Power Producer Procuremet Program (REIPPPP) is only scheduled to allow IPPs to be connected after 2021. New policy directions are needed to open up this sector and the renewable market.[137] The main sources of funding for such policy recommendations include international financial support from services that support environmental targets, including CDM, development banks and the United Nations. Sources of domestic financial support should arrive in the form of a levy; whereby abled customers pay a small revenue on top of electricity bills which is dedicated to renewable energy research and development.

Both international and domestic policies are needed to ensure efficient and appropriate policy frameworks are creating incentives for private and public investment into renewable technology and sustainable energy.[138] Although

[136] Winkler, 2005.
[137] Cloete, 2018.
[138] Pegels, 2009.

such excess charges will be difficult to motivate for in a political context due to past corruption tendencies, such taxes and dividends would seem necessary.

3.3.2. New Business Opportunities

Whilst 1.4 billion people live without access to electricity, every human being across the world experiences the phenomenon of sunlight on a regular basis. Capturing this solar energy seems to be a clear option for alleviating poverty whilst increasing economic prosperity.[139] In the post-apartheid era, South Africa found itself with an over-supply of electricity and energy which resulted in little sense of urgency for the country to transition and diversify its energy options. However, by 2005, as the middle class began to grow, the energy demand began to outweigh the supply provided by Eskom state utility by 5000 MW. At present, whilst about 90% of electricity is generated by coal, South Africa is becoming the largest market for solar photovoltaic (PV) and concentrated solar power (CSP) panels and a leading country for investment in solar panels, plants and installations.[140]

Kathu Solar Park, located in the Northern Province of South Africa, was the country's first official implementation of a solar energy farm. The project began construction in 2016 and began official operations in January 2019. Because of its recent inauguration, long term efficiency of the park is relatively unknown, however various predictions show that the 100 MW concentrated solar power (CSP) park is expected to save the country six

[139] Amankwah-Amoah, 2015.
[140] Ibid.,

million tons of carbon dioxide over twenty years of production, promoting the local economy and sustainable development and benefitting communities within close proximity to the park throughout its expected 30 years of operation.[141] The construction and development process provided over 500 jobs for local communities, and 1200 jobs in peak construction periods. During operation, the Kathu plant will supply more than 179 000 homes with electricity at peak demand periods.[142] The plant makes use of a molten storage system which allows for 4.5 hours of energy storage, necessary in times where sun shine is limited.

Solar panel producers across the world, including Western and Chinese producers and investors are beginning to view South Africa as a gateway to the African solar market. In this regard, *Hanwa Solar One*, and *Suntech Power* have announced plans to build solar power farms across South Africa to connect the remaining 12.5 million people who are not currently connected to the main grid.[143] The majority of Africa's solar panel manufacturers are located within South Africa, including manufacturers such as *Micro Care, MLT Drives, Rentech* and *SetSolar*.[144]

Whilst increasing the attraction for private businesses and IPPs, South Africa should consider using its state capital to introduce government owned firms and renewable manufacturing facilities. Government support in this area is expected to give African countries a starting point to enter the international renewables market which China currently monopolises.[145] This state-led

[141] Kathu Solar Park, 2019.
[142] Ibid.,
[143] Amankwah-Amoah, 2015.
[144] Ibid.,
[145] Ibid.,

model is inclusive of various non-governmental organisations (NGOs), *Emerging Markets Multinational Enterprises* (EMNEs) led and *pay-as-you-go* models which have emerged as the renewable industry has grown, allowing a bottom-up approach to supplement the current top-down governmental approach. A global trend is for government sectors to delegate renewable activities to NGOs and aid firms such as the *United Nations* and the *World Bank*. In South Africa however, the sector has been largely privately run due to a lack of government investment into the renewable sector thus far. Whilst a positive thing, various problems exist with leaving the industry in the hands of the private sector in a country like South Africa, where financial resources typically lie within the grips of a small percentage of citizens. These include gaps in the market where private investors are reluctant to invest due to uncertainty and fluctuation.[146]

Private investors, businesses and companies have taken it upon themselves to manage their corporate social responsibility by investing in community projects to increase renewable transitions, sustainable development and environmental protection. As an example, *Cadbury* invested 1.3 million USD providing 10 000 solar lanterns to their cocoa farmers across Africa, in an attempt to bring small-scale solar innovations to local communities. Whilst this sort of investment is essential and useful, Africa is experiencing a dire need to move away from donor led initiatives whereby instant gratification is encouraged, and towards more commercial investments which allow local private investors to benefit rather than international companies and organisations.[147] In this sense, local communities are encouraged to take

[146] Amankwah-Amoah, 2015.
[147] Ibid.,

control of their own economic, natural and geographical situations and create self-sufficient businesses.

The *Avon* model of *door-to-door* sales is an attractive renewable business model worth mentioning. Due to the fact that one fifth of the world's population lives without access to an official national electrical grid, an opportunity existed to develop a new model to provide and reach this sector of society. The *Solar Sisters Project* recruits' local women, trains them and provides them with access to jobs, selling small-scale renewable technologies across energy deficient villages across Africa. Whilst not yet used in South Africa, this model could be useful in the country, where millions are not connected to the state utility electricity grid, by providing local communities with access to cheap solar products whilst simultaneously empowering marginalised citizens to use their own social networks to sell products for a profit. This model has managed to reach some of the most remote areas in Africa due to the mobile ability of individual social spheres.

As a solar lighting system costs between 50 and 60 USD to purchase, install and maintain productivity, many South African households require a *pay-as-you-go* model whereby incremental payment can be used. This model has been expanded to include mobile phone payment services, increasing efficiency for both consumer and retailer and empowering people from the bottom of the pyramid. Businesses need to ensure that the high upfront costs of renewables do not deter buyers from purchasing products, and the *pay-as-you-go* model serves as a way to avoid these potential business losses.[148]

[148] Amankwah-Amoah, 2015.

Newly reduced PV production and installation costs as well as technological improvements are changing the landscape for new business opportunities to further the transition towards renewable energy in Africa and South Africa. This new renewable business industry requires a new level of education, training, skill enhancement and research and development to keep up with foreign competitors. This requires training and support programs and initiatives to assist renewable engineers and technicians in achieving their development goals as well as in managing their new equipment. This requirement for improved research and development proposed the need for a more collaborative way of thinking and investing between the private sector, public governmental sector and international agencies for achieving renewable proficiency. This collaborative action could include governments offering tax incentives for local businesses who install renewable technologies, which could save the firm financially in the long term as well as create multiple new job opportunities for research, construction, installation and repair procedures.[149] Further collaboration between international investors and local businesses offer local businesses the opportunity of knowledge diffusion to further technological leapfrogging. However, the tension between wanting to attract foreign investors and foster local growth should be managed efficiently by the government. In this way, the market should open up to new small-scale renewable businesses, who should lead the transition towards renewable technology privately.

[149] Amankwah-Amoah, 2015.

3.3.3. Smart City Innovation

Projections show that by 2050, 70% of the worlds' population will reside in urban cities. At present, cities use over two thirds of total energy produced, and are at a high risk of climate change disasters as a result. Cape Town has the opportunity to become a future 'smart city', built to function on renewable technologies. With a city population of 3.84 million people, Cape Town is home to 64% of the Western Cape population.[150] With a GDP of 34.1 billion USD, Cape Town falls short of international financial standards. The city is a member of the *Global Covenant of Mayors for Climate and Energy,* as well as the *C40* cities. The *C40* organisation is a data driven network of 94 cities who are committed to reducing climate change effects within the urban arena. The *C40* helps cities collaborate with each other to discuss and share different ideas, information, research and knowledge to drive measurable sustainable development and change.[151] The program facilitates sub-programs to connect, inspire, advise and influence sustainable practices within large cities.

A smart city refers to an urban center which encompasses the communal participation of all stakeholders. When designing such a city, it is important to create specific objectives regarding intended quality of life, energy access, services provided to the citizens, promotion of health, efficient urban management and economic diversification. Cape Town will need to understand and embrace the weaknesses and challenges that the city faces as well as how to overcome such challenges. In this context, special attention should be put on the high density of populations in informal settlement areas,

[150] C40.org, 2019.
[151] Ibid.,

the island like peninsula geography and climate change and pollution. When making Cape Town a smart and sustainable city, all stakeholders including administration, enterprises, economic power players, private and public sectors, start-ups, big businesses, academic research centers and governmental sectors would need to be actively involved in the entire process. If these stakeholders are not correctly included and consulted one could risk losing their support as well as risking these sectors not adopting the changes effectively. It could be a good idea to create a smart city innovation center, whereby citizens could visit and interact with data and progress in an educational forum. Cape Town should be used as a test bed for such a smart city, making the city an open laboratory whereby stakeholders are influenced to develop and test new economic fields, education and training methods. The territory could become a test bed for a multitude of projects useful for citizens and for businesses, including energy, waste management and water provision. A new data model should be incorporated ensuring that all data that is collected is shared freely between different departments and stakeholders, increasing research transparency and development potential across the city.

For such a smart city to operate, various technological innovations are necessary to deploy a Cape Town digital platform needed to keep, control and manage data. In this sense, high speed internet and fiber optic services would be necessary for educational priorities as well as development of solutions, whereby we can collect, transform and distribute data in a well-structured manner. This could take the form of a living laboratory, which would act as a co-working platform influencing collaborative innovation. Various technological innovations that could come out of these labs could

include the 'internet of things', referring to an attachment of life like characteristics to non-living objects and technologies. These could include smart cars, parking meter systems, touch payment, light sensors and car sharing projects.

Smart city funding should materialise from taxation and subsidies from the government, as well as from external private investment. However, as many changes are not immediately felt or recognised by the citizens, these financers need to be ensured that their financial effort is not meaningless. Once this funding is available, the management of such money is essential to ensure that finances go into the correct channels for change. In a country incapacitated by corruption, South Africa would need to make sure for efficient smart city administration and management teams to avoid this as well as manage other legal and social challenges. The benefit of turning Cape Town into a smart city is two-fold, improving both efficiency of city operations and mutually benefitting resources distribution between all citizens.

Whilst turning Cape Town into a '*smart city*' is an efficient and viable way to manage its transition towards renewable energy, the city could make use of tax exemptions and incentives to incentivise private action. Today, Kenya is one of the only countries worldwide which offers incentives to renewable energy producers and manufacturers in an attempt to increase capacity building across the country. South Africa should align its domestic priorities with this system to help increase and facilitate solar production to attract private investors and involvement.[152]

[152] Amankwah-Amoah, 2015.

In essence, a country's ability to use technological leapfrogging to achieve a level of development relies heavily on the country's ability to attract private investment from both foreign and domestic sources, through creating an investment environment that inspires the transition to renewable technologies and energy as the more efficient alternative for all stakeholders.[153] Different tax reliefs and subsidies should work as an incentive to encourage renewable participation. In this sense, businesses who adopt renewable technologies or companies who limit coal powered energy should be rewarded for their efforts, influencing their own actions further as well as those of other businesses in the vicinity.

[153] Amankwah-Amoah, 2015.

CONCLUSION

It is clear that in order to reach a low carbon future aligned with global climate objectives, transitioning to renewable energy is necessary. Ensuring energy security, equity and environmental sustainability in a developing nation is a complex and difficult task. This research shows Cape Town as a potential pioneer city for sustainable development to lead South African renewable energy transitions. Through focusing on the geopolitical, socio-economic, social, environmental and geographical and political sphere of the city within South Africa and linking these socio-political factors to the WEC energy trilemma, one is able to see that a transition will inevitably lead to simultaneous energy equity, security and environmental sustainability. Due to South Africa's past political hindrances, policy makers should ensure that all transitions are socially inclusive and just, as well as slow and stable in order to meet the various challenges posed by the political and social environment in the country. The effective implementation of such policy changes, together with necessary evaluation and measurement requires efficient communication and coordination at state and global levels.

This research has provided readers with an overview of the current energy sector in Cape Town and South Africa, showing both the strengths, weaknesses, challenges and opportunities that the country faces in the modern world. Taking into consideration these important socio-economic factors, various policy recommendations have been outlined in the hope that the local and international public and private sector, will come to understand the opportunities that the country holds regarding transitions to renewable energies. The extent and manner in which these policy options and

recommendations are implemented will inevitably have an effect on the future renewable energy mix in South Africa and Sub-Saharan Africa as a whole.

The study encountered various limitations and constraints. Each of the programs and initiatives working towards sustainable energy and environmental protection in South Africa aim to promote different objectives and were only recently introduced. In this sense, it is difficult to measure their absolute impacts on South African society and the environment. These programs could have a diverse array of outcomes in different socio-political sectors, and how they play out in reality has not yet been revealed. Due to the fact that renewable technologies are relatively new to South Africa, micro-level impact assessments are difficult to quantify in the region. These limitations could lead to a range of new, more in-depth analyses or studies. Future research should focus on the effects that these energies and transitions have on social spheres and communities, identifying how to reduce the negative economic and social impacts posed by transitions further. The study and policy recommendations have the potential to benefit a range of stakeholders including both international and local, private sectors, public sectors, governmental regulatory regimes, professional industries and NGOs amongst others.

In conclusion, sufficient human and financial investment in renewable energy is essential to reduce the negative economic, social and environmental impacts of local and global energy production and consumption.[154] Climate change is the greatest economic challenge faced by humans in the modern

[154] Winkler, 2015.

world. The cost of switching to renewable energies is infinitely cheaper than the inevitable consequences we face otherwise.

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