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# ASSESMENT OF THE NEXUS OF ENERGY, CLIMATE CHANGE, URBANIZATION AND INDUSTRIALIZATION FOR AFRICA'S TRANSFORMATION

The case of Ethiopia, Kenya, Nigeria and South Africa.

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*"We can't solve problems by using the same kind of thinking we used when we created them,"*

Albert Einstein (1879-1955)

*"Out of clutter find simplicity; from discord find harmony; in the middle of difficulty lies opportunity."*

Albert Einstein (1879-1955)

# Declaration

I Rehema Khimulu, hereby declare that this thesis represents my personal work, realized to the best of my knowledge. I also declare that all information, material and results from other works presented here, have been fully cited and referenced in accordance with the academic rules and ethics.

# Dedication

I would like to dedicate this thesis to my parents for their love, sacrifice throughout the years and support. You are all the core of my existence and I am blessed and grateful for all the love and joy you have brought to my life.

## Acknowledgment

My sincere gratitude to my parents, siblings and my friends for their encouragement and support. Appreciations go to my supervisors Professor Hassan Qudrat-Ullah, Dr Wanyama Masinde, internship supervisor Dr Linus Mofor, PAUWES and the African Union.

# Abstract

Humanity is urbanizing rapidly in Africa, and the demand for energy remains highest amongst other basic goods and services. Scenarios suggest that guarantees for energy poverty alleviation and availability will take longer. The ability to withstand the effects of Climate Change is, evidently, lacking. Many urban dwellers get immensely affected whenever there is an increase in fuel costs and majority of them still rely on kerosene and/or biomass for cooking. Industrialization is influencing R-U migration and the rising costs of industrialization is pushing countries to opt for imports as an alternative due to the high costs of inputs, especially energy. This contributes to the slowing down of Africa's structural transformation. For this to be ameliorated, I undertake an analysis of (i) the status of energy (ii) structural transformation and the underlying nexus and (iii) Climate Change measures.

While there is an increasing amount of research dealing with specific aspects of energy, climate change, urbanization and industrialization, new approaches that merge different knowledge have great potential in finding optimal pathways that could minimize the negative impacts as well as maximize the positive outcomes of the process of Africa's transformation.

The research presented in this thesis identifies policy interventions that foster less carbon-intense energy systems, urbanization and industrialization and promote social equity simultaneously. It makes comparisons between four African countries. Particularly, two mechanisms are analysed to achieve these outcomes. The first one considers climate change adaptation and mitigation strategies. The second one looks at institutional and governance structures. A qualitative analysis including textual analysis is conducted to respond to the research questions. Specific policy suggestions on how to maximize positive intervention outcomes are proposed and further discussed.

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## List of Abbreviations

| | |
|---|---|
| AA-LRT | Addis Ababa Light Railway Transit |
| ACPC | Africa Climate Policy Center |
| AFOLU | Agriculture, Forestry and Other Land Use |
| AR5 | Fifth Assessment Report of IPCC |
| ARI | Acute Respiratory Infection |
| ARV | Anti Retro Viral |
| ASAL | Arid and Semi-Arid Land |
| AUC | African Union Commission |
| BAU | Business As Usual |
| BRICS | Brazil, Russia, India and China |
| COMESA | Common Market for Eastern and Southern Africa |
| COP | Conference Of Parties |
| CRGE | Climate-Resilient Green Economy |
| CSA | Climate smart agriculture |
| EAC | East Africa Community |
| ECA | Economic Commission for Africa |
| EIDS | Ethiopia Industry Development Strategy |
| ERA | Economic Report on Africa |
| EKC | Environmental Kuznets Curve |
| EPZA | Export Processing Zones Authority |
| EPRDF | Ethiopian People's Revolutionary Democratic Front |
| FDI | Foreign Direct Investment |
| FIFA | Federation Internationale de Football Association |
| GBRS | Green Building Rating System |
| GDP | Gross Domestic Product |
| GCI | Global Competitiveness Index |
| GHG | Greenhouse gases |

| | |
|---|---|
| GNI | Gross National Income |
| GTP | Growth and Transformation Plan |
| HIV/AIDS | Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome |
| IAIPs | Integrated Agro-Industrial Parks |
| IAMs | Integrated Assessment Models |
| IAP | Indoor Air Pollution |
| IBVAs | Indicator-based Vulnerability Assessments |
| ICLEI | International Council for Local Environmental Initiatives |
| ICT | Information and Communication Technology |
| IEA | International Energy Agency |
| IPAP | Industrial Policy Action Plan |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPU | Industrial Process and Product Use |
| IRP | Integrated Resource Plan |
| IRRP | Integrated Resource and Resiliency Planning |
| KNCPC | Kenya National Cleaner Production Centre |
| LAC | Latin American Countries |
| LAPSSET | Lamu Port/ South Sudan/Ethiopia Transport Corridor |
| LDC | Least Developed Economy |
| LED | Light-Emitting Diode |
| LEED | Leadership in Energy and Environmental Design |
| LTMS | Long-Term Mitigation Scenario |
| MIDP | Motor Industry Development Programme |
| MMBOE | million barrels of oil equivalent |
| MtCO2e | million tonnes of carbon dioxide equivalent |
| MW | Megawatts |
| NAPAs | National Adaptation Plans of Actions |

| | |
|---|---|
| NBPE | National Biogas Program of Ethiopia |
| NCBDA | Nairobi Central Business District Association |
| NCCRS | National Climate Change Response Strategy |
| NCCRP | National Climate Change Response Policy |
| NDCs | Nationally Determined Contributions |
| NDP | National Development Plan |
| NGP | New Growth Path |
| NIP | National Infrastructure Plan |
| NIPF | National Industrial Policy Framework |
| NUDP | National Urban Development Policy |
| OECD | Organisation for Economic Co-operation and Development |
| PASDEP | Plan for Accelerated and Sustainable Development to End Poverty |
| PDNA | Post Disaster Need Assessment |
| PIDA | Programme for Infrastructure Development in Africa |
| PM | Particulate Matter |
| PMPA | Pharmaceutical Manufacturing Plan for Africa |
| PPD | Peak Plateau and Decline |
| PSDS | Private Sector Development Strategy |
| PV | PhotoVoltaic |
| RECP | Resource Efficient and Cleaner Production |
| SACN | South African Cities Network |
| SADC | Southern African Development Community |
| SALGA | South African Local Government Association |
| SDG | Sustainable Development Goals |
| SDPRP | Sustainable Development and Poverty Reduction Program |
| SES | Social-Ecological Systems |
| SEZ | Special Economic Zone |
| SME | Small Medium Enterprises |

| | |
|---|---|
| SSA | Sub Sahara Africa |
| TBL | Triple Bottom Line |
| UGGP | Urban Good Governance Package |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UN Habitat | United Nations Human Settlements Programme |
| UNIDO | United Nations Industrial Development Organization |
| VOCs | Volatile Organic Compounds |

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# CHAPTER I

# INTRODUCTION

## 1.1 Introduction

This research is about an *Assessment of the nexus of Energy, Climate Change, Urbanisation and Industrialization for Africa's Transformation.* Energy poverty ranks highest in Africa particularly in Sub Saharan Africa and the fastest rate of urbanization in the world is in Sub Saharan Africa. The rate is much faster presently, than the gradual process that was experienced by the developed countries. According to the Economic Report on Africa (2017), Africa's urban population is projected to reach 49%, by 2035. And this increase is majorly driven by a natural increase, contrary to popular belief that attributes this to purely rural migration. Such growths represent considerable demands for employment, services and infrastructure. They also create advantages for economic growth. In order for cities in Africa to reap large(er) productive benefits, they will be required to function and be managed better in terms of energy and climate change. With the inevitable growth rate of sprawling in urban areas around Africa, comes an instant and unavoidable pressure on their adaptability to such escalating occurrences.

Urbanization comes with its challenges of energy provision (for both household and industrial uses) and climate change mitigation and adaptation and there should be tools in place to address this. It is, thus, important for countries to have the proper energy and climate infrastructure to deal with urbanization.

The rising cost of industrialization is evidently pushing countries to opt for imports as an alternative and this is largely due to the high costs of inputs especially energy (ERA,2017). Rapid urbanization is manifesting itself across the continent with the fastest urbanization occurring in the least urbanized countries such as Ethiopia, Kenya and Uganda whose

urban populations fall below 30% of total population (ERA, 2017). The demand for basic goods and services, including energy, has tended to skyrocket over the past few years, making it difficult to guarantee energy poverty alleviation, in African cities. Cities' ability to withstand the effects of Climate Change is, evidently, lacking. Many urban dwellers get immensely affected whenever there is an increase in fuel costs and majority of them still rely on kerosene and/or biomass for cooking.

Most cities in Africa also suffer the extremes of flooding storm drains and lack of water during rainy and dry seasons respectively. The continued current trend of urbanization in the face of deindustrialization (in the context of the developing world) has resulted in cities characterised by poorer populations and higher informality (ERA, 2017). According to UNIDO (2013) deindustrialization may be defined as:

> "Long-term decline in manufacturing relative to other sectors. Typically measured in terms of a share of manufacturing employment in total employment."

Africa's industrial transformation and increasing urbanization subsequently requires sustainable energy and resilient infrastructure as key drivers and/or enablers. However, climate change poses a serious threat to energy systems and infrastructure. By understanding and integrating climate risks to planning energy and infrastructure, Africa can reap holistic benefits including sustainable growth. How does energy policy influence the global call for accelerating Africa's structural transformation via urban development?

There are energy and climate related costs to both urbanization and industrialization. As a result, there should be adaptation measures put in place to deal with the issues. The study focuses on the existence of these measures and the available tools to see how well they are connected, if at all they are, in order to reduce the problems in relation to urbanization, and in turn industrialization. If such exist, how well are they being used? Is the nexus well thought out?

# CHAPTER II

# STATEMENT OF THE PROBLEM

## 2.1 Relevance of the Study

Most of the policy recommendations provided in recent studies for the nexus approaches of energy and climate change sectors within the context of urbanization and industrialization are either provided for from a global perspective or within the Western countries' context but hardly are there robust sets of information targeting Africa, in particular within the SSA context. Also much of the integrated planning for municipalities exhibits a great lack of capacity in dealing with these issues as well as for the fact that much more scientific data is required to justify their decisions but it is hugely lacking, for example meteorological data.

Africa is one of the fastest growing continents with urban areas being the most preferable areas for a majority of the population. A majority of these cities still exhibit a centralised form of governance with much of the development being non-linear, leaving a majority of the rural areas lagging behind in development (ERA, 2017). Inevitably, there is a growing demand for energy and the need for better management of natural resources. This is so because a majority of the SSA countries tend to rely heavily on these resources for their source of energy. How well cities are prepared for this, in the wake of constant lobbying for structural transformation, poses a great question.

## 2.2 Key Questions

1. Will Africa's future inhabitants be able to have access to energy that is clean, affordable, available, accessible and reliable?

2. Is there an existing nexus between energy, climate change, urbanization and industrialization? If such exist how well do they gel in together?
3. How do the measures towards climate change and energy impact on Africa's urbanization and industrialization?

## 2.3 Hypothesis/Proposition

It was expected that a hypothesis (es) and / or proposition(s) would emerge in the course of my research. There is no undertaking to test my hypothesis. The following propositions are reflected in the course of the research:

i. The use of energy that is clean, affordable, available, accessible and reliable will increase Africa's resilience towards her urbanization and industrialization processes.
ii. Adequate transformation in Africa is as a result of a nexus approach of sustainable energy provision, climate change preparedness, urbanization and industrialization.
iii. There exists energy and climate change measures that are adaptive to climate change.

## 2.4 Area of Study

The research focused on Ethiopia, Kenya, South Africa and Nigeria. They have been selected based on the following motivation:

- They are all driven by the need to ensure that there is energy security within their countries
- They are all undergoing a phase of urbanization and industrialization
- Some regions rely more on renewables while others rely more on fossil fuels

## 2.5 Research approach and scope

The research was conducted on the basis of a desk top research with various consultations from time to time with a few experts. It also looked at the energy, industrial, climate and other related policies of Ethiopia, Kenya, Nigeria and South Africa.

## 2.6 Limitations

Disaggregated data in Africa and African countries is not easy to find, especially at the level of the city. Not unless one identifies single elements from a wide berth of sources, which may at times be conflicting, and then sum them to represent your objective, especially at the city level.

Provided that there is adequate time to delve deeper into the components that are driving and that will drive Africa's transformation, more research gaps will certainly be brought to light.

# CHAPTER III

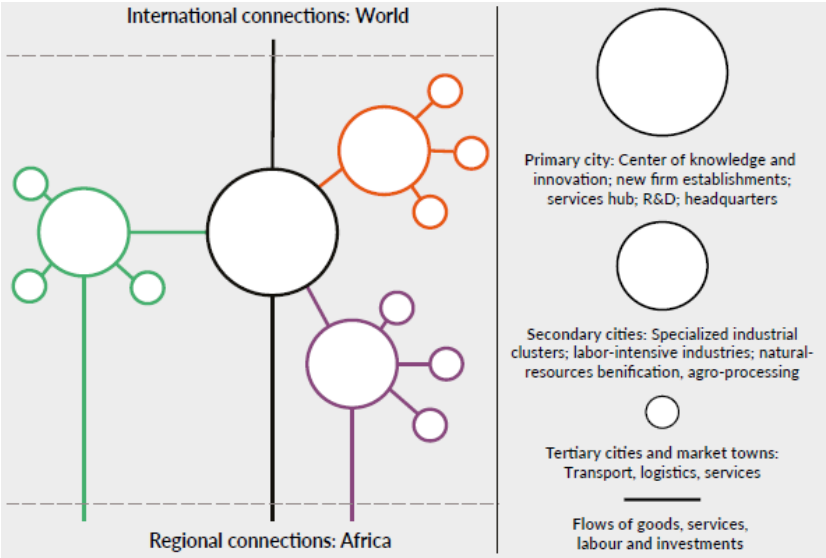
# LITERATURE REVIEW

## 3.1 Contextual overview of Cities

> "Half of the solutions, half of the work needed to resolve the problems of climate change, depend on the action of mayors," said Anne Hidalgo, the mayor of the French capital. "Cities are formidable providers of solutions."

Cities have long been centres of population and economic activity, thus, they potentially concentrate risks and amplify hazards at the same time. Cities are economic powerhouses. Dobbs et al. (2011) indicate that 60% of the global GDP is generated in only 600 urban centres. Studies by WHO and the World Bank (WHO, 2014, World Bank, 2016) project a faster growth rate of 1.6% annually in developing countries between 2025 and 2050 with a double increase in urban population from 2.5 billion in 2010 to above 5 billion in 2050. Predictably, Revi suggests a 'RUrbanism' approach for managing future populations in Indian cities, whereby the balance between rural and urban areas is maintained by altering their extractive relationship with the countryside caused by a pre-empted net primary productivity by human systems and disruptions induced by Climate change (Haberl H., 2007, Revi A., 2006). RUrban (rural + urban) refers to a geographical territory/landscape which possess the economic characteristics and lifestyles of an urban area while retaining its essential rural area features.

*Figure 1: A connected and complementary system of cities*




*Source 1: Economic Report on Africa (ERA) 2017*

In spite of the small percentages, the ensuing growth patterns will be exponential. Inevitably, the future of the demographic nature of developing countries, and in particular in Africa, will exacerbate the demand on the resources resulting to pressure and increases in pollution. Cities and local governments are presented with both an opportunity and a challenge to prepare and plan appropriately for conducive environments for the future populations. Cities that are poorly planned operate in reverse by exacerbating pressure on ecosystems and natural resources that are meant to act as instruments for mitigating climate change and physical buffers to climate related events (Lowe A., 2009).

## 3.2 Current global and regional setting

### *3.2.1 Addis Ababa Action Agenda on Financing for Development (AAAA)*

Financing sustainable development is a key enabler in this discourse. The AAAA came at a time (2015) whereby a need was identified to strengthen the role of local authorities and municipalities in public finance. This has been seen as one of the important elements of expanding domestic finance to include the implementing sustainable development (UNGA, 2015). In support of this, Action 14 of this agenda elucidates the looming gap in financing infrastructure in developing countries in stating that:

> "To bridge the global infrastructure gap, including the $1 trillion to $1.5 trillion annual gap in developing countries, we will facilitate development of sustainable, accessible and resilient quality infrastructure in developing countries through enhanced financial and technical support." – Article 14.

Indeed, it is a wakeup call for local governments to step up in steering forward the need to secure future generations. Acknowledging the daunting task and complex nature of an integrated approach in achieving this, the agenda calls upon concerted efforts as captioned below:

> "We will strive to support local governments in their efforts to mobilize revenues as appropriate. We will enhance inclusive and sustainable urbanization and strengthen economic, social and environmental links between urban, peri-urban and rural areas

> by strengthening national and regional development planning, within the context of national sustainable development strategies." – Article 58.

Article 15 underscores the importance of industrialization in developing countries in order for them to advance in their economic development and diversification. In essence, the world agreed to:

> "We will invest in promoting inclusive and sustainable industrial development to effectively address major challenges such as growth and jobs, resources and energy efficiency, pollution and climate change, knowledge-sharing, innovation and social inclusion."

### *3.2.2 Lima Declaration of 2013*

During the 15th session of the UNIDO General Conference, in Lima, it was identified globally, that poverty eradication remained as the central imperative. It was also recognized that it can only be achieved via inclusive, strong, sustainable and resilient economic and industrial growth, and the effective integration of the social, economic and environmental dimensions of sustainable development. This declaration recognizes the gains and fails since the initial global call for the redistribution of world industry so that developing countries would have 25% of it by the year 2000 (UNIDO, 2013). Article 3 captions this:

> "Since 1975, economic, political, social and technological developments, along with structural changes in global trade, have revolutionized the lives and livelihoods of many. Yet serious structural challenges remain for countries at different stages of development, foremost among which is eradication of poverty. These challenges also include inequalities within and between countries, unemployment and poor access to financial resources and economic opportunities, deindustrialization, depletion of natural resources, and the intensifying threats of environmental degradation and climate change."

The clarity of the Lima declaration states: 'Towards inclusive and sustainable industrial development' and is best spelled out under Article 7 as follows;

> "While integrating in a balanced way all three dimensions of sustainable development — economic, social and environmental — we believe that the effective measures towards inclusive and sustainable industrial development should encompass enhancing productive capacities in a way that supports the structural transformation of the economy; encourages economic growth and the creation of decent jobs; enhances productivity and development, transfer and absorption of technology on mutually agreed terms, infrastructure and technological innovation; advances trade and development, particularly in the small and medium-sized enterprise sector, micro-industries and other new forms of community-based entities; promotes the sustainable use, management and protection of natural resources and the ecosystem services they provide; and supports related research and development."

### *3.2.3 Lima Call to Climate Action of 2014*

This call to action is driven by the general objective of ensuring that all parties (member states) strive to achieve low greenhouse gas climate-resilient economies and societies, on the basis of equity and in accordance with their historical responsibilities, common but differentiated responsibilities / evolving common but differentiated responsibilities and respective capabilities, in order to achieve sustainable development, poverty eradication and prosperity for the benefit of present and future generations of humankind, taking fully into account the historical responsibility of developed country Parties and their leadership in combating climate change and the adverse effects thereof, and bearing in mind that economic and social development and poverty eradication are the first and overriding priorities of developing country Parties. This saw to it that every country designed their INDCs, which have now been adopted as NDCs after COP21 (UNFCCC, 2014). The NDCs were underpinned by Article 2:

> "Decides that the protocol, another legal instrument or agreed outcome with legal force under the Convention applicable to all Parties shall address in a balanced manner, inter alia, mitigation, adaptation, finance, technology development and transfer, and capacity-building, and transparency of action and support."

And Article 10:

> "Agrees that each Party's intended nationally determined contribution towards achieving the objective of the Convention as set out in its Article 2 will represent a progression beyond the current undertaking of that Party."

### *3.2.4 Paris Agreement of 2015 & Quito Declaration of 2016 (UN Habitat)*

The Lima Call to Climate Action culminated in the global adoption of the Paris Agreement which subsequently adopted the INDCs into NDCs that are meant to be reviewed every five years. This agreement is widely acclaimed for the global efforts towards curbing global emissions, and also details the way forward in promoting measures towards advancing adaptation, mitigation, resilience, loss and damage, among others (UNFCCC, 2015). Below are some of the captions:

> "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change; (b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and (c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development." - Article 2: 1 (a).
>
> "This Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances." - Article 2: 2.
>
> "Parties shall account for their nationally determined contributions. In accounting for anthropogenic emissions and removals corresponding to their nationally determined contributions, Parties shall promote environmental integrity, transparency, accuracy, completeness, comparability and consistency, and ensure the avoidance of double counting, in accordance with guidance adopted by the Conference of the Parties serving as the meeting of the Parties to this Agreement." - Article 4: 13.

The Quito Declaration on Sustainable Cities and Human Settlements for All contains several actions for Transformative Commitment for Sustainable Urban Development. It puts emphasis on an integrated approach to planning including energy security and sustainable urban development.

### *3.2.5 Africa Must Industrialize - 2015*

In their joint communique during the adoption of the post-2015 development agenda, the

AUC, OSAA, ECA and UNIDO delivered a global commitment in responding towards the urgency of Africa's need to industrialize (AUC, OSAA, ECA and UNIDO, 2015). The emphasis was laid on structural transformation, technological change and innovation. They state:

> "To be sustainable and inclusive, this progress must now be accompanied by structural transformation, which remains the only option to lift the people of Africa out of poverty. To fully benefit from its rich natural resources and to reap the benefits of the demographic dividend."

Industrialisation features prominently in the AU's First Ten-Year Implementation Plan (2014-2023) (AUC, 2015b) and earlier in the AU's "Action Plan for Accelerated Industrial Development of Africa" (AU, 2007). Looking at the determined demeanour of this century's leadership is safe for us to assume that there shall be an accelerated implementation of policies, and in particular, those that are advancing economic transformation across the continent. This, coupled with a growing improvement of better governance among many African states will go a long way in ensuring that the set ideals are realized.

### *3.2.6 Agenda 2030 & Agenda 2063*

Both Agenda 2030 and Agenda 2063 broadly recognize that poverty is the greatest challenge of the world today and that it is the most fundamental and indispensable requirement of sustainable development (UNGA, 2015(b)). They also share two significant common denominators first of which is sustainable development and transformation and the second is their ambition to allow all human beings to fulfil their full potential, ensure the respect of their dignity and equality, and live in a healthy environment.

Their implementation has been based on a joint integrated approach with the sole aim of guiding African countries design their national plans in line with these two agendas as well

as alongside their priorities at the national level. Again we see a sense of commitment in accelerating the transformation of policy into real tangible results via the harmonizing of efforts at international, regional and national levels. Whereas there are other policies that have been in place to drive the economic transformation on the continent, these two are currently the most significant in promoting the realignment and improvements of policy implementation, while prioritizing the need for innovative financing, advancing technology and an increased investment in both human and institutional capacity (ESC, 2016).

Energy, climate change, urbanization and the role of industry are rightly recognized by the Agenda 2030, and particularly by SDG 7, 9, 11 and 13 as follows:

> SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all.
>
> SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
>
> SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable.
>
> SDG 13: Take urgent action to combat climate change and its impacts. Shifting to low emission and climate resilient pathways falls neatly within this goal. This emphasizes the need to transform industry and the process of urbanization to become climate resilient. Inclusive and sustainable industrialization has strong ramifications for most, if not all, other SDGs.

Industrialisation is essential to realise the goal of the African Union (AU)'s Agenda 2063 for "A Prosperous Africa Based on Inclusive Growth and Sustainable Development" (AUC, 2015a). The Programme for Infrastructure Development (PIDA) in Africa is a flagship project of the Agenda 2063. It reports that Africa has 15% of world population but only 3% of primary energy consumption. It is approximated that energy and transportation programmes represent 95% of the total capital cost of the projected $7.5 billion per annum (AU, 2017).

## 3.3 Resilience

Resilience is defined as 'the capacity of a system to absorb disturbance and reorganize so as to retain essentially the same function, structure, and feedbacks – to have the same identity' or 'the ability to cope with shocks and keep functioning in much the same kind of way' (Walker and Salt, 2012). According to the International Energy Agency (IEA) (2015) resilience of the energy sector refers to the capacity of the energy system or its components to cope with a hazardous event or trend, responding in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation.

Carpenter et al (2012) define resilience as the aspect of being social-ecological which is a multidisciplinary perspective within resilience combining both social and ecological theories (social-ecological systems (SES)). Folke (2006) denotes that SES based resilience thinking emphasises on the indivisibility of humans and nature. In addition, Walker et al (2006) enthuse,

> ''Resilience thinking is all about seeing the system – the social–ecological system that we're all part of – as one interlinked system. . .take a good look at the systems of which we are all a part and it soon becomes apparent that the biophysical system constrains and shapes people and their communities, just as people shape the bio-physical system.''

Since climate change can create conditions that will negatively impact the energy sector, resilience becomes increasingly important. The IEA identifies businesses as the key actors in designing and implementing energy resilience-building measures and adaptive practices as they have a wealth of experience in identifying risks, managing their operations in a manner that minimises their exposure to risks and insuring against the likelihood of damages. Both governments and businesses have complementary and important roles to play in building resilience within the energy sector. Governments' active role involves creating an enabling environment that facilitates resilience-building actions by businesses; by developing policies that are supportive and stimulating; and by taking the initiative of

integrating future climate concerns into the current planning for publicly controlled assets and enterprises. In addition, they are also important in providing protection and supporting assets.

The triple bottom line (TBL) framework, 'a framework for dynamic systems and decision making employed by individuals, groups, or organizations that accounts for economic, social, and environmental issues associated with that system,' has been suggested for use for investigating climate change resilience at the local level (WMEAC, 2013). In their study (WMEAC, 2013) WMEAC[1] was able to identify key impacts across various sectors of the community and recommendations for confronting those impacts. It further goes to define climate resiliency as 'the ability of a community to simultaneously balance ecological, economic, and social systems to maintain or increase quality of life in an uncertain, dynamic climate future'**.** A community that is resilient positions itself to better mitigate both its climate change contribution(s) and the disruption of local climate impacts. Also, in the face of uncertainty, it is agile. Resilient cities are, therefore, positioned in a better way to capitalize on opportunities that come up in the face of an uncertain future (WMEAC, 2013). In his study, Haris Alibašić enthuses that "climate change presents a whole new set of challenges when it comes to emergency planning and preparedness for municipalities" and goes on to say showcase how both the planning and investments in infrastructure made by cities have been put to the test in the past (Alibašić, H., 2013). He denotes that energy efficiency could be the factor that provides the greatest contribution to the community from a triple bottom line perspective and he also explains that "if you address [energy efficiency] properly…It's a simple financial proposition," (Alibašić, H., 2013). Given the high costs of energy in SSA, energy efficiency would go a long way in freeing up cash within tight monthly budgets making more communities and families stable as monies spent on energy are returned to people's wallets and overall local economy.

[1] WMEAC - West Michigan Environmental Action Council

The IEA's tool, MOSES[2], is an example of a modeling tool that examines both risks and resilience factors associated with short-term physical disruptions in energy supply that last for days or weeks. Besides, energy sources it also analyses other noon-energy components like infrastructure that comprise an energy system (IEA, 2011). However, recent research indicates there has been a tendency to exaggerate future demand of official energy scenarios (Karjalainen et al., 2014). Much of this is attributed to the fact that the approach of past models has been largely based on a macro model approach, a top down rather than a bottom up approach which includes the very important role of social, political and ecological dimensions in energy and economic policy. An alternative to this would be the utilization of integrated assessment models (IAMs) that account for changes in the natural world in an explicit manner including, human activities, ecosystems, social and physical processes to account for atmospheric composition, natural changes (climate and sea level), and economic aspects (Springer U., 2003). The study (Karjalainen et al., 2014), also suggests that energy models based on a top-down approach present higher costs for technology change than models based on a bottom-up approach. Pursuing their logic insinuates that acting on climate change is a more difficult endeavour.

The manner in which communities, individual buildings and civilization are built contributes greatly to climate change. Different types of plans for community resiliency have been developed. Noteworthy, there's one (Coyle, S. J. 2011) that distinguishes between a conventional/high-carbon built environment and a resilient/low carbon built environment. Two goals are elaborated for the design of a sustainable and resilient community; they include:

i. 'Ensure that future patterns of growth and regrowth are efficient, resource-conserving, ecologically benign, and socioeconomically vibrant.
ii. Create an economy that reflects and reinforces the economic value of these efficiencies,' (Coyle, S. J. 2011).

[2] MOSES - Model of Short-term Energy Security

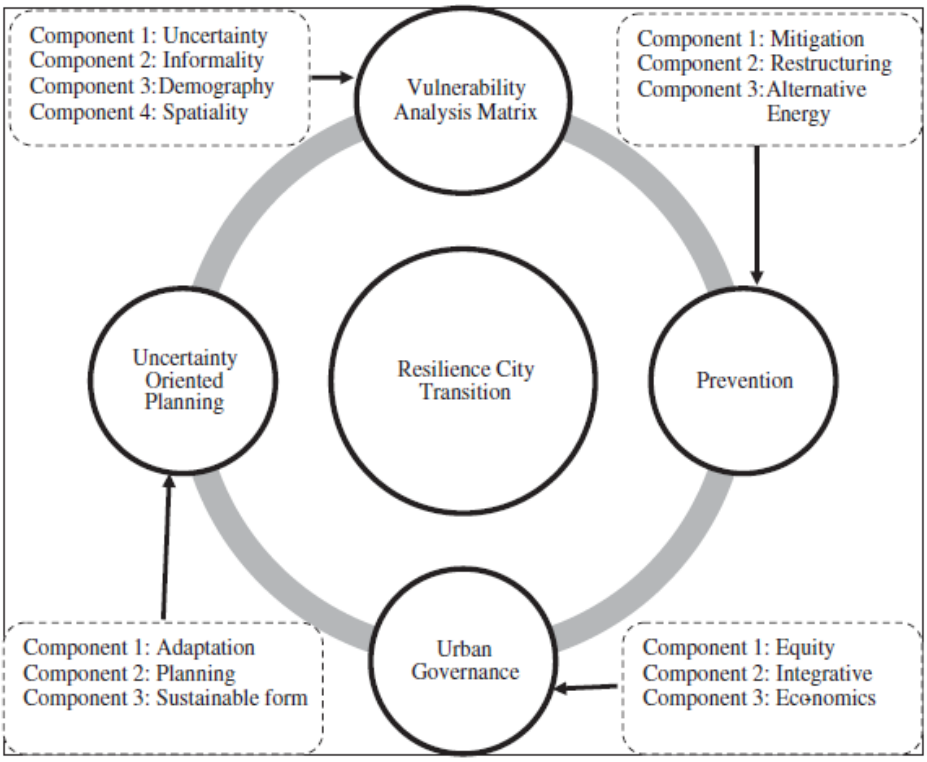
In their analysis, WMEAC identify the Leadership in Energy and Environmental Design (LEED) Green Building Rating System from the U.S. Green Building Council as the most widely embraced model for designing built environments that are sustainable (WMEAC, 2013). LEED measures green buildings in terms of providing a scorecard of benchmarks and best practices proven to improve building performance in energy savings, emission reductions, water efficiency, improved indoor environmental quality, stewardship of resources and sensitivity to environmental impacts. Of importance to note is that adaptation is not part of LEED certification.

The subject of resilience presents a theoretical challenge to scholars which is developing a theory that is multidisciplinary that integrates a range of urban dimensions such as economic, social, environmental, cultural, spatial and physical infrastructure, into a unified conceptual framework for understanding the resiliency of cities and how they should move towards a more resilient state (Jabareen Y., 2012). The following conceptual framework for a resilient city and a resilient community is thus proposed:

Figure 2 represents four main interrelated concepts and each has its own components arrived at following the seven stages of building a conceptual framework (Jabareen Y., 2012). Jabareen (2012) thus defines the Resilient City Planning Framework as ‘a network, or a theoretical plane of interlinked concepts, that provides a comprehensive understanding of City Resilience’.

Numerous literature showcases the dynamism and benefits of system dynamics in energy supply and demand planning although not much research work has been conducted in developing countries, as opposed to the developing world (Yacouba et al., 2014). Countries like the U.S have been updating their National Energy Plan since 1980 (Naill R., 1992).

*Figure 2: Resilient City Planning Framework*




*Source 2: Jabareen Y. (2012). Planning the resilient city*

Most of the studies and funding pertaining to adaptation and resilience have been conducted within the rural context. A huge gap in understanding resilience towards climate change impacts within urban areas in developing countries still remains (Dodman and Satterthwaite, 2008; EU, 2012; Gasper et al., 2011; McIntosh et al., 2008).

Community involvement in the urban areas is not without its challenges. Bahadur et al. (2013) echoes the general understanding of community involvement as vital to the processes of building resilience. He goes on to state that,

> *"Yet* seeking community involvement through established participatory methods is notoriously difficult in urban areas as the community is dynamic and heterogeneous due to high rates of in and out migration."

His sentiments are cemented by Korf (2002) who says that the traditional methodologies deployed in Participation Learning and Action often fail '. . . where the community is very

heterogeneous'. In their study it was realised that 'resilience thinking' brought along with it an emphasis on cross-sectoral collaboration but the prevailing policy context was not agreeable to this. Different departments operated in 'stove pipes/compartments'. Bahadur et al., (2013). The policy environments in urban areas in developing countries such as India are wont to be more compartmentalised than those in rural areas. This is especially so, for instance, because of the presence of urban 'parastatal agencies' (Mukhopadhyaya et al., 2000; Chamarajm, 2009). These agencies tend to have a powerful responsibility on particular sectors (having a direct link to the city's 'resilience') yet they do not effectually reflect the control of city governments, who then have little bureaucratic obligation to work alongside the other departments. It thus helps to relay explanations as to why urban contexts tend to pose challenges for operationalising resilience and systems thinking.

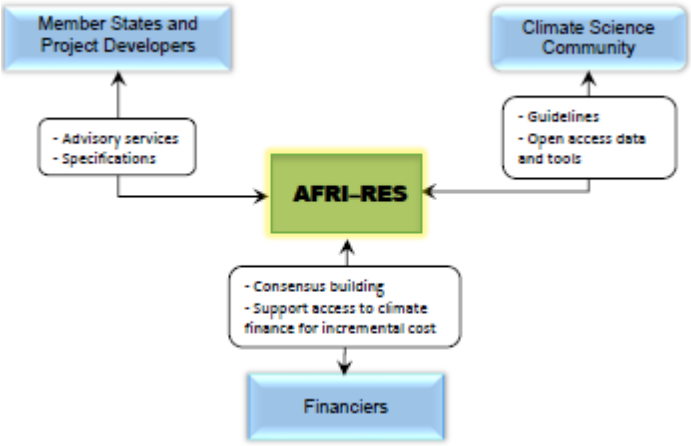
Walker et al. (2006) demonstrates that resilience isn't simply synonymous with adaptation and that adaptation can weaken or undermine resilience when, adaptation in one sector or location undermines resilience elsewhere. This also occurs when the management's focus on a known risk results in distracting attention from hazards that are emerging and vulnerability, and that an increase in efficiency within adaptation measures such as, risk management, can lead to infrastructural or institutional inertia and a loss of flexibility that is resilient.

The reports of the joint Economic Commission for Africa (ECA) and World Bank studies on *Enhancing the Climate Resilience of Africa's Infrastructure* (Cervigni et al., 2015, Cervigni et al., 2017), found that failure to integrate climate change in the planning and design of power and water infrastructure could result to, in the driest climate scenarios, losses of hydropower revenues of anywhere between 5 and 60% (depending on the basin), and increases in consumer expenditure for energy up to three times the corresponding baseline values. In the wettest climate scenarios, the business-as-usual infrastructure development could result to foregone revenues in the range of 15–130% of the baseline.

Dialogue sessions among the federal, state and local governments including the private sector are beginning to take an active role in responding to the threats of climate change.

Climate resilient energy infrastructure is a not a concept new in Africa but the implementation is yet to take shape. To this end the Africa Climate Resilient Investment Facility (AFRI–RES), a joint initiative of the Economic Commission for Africa (through its African Climate Policy Centre), the African Union Commission, the World Bank and the African Development Bank (AfDB), has been launched in 2017 with initial seed funding from the Nordic Development Fund. The overall objective of AFRI–RES is to: "strengthen the capacity of African institutions, including national Governments, regional economic communities, river basin organizations and power pools, among others, as well as the private sector - project developers and financiers, to plan, design and implement infrastructure investments that are resilient to climate change and variability in selected sectors, based on an operational framework and value proposition," as shown in the figure below.

*Figure 3: Operational framework and value proposition of AFRI–RES*




*Source 3: ACPC - UNECA*

Therefore, to increase or improve resilience of cities and energy systems, there needs to be a fully inclusive approach towards the designing of actions and strategies that would cement the nexus of the interacting variables, that is, combined efforts. Also a resilient ecosystem is highly likely to impact positively on the accessibility, affordability, reliability of energy.

## 3.4 Adaptation

Lowe A. (Lowe A., 2009) defines adaptation as ‘any action or strategy that reduces vulnerability to the impacts of climate change. The main goal of these and all adaptation strategies is to improve local resilience, or the ability of a community to bounce back quickly from climate impacts.’ Sims R. (Lowe A., 2009) notes that both adaptation and the need to address poorer communities are not adequately discussed. There are important benefits that will emanate from looking into this equity issue to aid present the largest benefits of climate change adaptation to them that need them most. The Committee on Climate Change defines adaptation as an ‘adjustment of behaviour to limit harm, or exploit beneficial opportunities, arising from climate change,’ (CCC, 2010). Barnett (2001) contends that adaptation is hard subject to comprehend because it demands system-wide analysis and intervention. According to the IEA (2015) adaptation of an energy system to climate change refers to the process of adjustment of all components of the energy system to actual or expected climate and its effects.

Climate mitigation has been looked into widely as compared to adaptation, which has been handled to a far less extent. Jane, et al, alludes to this in her critique of the international 3C Consortium of energy generators which only covers mitigation, adaptation support and technology transfer for the developing world, but not adaptation within the energy sector per se, (CCC, 2010). There needs to be increased efforts in integrating climate change adaptation within energy plans and planning and decision-making processes at all relevant levels. Mamouda’s (2009) study echoes these critique as it was found that only 3.7% of 455 proposed adaptation projects within the National Adaptation Plans of Actions (NAPAs) in developing countries were related to the energy sector. Following pre-COP21, the latest submissions have exhibited a higher percentage of adaptation projects relating to the energy sector.

Majority of the countries in Africa have not made legacy investments on fossil fuel and can thus avoid a carbon "lock-in" that is currently being experienced by most of the developed countries. It thus presents the continent with the opportunity to still make advances in their energy revolution but keeping in mind the ideals of the Paris Agreement[3], but not be necessarily limited by it. One way of doing it could be via 'leap-frogging' the old carbon-intensive models that have "locked-in" developed countries. Industrial policy within the SSA is ripe for embarking on ground-breaking technologies that are low carbon-based, promote carbon capture, storage and sequestration. Rifkin J., (2008) has sparked imaginations about democratizing energy through the post-carbon *Third Industrial Revolution* and a new distributed social vision; linking existing ICT solutions with renewable energy sources that exist locally, the idea suggests. His theory promulgates a revolution which is going to distribute the energies found on every square feet of the earth, and is driven by the affirmation that every earthly creature has a fundamental right to their fair share of the energy. He also opposes heavy new infrastructure that often attract huge investments and instead presents ideas such energy storage via hydrogen medium and within a universal storage mechanism, just like the digital divide (Rifkin J., 2008).

Jabareen (2012) advises planners to have a better understanding of climate change risks poised at households, infrastructure and communities and for those risks to be addressed they have at their disposal two types of uncertainty or adaptation management;

i. 'Ex-ante management, or actions taken to reduce and/or prevent risky events; and
ii. Ex-post management, or actions taken to recover losses after a risky event,' (Heltberg R., et al, 2009),

both which evaluate the adaptation strategies (ex-post and ex-ante) of a plan and policies, in addition to the planning strategies designed to address future uncertainties emanating from climate change (Jabareen Y., 2012).

[3] Paris Agreement calls for policies and measures that are sufficient to limit climate change to "well below" 2 degrees Celsius

Revi (2007) identifies the need to address an actual set of populations and other elements facing risks via risk adaptation and mitigation measures within a RUrban landscape in order for there to be effective responses in a heterogeneous field of opportunities and constraints. Therefore, centralized interventions that are top-down shall be less effective than adaptive management strategies that are decentralized and that engage with a political, policy and implementation continuum from the neighbourhood, city and region to the national level (Moffat S., 2003).

It is suggested that it may be necessary to take an adaptation action for a whole energy system or it may involve interactions between various segments of the energy sector or others such as agriculture or water. It so happens as there exists quite a number if indirect impacts of climate change in the energy sector (Jane E., et al, 2011).

### *3.4.1 Buildings*

On buildings, there lies opportunities to advance adaptation measures in already existing building sites. Going by the International Council for Local Environmental Initiatives' (ICLEI) sets of procedures of integration, therein lies adaptation strategies that local governments can exploit. They include:

i. Understand regional impacts: Identify climate impacts for the building's region.
ii. Evaluate current operations and maintenance targets: Understand the maintenance and operations to perform under current peak climate conditions.
iii. Conduct scenario analysis: Analyze how the building will respond to projected climate change impacts, modeling different system options under a variety of climatic conditions.
iv. Implement adaptation strategies: Install adaptation strategies that provide passive use of efficient responses to more extreme climate events in order to maintain occupant comfort while preventing increased energy use (ICLEI, 2010).

### *3.4.2 Transportation systems*

On transportation systems, they have been regarded globally as one of the largest contributors to climate change and it shall remain so for a while. According to the IPCC,

23% of energy related greenhouse gases are emitted by transportation, with road vehicles contributing three quarters of the emissions (Ribeiro, K. et al., 2007). One way of advancing a climate-resilient transportation system would be through integrating a multimodal approach in the transport infrastructure. Fridstrøm (2017) adds that there are three possible means to combat GHG emissions in transportation via the *avoid-shift-improve* paradigm:

> "One can either (i) reduce the total amount of transportation (avoid), (ii) shift travel and freight to more efficient and/or less carbon intensive modes (shift), or (iii) replace the energy technology of vehicles, vessels and crafts by more efficient and/or less carbon intensive alternatives (improve)."

The 'improve' strategy can also be viewed as 'energy transition' which presents the most promising path forward (Fridstrøm, 2017) in a situation where it is difficult to shift demand from the road mode, and then consequently either the road vehicles themselves, or the fuel in use, requires to undergo transformation.

### *3.4.3 Air quality*

On air quality, urban areas, cities specifically are particularly prone to the dire effects that Climate has on air quality, mainly ozone and particulate matter (PM) levels. This is according to a study conducted by Harvard University and US EPA that states that climate change will contribute to the increase of PM concentrations by 0.1–1.0 micrograms per cubic meter and will also directly increase summertime ground-level ozone in polluted regions by 1–10 parts per billion (ppb) in the coming decades, with the major effects expected to occur in urban areas (Jacob, D.J., et al., 2009). It continues to posit a strong correlation between elevated temperatures and elevated ozone concentrations, and shows that temperatures above 80°F correlate with a probability of excessive ozone levels that increase dramatically. Overall, formation of ozone increases with temperatures that are elevated. High temperatures have been associated with an increase in the rate of emission of volatile organic compounds (VOCs) from furnishings, building materials, carpeting, cleaning products and personal care products (WMEAC, 2013). D'Amato, et al., (2008)

affirm that in most of the urban settings, the main contributors to air pollution are particulate and gaseous emissions from vehicles.

### *3.4.4 Limitations to Adaptation*

Adaptation is not without its limitation as is illustrated by the three types of adaptation errors that planners and decision makers need to look out for (Jane E., et al., 2011, Willows R., 2003). They include **under-adaptation –** occurs when there is too little emphasis placed on climate risks, and not much priority or attention is given towards opportunities for climate adaption; **over-adaptation –** this could be a strategy that is deliberate taken by a decision maker who is risk-averse and adopts a precautionary measure when faced with the risks that are irreversible or serious damage caused by climate change**; and maladaptation – '**taken that (unintentionally) constrain the options or ability of other decision makers now or in the future to manage the impacts of climate change, thereby resulting in an increase in exposure and/or vulnerability to climate change' (Jane E., et al., 2011, Willows R., 2003). O'Connell et al. (2015) present adaptation and transformation as complementary processes.

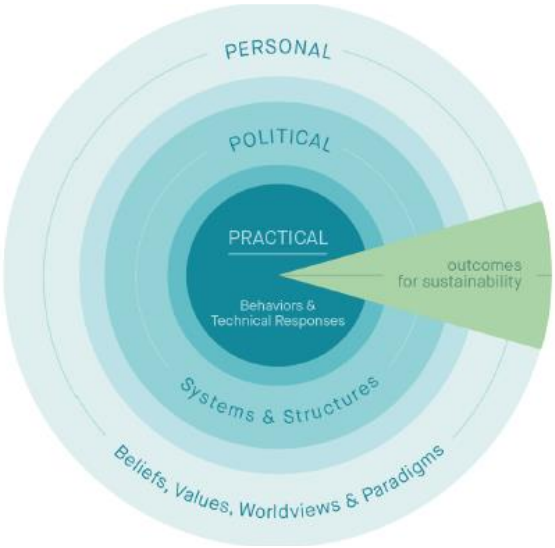
In order to cope with the impacts of climate change affecting urbanization, energy provision and industrialization, urgent adaptation measures are paramount.

## 3.5 Transformation and Structural Transformation

The IPCC defines transformation as the physical and/or qualitative changes in form, structure, or meaning-making, or as "the altering of fundamental attributes of a system (including value systems; regulatory, legislative, or bureaucratic regimes; financial institutions; and technological or biological systems)" (IPCC, 2012: 564). Transformations can be forced or deliberate depending on the level of transformability of the system (Folke et al., 2010).

Westley et al. (2011) defines transformability as "the capacity to create untried beginnings from which to evolve a fundamentally new way of living when existing ecological, economic, and social conditions make the current system untenable." The perceptions surrounding the idea of transformation can either be pertinent for some and threatening for others leading to trade-offs or conflicts that can result in either real or perceived winners, and losers at different scales. It means different things to different groups or people. The literature on transformative approaches majorly focus on transitions in energy systems, trajectories of emissions, cost-benefit analyses, changing risks, transitions in land-use patterns, carbon capture and sequestration, choice of technologies, and approaches in policy (Calvin et al., 2009; Thomson et al., 2011). Karen et al. (2013) suggest that there being numerous pathways for transformation, the decision ultimately encompasses weighing the various characteristics while considering possible trade-offs with other priorities. Literature on transitions looking at sustainability focus on deep and purposeful structural changes in energy, agriculture, transport, etc. (Geels, 2011). It is still claimed that there is still no elaborate understanding of 'deliberate transformations towards sustainable outcomes.

*Figure 4: Interaction of spheres of transformation*




*Source 4: Sharma, M. (2007). Kosmos Journal*

The figure below is Sharma's (2007) illustration of the interaction of the embedded practical, political and personal spheres of transformation. The practical sphere entails behaviours and technical solutions to climate change, including behavioural changes, technological and social innovations, and managerial and institutional reforms. The political sphere entails the ecological and social systems and structures that generate conditions necessary for the transformations to take place in the practical sphere. The personal sphere entails individual and collective beliefs, values and worldviews that shape the ways that the systems and

structures (i.e., the political sphere) are viewed, and influence what types of solutions (e.g., the practical sphere) are considered "possible" (Sharma, 2007).

Ulrich Beck's theory of reflexive modernity postulates that transformations in the nature of rationality are the basis for contemporary social and environmental challenges; change must arise at this deep level in order to avoid risks at root cause (Beck, 1992). Risk society comes about as a result of the continuity of autonomous modernization processes which are deaf and blind to their own threats and effects. Over time, the latter cumulatively produce threats, which then pose questions and in the end destroy the foundations of industrial society (Beck, 1992).

Archer (2007) views reflexivity as the cognitive process through which people resolve the tensions between their concerns that have been defined subjectively and the objective structural contexts they confront. She then defines reflexivity as the inner dialogue that allows humans to:

> "Pose questions to ourselves and to answer them, to speculate about ourselves, any aspect of our environment and, above all, about the relationship between them".

According to Beck, risk society is fundamentally reflexive and distinguishes the contradictions between its original principles - human advancement and the consequences - environmental disaster. He then stipulates that there has to be a radical change, which must come from socio-political interventions designed to transform development that is driven by industrialisation, and that goes beyond the risk management agenda to also include that that is associated with climate change. An ultimate attainment of reflexivity consists of changing values and requires both a political and cultural process in addition to the mainstream sectoral-technical (Pelling M., 2011).

A majority of the existing SES are being compelled to become transformational with the major driver being the human component that is best captured within the socio-political processes which either maintain or alter the set structures. Collins et al. (2012) and Young

(2014) argue that the changes in the global environmental compel us to employ novel forms of transformative politics, or even a new "politics of transformation" which is characterized by complex amalgamations of system-level socio-ecological dynamics and human intentionality.

### *3.5.1 Structural Transformation*

Urbanization has been pointed out as the single most important transformation that the African continent will undergo this century (World Bank, 2013); it is predicted that more than half of Africa's population will live in the cities by 2040. This translates into a population growth of more than 40,000 new urban inhabitants per day between now and 2040 (World Bank, 2013).

According to McMillan, M., & Headey, D. (2014) structural change entails the movement of labour from sectors of low productivity, such as agriculture, into more modern sectors of the economy. They suggest that structural transformation is inextricably connected to the growth or productivity, and development. Ocampo (2005), Ocampo and Vos (2008) and UNDESA (2006) define structural change (transformation) as:

> "The ability of an economy to continually generate new dynamic activities characterized by higher productivity and increasing returns to scale".

Therein lies enormous potential for structural change that leads to growth and poverty alleviation in Africa due to the high share of labour force in agriculture in most of SSA. In their summary: poor countries have much lower labour productivity in agriculture than in rich countries; they have lower labour productivity in manufacturing and services than rich countries, though the magnitude of these gaps is not as large as those in agriculture; and a larger share of the workforce in poor countries is concentrated in agriculture—the least productive sector. Also, structural transformation in Africa is still lagging far behind as industrialization has been limited. Despite there being a reduction in poverty levels, it seems to be largely driven by the diversification of the rural economy although there isn't much information showcasing what is driving this diversification. Ajakaiye and Page (2012) cement this discourse by providing indications that there is a great degree of

consensus among experts on there being an urgent need to revitalize Africa's industrial sector. Majority agree that the only viable path to accelerated structural change is breaking into global markets for agro-industry, manufacturing and tradable services. The key components driving Africa's transformation continue to present more avenues for interaction in order for this transformation to arrive at its optimum level. Industrialization being the mainstay of promoting this transformation requires a better performing urbanization and better functioning energy systems, and the vice versa is true.

## 3.6 Energy, Urbanization and Industrialization

There are several factors including urbanization, energy and the dynamics surrounding climate change that are key determinants of industrialization. In turn economic development involving structural transformation from an agricultural-based economy to an industry service-based economy is among other factors that are key determinants of urbanization. Developing nations are presented with a timely opportunity to either leapfrog traditional methods and approaches of industrialization and/or take the advantage of not having arrived at a lock-in stage. Also, this discussion is occurring at the fourth industrial revolution, one which gives more importance to services and promotes industrialisation based on shifting resources into more sectors than manufacturing alone.

### *3.6.1 Amiability of energy and urbanization*

Cities account for roughly two-thirds of the world's primary energy consumption. According to UNEP (2015), cities account for more than 70% of global energy demand. Jones D. (1991) denotes that statistical evidence indicates that an increase in 10% in the proportion of the population living in cities would increase modern energy consumption per capita by 4.5% or by 4.8%/$ GDP holding constant per capita income and industrialization. This has been a vital enabler for socio-economic activities although it has also created significant impacts on the environment at both local and global levels. At the local level there is a growing concern on indoor air quality (Barnes et al., 2005). Indoor

Air Pollution (IAP) is thought to cause about one-third of acute respiratory infection (ARI) cases, making solid fuels second in the ranks of the most important environmental cause of disease after contaminated waterborne diseases (Duflo E. et al., 2008). At the global level approximately 71% of fossil-fuel related and direct greenhouse gas emissions can be attributed to activities that are being undertaken in the urban areas (IEA, 2008b). 80% of anthropogenic based greenhouse gases are contributed by energy (Karjalainen et al., 2014) and yet the fossil fuel economy intends to burn close to 2,795 Gt of carbon (McKibbenet B., 2012) a portion too high if the world aims to stay below an average of +2°C warming. Achieving climate goals would subsequently require substantial decarbonisation of electric supply. The middle and low income earners find themselves still having to utilize biomass fuel, such as charcoal, in order to adequately meet their energy needs and the rising costs of energy and, to some extent, maintain the 'natural' taste of their food. Also, household income tends to be a major driver of the urban energy transition.

Due to economic growth leading to an increment of energy demand (Grönfors K., 2012) climate change mitigation would demand decoupling of the usage of fossil fuels from economic activity (Karjalainen et al., 2014). Andersen (2007) and Weizsäcker V. (1989) define decoupling as:

> "Weakening or breaking the link between environmental effects and economic activity so that output increases with a less than commensurate increase (or with a decrease) in energy consumption".

The total average per capita annual consumption in SSA, excluding South Africa is approximately 155 kWh. These figures are minute compared to South Africa (4770 kWh/per capita) or OECD countries (based on 2008 EIA data). Historically industrial and energy revolutions have always gone hand in hand bringing along numerous inventions. To put this in a much clearer perspective, in their study Eberhard et al., (2011) says that,

> "Installed capacity [in Africa] will need to grow by more than 10% annually just to meet Africa's suppressed demand, keep pace with projected economic growth, and provide additional capacity to support efforts to expand electrification. - Most new

> capacity would be used to meet non-residential demands from the commercial and industrial sectors."

A majority of the strategies designed for urban resilience often underappreciate energy security and energy efficiency. Developing nations wishing to enjoy the benefits of modern life and a high standard of living require to be self-sufficient in both food and energy supply. Energy, hence is certainly crucial in promoting sustainability and the amelioration of current living standards in developing regions such as Africa (Yacouba et al., 2014). Consequently, energy has become so important a commodity in the developing countries as witnessed in the impact on economies and subsequent impact on the environment (Koh et al., 2010). Africa's energy sector is currently undergoing a transition phase with the main goal of achieving a transformation that would ensure a sustainable and clean energy led economy. The ensuing demands of energy may not necessarily resonate at a similar rate with the current rates of transition.

In his study, Leach (1992) concludes that,

> "energy transition is driven, not an emerging desire for modern fuels so much as by socioeconomic changes which help to break the and constraints on their wider use, especially by the majority of poor biomass-using households. The most important of these changes are improved distribution of modern fuels, both within cities and across the urban-rural divide, and sufficient income to buy the modern fuel appliances (or alternatively various conditions which lower appliance costs)."

Fouquet's (2010) dissection on energy transition concludes that:

> "(i) that the main drivers for energy transition were the opportunities to produce cheaper or better services, (ii) that government intervention may be needed for low carbon technologies to overcome early competitive disadvantages, and (iii) that "a complete transition to a low carbon economy is likely to be very slow".

Africa's energy sector is still poorly developed with millions of people, including in urban areas being rendered 'energy poor'. Human poverty on the continent is characterised by energy poverty.

> "Poverty is not the only reason for slums and inadequate infrastructure – these are also the outward sign of failed policies, bad governance, in appropriate legal and regulatory frameworks, dysfunctional land markets, unresponsive financial systems, corruption and – last but not least – a lack of political will." (Tannerfeldt and Ljung, 2006, p. 82).

Cain A., (2017) characterizes majority of Africa's cities as having slums which bear indications of insufficient investment in infrastructure and industrialisation in most of the countries. The impact of energy access on poverty outcomes such as education, health and income becomes visible when it provides opportunities that is income and capabilities, and empowerment to, and secures the poor. When the provision of energy services is improved and combined with other services such as communications, transport and water services, it leads to increased productivity, which then leads to increased income and then increased income levels result in the ability to pay for increased energy services (World Bank, 2001).

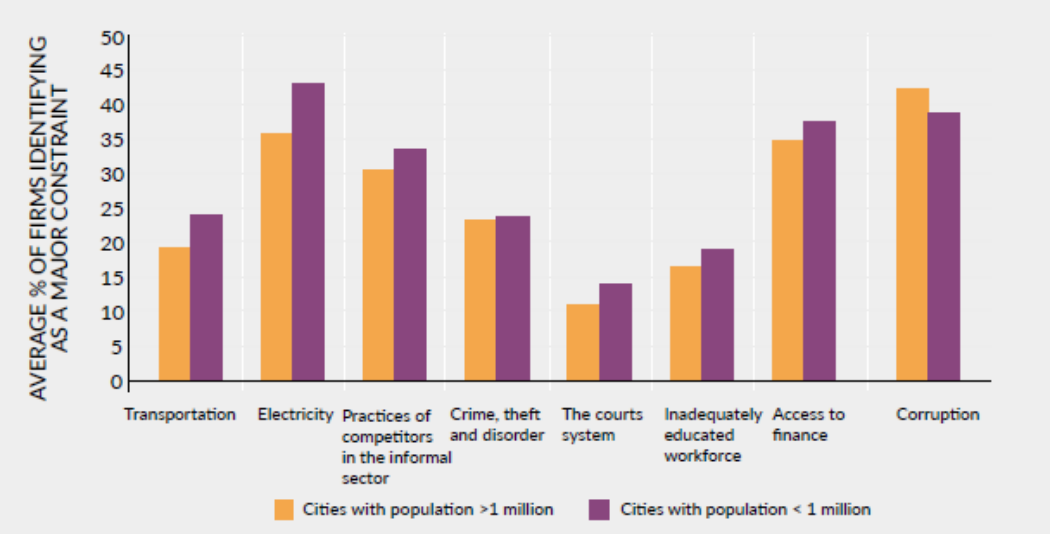
### *3.6.2 Amiability of energy and industrialization*

The total installed grid-based capacity in Africa of roughly 158 GW in 2012 (IEA, 2014) was less than Germany's power generation capacity (REN21, 2015). Power outages are the norm with electricity tariffs in Sub Sahara ranging among the highest in the world. They average from USD 130-140/MWh (IEA, 2014). Eberhard et al., (2011) estimates that it costs firms an average of $307 per hour. Due to this, the IPCC [2012] estimates that 50% of SSA firms resort to costly back-up generators that are oil-fuelled. Electricity is a major constraint of doing business as can be seen in Figure 5. Four out five Africans in SSA rely on traditional biomass for cooking (REN21, 2015). According to The Economist (2015) 910 million people living in sub-Saharan Africa consume much less electricity than the 4.8 million people living in the state of Alabama, US. The low levels of economic development and low energy services means that two-thirds of total energy use is utilized in the residential sector where much of it is used for cooking (IEA, 2014). At the G7 summit of 7/8/2015 it was declared, 'to accelerate access to renewable energy in Africa and developing countries in other regions with a view to reducing energy poverty and

mobilizing substantial financial resources from private investors, development finance institutions and multilateral development banks by 2020 building on existing work and initiatives' (Rainer Q. et al., 2016). Cartwright's (2015) reflection on this within the context of energy demand in relation to urbanization can be well summarized as:

> "Africa's urbanisation and economic growth is driving demand for energy on the continent, but Africa's cities have historically had very little influence over energy generation. This is beginning to change as new technologies and critical need combine to create opportunities and fracture the continent's energy regime."

*Figure 5 Major constraints listed by firms in cities above and below 1 million populations, 2006–2015*




Source 5: World Bank Enterprise Surveys. Note: 188 subnational locations (25 over, 163 under 1 million) in 45 African countries

### *3.6.3 The urbanisation and industrialization prism*

UN-Habitat's (2014) report on *The State of African Cities. Re-imagining sustainable urban transitions* states that Africa's urban population is expected to triple between the years 2011 and 2050, from 471 million to 1.34 billion, and that more than half of the continent's population will reside in cities by 2035. Africa's population living in urban areas shall be approximately 21% of the world's urban population, by 2050. The population growth in the next forty years is postulated to be (1 billion) greater than the urbanisation phase in North America's and Europe, and urbanisation in Africa will take place in a more rapid

fashion of less than half the time taken in those regions (UN DESA, 2014). Every year, cities in Africa grow by over 22 million people while 11 million enter the labour market for the first time every year (World Bank, 2014). Africa's rapid urbanization could be a powerful asset for industrialization so long as it is harnessed via a strategic cross-sectoral policy framework(s), anchored in national development planning (ERA, 2017). Below is a categorization of African countries by extent of urbanization:

*Figure 6: African countries by extent of urbanization*

| CATEGORY | URBAN POPULATION AS % OF TOTAL POPULATION | NUMBER OF COUNTRIES | COUNTRIES* | | AVERAGE PER CAPITA GNI (2011 PPP $) |
|---|---|---|---|---|---|
| | | | RESOURCE-RICH | NON-RESOURCE-RICH | |
| I | >60 | 10 | Algeria, Libya (NA); Djibouti (EA); Rep. of Congo, Gabon (CA); South Africa (SA) | Morocco, Tunisia (NA); Cabo Verde (WA); São Tomé and Príncipe (CA) | 9,201 |
| II | 51–60 | 7 | Mauritania (NA); Côte d'Ivoire (WA); Ghana (WA); Cameroon (CA); Botswana (SA) | Seychelles (EA); Gambia (WA) | 7,834 |
| III | 41–50 | 10 | DRC (EA); Benin, Liberia, Nigeria (WA); Angola, Namibia, Zambia (SA) | Egypt (NA); Guinea-Bissau, Senegal (WA) | 4,263 |
| IV | 31–40 | 13 | Sudan (NA); Madagascar, Tanzania (EA); Guinea, Mali, Sierra Leone, Togo (WA); Central African Republic, Equatorial Guinea (CA); Mozambique, Zimbabwe (SA) | Somalia (EA); Mauritius (SA) | 4,590 |
| V | <30 | 14 | Eritrea, Rwanda, South Sudan, (EA); Burkina Faso, Niger (WA); Chad (CA); Lesotho (SA) | Burundi, Comoros, Ethiopia, Kenya, Uganda (EA); Malawi, Swaziland (SA) | 1,937 |
| | | 54 | 36 | 18 | 5,031 |

*Source 6: ERA, 2017*

The categories have been further designed to distinguish between resource-rich countries and non-resource-rich countries whereby several myths can be dispelled such as, 'resource-rich countries feature better urbanization than those that are not'. There are various reasons that lead to these disparities including consumption-led economies, but we shall not delve into that.

Africa's definitive challenge is faced with the dire need to provide services towards the rapid urban population growth and to create job opportunities while competing in a global

economy that is carbon constrained and managing the concentration of biophysical and institutional climate-change risks. Pieterse (2013) coins the term "Urban dividend" to describe the economic benefits that emanate from an alignment of talented but unemployed people, livelihood opportunities and services in cities. This alignment features in OECD and Asian countries' economic growth, where differences in the rural–urban productivity contributed towards urbanization generating productivity gains and economic growth (Spence et al., 2009). This had been in alignment with a simultaneous provision of energy that offered safeguards towards this growth. But Africa's urbanisation defies convention in a number of structural ways. That so much of the continent is unbuilt and under serviced urban environment thereby creating an opportunity to decouple urban development from emissions and to anticipate risks associated with climate-change and the potential impact of carbon constraints on global markets (Cartwright, A., 2015). Acknowledging this grand opportunity is underscored by the recent increases in access to clean energy (renewables), technology and information and the recent economic growth. Figure 7 presents an illustration of the nexus of urbanization and industrialization and the energy driven elements that lie at the core of the nexus.

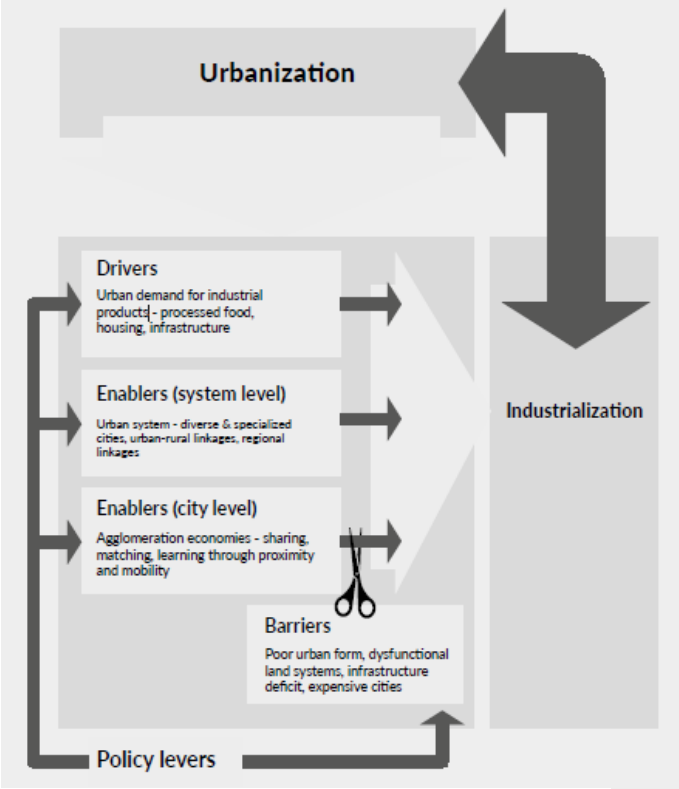
The Economic Report for Africa (ERA) (2017) examines deeply the correlation between urbanization and industrialization (harness urbanization for industrialization) stating that:

> "Under the right policy framework African countries can leverage the momentum of urbanization to accelerate industrialization on for a more prosperous and equitable future."

The report also points out the crucial need for coordination with the energy, transport, communications and technology sectors, other than industry in shaping the continent's urban landscape. However, the challenge facing Africa is to accelerate structural transformation by harnessing the rapid urban transition to promote economic diversification. As it is there is a continued trend of urbanization within the context of

deindustrialization resulting in cities with poorer populations and higher informality (ERA, 2017).

*Figure 7: The urbanization–industrialization nexus*



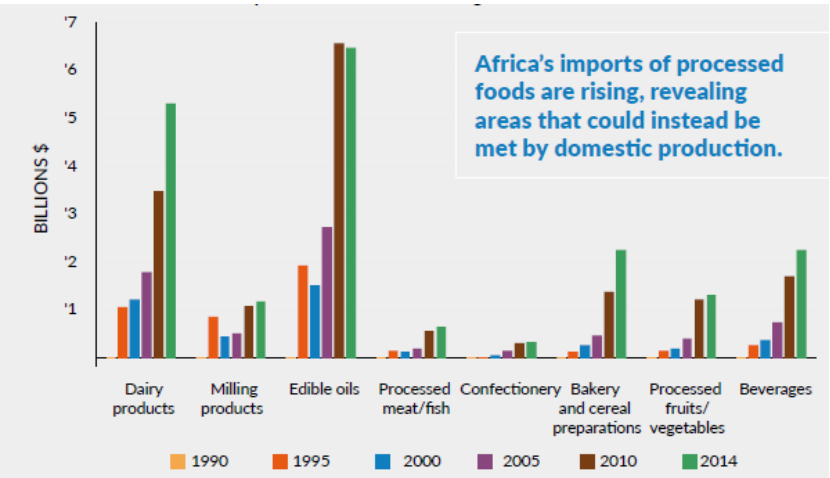

*Source 7: ERA (2017).*

Measures are still yet to be put in place to promote faster avenues for higher productivity such as manufacturing, even if there are potentially high costs involved such as the afore mentioned energy efficiency losses.

Barrios et al. (2006) estimated that a reduction in national rainfall of 1% led to an increase in the national urban share of 0.45%. The lack of structural transformation in Africa poses even greater problems when faced with the climate-induced declining productivity in the agricultural sector. In their eye opening study, '*Has climate change driven urbanization in Africa*?' Henderson J. et al. (2017) poises that a decrease in moisture levels leads to an increase in populations in cities and incomes in places whose cities are likely to have manufacturing, and are therefore more likely to be able to absorb workers leaving farms into the urban labour force. Therefore, a persistent occurrence in climate change would further accelerate migration to more industrialized cities and furthermore, if structural transformation continues to be elusive, it will become more critical to extend support towards agricultural adaptation. The ERA (2017) reiterates this as it points out three key components that are critical towards achieving structural transformation in Africa: (i) productivity gains in agriculture (ii) expansion of employment in industry and

services at a rate fast enough to absorb the surplus in agricultural labour and (iii) links between domestic agricultural production and urban food consumption. To add to that there is a growing need for cities to meet the demand for food hence the rapid increase of importations as showcased in Figure 8. In all these three energy plays a very critical role, and more so, reliable, affordable, accessible and clean sources.

*Figure 8:Major constraints listed by firms in cities above and below 1 million population, 2006–2015*




*Source 8: ERA, 2017*

Numerous literature points us in the berth of evidence that urban and industrial development in Africa are disconnected. This explains why there has been a loss in opportunities for creating jobs and improving the well-being of the people. According to the 2017 ERA's report, a majority of the cities are also crippled by severe gaps in infrastructure and the service sector, low productivity, tepid job creation (an inability to generate employment at the same rate as the arising demands especially for bulging youth), high informality (including the precariat), weak linkages with rural areas (also, with time some rural towns are reclassified to urban areas), high degrees of informality, increasing inequalities, growing instances of damages to the environment and vulnerability to climate change and weak institutional systems and capacities. Ensuring the sustainability of Africa's cities and industries means prioritizing the need to reconnect urban and industrial development through deliberate policies, strategies and investments.

> "Cities require better performing industrialization and industrialization requires better functioning cities" (ERA, 2017).

> "Importantly, the opportunities arising from urbanization for industrialization and

from industrialization for urbanization need to be articulated in national development plans if the respective sector policies are to be linked. In turn, this should inform sector policies guiding urban and industrial development" (ERA, 2017).

A multi-dimensional approach towards urbanization encompasses and shapes all the three pillars of sustainable development which include, the economic development, social development and environmental protection (UNDESA, 2014).

The table below is a summary of the common urban and industrial issues (ERA, 2017).

*Table 1: Common urban and industrial issues*

| URBAN | INDUSTRIAL |
|---|---|
| Urban infrastructure: electricity, transport, water and sanitation, and so on | Infrastructure for industry: electricity, transport, logistics, and so on |
| Employment clusters and urban jobs | Clustering of competitive sectors |
| Cities in a nursery role, firm churning | Industrial innovation |
| Urban-based R&D, IT and training institutions; education and human capital | Industrial upgrading |
| Consumption cities | Resource-rich disadvantages, including currency overvaluation |
| Duality of labour market in cities, constraints to labour mobility | Flexible labour markets, labour pooling, labour matching |
| Port cities, trade logistics | Export competitiveness |
| Clustering; proximity; co-location of industries; urban efficiency | Agglomeration economies |
| Urban systems and SEZs | Industrial location matching |
| Urban land market functionality | Access to land |

*Source 9: ERA, 2017*

The inefficiency of sub-Saharan Africa's state-owned and run utilities cost 0.68% of GDP, and if operational efficiency, rates of revenue collection, transmission losses and staffing levels at these utilities were standardised with international norms, this would recover approximately $8.2 billion in efficiency gains (Eberhard et al., 2011)! An amount that if redirected towards industrial and infrastructural development would accelerate the

attainment of the set goals. Such losses tend to delay the much desired growth and improvement of livelihoods.

### *3.6.4 Manufacturing Value Addition (MVA) in relation to Productivity*

According to the Industrial Development Report of 2016, Africa's MVA remained very low and accounted for only 1.6% of the world's MVA. Industrial and manufacturing development has not improved over time. The share of African MVA in GDP fell from 12.8% in 1990 to a low of 10.1% in 2014. The IDR (2016) reiterates that both innovation and structural changes are the drivers of inclusive and sustainable development, and are largely attributable to its higher productivity and scope for innovation. Technological change enables countries to upgrade their productive system, thus providing the conditions for access to foreign markets and the opportunity for export-based growth. The report underscores this in distinguishing how developing and high-income countries display a range of differences in the way manufacturing drives economic growth. Contributions to output growth in developing countries are mainly derived from capital investments, natural resources and energy while in high-income countries, they mainly come from productivity.

Looking at Africa's performance within the Competitive Industrial Performance (CIP) index, in 2013, out of 141 countries, South Africa ranked 41$^{st}$ at 0.088, Algeria ranked 87$^{th}$ with a CPI of 0.022, Nigeria ranked 110$^{th}$ at 0.011, Kenya ranked 113$^{th}$ at 0.010 and Ethiopia ranked 138$^{th}$ at 0.002 (UTIP-UNIDO, 2015). Between 1990 and 2014, Africa's share in the global total world manufacturing value added ranged only between 1.5 and 1.7%, while the rest of the regions (with the exception of Latin America) ranged between 20 and 45% (UNIDO, 2015).

### *3.6.5 Urbanization, industrialization and CO2 emissions*

A recent study shows that, there is no significant relationship between urbanization, industrialization and CO2 emissions in low-income countries, in the short run, but,

urbanization and industrialization are positively correlated with CO2 emissions in the long run. In upper-middle-income countries, only urbanization has a significant correlation in the short run, but in the long run, both urbanization and industrialization have significant effects on CO2 emissions. In lower-middle-income countries, only industrialization is lightly correlated with CO2 emissions in the long run (Ntouko C. et al, 2016).

### *3.6.6 Innovativeness in Industrialization*

Industrialisation strategies of the twenty-first century call for innovative approaches, especially in Africa where numerous new opportunities and challenges await to be harnessed. Especially those which other regions did not (or won't have) to face. Africa cannot afford to miss out on the opportunity to create enabling environments including the designing of relevant policies that would aid tap into this opportunity. According to the African Economic Outlook (2017) the refined strategies include:

i. the new industrial revolution enhancing automation in industrial production,
ii. the changing economic environment characterised by the slow-down in global growth and by the end of the commodity super-cycle and
iii. the rising labour costs in East Asia

The role of entrepreneurs in Africa's transformation has become pivotal as they are proving to play an essential role in bringing innovation to an economy, notably new technologies and production methods. Those categorised as high-potential tend to experiment with new products in local markets whilst they offer fresh ideas and exchange information with other local producers, potentially increasing competitiveness by shifting resources to higher-productivity activities (AEO, 2017). The role of entrepreneurship in industrialisation has been highlighted severally in economic theory (Cantillion, 1730; Knight, 1921; Schumpeter, 1942). According to Schumpeter (1942) the inventor produces ideas, the entrepreneur 'gets things done'. Africa's entrepreneurs are younger than in other developing regions at a median age of 31, which is much younger than counterparts in East Asia at 36 years and Latin America at 35 years (AEO, 2017). The 25-34years age bracket

accounts for 38% of entrepreneurs in Africa, followed by the 18-24 and 35-44 age groups that each account for 23% of the working-age population. Some entrepreneurs promote growth more than others, such as those that are opportunity driven. They are the most productive as they are motivated by a desire for self-realisation or by a wish to exploit a business opportunity. On the other hand, entrepreneurs who are rent-seeking tend to be highly unproductive (Baumol, 1990) and engage in illegal or market-capturing behaviour (Landes, Mokyr and Baumol, 2012).

This Fourth Industrial Revolution gives more importance to services and promotes industrialisation based on shifting resources into more sectors than manufacturing alone. This then brings forth the urgency to advance in embarking on increasing the levels of science, technology and innovation. Also, policies on green industrialisation can help avoid the environmental degradation caused by industrialisation processes and thus contribute towards the desired innovativeness (UNECA, 2016).

## 3.7 Energy, Climate Change and Vulnerabilities

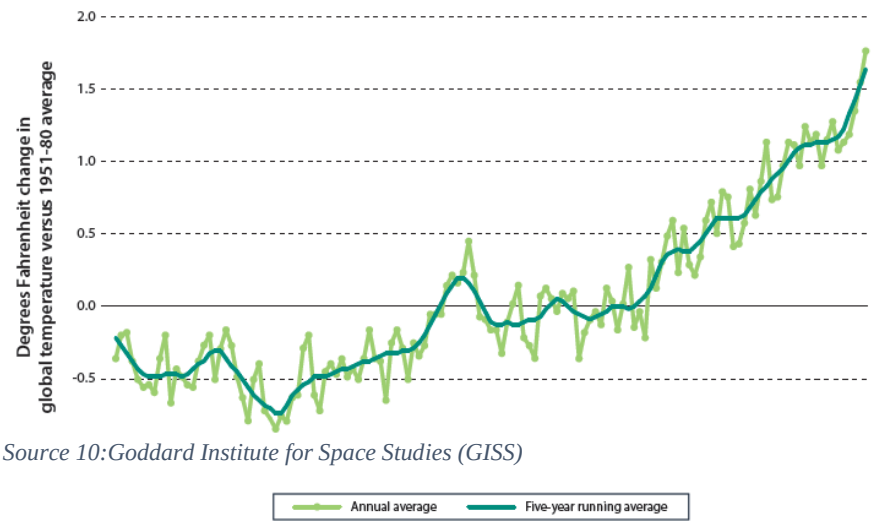
The IPCC (2007b) mentions that time taken to remove CO2 from the atmosphere is at a very slow rate such that even if policy actions were to be undertaken today to completely eliminate CO2 emissions, the atmospheric CO2 concentration would fall by just 40 parts per million over the entire 21st century. It has been evidenced that global warming would still continue for some time even if anthropogenic induced greenhouse gas production ceased, a concept defined as 'the Climate Commitment' whose definitive scientific consensus on the extent of that commitment have been prevented by complex atmospheric physics (Armour, K. C. et al., 2011).

Lucas et al., (2015) deduce that a lack of a climate policy in Africa is characterised by an increase of her share in the world's energy-related CO2 emissions, projected to increase to

between 3–23% by 2100 and that it is highly likely that this increase in demand will be met with a supply by sources from fossil fuels.

As a result, Africa's energy-related CO2 emissions are expected to increase by a factor 7 to 50 between 2010 and 2100, which is much faster than the current global projections.

*Figure 9: Global Temperature Change, 1880–2015*




*Source 10:Goddard Institute for Space Studies (GISS)*

Consequently, the share in global energy-related CO2 emissions is projected to increase from 1–4% in 2010 to 3–23% in 2100, with emissions beginning to become really significant on a global scale after 2050.

Just as the impacts of climate change on economic or natural systems can affect the demand and supply for energy, likewise impacts of climate change on energy systems may have indirect effects on the former. Schaeffer R, et al., (2012) identify two main cross-sector impacts on energy from climate change as (i) competition for water resources (in generation of electricity, oil refining and irrigation of energy crops) and (ii) competition for land (majorly for the production of biofuels). The table below showcases energy sector's vulnerability to climate change.

### *3.7.1 Energy sector's vulnerability to climate change*

*Figure 10: Energy sector's vulnerability to climate change*

| Item | Relevant climate impacts | | | Impacts on the energy sector |
|---|---|---|---|---|
| | General | Specific | Additional | |
| **Climate change impacts on resource endowment** | | | | |
| Hydropower | Runoff | Quantity (+/-)<br>Seasonal flows high and low flows<br>Extreme events | Erosion<br>Siltation | Reduced firm energy<br>Increased variability<br>Increased uncertainty |
| Wind power | Wind field characteristics, changes in wind resource | Changes in density, wind speed<br>Increased wind variability | Changes in vegetation (might change roughness and available wind) | Increased uncertainty |
| Biofuels | Crop response to climate change | Crop yield<br>Agro-ecological zones shift | Pests<br>Water demand<br>Drought, frost, fires, storms | Increased uncertainty<br>Increased frequency of extreme events |
| Solar power | Atmospheric transmissivity | Water content<br>Cloudiness<br>Cloud characteristics | | Positive or negative impacts |
| Wave and tidal energy | Ocean climate | Wind field characteristics<br>No effect on tides | Strong nonlinearity between wind speed and wave power | Increased uncertainty<br>Increased frequency of extreme events |
| **Climate change impacts on energy supply** | | | | |
| Hydropower | Water availability and seasonality | Water resource variability<br>Increased uncertainty of expected energy output | Impact on the grid<br>Wasting excessive generation<br>Extreme events | Increased uncertainty<br>Revision of system reliability<br>Revision of transmission needs |
| Wind power | Alteration in wind speed frequency distribution | Increased uncertainty of energy output | Short life span reduces risk associated with climate change<br>Extreme events | Increased uncertainty on energy output |
| Biofuels | Reduced transformation efficiency | High temperatures reduced thermal generation efficiency | Extreme events | Reduced energy generated<br>Increased uncertainty |
| Solar power | Reduced solar cell efficiency | Solar cell efficiency reduced by higher temperatures | Extreme events | Reduced energy generated<br>Increased uncertainty |
| Thermal power plants | Generation cycle efficiency<br>Cooling water availability | Reduced efficiency<br>Increased water needs, for example during heat waves | Extreme events | Reduced energy generated<br>Increased uncertainty |
| Oil and gas | Vulnerable to extreme events | Cyclones, floods, erosion and siltation (coastal areas, on land) | Extreme events | Reduced energy generated<br>Increased uncertainty |

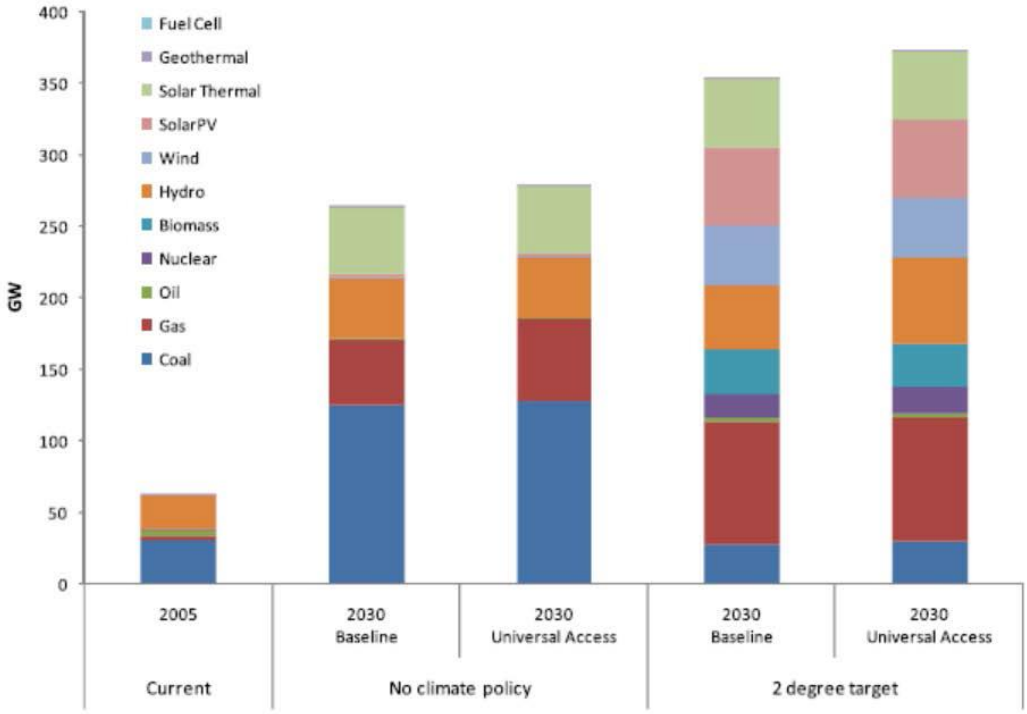
*Continued.*

| Item | Relevant climate impacts | | | Impacts on the energy sector |
|---|---|---|---|---|
| | General | Specific | Additional | |
| **Impacts on transmission, distribution, and transfers** | | | | |
| Transmission, distribution, and transfers | Increased frequency of extreme events<br>Sea level rise | Wind and ice<br>Landslides and flooding<br>Coastal erosion, sea level rise | Erosion and siltation<br><br>Weather conditions that prevent transport | Increased vulnerability of existing assets |
| **Impacts on design and operations** | | | | |
| Siting infrastructure | Sea level rise<br>Increased extreme events | Flooding from sea level rising, coastal erosion<br>Increased frequency of extreme events | Water availability<br>Permafrost melting<br>Geomorphodynamic equilibrium | Increased vulnerability to existing assets<br>Increased demand for new good siting locations |
| Downtime and system bottlenecks | Extreme weather events | Impacts on isolated infrastructure<br>Compound impacts on multiple assets in the energy system | Energy system not fully operational when community requires it the most | Increased vulnerability.<br>Reduced reliability<br>Increased social pressure for better performance |
| Energy trade | Increased vulnerability to extreme events | Cold spells and heat waves | Increased stress on transmission, distribution, and transfer infrastructure | Increased uncertainty<br>Increased peak demand on energy system |
| **Impacts on energy demand** | | | | |
| Energy use | Increased demand for indoor cooling | Reduced growth in demand for heating<br>Increased energy use for indoor cooling | Associated efficiency reduction with increased temperature | Increased demand and peak demand, taxing transmission and distribution systems |
| **Other impacts** | | | | |
| Cross-sector impacts | Competition for water resources<br>Competition for adequate siting locations | Conflicts in water allocation during stressed weather conditions<br>Competition for good sitting locations | Potential competition between energy and nonenergy crops for land and water resources | Increased vulnerability and uncertainty<br>Increased costs |

*Source 11: Ebinger J. (2011)*

Bazilian et al., (2012) presented a set of scenarios of energy futures for economy-wide access in SSA based on Global energy assessment scenarios, with and without the climate policies in place as shown below: With a climate policy there are more opportunities and avenues for exploring different sources of energy.

*Figure 11: GEA scenarios with resultant generation types to 2030*




*Source 12: Riahi et al., 2011*

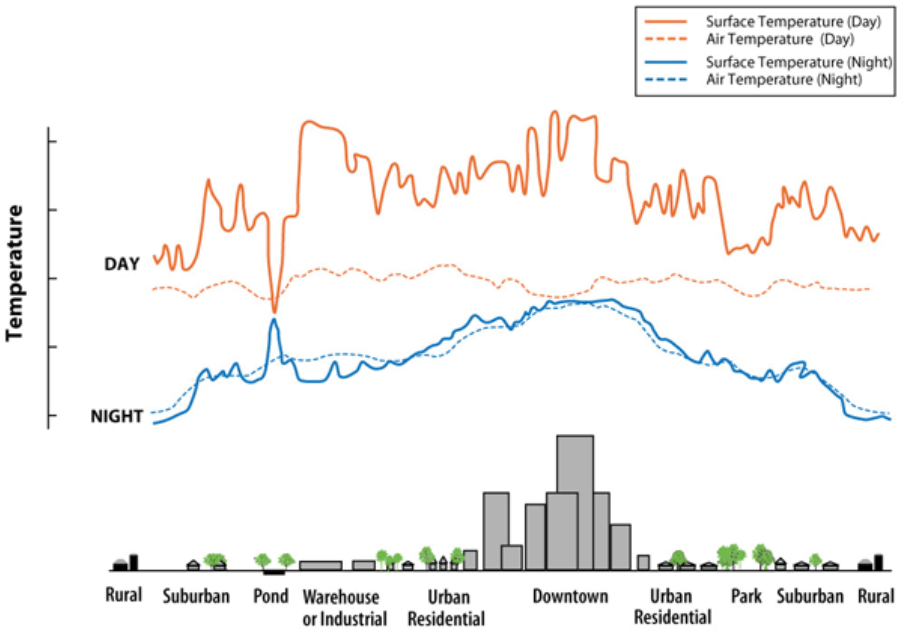
The figure above shows access rates in the base year and projections up to 2030 for a scenario with 'no new policies' or resources for improving the rate of electrification, and another with a 'universal rural electricity access' target. In sub-Saharan Africa, rural electrification in 2005 was less than 10%. If we maintain the trend with increasing GDP per capita within the 'no new policies scenario', this is projected to increase to only 15% by 2030. The study estimates that an additional generation capacity, between 14 and 20 GW, is required by 2030 to achieve universal rural electrification in Sub-Saharan Africa (Bazilian et al., 2012).

Looking at the cost benefit analysis of climate change impacts on developing country cities, estimates have been drawn from various sources including the World Bank who estimate that 2°C of warming would cost an additional $56–$80 billion per year in 2050. In 2015,

UNEP released a report suggesting that 2°C of warming could cost Africa $50 billion per year by 2050.

The Fifth Assessment Report of IPCC (AR5) of 2014, alludes to there being three core components determining climate-driven risks with vulnerability being one of them. The other two include hazard and exposure (IPCC, 2014). The AR5 defines vulnerability as "the propensity or pre-disposition to be adversely affected", encompassing "a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2014). The Indicator-based Vulnerability Assessments (IBVAs) are aimed at characterizing processes shaping vulnerability within specific domains of the system being analysed (Tapia C., et al., 2017). The vulnerabilities of cities to climate change cannot be gainsaid. African cities are increasingly facing the urban heat island effect (Fig. 11) particularly in warm weather due to high levels of surfaces that are sealed and built density and flooding as a result of increased precipitation levels (Kuttler, W., 2010, EEA, 2012). The idea of integrating green infrastructure into the built environment for positive effects on microclimates has been showcased by several studies (BMUB, 2015, Gondhalekar et al., 2016). There is a study that showcased an increase of temperature of up to 4°C by 2080 in high-density built areas if no changes to green cover were made, that temperatures would almost remain the same with just an increase of 10% of green cover and that a temperature increase of about 8% would occur if 10% of the prevailing green cover is no longer available or removed (Gill, S.E et al., 2007). Indeed, it is essential for green infrastructure to be capitalized on in current and future plans. Green infrastructure is not a silver bullet in itself. It carries along with it some constraints (WMEAC, 2013); it largely works better in sandy soils and above water tables. Difficulties are encountered with clay-filled soils and low-lying areas. Another constraint is integrating it into built, dense environs although, tree canopies, rooftops, right-of-way(s) and parking space can be utilized.

*Figure 12: Urban Heat Island Effect*




*Source 13: Ebinger (2011)*

Urban agriculture is also slowly gaining popularity in the African context where food prices continue to soar. This is so especially due to extreme weather events such as drought and the distances from their source in rural areas, not to mention poor road infrastructure and costly preservation mechanisms, if any. There are much more cost saving opportunities in urban agriculture and potential; for meeting future increased demands for food.

## 3.8 Sub Nexuses

According to UNEP, within 20 years, global water demand is expected to exceed supply by 40% (UNEP, 2014) and according to the IEA by 2030 the global energy demand will have grown by 40% (IEA, 2009). There are close links between energy and water systems. The consumption/production of one of these two resource cannot be achieved without making use of the other. At the same time, both their supply is affected by climate change. Demand for food is also expected to increase by 60% (WBCSD, 2014). It has been noted that cities exhibit limited capacity that is necessary to embark on climate change mitigation,

in the form of energy efficiency and adaptation. This is especially so where the management of water resources is pertinent (UN Water, 2010). In order to support the resilience of cities, there is need to integrate these two fundamental areas (Head, P. et al., 2011, Jane E., et al., 2011).

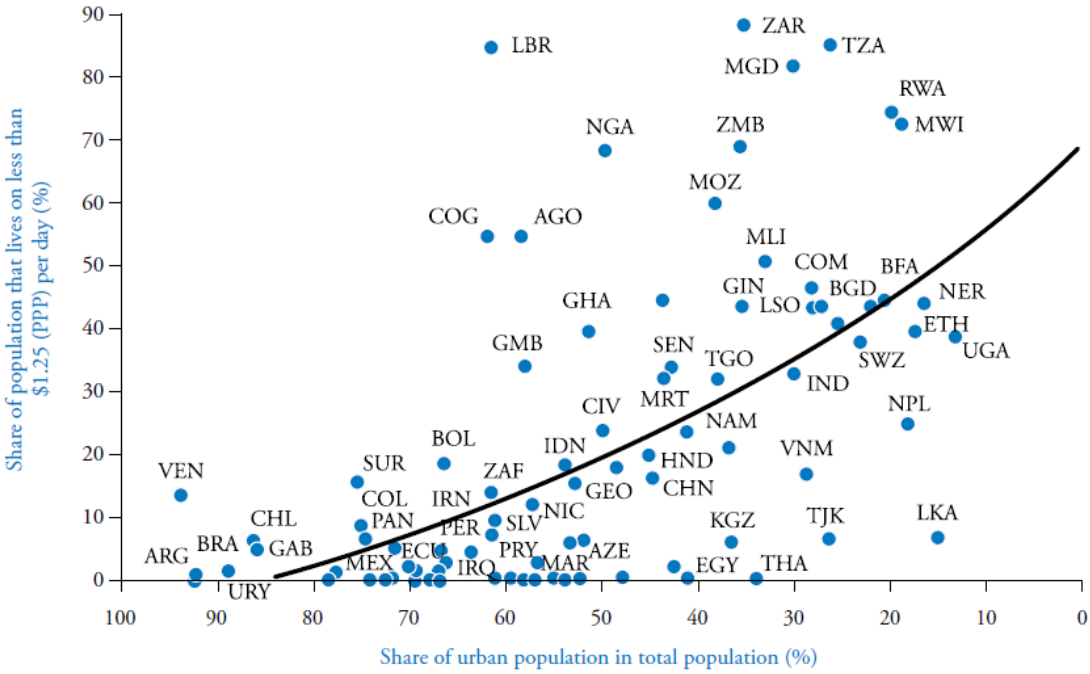
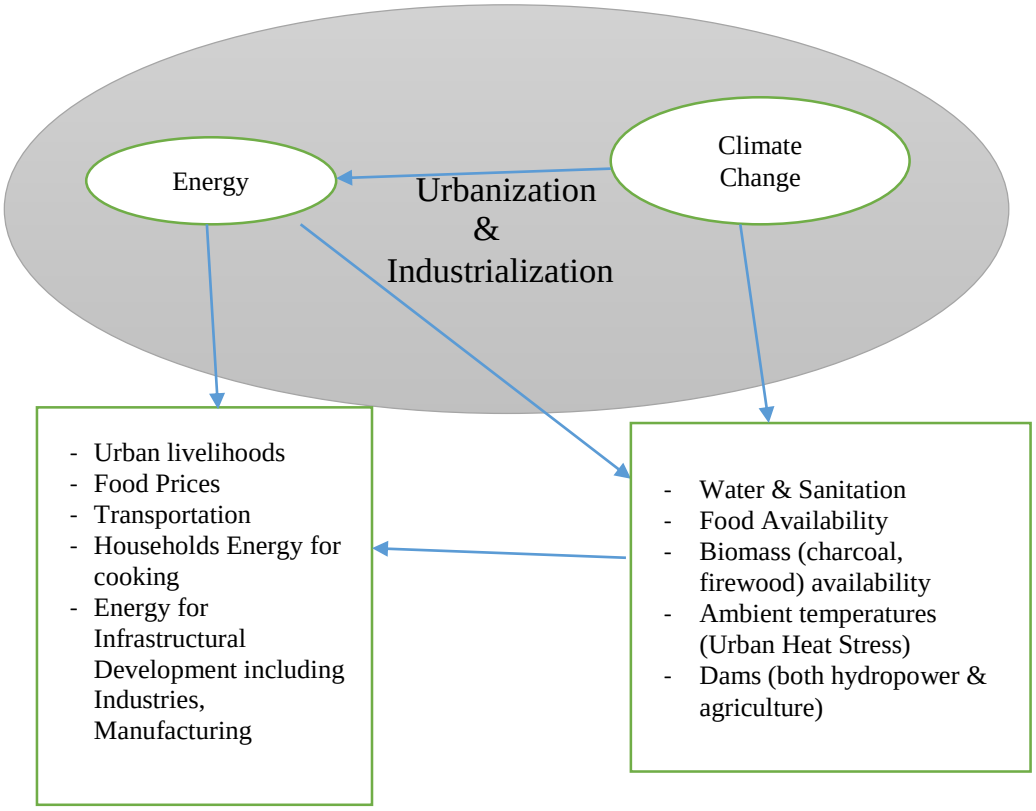



*Figure 13: Nexus between Urbanization, Poverty and Prosperity*

*Source 14: World Bank. 2013. "Global Monitoring Report 2013: Rural-Urban Dynamics*

*In Summary…*

*Figure 14: Summarized conceptual framework*




*Source 15: Author's own*

# CHAPTER IV

# METHODOLOGY

In applying a qualitative approach, a textual analysis was conducted focusing primarily on desktop research with accompanying informal interviews from key personnel specializing in some identified fields of profession such as Climate Change, Energy, Public Policy and Economics. As a multifaceted study a comprehensive review on the topic included both academic and grey literature (Vetenskapsrådet, 2011).

The analysis is based on a qualitative text analysis, based on some documents such as journals, reports, policy documents, action plans and strategies. Focus has been put on the texts contextualises, and their relation to and interpretation of energy, climate change, urbanization and industrialization. According to this method (Kohlbacher, F. 2005) the content has been ordered structurally in line with the thesis' aim and research questions (Ibid.).

Since the methodology majorly focuses on textual analysis the material is interpreted in regards of their context and contents, and thereafter connected to the overall aim of the study. To avoid misinterpretations, various and differing references are used as well as analysing the texts based on systematic and uniform perspectives (Vetenskapsrådet, 2011). As earlier mentioned, most of the texts have been analysed based on the following themes: underlying reasons and problems, implementation processes as well as visible results and outcomes (Kohlbacher, F., 2005). In their text analysis Pennycook G. and Medimorec (2015) are able to reveal the differences in language use between climate change proponents and sceptics. Unlike them who deployed tools such as Linguistic Inquiry and Word Count (LIWC; Tausczik and Pennebaker 2010), I based mine on observation. The themes have been identified using techniques such as 'Word repetitions', 'Key-words-in-context (KWIC)' and 'Compare and Contrast' as identified across the texts and the informal

interviews (Wiener J., 1997; Ryan G. & Bernard H., 2003).

The following themes have been utilized throughout the research. They include:

i. Clean, affordable, available, accessible, reliable and sustainable energy
ii. Climate change adaptation and mitigation
iii. Urbanization
iv. Industrialization
v. Structural transformation.

The mode of collecting information was as follows:

*Table 2: Mode & Means of Verification*

| | **Mode** | **Activities/Means of Verification** |
|---|---|---|
| 1 | Desktop | Identification of key factors, statements and data |
| 2 | Interviews/Consultation | Dialogues on counter checking my results and perspectives and verification of my understanding |

*Source 16:( Strauss & Corbin, 1990; Wiener J., 1997)*

The themes and the information gathered led to the following set of variables:

*Table 3: Variables/Underlying Theme*

| | **Variable/Underlying theme** | **Motivation** |
|---|---|---|
| 1. | Energy | i. Factors exacerbating Energy Poverty<br>ii. Characterise the difference sources of energy: Availability, Accessibility, Affordability<br>iii. Status of energy transition towards renewable sources: Past and present Enablers and Drivers of Energy Security<br>iv. Impacts of Climate Change on the existing Energy Systems |

| | | |
|---|---|---|
| | | v. Energy resilience to climate impacts (Energy mix etc. decentralisation of distribution system etc.) |
| 2. | Demographic changes | i. Projected population dynamics including natural growth vs migration |
| 3. | Structural transformation | |
| 4. | Climate change adaptation and mitigation | i. Status of Climate Change adaptation and mitigation strategies and plans: Integrated and multidimensional policies addressing Climate Change adaptation<br>ii. Climate Resilience Planning (Energy and some key sectors such as water and sanitation, food availability) |
| 5. | Emissions | i. Status of Emissions<br>ii. Emitting sectors |

*Source 17: Author's own*

# CHAPTER V

# RESEARCH FINDINGS AND DISCUSSION

## 5.1 Introduction

Energy has been the most fundamental panacea for our existence. Her dynamic inextricable linkages continue to weave into more complex, nay transformative learning opportunities, especially within the SSA context. Tapping into this resource means that the uncharted paths, within the existing (and potential) linkages of climate change, urbanization and industrialization are explored. Africa is already experiencing significant climate variability. The region is warming faster than the world as a whole, with climate impacts varying greatly by location and felt disproportionally by the poor. Amidst this is a ray(s) of silver lining of opportunities for transformation. Look at the facts below, for instance:

i. More people start a new business in Africa than in LAC or Asia
ii. African women are twice as likely to start a business than women elsewhere
iii. 20% of new African entrepreneurs (working-age population) are introducing a new product or service
iv. At least 26 African countries have industrialisation strategies in place in 2017.
v. Every year between 2015 and 2030, 29 million new entrants will join Africa's labour force and
vi. Manufacturing remains the central sector on which Africa's industrialisation policies can rest (AEO, 2017).

The link between energy and climate change has the following dimensions; (i) vulnerability of energy supply to climate change, (ii) greenhouse gas emissions from the energy sector, and (ii) access to energy to enhance adaptive capacity.

The prospect of an urbanized humanity in Africa has put her cities in the spotlight for climate action. Although cities are at the forefront of mitigation and adaptation actions and measures climate strategies are not implemented within a vacuum. They are bound to interact with other local economic and social policies. These interactions can lead to trade-

offs and obstacles in their implementation, or to potential synergies. Furthermore, the implementation of climate actions and strategies introduces competition for investments from already existing social and economic public finances.

Urbanization is the single most important transformation that the African continent will undergo this century. More than half of Africa's population will live in its cities by 2040. This translates into a population growth of more than 40,000 new urban dwellers per day between now and 2040.

Industrialization is an important concern in Africa for some reasons. Firstly, there is a positive link between industrialization and growth. Secondly, economies in African countries rely on the exportation of commodities. The ensuing volatility of prices of commodities exposes them to a pro-cyclical budget and consequently, it cannot lead to any development program. Thirdly, African countries need to diversify their economies through the processing of primary products adding to them greater value. As a result, there would be creation of more job opportunities and a substantial reduction of poverty.

Given the above, a careful analysis of how well the energy, climate change, urbanization and industrialization policy measures are being integrated needs to examined, and a deduction made to ascertain their integration in the first place. For this case we looked at Ethiopia, Kenya, South Africa and Nigeria.

## 5.2 The case of Ethiopia

### *5.2.1 Introduction*

Ethiopia's rise in economic development and growth can be summed as one driven by the awakening of the giant within the country's energy and infrastructural potential. In order to sustain this growth, the country has laid down various road maps to steer their ship taking into account the available labour. The fundamental questions in this segment are:

1. Will Ethiopia's future inhabitants be able to have access to Energy that is clean, affordable, available, accessible and reliable?
2. Is there an existing nexus between energy, climate change, urbanization and industrialization? If such exist how well do they gel in together?
3. How do the measures towards climate change and energy impact on Ethiopia's urbanization and industrialization?

Ethiopia's national long-term development blueprint is the Grand Transformational Plan which is now in its second phase (GTP II). According to ECA (2016) 2004 marks a turnaround for the Ethiopian economy whereby results from policies of the first development plan that covered 2002-2005, the Sustainable Development and Poverty Reduction Program (SDPRP) begun to materialize. This plan was followed by the first 5-year development plan, the Plan for Accelerated and Sustained Development to End Poverty (PASDEP), covering 2005-2010. Since then, 5-year development plans have become a hallmark of Ethiopian development policy, with the GTP covering 2010-2015, and the GTP2 covering 2015-2020.

Real GDP growth slowed to 8.0% in 2015/16 from 10.4% last year and is projected to remain stable at 8.1% in 2016/17 and 2017/18 (AEO, 2017). With a GDP per capita of around USD380, Ethiopia is still one of Africa's poorest countries. With an annual population growth of more than 2%, Ethiopia will have more than 120 million people by 2030 (FDRE, 2011). Below is a summary of the current status of the country in terms of the population, GDP per Capita, etc.

*Table 4: Basic indicators of Ethiopia, 2016*

| . **Basic indicators, 2016** | | | | | | |
|---|---|---|---|---|---|---|
| | **Populati on** (thousan ds) | **Land area** (thousands of km2) | **Population density** (pop. / km2) | **GDP based on PPP valuation** (USD Million) | **GDP per Capita** ( PPP valuation, USD) | **Annual real GDP growth** (average over 2008-2016) |
| Ethiopia | 101 853 | 1 104 | 92 | 174 742 | 1 716 | 9.7 |

*Source 18: AEO, 2016*

With regards to Ethiopia's SES, the variation in climate, soil type and cultural practices across the country are accounted for by the variation in the biophysical characteristics which range from hot arid desert to mountain ranges (ENC, 2016).

### *5.2.2 Status of Energy in Ethiopia*

About 80% of Ethiopia's populace relies on biomass; firewood and charcoal specifically, majorly for residential usage. Biomass energy, consisting of wood, charcoal and agricultural residues, provides ninety-two% of the total final energy consumed. As it can be witnessed it is neither entirely clean nor entirely reliable. There is growing pressure arising from urbanization and a vision to economically transform the country from a least developed economy (LDC) to better rankings, globally.

Ethiopia is endowed with vast untapped resources for harnessing energy, especially in renewable energy such as solar, hydro, biomass and wind. As of 2011, the country's hydro power potential had been estimated at over 45,000 MW but had only been developed at less than 5% of this potential capacity (ADB, 2011). It has since increased. Solar energy has a national annual average daily irradiance estimated at 5.2 kWhm-2day-1 with seasonal variations that range between a minimum of 4.5 kWhm-2day-1 in July to a maximum of 5.6 kWhm-2day-1 in February and March (ENEC-CESEN, 1986). This is yet to be harnessed. There is great potential to derive bioenergy from forest resources (Prosopis juliflora), agricultural and agro-industrial waste and liquid biofuels. Despite that the utilization of Ethiopia's forest resources is not sustainable (as at 2013), there are areas where biomass resources are underutilized. Bamboo forests and shrubs are considered to be inexhaustible biomass resources. The bamboo forests in the southern parts and western periphery of Ethiopia is estimated to be spread over an area of 0.5-1.0 million ha, whereas there are huge tracts of shrubs in the lowland areas towards the east (ENC, 2016). Also, waste and by-products from agriculture and agro-based industries (coffee, cotton, oilseeds and sugarcane processing) potentially serve as untapped energy sources. The biomass waste from these sources is estimated to be 4 million tons annually and only a small portion

is currently utilized. There is availability of urban solid and liquid waste in the major cities but there are currently no projects converting it into energy (ENC, 2016).

The total energy consumption is estimated to be approximately 1,250 PJ, with the traditional biomass fuels (the main sources of energy) translating to 16 GJ of energy (1,000 kg of wood equivalent) per capita (ENC, 2016).

In the past the cost of doing business was quite high, in terms of the availability of firms to afford and access energy. In light of this, various targeted efforts have been put in place to aid in alleviating this problem, and in a bid to provide energy that is clean, affordable, available, accessible and reliable.

Firstly, a key objective set in the Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) covering the 2005/06-2009/10 period was to increase the country's generating capacity from 791 MW in 2005 to 2,842 MW by 2010, particularly through the development of the country's hydro power potential, which has been aforementioned.

Secondly, in 2012, it was projected that the Grand Renaissance Dam on the Nile would be completed in 2017, quadrupling its power generation capacity and be able to generate 10,000 MW (EIU, 2012). The dam had been set to be one of the largest hydroelectric power stations in the world and generating twice as much power as Nigeria's current capacity (ECA, 2016), thus leading to attaining one of the major Grand Transformation Plan's (GTP) goal. Ethiopia reached this significant milestone in 2016 with the remaining 1.5 GW of Ethiopia's Gibe III coming online, marking the completion of the 1.87 GW plant, with an additional 800MW (Impregilo S., 2016, ESI, 2016). The plant is expected to serve about half of its output to neighbouring countries Kenya, Sudan and Djibouti. Alongside this project, a transmission interconnection is being built in order to export power, firstly, to Kenya where it is set to be completed in 2018, secondly, to upgrade internal transmission to improve poor grid reliability at home (ESI, 2014). Other/additional targets for renewable energy set by Ethiopia include:

i. Bio-power from bagasse is set at 103.5 MW but no date has been provided

ii. Geothermal power is set at 450 MW by 2018, 1 GW by 2030
iii. Hydropower 22 GW by 2030
iv. Wind power 7 GW by 2030, 770 MW by 2014 (REN21, 2017).

There is also the National Biogas Program of Ethiopia (NBPE) is part of a continental program for large-scale deployment of domestic biogas, which is implemented in four regional states of Ethiopia. These states account for 85% of the total population.

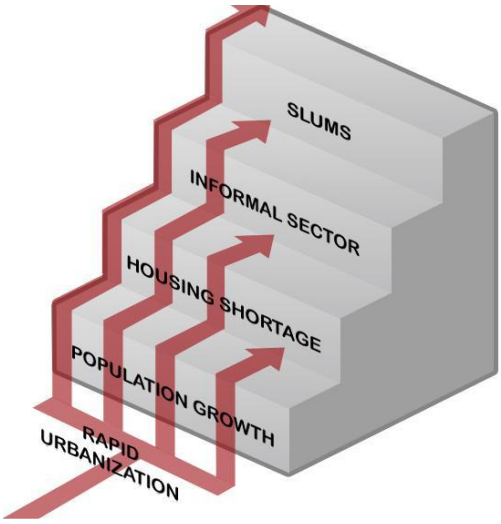
Whether the country's energy development will be clean, affordable, available, accessible and reliable is not succinctly expressed in totality, however the various initiatives are contributing immensely towards achieving this goal. The government identifies the energy sector as a key economic infrastructural component in the country's development plans. The GTP envisages a reliable supply of energy to the different economic and social sectors as well as the generation of foreign currency earnings by developing the country's potential. The key focus areas in the energy sector include (i) developing renewable energy sources and (ii) strengthening the capacity to administer the energy infrastructure. It may take some time and much more investments to enable each and every citizen to gain access to modern forms, such as electricity. However, with improved economic development and an accelerated development of the energy infrastructure, the people will increasingly manage to afford the associated costs thus enabling a faster means of their access. Given the climate driven sources, chances of ensuring that reliability will improve will depend on how well they are adapted to the looming climate change, as mentioned elsewhere in this chapter.

### *5.2.3 Ethiopia's structural transformation, what is the underlying key nexus (es)?*

In Ethiopia, 16% of the population lives in urban areas and it is projected to increase to 129.1 million by the year 2030 (ENC, 2016). Addis Ababa is characterised as a primate city facing numerous pressures as a result of rapid urbanization, housing shortage and increased growth of the informal sector (Robi E., 2011). Approximately 52% of females and 38% of males have had no formal education and there is a high dependency ratio of

close to 45.4% of the total population under the age of 15 years and 3.2% aged 65 and above (ENC, 2016).

*Figure 15: Effects of Ethiopia's Rapid Urbanization*




*Source 19: Robi E., 2011*

The World Cities Report (2016) elucidates that the ongoing major construction projects in Addis Ababa focus on the middle class, as well as attracting foreign companies into the country. In his research Tegenu T., (2010) noted that only one tenth of the natural growth of the rural population is absorbed by urban areas in Ethiopia, against two thirds in West Africa. He goes on to inform that a migration – led urbanization has led to an increased demand for more services such as housing, energy, education, sanitation, health, communication, transport and business services, and consequently an urban sprawl (Tegenu T., 2010). In 2004, the Government of Ethiopia formulated the National Urban Development Policy (NUDP), ten years after the problems of spontaneous and rapid urbanization had reached a climax. The NUDP has two principal packages of the NUDP consists of:

i. Urban Development Package (UDP) consisting housing development program, MSE development program, land and infrastructure development program and urban-rural linkages.

ii. The Urban Good Governance Package (UGGP), the second principal package which consists of sub-programs that reinforce the UDP.

The policy finds solutions to the effects of rapid urbanization in Ethiopia (symptoms), however, it does not address the problem related to the root causes of migration, that is the high rural fertility rates, increasing requirements for food consumption, resource scarcity (land), growth in new entrants in labour force and low economic capacity of the urban formal and informal sectors to absorb the surplus rural labour. He then asks, ‘Given the demo-economic situation in rural areas and the economic impedance nature of the urban

centres, how can a rural surplus labour be absorbed and agglomeration economies created?' and proposes a green revolution and a decentralized industrialization as some of the responses (Tegenu T., 2010).

The highest concentrations of ambient air pollution in the world now occur in developing country cities, including Addis Ababa. Urban air pollution includes the release of black carbon (soot), aerosols, nitrogen oxides, sulphur oxides, lead and other forms of particulate matter, as well as the creation of ozone at surface level (Daley B., 2015). Household air pollution due to biomass fuels, is also of major concern and is increasingly becoming recognized as a major global health concern. This kind of pollution is also strongly poverty related and is known to cause acute respiratory infection in children in developing countries, such as Ethiopia (Gebreyesus, B., et al., 2009). Recognizing the need to reduce air pollution in Ethiopia's urban areas requires policies that deliberately tackle this phenomenon. Policies related to energy, transportation and urban planning, as well as to agriculture and forestry, need to be cross-sectoral and well integrated giving particular consideration to the impacts of each strategy on poor communities.

80% of Ethiopia's population's livelihoods is dependent on agriculture. Therefore, industrial policy has focused heavily on promoting manufacturing industries that provide linkages to the agricultural sector such as the textile and garments industry and the leather industry. The main manufacturing activities include production of food and beverages, tobacco, textiles and garments, leather goods, paper, metallic and non-metallic mineral products, cement and chemicals. There are manufactures activities that are meant for the export market, as indicated in the industrial development strategy. They include textiles and garments, leather products and agro-processing. The largest manufacturing industry is textiles and garments, which includes both state-owned and private factories.

This is so because of the:

i. strong linkages with the agricultural sector (utilizing inputs from the cotton and the livestock sectors)

ii. they both are labour-intensive in nature (thus absorbing labour from the agricultural sector),
iii. have a great potential for export, and have
iv. low entry barriers (ECA, 2016).

According to Birhanu (2014) agriculture provides about 70% of the raw material for the food processing, beverage and textile based industries in the country. It also accounts for around 50% of GDP and employs about 85% of the labour force. Moreover, agriculture is also Ethiopia's main foreign exchange earner accounting for 90% of the overall total, with coffee contributing about 60% of total export value (Daley B., 2015).

The Ethiopia's recent economic history can be divided into three policy regimes (Gebreeyesus M., 2014); the first one may be described as a laissez-fair and 'hands off' regime covering the period prior to 1974, the second one is a closed economy that was rigid regime from 1975 to 1991 and the third can be labeled as economic reforms regime-onwards of 1991. The economic growth can be deemed as extraordinary following the last decade of dutiful implementation of the successive five-year development plans and strategies belonging to various sub-sectors.

Ethiopia experienced a GDP growth of about 10.7% per annum between 2003/04 and 2011/12 but despite this robust economic growth the country fared little in terms of structural transformation (Gebreeyesus M., 2014). The Ethiopia Industry Development Strategy (EIDS) of 2002 identifies SMEs as an important sector for domestic entrepreneurs and for employment creation. The strategy dedicates federal and regional agencies to work with municipalities to support these enterprises (AEO, 2017). The manufacturing and industrial sectors' contribution to the economy remained stagnant at below 6% and 14%. The objectives set in the GTP I included:

i. increase additional installed capacity of 8000 MW by 2015,

ii. double electricity customer base to 4 million and the general access rate (rural towns and villages coverage) from 41% to 75% (Abayneh G., 2012).

More than 1,500 towns and villages were electrified per year and more than 3 million solar lanterns and 9 million efficient cook stoves distributed with the assistance of Development partners such as the AfDB, the World Bank etc. (Abayneh G., 2012).

Between 2009–2013, Ethiopia recorded the fastest growth of 9.4% per annum in Africa evidenced by the expansion in services and construction, aggressive public spending on infrastructure and public services, and an increasing agricultural production driven by a rising domestic demand (Ethiopian Economic Association, 2013). UNIDO (2016a) suggest that the development of integrated agro-industrial parks (IAIPs) and associated rural transformation centres (RTCs) is a key component within the agro-food sector of their country partnership with Ethiopia.

GTP II prioritises export-led industrialisation whose approach to promoting industrialisation is consistent with the Inclusive and Sustainable Industrial Development (ISID) framework. Ethiopia, as one of the three pilot countries under this framework, has developed a Programme for Country Partnership (PCP) in collaboration with other partners, including UNIDO (AEO, 2017). Ethiopia's national development plans place emphasis on promoting export-led industrialisation with a focus on light manufacturing. However, the contribution of the industrial sector to GDP, employment and exports still remains low (AEO, 2017). Manufacturing is at the heart of Ethiopia's economic transformation programme. For example, there is a large investment by a Chinese firm producing designer leather shoes for the United States and European Union markets. Production is in an industrial special economic zone (SEZ) just outside Addis Ababa. It is estimated that more than 25,000 jobs have been created through similar enterprises in the country (Lopes, 2013). This is an indication of a direction that is benefitting from agglomeration.

In his comparison of the growth of the floriculture and the metal and engineering industry, the flower industry succeeded but and the metal and engineering industry declined (Gebreeyesus M., 2014). It revealed that energy played a major role in the unsuccessful take off of the latter. Other reasons included frequent power cuts, low quality telecom services, and shortage of land. Some lessons were carried forward from the floriculture industry, such as better modalities of rent management in the other sectors. Supporting this approach, Hausmann, R., et al. (2013) and Khan, (2008) reiterate that state-business relations and in particular rent management has taken centre stage in industrial policy debate(s). Additionally, the Ethiopian government has made massive investments in the development of transport. According to the Ethiopian Road Authority, the road network expanded from 26,550 km to 53,997 km between 1997 and 2011.

*Figure 16: Effect of rapid urbanization in Ethiopia at present*

*Title: 1 UNIDO Director General LI Yong with the Prime Minister of Ethiopia, Hailemariam Desalegn, leading the cornerstone laying ceremony at the inauguration of the integrated agro-industrial park in Yirgalem, SNNP region, Ethiopia.*
*Source 20: (UNIDO, 2016a)*

Despite the small gains of its structural transformation (ACET, 2014) and catch-up so far, it is believed that Ethiopia is in a position to catch up with Vietnam and China in the light manufacturing industries in the near future. These are industries whose costs of labour are very important and Ethiopia has a labour cost advantage over both China and Vietnam (ECA, 2016).

There are various reasons to be optimistic about Ethiopia's prospect for catch-up, one of them features the impressive industrial policy-making capability that it has accumulated since the Ethiopian People's Revolutionary Democratic Front (EPRDF) government came to power in 1991. Ohno (2011) reiterates that the quality of Ethiopia's industrial policy-

making is represented by the GTP which covers 2010-2015, and is unusual in its brevity, coherence and strategic direction. Priority manufacturing industries designated in the plans were based on considerations of resource availability, linkages to agriculture, labour intensity, export potential, and (relatively) low technological entry barriers. They include garments and textiles meat processing, agro-processing, leather and leather products, and construction. For each of these industries, the state has set up supporting institutes to coordinate the value chains effectively (for example, ensuring efficient supply of inputs to manufacturers) and assist firms with technological upgrading in any capacity needed. Oqubay (2015) characterized the Ethiopian state as one that was clearly aspiring to become developmental – a state, one characterized by its exclusive focus on development, public mobilization around a grand vision, the commitment to improving state capability and an embedded autonomy.

Every year close to 140 million Africans in the diaspora save up to USD53 billion in destination countries (AfDB, 2010). In 2011, Ethiopia was the first country in Africa to issue a diaspora bond to finance its Renaissance Dam project (ERA, 2014).

With all these tremendous and ambitious efforts, one begs the question, 'How has Ethiopia set itself up to be competitive at the international level, especially in the two sectors that have been prioritized?' To become internationally competitive in these two sectors, the Ethiopian government has invited the provision investment capital and technological capabilities from foreign investors. Various incentives have been put in place in order to woo the investors, who also include the local. They include:

(i) subsidized land rent in industrial zones;
(ii) generous credit schemes and facilities;
(iii) 100% exemption from the payment of duties on the importation of all capital goods and raw materials that cannot be provided domestically but are necessary for the production of export goods; and
(iv) five-year tax holidays on profits (Gebreeyesus, 2011).

Ethiopia's industry comprises the heavy industry such as oil and gas production in the Ogaden region, East of Ethiopia, and light manufacturing such as the leather industry (Daley B., 2015). These industries have different types and magnitudes of environmental impact. There exist strong linkages between urban and rural areas of Ethiopia through the use of biomass (wood and charcoal) for fuel as Gebreegziabher et al, (2012) illustrate that urban Ethiopian households are dependent on rural areas for around 85% of their fuel needs. This has significant implications for deforestation and forest degradation. As a result of this demand, there is a risk of growing fuel scarcity and higher prices for firewood and charcoal.

### *5.2.4 Climate Change Measures*

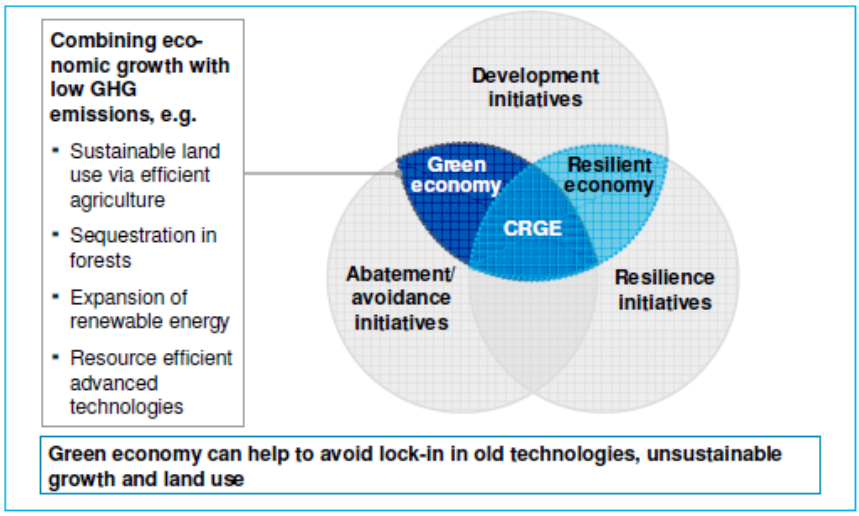
Ethiopia intends to reach middle-income status before 2025. It aims to do so by building a green economy that will boost agricultural productivity and strengthen the industrial base. The Climate-Resilient Green Economy (CRGE) initiative is a ground breaking milestone for use for attaining this goal. It is also integrated into the GTP II. It has the following objectives:

i. guide the country against adverse effects of climate change,
ii. utilize the country's hydro, wind and geothermal resources, develop fuel efficient stoves and
iii. totally discontinue the fuel based generation by 2015 (Abayneh G., 2012).

Figure 17 summarizes CRGE's approach that is a combination of abatement initiatives, resilient initiatives and development initiatives and their interactions that lead towards having a climate-resilient green economy. So far there are 60 priority initiatives, split across the seven different sectors. They underwent an analysis via the following criteria:

i. Pass an initial assessment of relevance and feasibility to be implemented in the local context,

*Figure 17: Climate Resilient Green Economy (CRGE)*



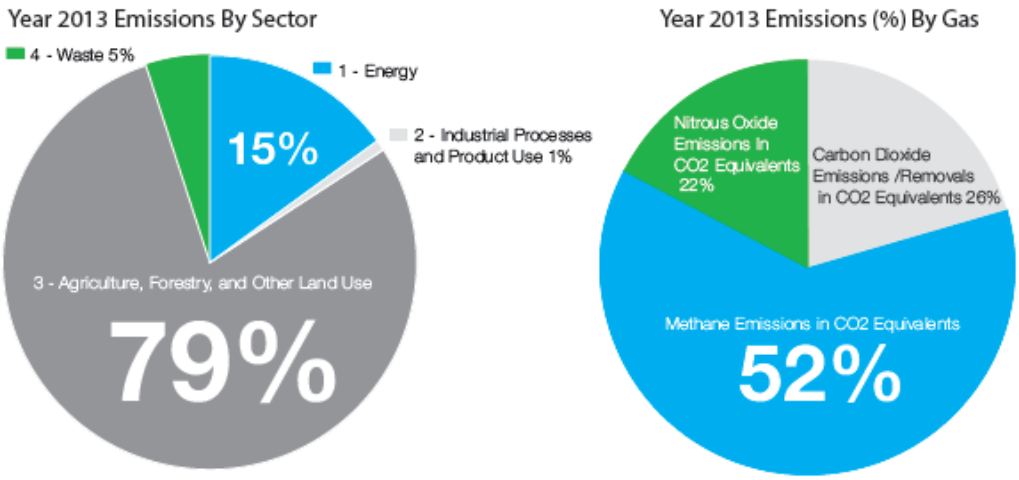

*Source 21: (FDRE, 2011)*

ii. Enable a positive contribution to reaching the targets of the GTP,
iii. Provide significant abatement potential at reasonable cost for the respective sectors

Key for this initiative is the development of a transport sector which responds to sustainable development and green growth. Climate-resilient transport infrastructure projects include the construction of an electric rail network, with the recent launch of the Addis Ababa Light Railway Transit (AA-LRT) which bears a significant potential for emissions reductions through switching freight transport from road to electric rail (Daley B., 2015).

More than 85% of GHG emissions in Ethiopia come from agriculture and forestry. The current cattle population is more than 50 million and other livestock nearly 100 million amounting to 65 Mt CO2e in 2010. The impact of human activities on the forestry is also a large source of CO2 emissions amounting to almost 55 Mt CO2e in 2010. Forestry emissions are driven by deforestation for agricultural land (FDRE, 2011).

*Figure 18: Emissions by Sector and by Gas*



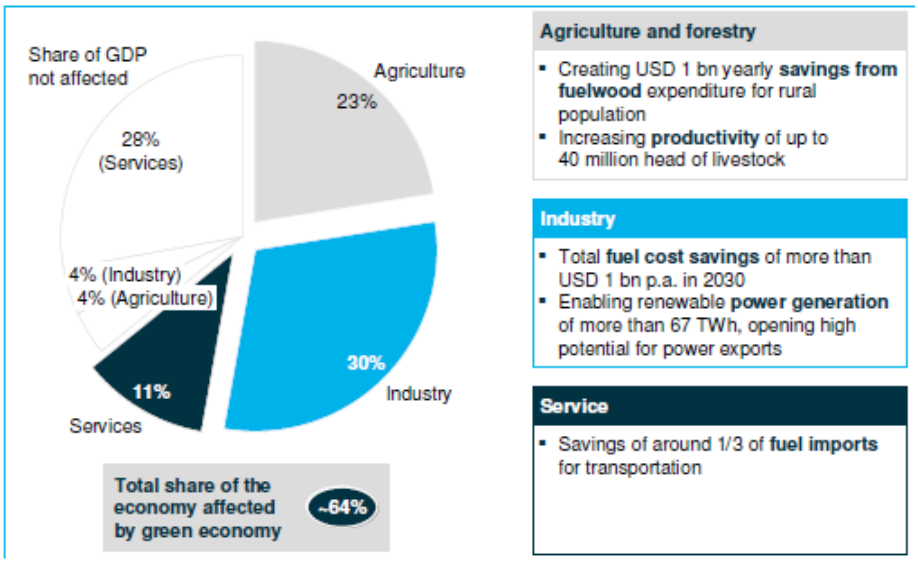

*Source 22: (FDRE, 2015)*

The government estimates that under the current (BAU) practices, GHG emissions would more than double from 150 Mt CO2e in 2010 to 400 Mt CO2e in 2030. The country's development could face resource constraints, for instance, it could reach the carrying capacity for cattle. Furthermore, it could lock its economy into outdated technologies (FDRE, 2011). According to Ethiopia's NDC, it intends to limit its net GHG emissions in 2030 to 145MtCO2e or lower (FDRE, 2015).

Overall, Ethiopia's green economy plan is based on four pillars, which also serve as the country's mitigation measures (FDRE, 2015):

i. Improving crop and livestock production practices for higher food security and farmer income while reducing emissions
ii. Protecting and re-establishing forests for their economic and ecosystem services, including as carbon stocks
iii. Expanding electricity generation from renewable sources of energy for domestic and regional markets
iv. Leapfrogging to modern and energy-efficient technologies in transport, industrial sectors, and buildings.

*Figure 19: Share of GDP affected by CRGE by 2030*




*Source 23: (FDRE, 2011)*

Overall, up to two-thirds of the economy would be affected by moving to a green growth path. Figure 18 represents the share of GDP affected (2030) and examples of economic impact/benefits from green economy.

The country has undertaken several strategic and programmatic actions in integrating Climate Change into National Development Policies and Planning. In the near term, the strategies and plans include the:

i. National Adaptation Programme of Action (NAPA) since 2007,
ii. the Ethiopian Programme of Adaptation to Climate Change (EPACC 2011),
iii. nine National Regional States and
iv. two City Administrations adaptation plans, five sectoral adaptation plans and the Agriculture sector adaptation strategy.

Long term strategies feature increase in resilience and reduction of the vulnerability of livelihoods and landscapes in three pillars: - drought, floods and other crosscutting interventions (FDRE, 2015). Others include:

i. the Environmental Policy,
ii. Ethiopia's Growth and Transformation Plan (GTP),
iii. Nationally Appropriate Mitigation Action (NAMA) (which includes various

concrete projects in the agriculture, energy, forestry, transport and urban waste management sectors)

Ethiopia's Programme of Adaptation to Climate Change (EPACC) – whose core objective is to create the foundation for a carbon-neutral and climate-resilient path towards sustainable development in the country

i. Climate Resilient Green Economy (CRGE)
ii. Energy Policy - policy priorities include the development of hydropower sources; a gradual transition from traditional to modern fuels; publicizing standards and codes which will ensure that energy is used efficiently and properly; developing human resources and establishing competent energy institutions.
iii. Water Policy – whose overall goal is to enhance and promote national efforts towards the efficient, equitable and optimum utilization of the water resources of Ethiopia for significant socioeconomic development on sustainable basis.
iv. Agricultural and Rural Development Policy Strategies (RDPS).

The country's energy system is vulnerable to climate change because the major sources of energy, which are bioenergy and hydropower, directly depend on the climate. The energy sector's contribution to greenhouse gas emission in Ethiopia is approximated at 15%. Emissions mainly emanate from the use of fossil fuel in the transport, residential and industrial sectors.

There is scare research into the environmental impacts of industry in Ethiopia, an important research gap. However, some environmental impact assessments have been produced for key industrial developments in the country (Daley B., 2015).

Energy use in Ethiopia currently comprises more than 90% traditional biomass although this might change with the increasing hydropower production. In one of my past travels, I witnessed vast deforested areas in some parts of the north of the country, which is also coupled with the fact that wood is also used for lots of construction in the rural areas. Indeed, an urban energy transition to cleaner affordable and reliable energy sources is required.

## 5.3 The case of Kenya

### *5.3.1 Introduction*

Kenya's increment towards her transformation path can be attributed to a recent governing system that is decentralized. This involves devolving a majority of the national government's responsibilities to the forty-two counties. As this is fairly new, much of the county level launch pads are still shaping up as the practitioners at the national level continue to impart their mandate in providing due guidance to the counties. The fundamental questions in this segment are:

1. Will Kenya's future inhabitants be able to have access to Energy that is clean, affordable, available, accessible and reliable?
2. Is there an existing nexus between energy, climate change, urbanization and industrialization? If such exist how well do they gel in together?
3. How do the measures towards climate change and energy impact on Kenya's urbanization and industrialization?

Kenya's national long-term development blueprint is the Vision 2030 which aims at raising Kenya to a globally competitive and prosperous middle income nation with high quality of life by the year 2030. The vision's three pillars are: Economic, Social and Political pillars. Six key sectors have been given priority in Vision 2030: (i) tourism (ii) agriculture and agro-industries (iii) wholesale and retail trade (iv) manufacturing (v) IT-enabled services (previously known as business process off-shoring) and (vi) financial services. Other policies anchored inside Vision 2030 include the Private Sector Development Strategy (PSDS) (2006-2012), the Industrial Master-plan (MAPSKID) and the National Industrialization Policy. The PSDS focused on the following five goals: (i) Improving Kenya's Business Environment (ii) Accelerating Public Sector Institutional Transformation (iii) Facilitating Growth through Greater Trade Expansion (iv) Improving Productivity and (v) Supporting Entrepreneurship and Indigenous Enterprise Development.

The country's outlook is positive, with growth projected at 6.1% in 2017 and 6.5% in 2018. Consumer Price Index (CPI) inflation projections remain slightly above 5% over the same period (AEO, 2017). Below is a summary of the current status of the country in terms of the population, GDP per Capita, etc.

*Table 5: Basic indicators in Kenya, 2016*

| **Basic indicators, 2016** | | | | | | |
|---|---|---|---|---|---|---|
| | **Population** (thousands) | **Land area** (thousands of km2) | **Population density** (pop. / km2) | **GDP based on PPP valuation** (USD Million) | **GDP per Capita** (PPP valuation, USD) | **Annual real GDP growth** (average over 2008-2016) |
| Kenya | 47 251 | 580 | 81 | 152 735 | 3 232 | 5.3 |

*Source 24: AEO, 2016*

According to the Government of Kenya (MENS, 2015) approximately 67.7% of the country's population resides in the rural areas and relies predominantly on scarce natural resources and an ever-degrading environment for their livelihoods. This situation seems to change with an increasing in rural-urban migration. The urban population increased from 5.4 million in 1999 to 12.2 million in 2009 and is projected to reach 17.64 million in 2017. In 2012, 49.8% of the total population was living below the poverty line, below 1 USD per day, with the level being higher in rural areas at 55% than in urban areas estimated at 35.5%.

### *5.3.2 Status of Energy in Kenya*

The Kenyan energy sector is dominated by an over reliance on the ever decreasing biomass energy resource to meet most of the energy needs especially of the rural households. Currently, biomass energy accounts for about 85% of all energy consumed while electricity and petroleum account for only 21% and 9%, respectively. Kenya has an overall national electrification rate of approximately 20% among 36 Million Kenyans (REN21, 2017) with

rural households and small businesses access to the grid being at about 5% and urban access at 50% (UNIDO, 2013).

Kenya's energy policy of 2004 encourages implementation of indigenous renewable energy sources to enhance the country's electricity supply capacity. The policy is implemented through the Energy Act of 2006, which provides for mitigation of climate change, through energy efficiency and promotion of renewable energy. In addition, the Feed in Tariffs (FITs) policy of 2008 (revised in 2012) promotes generation of electricity from renewable sources. It applies to solar, wind, geothermal, small hydro and biomass. Kenya's Updated Least Cost Power Development Plan of 2011-2030 (LCPDP). The government of Kenya (GoK) identifies nine projects as key pillars to the successful implementation of Vision 2030. These are expected to push the country's energy requirements by about 890 MW, with highest demand expected from the Konza City ICT Park at 440 MW and the iron and steel smelting industry in Meru at 315 MW. The LCPDP is the Ministry of Energy (MoE's) power implementation plan for delivering the power sector targets outlined in Vision 2030. Under the LCPDP, Kenya's generation capacity is projected to increase to 19,220 MW by 2030, with geothermal contributing a quarter of Kenya's total installed capacity and hydro power dropping ten-fold to about 5%. The plan also highlights nuclear power as a potential power source, with an inaugural 1,000 MW plant planned for 2022. Commissioning of subsequent nuclear plants is expected to increase nuclear power generation to 3,000 MW by 2030. The Energy Regulatory Commission was established as an Energy Sector Regulator under the Energy Act of 2006 to oversee matters of energy regulation in the country.

In the recent past there has been a rapid but unsustainable growth of the country spurred on by dependence on imported petroleum for local consumption. Petroleum products demand grew by 4.3% from 3,610 thousand tonnes in 2009 to 3,760.7 thousand tonnes in 2010. During that same period there was a growth of GDP by 5.6% with 2011 projections estimated between 3.5% and 4.5% (Government of Kenya, 2011). The decelerated but

positive GDP growth is attributed to high international oil prices brought about by instability in Libya and the Middle East.

Kenya recently launched the first biogas-powered grid-connected CHP plant which commenced generation at a commercial farm, producing 2 MW of electricity and enough heat to cultivate 704 hectares of vegetables and flowers with enough surplus power to supply 5,000 to 6,000 rural homes (REN 21, 2017). The Lake Turkana wind project (310 MW) is the single largest private investment in Kenya's history to date and, upon commissioning in 2017 (expected) will constitute approximately 15% of the country's total generating capacity and will be Africa's largest wind farm (REN 21, 2017). Other plans/targets include (i) Geothermal power at 1.9 GW by 2016; 5 GW by 2030 (with an overall estimated potential of between 7,000 MWe to 10,000 MWe) (ii) Hydropower at 794 MW by 2016 (with small hydro potential estimated at 3,000 MW); Solar PV at 423 MW by 2016 (solar radiations of 4-6kwh/m2/day); Wind power at 635 MW by 2016 (REN21, 2017; REEEP, 2017).

The Government of Kenya has made it a priority to shift the underlying patterns of energy consumption towards cleaner and modern forms of energy, renewable energy in this case. Another driver is the desire to reduce the negative impacts on the economy due to the unstable international oil prices (UNIDO, 2013). Recent discoveries of natural gas and crude oil deposits in the coast and Lake Turkana regions will change the energy and economic growth prospects for Kenya significantly in the medium term (Tullow, 2017).

### *5.3.3 Kenya's structural transformation, what is the underlying key nexus (es)?*

Generally, Kenya's policy landscape acknowledges a growing urban population, the need for energy for the country's structural transformation and the significance of ensuring that the energy systems are climate resilience since much of it relies on the climate. In order to

understand this a bit further, we looked into some policies as well as some few select outcomes.

#### *5.3.3.1 Kenya's Industrial Policy*

According to the 2010 economic survey, in 2009 the contribution of the industrial sector to GDP in was 9.5% from manufacturing; 4.4% from construction; and 0.5% from mining and quarrying (KNIPF, 2010). Currently, the overall goal for the industrial sector is to increase its contribution to GDP by at least 10% per annum and propel the country towards becoming Africa's industrial hub. Presently, the outlook is positive, with growth projected at 6.1% in 2017 and 6.5% in 2018. Consumer Price Index (CPI) inflation projections remain slightly above 5% over the same period (AEO, 2017). Kenya has sophisticated entrepreneurship by regional standards which could increase its global footprint through increased investments in ICT.

Since independence, industrialization has not been looked into from a political lens. Exacerbating this has been the existence of numerous laws, a weak legal framework, corruption and overlapping ministerial mandates. This has then culminated into an uncoordinated and slow industrialization process in Kenya. Further to this there has been rising levels of unemployment and a rapid growth of informality such as the *mitumba* (second hand clothes) and *JuaKali* (artisans) sectors.

The National Industrial Policy Framework of 2010 was passed by the Cabinet in October 2012 (GOK, 2012). The policy vision is to: To enable Kenya to become a regional leader in industrial growth and development contributing upwards of 15% of annual national GDP. It is paramount to bear an understanding of the set plans and goals, and their integrated nature in order to scrutinize better how drivers such as energy supply's significant role comes into play within these planned developments.

The industrialization policy of 2010 identified strongly with the then current status and spelled out a detailed policy action for the same, as indicated in some captions noted below:

a. Policy Statements on provision of energy for industrialization
   i. Fast track the expansion and diversification of the power generation sources in a cost effective manner.
   ii. Separate power feed for industrial consumers from power feed for residential use to increase reliability especially during times of rationing.
   iii. Fast track provision of electrical energy to areas of existing and high potential for industrial development prioritized in this Policy document.
   iv. Provide a preferential electricity tariffs for heavy industrial consumers in key industries prioritized in this Policy document.
   v. Promote the Public-Private-Partnerships in generation and distribution of energy.

b. Policy Statements on Dispersion of Industries
   i. Fast track the development of Special Economic Zones (SEZs), Industrial Zones and SME Parks in line with Vision 2030.
   ii. Provide incentives for the establishment and dispersion of industries across the counties.
   iii. Promote development of MSMIs in rural areas.

c. Policy Statements on Trade Policy
   i. Align Trade Policy with Industrialization Policy to address issues of tariffs, bi-lateral and multi-lateral trade policies, for enhancing competitiveness and market access for industrial products.

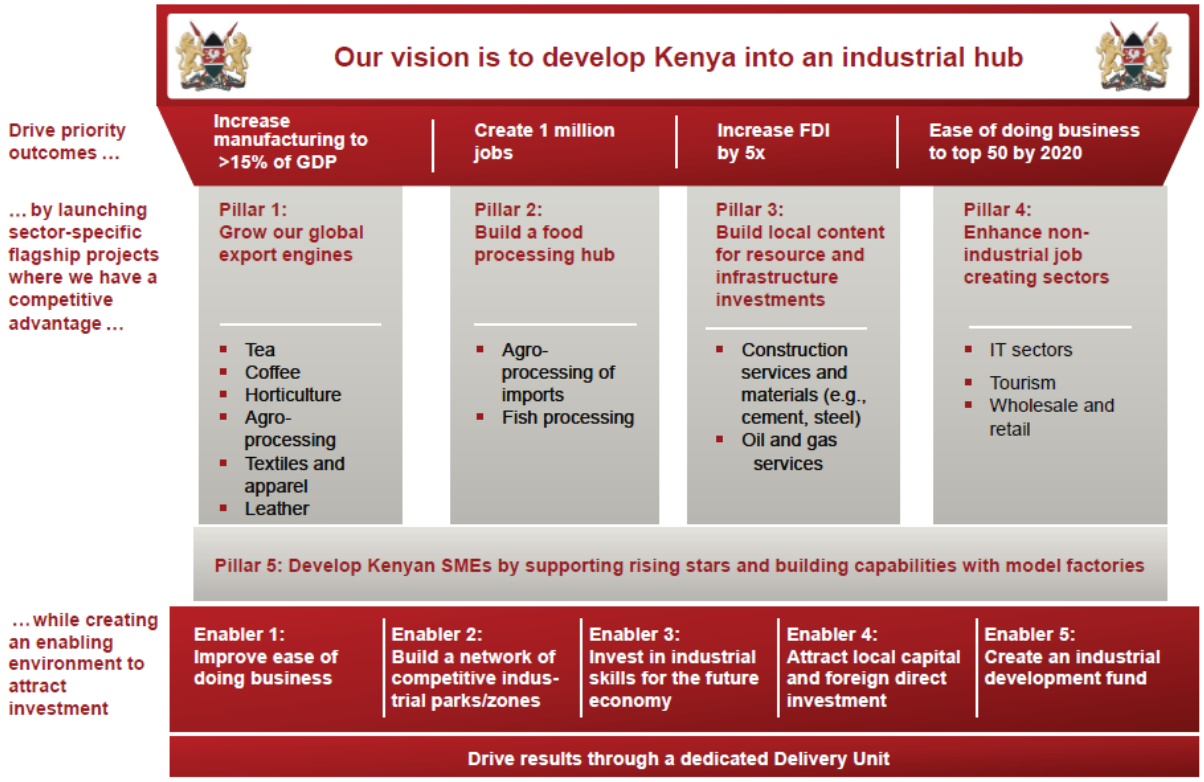
d. Policy statements on Green Energy
   i. Promote the manufacture of affordable equipment including solar panels, windmills, digesters, cookers, refrigerators and micro-hydro generators.
   ii. Promote energy efficiency by facilitating investments in energy saving technologies.

The Kenya Industrial Transformation Programme (KITP) of 2015, builds upon the synergies spelled out in the previous policy. It also bolsters a global outlook in staging Kenya as an industrial hub, across the region (KITP, 2015). It is underpinned by Kenya's transformational 'Vision 2030'. Figure 21 summarizes the sector's revamped strategy. The programme ascertains that attaining the ideals of this vision will require the economy to

grow the GDP by $4-6 Billion per year for the next 16 years. This translates to a growth rate of 10% per annum. This can be arrived at by the following;

i. Dramatically increasing FDI inflows
ii. Reducing the cost of doing business; current industrial tariffs stand at 17.3USD per kwh and average importation costs stand at 2,350USD per container – highest costs in the region in comparison to the least in Ethiopia at 5.4USD/kwh and 1,565USD per container in Tanzania, respectively,
Addressing the country's poor ranking in regional competitiveness, Kenya ranks 129 globally in comparison to Rwanda's 32nd position (MOIED, 2015).

*Figure 20: Strategy for the Implementation of the Industrial Transformation Programme*




*Source 25: KITP, 2015*

The economic Pillar of Vision 2030 seeks to create a robust, diversified and competitive manufacturing sector in three ways: by (i) boosting local production, (ii) expanding to the regional market and (iii) taking advantage of global market niches. The KITP (2015) justifies Kenya's repositioning of the sector because it recognizes that as at the year 2015,

there has been a stagnation in the manufacturing 11% of GDP over the past ten years; the number of formal jobs in the sector grew at just 7% per year over the past four years; exports stagnated at 15% of GDP; and imports grew to 40% of GDP. This created an imbalance of trade, weakened Kenyan Shilling and increased inflationary pressure. Kenya's industrial sector, thus, requires revitalising in order to narrow and close these gaps in her bid to turning into an industrial hub.

The latest milestones include the recent launch of the Standard Gauge Railway (SGR) which will improve linkages between the coast and the interior, into Uganda, DRC Congo, etc., expansion of the port of Mombasa, substantial progress on the development of LAPSSET (Lamu Port/ South Sudan/Ethiopia Transport Corridor Programme), the rapid construction of 10,000 km of new roads and plans are in place to pursue the generation of an additional 5,000 MW of electricity to drive down the cost of electricity. There is sufficient dedication towards the human capital and resources required to realise this Programme (KITP, 2015).

This programme also boasts of a middle income population currently comprising 45% of the populace and the quality of educational system is ranked first in Africa by the World Economic Forum (KITP, 2015). According to the Africa Economic Outlook (2016), the annual real growth rate is 5.3% per year, a higher growth rate than that of Brazil and India. At 55 Billion USD, Kenya is the 5th largest economy in SSA (KITP, 2015). There has been a 100% increase in manufacturing jobs from industrial transformation programme initiatives. The value of agro-imports entering the region stands at $3.8 Billion, a grand opportunity for replacing this with local production. The region has also made simultaneous and substantial discoveries of oil, gas and minerals. Kenya's 700 million barrels of oil equivalent (mmboe) is amongst the other reserves of 17,000 mmboe in Mozambique, 5,400 mmboe in Tanzania, 1,200 mmboe in South Sudan and 1,000 mmboe in Uganda (KITP, 2015). The leather industry has also been identified as an underutilized sector yet the country holds one of the largest livestock herds in Africa (60 million heads)

and 90% of the USD 94 million leather exports are unfinished wet blue leather (KITP, 2015).

The Kenya National Cleaner Production Centre (KNCPC) is a Trust under the Ministry of Industrialisation and Enterprise Development. It was established in July 2000 as part of the global UNEP/UNIDO National Cleaner Production Centre program. The Centre is a nodal Government agency in providing advisory services in Resource Efficient and Cleaner Production (RECP) which seeks to increase the productivity of enterprises by reducing wastage of resources (water, energy and raw material) and their associated negative environmental impacts.

According to UNIDO (2013) Kenya is the most industrially developed country in East Africa with manufacturing accounting for only 14% of GDP, a slight increase since independence in 1963. Although it has been expressed that the labour productivity is quite low and the human development indicators are also fairly low (PWC, 2013). The expansion of the manufacturing sector was rapid initially after independence, and then it stagnated since the 1980s. This was hampered by shortages in energy supply, high costs of energy and a transport infrastructure that was degraded. The country's rapid urbanization has caused the industry and manufacturing sectors to become increasingly important to the economy. Industrial activity is mainly concentrated around the three largest urban centers: Nairobi, Kisumu, and Mombasa. The industrial sector is mainly dominated by agro/food-processing industries such as sugarcane crushing, beer production, grain milling and manufacture of foodstuff. The structure of Kenya's manufacturing sector comprises of micro, small and medium and large industries. The SMEs are undercapitalized and face very poor transformation prospects. Many farmers are still faced with the challenge of the inability to access markets due to lack of energy for post-harvest processing and storage, post-harvest losses partly caused by a lack of suitable storage and processing facilities or

opportunities, and poor road and rail infrastructure. Nairobi's municipal authorities have worked with UN-Habitat to develop one-stop Youth Resources Centres since 2003 (AEO, 2017). Their main objective is to train young people in ICT, entrepreneurship, business incubation, financial literacy and generation of employment.

The Global Competitiveness Index (GCI) in 2015 showed the top major constraints for industrial and business development in Kenya as corruption, burdensome taxes, lack of access to finance and poor road, rail and energy infrastructure, ranking Kenya 99th out of 140 economies. This ranking is down from 90 in 2014 and trails the regional rival, Rwanda, which had risen to position 58 (Njoroge, 2015). There are many useful policies that have been developed in the recent past which have not yet been implemented (Ngui D., et al, 2016). Failure to implement has often led to the loss of industrial development opportunities, leaving various elements to still lag behind. For example, the NIP, which makes significant proposals, is yet to be implemented, yet we now have a new have a new one as of 2015. It is not clear how these two policies will or/are interacting with each other. While other countries have used the less technologically complicated textile sector to kick off rapid industrialization, Kenya appears to be taking longer in their strategy.

As of 2016, the following were listed as economic growth indicators for Kenya:

i. A vibrant private sector
ii. Favourable investment policies
iii. Increased FDIs
iv. Modernization of industries
v. Increased public investment in Agriculture, Manufacturing, Service sector and Energy
vi. Infrastructural development, among other key sectors in the economy (Kittony K., 2017)

#### *5.3.3.2 Kenya's Urbanization landscape*

The Urban Areas and Cities Act of 2011 provides that every municipality must have an integrated development plan, prepared by the municipal board and approved by the county

assembly (UNEP, 2015). These provisions in turn introduce parallel procedures that is, there is lack of clarity between the relationship or connection between local physical and integrated development plans, a lack of coordination mechanisms, statutes are inconsistent with the Constitution and planning comes under two distinct ministries with overlapping functions (Mousmouti et al., 2015). As a result, it becomes challenging to determine which provisions apply, where to find them, and what they mean. Another challenge is the lack of legislative transparency and clarity which stand in the way of both enforcement and accountability. According to Nabutola (2010) Kenya has not had a National Urban Development Policy (NUDP) until 2015 when the Ministry of lands embarked on a country wide consultation series ahead of the adoption of a draft NUDP (UN-Habitat, 2015). Whereas it mentions 'land environment and climate change' as one of the thematic areas, there is no mention, however succinct, of any energy approach. It appears that this area still remains a function of the national legislature (NUDP, 2016).

If you look at Nairobi, the largest local authority in Kenya, the city has grown to more than 3.5 million people in less than 50 years. 60% of the people live on less than 1/6th of the total land surface of the city (Nabutola, 2011). The NCBDA (Nairobi Central Business District Association) lobby group, an association of professionals and business people, was formed as result of the deterioration in services delivery and the severe loss of governance processes by the city's local authority. They carried out a study which showed that 45% of the working population in Nairobi belonged to the Informal Sector as at 2010 (Nabutola, 2011). According to the Nairobi City Council, the current spread of street trading wasn't catered for in the city's plan and was for a long time perceived as a 'temporary intrusion that could be addressed through forceful evictions'. As is expected the trade has resisted eviction, has kept persisting and continues to grow whereas the reluctance to accept it remains. The industrial policy of the country has no mention as to how it can contribute towards aiding local governments in dealing with informal trading that is a growing phenomenon across other major cities as well. Also, it is not well spelt out how the local

governments intend to support the national industrial policy via urban policy. Is it a case of 'the chips will fall in place?' However, the country's energy policy is mandated to shift the responsibility of energy delivery from the national government to counties as stipulated under the new constitution. With the support of partners such as UNIDO, training of local personnel to develop sustainable energy plans and oversee their subsequent implementation has already begun in the counties (UNIDO, 2016b). The climate policy also outlines the role that urban areas should undertake in aiding to implement the adaptation and mitigation measures, as aforementioned.

### *5.3.4 The opportunities/gains/challenge/gaps in the nexus*

Energy shortages have been highlighted by the Government of Kenya as a major impediment to enhanced economic growth, particularly for industry; the peak demand, measured in 2009-2010, was just above 1000 MW (UNIDO, 2013). With a growth of 7% per annum, Kenya is likely to face increasing energy shortages over the next decade unless a lot of investment is undertaken, and a timely one at that. For instance, in 2010, the manufacturing sector grow by 4.4% compared to marginal growth of 1.3% the previous year, following a reliable power supply as a result of good rainfall between March-April to May-June and October-December.

The weaknesses of the power system contribute to the high cost of doing business in Kenya. Other challenges include low per capita power consumption at 121 kWh and low countrywide electricity access at 20% of the total population, and 3.8% of the rural population (Kenya, 2004, REN21, 2017).

The advantage of Kenya's geographical location means that it is a major hub for the transportation of goods and services to Rwanda, Ethiopia, Uganda, Southern Sudan and Eastern Congo.

The success of a nexus approach is well exemplified via the example of Kenya's Solar Market. The solar industry in Kenya is among the highest thriving across the continent. The reason behind this flourishing growth can be attributed largely to the deliberate and integrated measures taken up by key stakeholders including the government, the private sector and learning institutions. It has three features. Firstly, it is the most dynamic and largest private sector-led PV panel market in Africa as measured in per capita solar home systems units in use. Secondly, it has now become a driver of East African regional PV solar home system sales (Duke D, et al., 2002). Thirdly, it represents a promising policy and development model because of the lead taken up by the private sector in the development of clean energy technologies (Tsidiso, 2009). Officials at the Ministry of Energy say that if just 10% of the 300 million MW of solar radiation Kenya gets in a day, is converted to power on the national grid, there will be an oversupply of electricity by over one fourth (Kenya, 2008). Value added tax on solar panels and accessories was removed in 2007 (Ibid).

According to the Ministry of Energy, the demand for solar water heating is projected to grow to 400 000 units by 2020 an equivalent of 150 000 TOE. This represents a growth rate of 10% per annum that is expected to hail from households, public institutions such as hospitals and higher learning institutions, and commercial households such as hotels. The Kenyan government set out to do the following in order to encourage private sector participation in harnessing solar energy:

- formulate and enforce standards and codes of practice on renewable technologies in order to safeguard consumer interests;
- package and disseminate information on renewable energy systems to create investor and consumer awareness of the economic potential offered by alternative sources of energy;
- promote research and development, and the manufacture of cost-effective renewable energy products;
- promote the development and widespread utilisation of renewable energy technologies;
- allow the duty-free importation of renewable energy hardware to promote widespread usage;

- provide tax incentives to producers of renewable energy technologies and related accessories to promote their widespread use; and
- provide fiscal incentives to financial institutions to provide credit facilities for periods of seven years to consumers and entrepreneurs (SAIIA, 2009).

Kenya's Electrogen Technologies and China's Tianpu Xianxing Enterprises entered into a partnership worth $140 million to build a solar panel factory in Nairobi, the first in the Horn of Africa (Munyao, 2008). Indeed, the opportunities that solar presents to the Kenyan economy are being well harnessed with a nexus approach shaping its success.

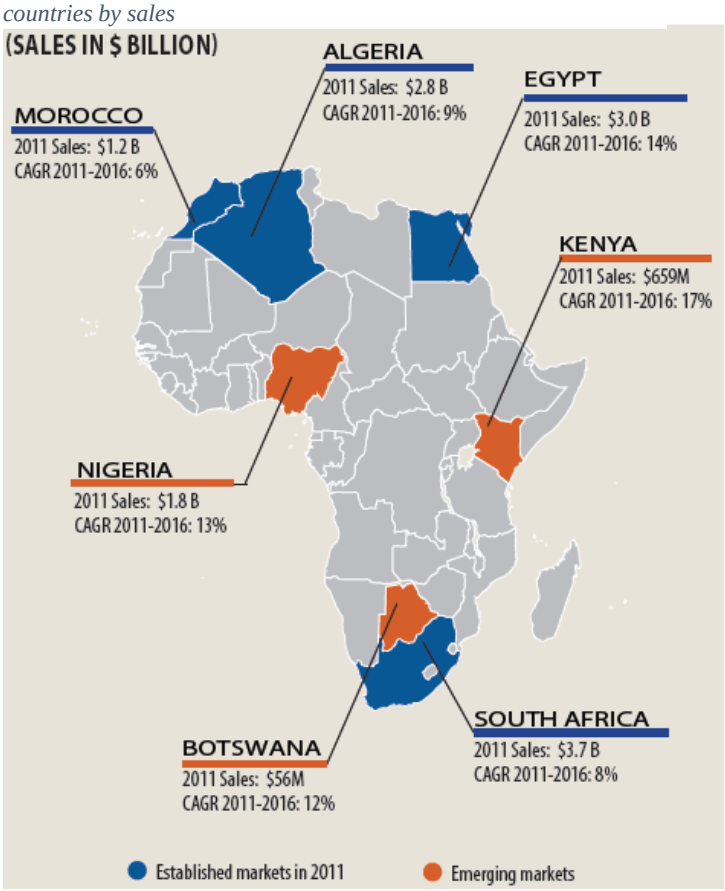
The failure of not harnessing a nexus approach can be demonstrated by the Export Processing Zones Authority. The Export Processing Zones Authority (EPZA) has faced a lot criticism in the past due to mismanagement and other issues. It was established through the Export Processing Zones Act (CAP 517) of November 1990 as a state corporation under the Ministry of Industrialization and Enterprise Development. As at 2014, the EPZA lacked autonomy from its overseeing ministry and did not consult the private sector in its strategy development (ERA, 2014); the Authority had also failed to address many concerns facing companies in the zone such as high energy costs and delays in clearing goods at the port. EPZA's failures have even prompted debate on the usefulness of setting up special economic zones as alternatives for industrial development (ERA, 2014).

Therein lies numerous opportunities to be harnessed from this nexus. For instance, Kenya ranks high on the map of Africa's pharmaceutical and tea industries.

One of the biggest opportunities waiting to be tapped on the continent is the local manufacture of pharmaceuticals (ERA, 2014). Africa depends largely (more than 80%) on imported medical and pharmaceutical products. Thus, pharmaceutical production in and for Africa presents the continent with an opportunity to industrialize, reduce external dependency, facilitate stronger regulatory oversight to curtail counterfeit products, improve the trade balance and create jobs (ERA, 2014). For instance, the tremendous

impact of Antiretroviral (ARV) drugs has had on the AIDS epidemic in the continent, with approximately 7.6 million people on ARV treatment (UNAIDS, 2013). This market will more than treble over the next decade as more people are placed on ARV treatment and other uses of ARV treatment are expanded. The continent spent an estimated total of $18 billion on pharmaceuticals in 2012 and the market was projected to reach $30 billion by 2016 and $45 billion by 2020 (ERA, 2014). Kenya is among the top 7 emerging markets on the continent as shown in figure 22.

*Figure 21: Pharmaceutical industry in Africa's seven largest countries by sales*




*Source 26: ERA, 2014*

India is a remarkable example of the successes of state interventions to promote low-cost quality domestic generic drugs which has resulted to Indian pharmaceutical firms controlling 70% of the domestic market today. Previously, non-Indian firms enjoyed almost 80% of the Indian market. India's pharmaceutical industry ranks third globally in terms of the volume of products manufactured (ERA, 2014). Kenya can borrow a leaf from India's experience.

At the regional level, the Business Plan of the African Union Pharmaceutical Manufacturing Plan for Africa (PMPA) lists flexible and comprehensive solutions that can be applied for internationally standardized, sustainable local production of essential medicines. The PMPA Consortium, (consisting of the African Development Bank, the Joint United

Nations Programme on HIV/AIDS, the New Partnership for Africa's Development, the United Nations Industrial Development Organization, the United Nations Development Programme, the United Nations Population Fund and the World Health Organization) is providing means to encourage interaction between stakeholders at the national, regional and continental levels (Regional integration, an often overlooked aspect that's important for industrialization). According to ERA (2014), regional integration has not been sufficiently utilized as a tool for industrial growth, yet it has the potential to be used much more systematically to promote regional industrial policy. Herein lies an opportunity for Kenya to spearhead the much needed dialogues in this industry and within the region, in order to fully reap the benefits of this untapped opportunity.

Kenya is the largest tea producer in Africa and is also Africa's largest flowers exporter but overall Kenya's export base is still narrow (PWC, 2013). Inadequate power, transport infrastructure and poor trade logistics have been identified as the major obstacles to growth in the sector, in spite of there being a grand opportunity for value addition. The country's tea sector contributes 10% of the total global tea production and commands 21% of the global tea exports outside producing countries, however, value addition has not been explored much.

#### *5.3.4.1 Climate Change Measures*

Kenya is striving to be a newly industrialised middle income country by 2030 and with that emissions are expected to increase especially from the energy sector. Kenya has a land area of 580,728km$^2$, out of which approximately 85% is classified as ASAL. According to the Nationally Determined Contributions (MENS, 2015) submitted as a response to the decisions adopted at the 19$^{th}$ and 20$^{th}$ sessions of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), and in response to the challenges posed by climate change, Kenya has developed a National Climate Change Response Strategy (NCCRS 2010), National Climate Change Action Plan (NCCAP 2013),

and a National Adaptation Plan (NAP 2015-2030) which provides a vision for low carbon and climate resilient development pathway, while a National Climate Change Framework Policy and legislation are in their final stages of enactment to facilitate effective response to climate change. The main climate hazards which include droughts and floods have caused and continue to cause economic losses estimated at 3% of the country's GDP. Other existing policies include the Environmental Management and Co-Ordination Act (EMCA) of 1999, the Kenya Climate Smart Agriculture Strategy of 2017 – 2026, among others.

On emissions, electricity emissions have been singled out to grow the most in Kenya, increasing from 2.2 million tonnes of carbon dioxide equivalent (MtCO2e) in 2010 to 18.5 MtCO2e in 2030. Much of this increase is attributed to new coal and natural gas coming online to meet increasing energy demand. Transport emissions are projected to increase by about three times between 2010 and 2030, and emissions from the waste sector and energy demand doubling in the same time period. The industrial sector is relatively small in Kenya, both in terms of its share of GDP and contribution to total GHG emissions (in terms of process emissions). 95% of industrial process emissions in Kenya are created by two industries namely cement manufacturing at 1.7 MtCO2e in 2010 and charcoal manufacturing at 0.8 MtCO2e in 2010. Agriculture remains the largest source of GHG emissions as it was responsible for one-third of Kenya's total emissions in 2010 and there is likely to be an increase from 20 MtCO2e in 2010 to 27 MtCO2e in 2030.

*Figure 22: Emissions in Kenya*

| No. | Sector | 2000 Emissions (CO2e - Gg) | | | | TOTAL | TOTAL as % |
|---|---|---|---|---|---|---|---|
| | | CO2 | CH4 | N2O | HFCs | | |
| 1 | ENERGY SECTOR | 7,227 | 1,932 | 601 | | 9,760 | 17.76 |
| 2 | INDUSTRIAL PROCESS SECTOR | 694 | | | 118 | 812 | 1.48 |
| 3 | SOLVENT AND OTHER PRODUCT USE | | | | | - | - |
| 4 | AGRICULTURE SECTOR | - | 13,041 | 9,498 | | 22,539 | 41.01 |
| 5 | LAND USE, LAND-USE CHANGE AND FORESTRY | 20,571 | 57 | 9 | | 20,637 | 37.55 |
| 6 | WASTE | 7 | 697 | 502 | | 1,205 | 2.19 |
| | **TOTAL** | **28,499** | **15,726** | **10,611** | **118** | **54,955** | **100** |

*Source 27: (MENS, 2015)*

The National Climate Change Action Plan spells out some key actions including:

i. Restore forests on 960,000 hectares of degraded lands by 2030 to abate 32.6 MtCO2e.
ii. Development of an additional 2,275 MW of geothermal capacity by 2030 to abate 14.1 Mt- CO2e by 2030
iii. Restore forests on 960,000 hectares of degraded lands by 2030 to abate 32.6 MtCO2e.
iv. Programme to support the use of improved cookstoves and of LPG cookstoves to abate 7.3 MtCO2e by 2030.
v. Implement an extensive Mass Transit System for greater Nairobi, based predominantly on Bus Rapid Transit Corridors complemented by a few Light Rail Transit Corridors to abate 2.8 MtCO2e by 2030
vi. Develop Kenya's GHG inventory, building on the information developed in the SC4 reference case of GHG emissions, and build capacity to develop, use and monitor data and impacts.
vii. Develop a process to mainstream low-carbon development opportunities into the Government of Kenya planning process (GOK, 2013).

Kenya has embarked on mitigation by seeking to abate its GHG emissions by 30% by 2030 relative to the BAU scenario of 143 MtCO2eq; and in line with its sustainable development agenda. It intends to do so by:

i. Expansion in geothermal, solar and wind energy production, other renewables and clean energy options.
ii. Enhancement of Energy and resource efficiency across the different sectors.
iii. Make progress towards achieving a tree cover of at least 10% of the land area of Kenya.
iv. Clean energy technologies to reduce overreliance on wood fuels.
v. Low carbon and efficient transportation systems.
vi. Climate smart agriculture (CSA) in line with the National CSA Framework.
vii. Sustainable waste management systems.

Kenya has also embarked on adaptation by identifying priority actions within the NCCAP and further elaborated in the NAP. The actions are based on risk and vulnerability assessments across the Medium Term Plan (MTP) (as found within the Vision 2030) sectors. Many of the actions have strong synergies with mitigation actions. Kenya's capacity to undertake strong mitigation actions is dependent upon support for the

implementation of these adaptation actions. Some of the actions can be seen in Table 2 below:

*Table 6: Kenya's Priority Adaptation Actions*

| **MTP SECTOR** | **PRIORITY ADAPTATION ACTIONS** |
|---|---|
| Energy | Increase the resilience of current and future energy systems. |
| Science, Technology and innovations | Support innovation and development of appropriate technologies that promote climate resilient development. |
| Public sector reforms | Integrate climate change adaptation into the public sector reforms |
| Infrastructure | Climate proofing of infrastructure (energy, transport, buildings, ICT). |
| Environment | Enhance climate information services. |
| | Enhance the resilience of ecosystems to climate variability and change. |
| Agriculture, livestock development and fisheries | Enhance the resilience of the agriculture, livestock and fisheries value chains by promoting climate smart agriculture and livestock development. |
| Oil and mineral resources | Integrate climate change adaptation into the extractive sector. |
| Population, urbanisation and housing | Enhance the adaptive capacity of the population, urbanisation and housing sector. |
| Private Sector/ Trade; Manufacturing; Business Process Outsourcing, Financial services | Create enabling environment for the resilience of private sector investment, demonstrate an operational business case. |
| Devolution | Mainstream climate change adaptation into county integrated development plans and implement the Ending Drought Emergencies Strategy. |

*Source 28: (MENS, 2015)*

The NAP provides a broad plan for a Low Carbon Climate Resilient Development that touches on the major economic avenues of the country including tourism, agriculture, water, and infrastructure. According to the plan, this transition to a low carbon climate

resilient development pathway can include a shift to green jobs. Such green jobs are those that:

i. Reduce consumption of energy and raw materials;
ii. Limit GHG emissions
iii. Minimise waste and pollution; and
iv. Protects and restores ecosystems.

It presents a holistic approach and identifies opportunities in gelling in actions that the energy, industrialization and urbanization sectors need to undertake in order to promote climate resilience, adaptation and mitigation. Examples include promoting renewable energy, initiating a BRTS, hybrid vehicles and conservation tillage technologies. It also acknowledges that legislature via the Energy Act, Energy Policy, Updated Least Cost Power Development Plan (ULCPDP), Feed-in Tariff Policy and Power Purchase Agreement Policy have promoted the transfer and diffusion of low carbon technologies in Kenya.

In summary, the climate change policy in Kenya leads in promoting the nexus of energy, climate change, urbanization and industrialization. Kenya showcases an active role in mainstreaming climate change interventions within and alongside the processes of industrialization ad urbanization, albeit still in its early stages.

*5.3.4.1.1 Links between Energy and Climate Resilience and Adaptation*

A report by PWC (2013) states that less power is available during periods of drought since Kenya relies heavily on hydroelectric power generation. Kenya's reliance on hydropower can pose certain energy security challenges. Dependence on hydro-based power generation increases vulnerability to drought-related electricity shortfalls. Drought causes shortfall in generation capacity with negative economic implications. For example, the country suffered persistent power rationing of up to eight hours per day in 2000/2001 partly because of a drought the country was experiencing which adversely affected the hydropower plants.

Consequently, the country incurred losses amounting to as much as $2million per day due to this power rationing (World Bank, 2000). The vulnerability of large scale hydropower generation to the impacts of climate change such as droughts, needs to be heavily reduced. There is need to adopt more resilient, robust and well thought out strategies for dealing with drought related power crises, especially with respect to hydropower generation. The National Climate Change Response Strategy paper (MENS, 2010) recommends that the country should pursue an energy mix that greatly relies on carbon neutral energy sources such as geothermal, renewable biomass, solar and wind.

There exist barriers towards low carbon development such as poor policy and legal frameworks, inadequate planning, high initial capital costs, lack of skilled manpower, lack of co-ordination and linkages in renewable energy programmes, weak dissemination strategies, pricing distortions that place renewable energy at a disadvantage, poor baseline information, low maintenance capacity, among others.

In summary, Kenya has embarked on making huge investments for increasing the amounts of energy supply via both renewable and non-renewable in a bid to promote energy poverty alleviation as well as ease the cost of doing business via affordable energy. As much of it is heavily reliant on hydropower, the susceptibilities to climate change have been greatly felt, and also on other sectors such as agriculture as well. Climate change is heavily influencing the country's urbanization which is currently at a phase on expanding her industrialization base utilizing the growing population. The policies have integrated climate change quite well, but there still needs to be a fusion and better integration across both urbanization and industrialization policy interventions.

## 5.4 The case of South Africa

South Africa is a dominant economy in Africa's economic landscape and accounts for a quarter of total GDP in SSA and is the largest national investor on the continent. South

Africa boasts the largest economy in Africa and the most developed in sub-Saharan Africa. It is a non-energy commodity exporter (AEO, 2017). South Africa's recognition as a key emerging market, along with other major emerging economies, Brazil, Russia, India and China, formed the BRICS. It is the largest national investor on the continent whose investments feature in a number of Africa's economic sectors and extend beyond traditional southern African markets, into the west, east and central parts of Africa (Fakir S., et al., 2017). The fundamental questions in this segment are:

1. Will South Africa's future inhabitants be able to have access to Energy that is clean, affordable, available, accessible and reliable?
2. Is there an existing nexus between energy, climate change, urbanization and industrialization? If such exist how well do they gel in together?
3. How do the measures towards climate change and energy impact on South Africa's urbanization and industrialization?

According to Sustainable Energy Africa (2015) approximately 64% of the country's population lives in urban areas of which 40% are situated in the metropolitan municipalities. The projections forecast that urban populations will reach 70% of the overall total by 2030, and 80% by 2050 (SEA, 2015). With a population of about 55,000 at a density of 45/km$^2$, the country's GDP per Capita is valued at USD13, 393 as indicated below. It ranks position 118 globally in this scale.

*Table 7: Basic Indicators of South Africa, 2016*

| Basic indicators, 2016 | | | | | | |
|---|---|---|---|---|---|---|
| | **Population** (thousands) | **Land area** (thousands of km2) | **Population density** (pop. / km$^2$) | **GDP based on PPP valuation** (USD Million) | **GDP per Capita** (PPP valuation, USD) | **Annual real GDP growth** (average over 2008-2016) |
| South Africa | 54 979 | 1 219 | 45 | 736 325 | 13 393 | 1.7 |

*Source 29: AEO, 2016*

### *5.4.1 Status of Energy in South Africa*

South Africa's energy sector is dominated by coal, accounting for three-quarters of the

primary energy supply (IGD, 2009). As at 2006, renewable energy accounted for approximately 7.98% of primary energy supply, half the renewable energy was wood fuels (biomass) as opposed to renewable energy technology. Electricity is generated from low-grade coal and is regarded as 'cheap energy'. South African electricity costs are generally considered to be amongst the lowest in the world (2015). South Africa's reliance on coal has made it a major contributor to carbon dioxide emissions. The country is ranked the 11th largest emitter in the world (Hallowes and Munnik, 2007).

The government has developed a Biofuels Strategy and has plans to expand this sector. South Africa is a net energy exporter in coal but imports large amounts of oil and some natural gas. According to Wakeford (2006), South Africa's economy is somewhat vulnerable to oil price shocks.

At 16.4%, residential demand for electricity use is much less compared to 62.7% demand for industry and mining use whereby the energy consumed is used in minerals beneficiation and mining at 50% and manufacturing at 20%. Mining relies heavily on electricity, with 70% of energy consumption on the mines being electricity (Pressend M., 2011).

About 30% of the population do not have access to electricity and are dependent on biomass and paraffin to meet their energy needs. Although there is a roll out in infrastructure to ameliorate the rate of access, it is limited to only those who can afford the service. A lack of payment for the services is majorly associated with the consumers' inability to pay. The implications, thus, are that the affected households revert to using paraffin and biomass particularly in rural areas in order for them to meet their energy needs.

South Africa has amongst the highest solar power potential in the world, estimated at 548GW. This opportunity has yet to be fully grasped. If adequately deployed at low-mid to high income homes alone, 1,014MW and 4,747MW can be removed from summer standard

load and winter peak load but there exist various barriers. Some include unit certification, problems with the subsidy process and a lack of a vibrant local manufacturing sector. Similarly, if just 5% of households were to install a 2kW grid connected system, they would contribute 800MW (Niekerk V., 2010).

Renewable Energy Policy Instruments in South Africa

i. National Integrated Resource Plan (IRP)
ii. Renewable Energy Market Transformation (REMT)
iii. Renewable Energy Feed in Tariffs (REFIT) – 2008
iv. Renewable Energy Independent Power Producer Procurement Programme (REIPPPP)
v. Tradable Renewable Energy Certification (TREC)
vi. Renewable Energy Finance Subsidy Office (REFSO)
vii. Biofuel Industrial Strategy
viii. Demand Side Management Subsidy Solar Water Heater Programme
ix. Traffic lights and public lighting
x. Clean Development Mechanism (CDM)

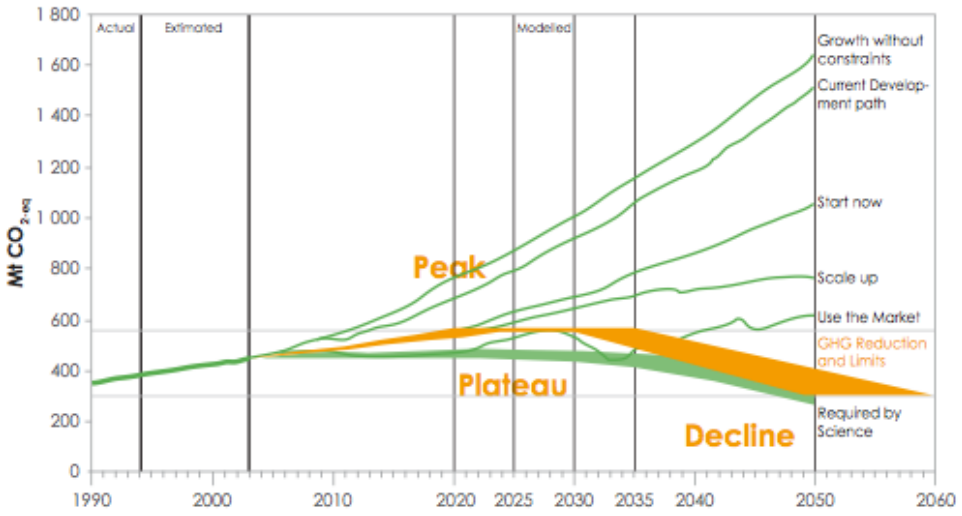
The Industrial Policy Action Plan and the New Growth Path have itemized some targets towards making advancements in South Africa's energy sector. They include:

i. Supporting 'green and energy saving industries' by committing to the installation of one million solar water heaters (SWHs) by 2014 to meet the Renewable Energy White Paper goal of 10,000GWh (EDD, 2011).
ii. Targeting 300,000 additional direct jobs by 2020 to 'green' the economy, with 80,000 in manufacturing, and the rest in construction, operations and maintenance of new environmentally friendly infrastructure. The potential for job creation rises to well over 400,000 by 2030.
iii. Creating additional jobs by expanding the existing public employment schemes to protect the environment, as well as in production of biofuels.

The White Paper of 2011 is the third influential policy paper that supported the country's renewable energy and was largely informed by a process known as the Long-Term Mitigation Scenario (LTMS) formulation. The scenarios included the peak, plateau, and

decline scenarios (see the Figure below) for carbon emissions were taken into account for the development of the Integrated Resource Plan (IRP) 2010-2030.

*Figure 23: South Africa Greenhouse Gas (GHG) emission reductions and limits*




*Source 30: (DEA, 2015)*

After at the beginning of 2008, South Africa's power sector reached a crisis point following years of underfunding. Power shortages and steep tariff increases seriously damaged South Africa's economy, as well as, the appeal to foreign investors was greatly reduced (Hartleb T., 2008). Notwithstanding there being two large-scale 4,800MW coal-fired power stations currently under construction as well as a number of renewable energy projects, energy supply remains a major risk factor in the country (PWC, 2013).

The electrification rate as at 2014 stood at 86% whereas those without access to electricity constituted 8% of the population. At 10% reliance on traditional biomass remains the least on the continent (REN21, 2017).

Early 2016 saw South Africa bringing its first commercial tower plant online with the launch of the 50 MW (with 2.5 hours of TES; 465 MWhi) Khi Solar One facility followed by the 50 MW (9.3 hours; 100 MWh) Bokpoort parabolic trough plant (REN21, 2017). These total installed capacity in the country comes to 200 MW following the launch of two plants.

The 2016 World Cities Report illuminates South Africa's urban energy initiatives in eThekwini (formerly Durban) where there are three waste-to-energy plants that generate USD3.2 million annually in revenues via sales of electricity and carbon credits and (UN Habitat, WCR, 2016).

According to REN21 (2017) Cape town committed to transitioning to 100% renewable energy in total energy use in 2016 joining other municipalities around the world in initiating such a local government renewable energy policy. The country has also launched specialized centres of industrial activity for wind turbine and solar PV modules components. South African company, Ethala Biofuels, announced plans for a sweet sorghum bio refinery project that will produce ethanol and other products (IRENA, 2012). A South African renewable energy developer New Horizons has teamed with a gas firm Afrox to open an energy-from-waste biogas plant near Cape Town, at a cost of USD 29 million (BMWi, 2017). The installation of three turbines (333 MW each) of the 1.3 GW Ingula pumped storage plant was completed in 2016 while the fourth and final turbine became operational in January, 2017. The peak flow through the plant's turbines is said to equal the volume of eight Olympic-sized swimming pools in every minute (REN21, 2017).

South Africa is among the first African countries embarking on developing a new robust Integrated Resource and Resiliency Planning (IRRP), however the time for its completion is not known yet.

### *5.4.2 South Africa's structural transformation, what is the underlying key nexus (es)?*

#### *5.4.2.1 Energy and Urbanization in South Africa*

The total population in South Africa is growing at around 1% p.a., and the urbanisation rate is 1.2% p.a. The population is predominantly urban, and currently 64% of the approximately 52 million total population live in towns or cities, of which 40% are located in the large metros. This is expected to increase to 70% by 2030 (DCOG, 2014). Poor households, on average, spend 14% of their income on basic energy needs, as opposed to

2% or 3% for wealthier households (Swart D. and Bredenkamp B., 2012, DoE 2013b, SEA, 2014).

Integrated Urban Development Framework discussion document (DCOG, 2014) noted that local government planning is too short-term, and advocated an overarching 30year planning framework. The South African Local Government Association (SALGA) and the South African Cities Network (SACN) are involved in providing support to urban areas with sustainable energy and climate change planning in recent years.

The Department of Energy has allocated significant money to some selected municipalities for the implementation of electricity efficiency and those granted the funds have successfully undertaken substantial streetlight and traffic light retrofits (sometimes with LED technology), as well as public building lighting retrofits. The experience with this programme showcases that municipalities require support to be able to engage with such programmes effectively. It is not enough to merely allocate funds to them. However, support in the initial phases can aid municipalities run these programmes sustainably thereafter (Euston-Brown M., 2013). They are also recipients of various conditional and unconditional grants from the national government, including the Equitable Share Grant (which includes the Free Basic Electricity grant) and the Municipal Infrastructure Grant. Municipalities are also able to raise their own loans.

Some municipalities such as eThekwini municipality has implemented a renewable energy programme, the eThekwini municipality landfill gas generation project that is approximately 6MW (SEA, 2013). Other cities are planning to follow suite. A few cities are looking at run-of-pipe hydro schemes, which may deliver up to 5MW of power each.

There are several factors that have shaped South Africa's urban energy picture. Some of these factors include:

i. Sprawling, low density cities - energy inefficient cities where transport energy demands, and thus expenditure, are high; where dependence on private vehicles is widespread; and where infrastructure costs to provide adequate public transport are prohibitive
ii. Apartheid-based urban layout – majority of the informal settlements are marginalized thus cost of infrastructure is high
iii. A steady urbanization rate of 1.2% pa and a growth in informal housing because the state housing programme has not been able to keep up with the demand. Currently 13.6% of the population live in informal housing, with around 1.96 million informal households living in about 2,700 informal settlements across South Africa. State support services reach few of these people, and even though informal settlement electrification is gaining ground in the country, they remain amongst the most marginalized population.
iv. There is a persistent high unemployment rates of around 25% (or around 34% if discouraged work-seekers are included) which exacerbates the pressure on state welfare subsidies, thus stretching further provision of energy services.
v. A history of centralized energy planning – historically such planning was undertaken de facto by Eskom – the national electricity utility - and the oil companies, and driven by the need for energy security in the face of apartheid sanctions. This has since shifted and national government now has a stronger planning role. Although, the culture of centralized planning still persists, and the potential strong role of municipalities in directing the country's energy future remains inadequately recognised
vi. A national electrification drive to support poverty alleviation, which has reached almost all urban formal houses, and is being extended to urban informal areas. The state funds this electrification, and provides a Free Basic Electricity consumption subsidy for low income electricity consumers, although the subsidy only reaches 69% of the indigent population (DoE 2013b).
vii. Low adoption of energy alternatives such as renewable energy because of historically low energy prices.
viii. A high carbon footprint per capita due largely to the reliance on coal, which makes up 67% of primary energy supply

When it comes to managing the energy sector in urban areas and at the municipal level, South Africa showcases the possibility and benefits of national policies to actively engage local authorities. This in turn aids in the implementation of other policies which may be directly or indirectly linked to the energy sector, such as energy efficiency in both residential and industrial areas, reduced emissions from incentivising great initiatives such as the eThekwini landfill, among others.

South Africa was part of a joint study that was conducted on 'deep decarbonization' for her economy and two scenarios were arrived at: (i) the Economic Structure Scenario and (ii) the High Skills Scenario. According to Altieri, K. et al. (2015) 'deep decarbonisation is the transition towards reaching significant decarbonization of energy systems, one measurement of which is a global average below 2 tons CO2/capita, within a selected time frame, e.g. by 2050. Both scenarios are aimed at improving development metrics within a 14 Gt CO2-eq cumulative energy sector carbon constraint (Altieri, K. et al. (2015). The first scenario explores ways to reduce unemployment via incentivizing growth in sectors with low-carbon emissions and high levels of absorption of labour whereas the second scenario mimics significant improvements to the training and education sectors thereafter injecting high skilled labour into the economy, thus fundamentally changing the labour force. In both scenarios, GDP per capita increases by 170% from 2010 to 2050. The population constituting the low-income bracket, a below-poverty-line category, decreases from 50% to ~18% in both scenarios by 2050. The drivers behind the study are characterized by the country's huge constraints to economic development presented by education, inadequate training and unemployment present, and the critical need for decarbonization of the electricity sector in order for it to meet the emissions constraints, as power supply currently accounts for just under half of national GHG emissions. This results in the decrease of GHG emissions from the electricity sector from 226 Mt CO2-eq in 2010 to 11 Mt CO2-eq in 2050. This will be due to a complete phase out of coal-fired power generation as current and in-construction plants are getting obsolete, and also due to the introduction of large amounts of solar (photo-voltaic -PV and concentrated solar power - CSP) and wind generation.

#### *5.4.2.2 Industrialization and subsequent linkages in South Africa*

Originally the economy was based on mining and agriculture but there has been a change over the years with manufacturing and services now contributing the greatest share to GDP (PWC, 2013). On average South Africa's economy grew at 3.2% a year from 1994 to 2012

(Bhorat H., et al, 2014). Potential growth is currently thought to be estimated at around 4.5%. Six major cities account for 55% of GDP, collectively, whereas the most unequal cities in Africa and probably in the whole world are also located in South Africa. The Gini coefficients in Johannesburg, Buffalo, eThekwini (Durban), Port Elizabeth, Ekurhuleni (East Rand) and Tshwane (Pretoria) stand above 0.7 (UN Habitat, WCR, 2016).

In his presentation at the Chatham House, the Minister in the Presidency of the Republic of South Africa, Radebe J. et al., (2014) stated that in 2008, the financial crisis took a heavy toll on South Africa particularly on the critical and manufacturing mining sectors. The government responded by implementing an expansive National Development Plan (NDP) 2030, the economic blueprint of South Africa. The aim of this plan is to coordinate all aspects of government policy for the next two decades. It is a plan for the radical socio-economic transformation for the next 20 years. He went on to inform the audience that the NDP is complemented by a National Infrastructure Plan (NIP) which features 18 Strategic Integrated Projects. Each of the projects contains specific infrastructure components and programmes, covering social and economic infrastructure across all the nine provinces in South Africa. It offers a:

i. framework for faster growth and socio-economic progress;
ii. promotes enhanced competitiveness,
iii. expanded infrastructure,
iv. greater spatial efficiency in growing cities,
v. accelerated rural development and
vi. Prioritizes measures to build a capable, effective state that delivers services to citizens while encouraging business investment and growth.

Political developments and industrial unrest have led to a loss of momentum with the implementation of the NDP (PWC, 2013).

Radebe J. et al., (2014) reiterated PriceWaterhouseCoopers' past presentation at the World Economic Forum relating to agro-industries illustrating that Africa produces and exports

USD6 billion of coffee yet that is turned into products outside the continent's borders that are worth USD100 billion. He enthuses that,

> "The common objective of the African continent, particularly in the period after the peak of the commodity super cycle passed in 2012, has been defined as diversifying our economies and moving up the value chain."

In the last five years, the South African government has spent more than R1 trillion on infrastructure (energy, ports, road and rail, broadband and social infrastructure projects) (Radebe J. et al, 2014). There is a lot of initiatives in the spheres of industrial development, and also involving a number of supply industries that are involved in the creation of infrastructure (Radebe J. et al, 2014). They go on to base South Africa's plans for expansion beyond the country's borders on the justification that even the biggest countries in Africa have populations that are too small to sustain industrialization based on the domestic market alone; and that it is no longer possible to count on flooding the developed world with manufactured goods. Thus it is paramount and timely to utilize the accumulated continental market certainly to support diversification and industrialization. Intra-African trade only constitutes about 12% of total trade and this compares with about 79% in the European Union. The COMESA-EAC-SADC Tripartite Free Trade Area presents a novel and desired avenue to promote regional integration which is proposed to also include the trade integration component and complemented by the promotion of regional infrastructure (Radebe J. et al, 2014).

South Africa's national industrial policy vision is articulated by the National Industrial Policy Framework (NIPF) and its implementation is driven by the Industrial Policy Action Plan (IPAP). IPAPs are three-year rolling plans published annually (South Africa is currently implementing IPAP 2). According to an interviewee at the Department of Trade and Industry, these plans "emphasize the importance of manufacturing and its ability to generate dynamic increasing returns to the depth of its linkages (and) recognize the

technological progress (that) is embedded within manufacturing," (ERA, 2014). The AEO (2017) underscores the interviewee as it states that IPAPs serve to diversify the economy beyond the mining sector giving priorities to sectors that are medium to high value added and labour-intensive such as vehicles, agro-processing, textiles and green energy. Local governments can also mobilise industrial and innovation policies, notably by raising local revenues (AEO, 2017). South Africa has been ranked high among other African countries (Ghana, Botswana and Mauritius) in their capability to implement industrial policies than some Asian competitors (AEO, 2017).

South Africa's industrialisation strategy is also geared towards promoting entrepreneurship, which will also help to generate employment. For instance, in 2009, Johannesburg City developed a Youth Entrepreneurship Strategy and Policy Framework whose plan is to transform South Africa into the developing world's leading country in entrepreneurship by 2025 (AEO, 2017).

According to the latest survey by the Manufacturing Circle (2013), more than 75% of South African manufacturers were exporting to Africa. It is also the world's largest producer and exporter of gold, platinum and chromium. The Chamber of Mines of South Africa (2002) indicates that 90% of the world's global platinum mineral resources are estimated to be in South Africa's Bushveld Complex.

South Africa experienced an accelerated and rapid urbanisation that was intimately bound up with a swift economic progress stated to have been majorly influenced gold mining industry. The leap is described by Yudelman (1984) as 'the leap from a fledgling quasi-state to a surprisingly advanced modern industrial state within the space of eighty years' a process that took centuries in Europe, in comparison. Chang (1997) elucidates that the country's economy managed to survive a tough past due to the abundance of natural resources. The tough period the country faced featured an unproductive manufacturing

sector that was characterised by outdated technology(ies), processes, procedures, administration and organisation (Joffe et al, 1995) majorly induced by international sanctions South Africa firms faced, an undeveloped human capital and the protectionist policies (Green P., 2009). Subsequently the manufacturing sector resorted to relying on producing goods for the domestic market (Barnes J., et al., 2000; Roberts S., et al, 2004). The small and medium enterprises (SMEs) were suppressed as a result of government policies causing the industry to be dominated by large firms that relied on subsidies (Joffe et al, 2005). Additionally, the high tariffs on imports and international sanctions created an uncompetitive business environment coupled with a lack of incentives for firms to improve on their productivity (Joffe et al, 2005). Indeed, the industrialization landscape has changed significantly. Previously, policies that had initially been designed to benefit 25% of the population had created a situation whereby the industrial structure was inefficient (Chang, 1997). Three industries will help scrutinize this discussion further: The Automotive, Textiles and Furniture industries.

*The Automotive and Component Industry*

Trade liberalisation in South Africa accounted for 7.4% of South Africa's GDP in 2005, dispelling fears of its demise (DTI, 2007c). The enforcement of effective policies enabling the automotive industry to respond to globalisation and become a significant exporter led to this insurmountable success (Green P., 2009). Vehicle exports increased from 20,000 in 1997 to 285,000 in 2008, a huge leap in just less than 10 years (Kaplinsky, 2005). Launched in 1995, the Motor Industry Development Programme (MIDP) encouraged manufacturers to produce certain components while enabling them to import others on duty-free basis (Black, 2001). Specialisation set in making the industry more productive. The MIDP encouraged firms to export, as they weren't allowed to import in excesses of what they exported (Kaplinsky, 2005). These conditions were favourable enough to provide foreign firms such as Ford and Toyota with the incentives required to reinvest in the country (Barnes & Kaplinsky, 2000). As a result, there was importation of up-to-date technology

and processes and help for local firms, including component SMEs, to connect to the global motor industry (Kojima & Kaplinsky, 2004). The MIDP played a significant role in enabling the assembly industry to become more productive, although the sector also benefited a lot from cheap electricity (SAinfo, 2008) and access to affordable aluminium (Kojima & Kaplinsky, 2004).

*Textiles*

South Africa's textile and clothing industry was quite uncompetitive and relied on quota restrictions and import tariffs to shield it from foreign imports (Bezuidenhout et al, 2007). Between 1990 and 2000, there was an improvement in productivity in this sector and clothing exports increased from 4% to 18% respectively due to the large firms' response to the global market. They did so by attracting investment that enabled them to update their machinery and processes (Roberts & Thoburn, 2004). It goes without saying that employment was affected; Bezuidenhout et al, (2007) remarks that it will be extremely difficult to increase productivity, without reducing levels of employment level.

*Furniture*

Despite utilizing outdated processes, cheap labour and an abundant supply of raw materials enabled the industry to be competitive, resulting in exports rising from 4% in 1990 to 44% in 2000 (Jooste et al, 2003). The industry reaped great benefits from contracts with large European companies such as IKEA & B&Q (Kaplinsky et al, 2002). Relationships with these companies provided producers with access to the finance and technology they required to upgrade (Kaplinsky et al, 2002). However, South Africa's furniture industry has been undermined by low quality and widespread inefficiency (Green, 2009).

It is widely known that the "days of cheap electricity and energy are coming to an end" (DTI, 2007b: 3), and it still remains a government responsibility to ensure that there is

enough supply that meets the increasing demand. South Africa's instability was one reason for struggling to attract FDI whereas a high crime rate is still a key constraint for potential investors (Thomas et al, 2005). In essence, integrating into the global economy entailed a major shift from protectionist policies that resulted in low productivity towards policies that promoted competition and facilitated efficiency, leading to improved livelihoods.

*Logistics*

Performance in the logistics showcase an overall ranking of 23rd out of 155 countries in the 2012 Logistics Performance Index (PWC, 2013). The rail and air networks are the largest on the continent, and the major roads are in good condition and Durban is Africa's busiest port (PWC, 2013). The only high speed train in Africa, the Gautrain was opened just days before the start of the 2010 FIFA World Cup transports about 40 000 people every day and it connects Johannesburg, Pretoria and OR Tambo International Airport. The network faces challenges such as signalling failures, rolling stock failures, security and power outages, including power outages as a result of cable theft (PWC, 2013). South Africa's road network is the longest whole of African with about 89% of the country's freight relying on road (CSIR, 2008).

*The mineral-energy complex*

What Fine and Rustomjee (1996) named 'the mineral-energy complex' (MEC) elicits significant government support and attention whereby government has sought, 'quick wins'—such as the Maputo Corridor and other large, capital-intensive and energy-hungry projects. These projects perpetually serve to support the mining industry and are focused on capital-intensive and heavy manufacturing (Bhorat H., et al, 2014). For a long time, I have tried to derive the surreal linkages between the two within metaphorical contexts across the continent.

#### *5.4.2.3 The opportunities/gains/challenge/gaps in the nexus*

South Africa is exemplary in the manner in which it is harmonizing her policies, and especially in an integrated and decentralized fashion. There is readiness to empower local authorities who have to face the challenges of urbanization first hand and who also help in providing speedy feedback towards improving the delivery of services and improvement of livelihoods. The major challenge remains if it will manage to achieve her target of emissions given the growing opportunities for economic diversification and need to alleviate the energy poverty facing 25% of the population.

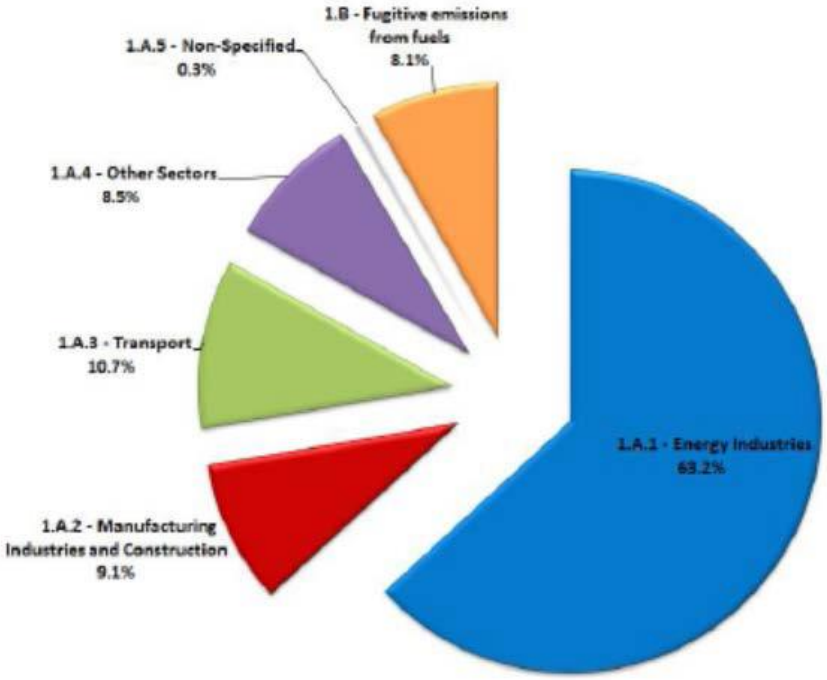
### *5.4.3 Climate Change Measures*

South Africa submitted her NDC on adaptation, mitigation as well as finance and investment requirements for both on the understanding that the Paris Agreement would be fair, binding, effective and incorporate a "no-backsliding" and a "progressive" approach to enhance climate change mitigation and adaptation, implementation and ambition (SANDC, 2015). The country's commitment to addressing climate change is largely based on science and equity. Although there is commitment to ensure that increases in temperature are kept well below 2°C above pre-industrial levels, there is a proposal to revise further the temperature goal to below 1.5°C in light of emerging science. This is because a global average temperature increase of 2°C translates to up to 4°C for South Africa by the end of the century (SANDC, 2015). There is wide acknowledgment that the country is vulnerable to the impacts of climate change, particularly in respect to food security and water. There are also rising impacts on human settlements, health, infrastructure and ecosystem services.

The total CO2 contribution in 2012 is 454,921 Gg CO2 (excl. FOLU) which is up from 376,050 Gg CO2 in 2000. The energy sector is the largest contributor to the total GHG emissions in South Africa providing 77.3% in 2000 and increasing to 79.4% in 2012. It is

also the largest contributor to CO2 emissions in South Africa, contributing 92.5% in 2012 with the largest CO2 emitters being energy industries contributing 61.1%, transport 10.3%, and other sectors 8.8%. The metal industries subsector is the most significant source of emissions in the IPPU sector, contributing between 79.9% and 80.5% over the period 2000 to 2012. The iron and steel industry was the biggest contributor in 2012 to the metal industry emissions at 50.5% (DEA, 2017).

*Figure 24: Average contribution of source categories to the total energy sector GHG emissions between 2000 and 2012*




*Source 31: (DEA, 2017)*

The NDC reports that there has been significance progress in the implementation of climate policy via the of 2011, climate-compatible sectoral plans, National Sustainable Development Strategy, climate-compatible sectoral plans, such as the integrated energy and electricity plans (IEP and IRP), industrial policy action plans (IPAP) and the new growth path (NGP). If fully implemented the curve of South Africa's GHG emissions will bend towards a peak, plateau and decline trajectory range. A National Climate Change Adaptation Strategy and Plan (NCCASP) is being developed and will be integrated into all

relevant sector plans, and upon which its UNFCCC National Adaptation Plan (NAP) will be based. This plan is being informed by an assessment of sectoral, cross-sectoral and geographical vulnerabilities to the adverse impacts of climate change, and it will quantify and present pathways for adaptation, towards an inclusive and just transition to a climate resilient economy and society. It will also take into account the local and indigenous knowledge, gender considerations, as well as social, economic and environmental implications. The tables below are a summary of South Africa's adaptation and mitigation plan of implementation, guided by their NDC.

South Africa addresses adaptation through six goals, underpinned by key elements of adaptation planning, costing of adaptation investment requirements, equity, and means of implementation as captioned in Table 3.

*Table 8: South Africa's Adaptation component of the NDC*

| **Element** | **Undertaking for the period 2020-2030** | **Assumptions / Methodologies** |
|---|---|---|
| Adaptation objectives and planning for implementation | **Goal 1**: Develop a National Adaptation Plan, and begin operationalization as part of implementing the NCCRP for the period from 2020 to 2025 and for the period 2025 to 2030. | National Development Plan Vision 2030, sector plans and any future variants thereof are the underpinning foundation for sustainable development planning in South Africa. The NCCRP provides guiding principles and will form the basis for the integrative NAP focused on vulnerable sectors and geographic vulnerabilities. |
| | **Goal 2:** Take into account climate considerations in national development, sub-national and sector policy frameworks for the period 2020 to 2030. | Integrate flexible adaptation sector policies and measures into national and sub-national policy frameworks to enable implementation of climate change adaptation programmes and projects. Sector adaptation plans will be integrated into broader sector plans consistent with relevant sector planning or regulatory legislation. |
| | **Goal 3**: Build the necessary institutional capacity for climate | National and sub-national policy and legislation development and budget |

| | | |
|---|---|---|
| | change response planning and implementation for the period 2020 to 2030. | reprioritisation to enable institutional capability to plan and implement catalytic adaptation programmes and projects.<br><br>Comprehensive adaptation related training of development planners, regulators and practitioners.<br><br>Specific adaptation planning at sub-national level, taking into account specific or unique geographical circumstances, will be integrated into sub-national development frameworks, land use schemes and the planning authorisation system in terms of provisions of and standards set in the Spatial Land Use Management Act (SPLUMA). |
| | **Goal 4**: Develop an early warning, vulnerability and adaptation monitoring system for key climate | Development of national framework for early warning, vulnerability and needs assessment well before 2020. Develop and support a climate change early warning and vulnerability network with the involvement of relevant stakeholders, e.g. SA Weather Services, SA Earth Observation Network, the downscaling modelling and adaptation academic community etc. |
| Adaptation needs and costs | **Goal 5**: Development of a vulnerability assessment and adaptation needs framework by 2020 to support a continuous presentation of adaptation needs | Biennial study of climate related impacts and responses detect through the early warning, vulnerability and adaptation monitoring system, with a view to determine cost effectiveness of responses and recommend improved or alternative responses.<br><br>Damage costs associated with severe climate related events (wild fires, storms, droughts and floods), including both direct and downstream costs were estimated for the present-day climate and for the near future under low and moderate-high mitigation scenarios. |

| | | |
|---|---|---|
| | | Emission scenarios considered are RCP 8.5 (low mitigation) and RCP 4.5 (moderate-high mitigation). The cost estimates provided are in terms of the 10th and 90th percentiles of annual costs occurring within the periods of interest.<br><br>Annual costs were estimated for 2020-2030 and 2020-2050.<br><br>Sectors covered; Water, Agriculture, Forestry, Energy, Settlements, Biodiversity, Disaster Risk Reduction (DRR) |
| Adaptation investments | **Goal 6**: Communication of past investments in adaptation for education and awareness as well as for international recognition | Development & implementation of a climate change adaptation communication, education and awareness framework, with a view to drive behaviour change based on the early warning and vulnerability assessments and studies of response effectiveness. Specific indicators for tracking outcomes and scale of domestic investment and any international support will be developed and reported.<br><br>Adaptation investments were gleaned from official annual reports. The years covered are 2010 – 2015. |

*Source 32: NDC (c), 2015*

South Africa is committed to mitigate climate change in line with the principle of common but differentiated responsibilities and respective capabilities. It moves from a "deviation from business-as-usual" form of commitment and takes the form of a peak, plateau and decline GHG emissions trajectory range. The country's emissions by 2025 and 2030 will be in a range between 398 and 614 Mt CO2–eq.

*Table 9: South Africa's Mitigation component of the NDC*

| **Reference point (including, as appropriate, a base year)** | **Peak, plateau and decline (PPD) is a GHG emissions trajectory range after mitigation. The starting point for PPD considered here is 2020 year-end.** |
|---|---|
| Time frames and / or periods for implementation | The time-frames within the PPD trajectory range that are communicated in South Africa's INDC are 2025 and 2030, in which emissions will be in a range between 398 and 614 Mt CO2–eq.<br><br>The policy instruments under development include a carbon tax, desired emission reduction outcomes (DEROs) for sectors, company-level carbon budgets, as well as regulatory standards and controls for specifically identified GHG pollutants and emitters. |
| Scope and coverage | Economy-wide, all sectors, six greenhouse gases (GHGs), with a material focus on three GHGs: carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O).<br><br>IPCC major categories: energy, IPPU, waste and AFOLU (agriculture, forestry and other land use).<br><br>Increased disaggregation over time will be enabled through the introduction of mandatory GHG reporting domestically, no later than 2016, with regular reporting to the UNFCCC as multi-laterally agreed. |
| Planning processes, assumptions and methodological approaches including those for estimating and accounting for anthropogenic greenhouse gas emissions and, as appropriate, removals. | *Planning processes*: The approach to the current NDC is based on national climate policy (NCCRP) and the national development plan (NDP), and will be given effect through energy, industrial and other plans and legislation.<br><br>*Assumptions*: In accordance with the Convention, it is assumed that the extent to which developing country Parties will effectively implement their commitments will depend on the effective implementation by developed country Parties of their commitments under the Convention relating to financial resources, development and transfer of technology, and capacity building.<br><br>*Metric applied*: 100-year Global Warming Potential, as in the IPCC's 4th Assessment Report (AR4). Note that the current GHG inventory, consistent with the 2006 IPCC guideline reporting requirements, used GWPs from the Third Assessment Report (TAR) and indicated that future inventories will use GWP values from AR4. |

| | |
|---|---|
| | *PPD trajectory range*: South Africa's NCCRP "details the 'peak, plateau and decline trajectory' used as the initial benchmark against which the efficacy of mitigation actions will be measured". This is the PPD trajectory range in the NDC. Values for key years are specified in the NCCRP. |

*Source 33: NDC (c), 2015*

The mitigation and adaptation measures outlined above are very fundamental in shaping the current and future urbanization and industrialization processes in South Africa. They demonstrate efforts that lead towards sustainable urbanization and industrialization. However, there is still a lot that is yet to be done and the ambitious targets, especially on curbing emissions, leaves us with a great anticipation to see how this will unfold. Without a doubt South Africa is going to continue reaping the benefits of expanding her industrialization tentacles across SSA. This opportunity further presents a greater responsibility for the country to sharpen their geopolitical approach taking into consideration the local existing policies of their partner countries.

## 5.5 The case of Nigeria

### *5.5.1 Introduction*

Nigeria is rapidly advancing and scale of real growth stands second only to government plans. Key supporting factors will be the huge, young and urbanised population, large oil and gas reserves and an increasingly diversified economy. The country is also Africa's second-largest economy and leading oil producer (Nigeria, 2012). Given the high rates of urbanisation, the bubbling youthful population and a vast economic potential, Nigeria will increasingly and inevitably grow into an industrial and services-based economy. Nigeria's population is 50% urbanised making retail & consumer sectors very attractive. The fundamental questions in this segment are:

1. Will Nigeria's future inhabitants be able to have access to Energy that is clean, affordable, available, accessible and reliable?

2. Is there an existing nexus between energy, climate change, urbanization and industrialization? If such exist how well do they gel in together?
3. How do the measures towards climate change and energy impact on Nigeria's urbanization and industrialization?

Nigeria economy has been being guided by the Vision 20:2020 blueprint, where it aims to be among the world's top 20 economies by 2020. Nigeria's tariff system used to feature a 19-band tariff regime which has since been simplified and replaced with the ECOWAS five-band Common External Tariff system, which bears more relaxed trade restrictions (PWC, 2013). Trading in Nigeria still faces some impediments including, several protectionist measures and bureaucracy, and graft (one of the highest in Africa).

Nigeria's human development is still fairly low in comparison to the economic growth. Regionally, the country's labour productivity has improved faster compared to its regional peers (PWC, 2013). Some basic indicators are captioned below:

*Table 10: Basic Indicators in Nigeria, 2016*

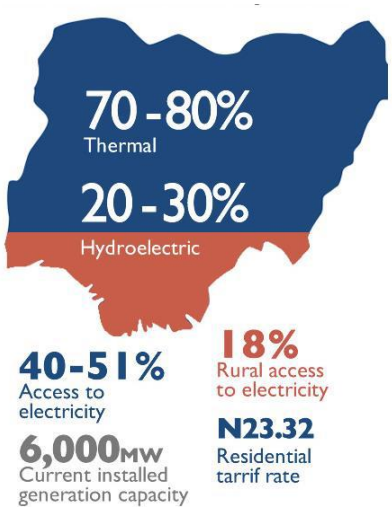
| Basic indicators, 2016 | | | | | | |
|---|---|---|---|---|---|---|
| | **Population** (thousands) | **Land area** (thousands of km2) | **Population density** (pop. / km2) | **GDP based on PPP valuation** (USD Million) | **GDP per Capita** ( PPP valuation, USD) | **Annual real GDP growth** (average over 2008-2016) |
| Nigeria | 186 988 | 924 | 202 | 1 088 938 | 5 824 | 4.8 |

*Source 34: (AEO, 2016)*

The current population density varies among the various states. Those in the north east and north west tend to be less populated whereas the megacity of Lagos is the only state with a population density greater than 1000persons per square kilometre. Despite these rich human and natural resources, various sectors of her economy still suffer and 46% of its population live below the poverty line (World Bank, 2016).

### 5.5.2 *Status of Energy in Nigeria*

*Figure 25: Current Generation Input Mix*




*Source 36: US Energy Information Administration, International Energy Statistics, 2010*

*Source 35: NERC. Multi-Year Tariff Order (MYTO) 2.1, 2015 - 2018*

Despite the abundance of resources in an economic powerhouse as Nigeria's, I ask, is oil manna from the heavens and or is it a precursory blessing? Four refineries in Nigeria operate at a fraction of capacity yet most businesses rely heavily on generators. This makes Nigeria one of the most energy-intensive countries in the world. It also has a maximum capacity oil production of 2.5 million barrels/ day and it is strategically placed as the largest oil producer in Africa and the sixth largest in the world; it is also blessed with one of the largest natural gas reserves in the world. As at 2012, Nigeria was the fourth largest exporter of Liquefied Natural Gas (LNG). It also has about 37 billion barrels of proven oil reserves and 187 trillion cubic feet of proven natural gas reserves (OPEC, 2016). It is a regional power, listed among the "Next Eleven" economies, and a member of the Commonwealth of Nations (EIA, 2014). Power supply in Nigeria has, typically, been epileptic and characterized by its high cost and overall electrification rate of 45% (IEA, 2014). The energy sector like other sectors in its economy has suffered a huge dependence on crude oil products and price variability. Although the country is one of the largest producers of oil, it still imports 85% of refined products due to its low capacity utilization of its local refineries (GIZ, 2015). According to the second draft of the Renewable Energy Master Plan (REMP) (2012) as prepared by the Energy Commission of Nigeria it seeks to increase the supply of renewable electricity from 13% of total electricity generation in 2015 to 23% in 2025 and 36% by 2030. This means that by 2025, renewable electricity would then account for 10% of Nigeria's total energy consumption (ECN, Nov 2012).

Agriculture takes a significant share in the Nigerian economy, in spite of the dominance of oil, accounting for about 42% of GDP in 2012. Agriculture presents a major opportunity

for driving Nigeria's economic growth if it undergoes sustainable expansion. Poverty levels will reduce and food security enhanced especially if done in a timely manner and in a bid to reduce its dependence on oil (PWC, 2013).

Although Nigeria has a growing population of more than 179 million, it generates less than 4,000 MW per year leading to a scarcity of reliable and sufficient electricity that severely constrains the economic growth and development of the country (Power Africa, 2015).

The Federal Government of Nigeria (FGN) has put in place plans to tackle the aforementioned issues via the implementation of a three-phase liberalization process. The first phase features the privatization of five generation and ten distribution companies which are linked to the country's main power holding company, PHCN, since 2013. The Niger Delta Power Holding Company (NDPHC) is in the process of privatizing ten newly built generation plants. These privatized companies are contractually obligated to increase generation for each plant over the next five years, achieving a target 6,000 MW of installed capacity. Estimates provided for by the government target a generation of an additional 5,445 MW. Additionally, investments by new independent power producers will generate 2,000 MW (Power Africa, 2015).

Nigeria launched the first national biofuels strategy in 2016 (REN21, 2017). The Nigeria National Petroleum Corporation (NNPC) announced plans to set up a bio-refinery that will use agricultural products to produce ethanol and other products, and Union Dicon Salt has agreed to a joint project with Nigeria's Delta State to plant 100,000 hectares of cassava and to build an ethanol processing plant that will produce 22,000 litres a day along with starch products (Sapp M., 2016). Biofuels Nigeria is also planning to build a biodiesel plant in Kogi State using jatropha as feedstock (Heida, L., 2016).

The National Energy Efficiency Action Plans (NEEAP) was published in July 2016. The current targets for Renewable Power Installed Capacity and/or Generation include Bio-power for 400 MW by 2025, Hydropower (small-scale) for 2 GW by 2025, Solar PV (large-

scale, >1 MW) for 500 MW by 2025, CSP for 5 MW by 2025 and Wind power for 40 MW by 2025 (REN21, 2017).

### *5.5.3 Nigeria's structural transformation, what is the underlying key nexus (es)?*

Nigeria's industrial sector is governed by the Nigeria Industrial Revolution Plan (NIRP) of 2014-19. The manufacturing share of GDP increased to 9.5% in 2015, up from 2.8% in 2005 (AEO, 2017). Strong performance from sub-sectors such as textile, apparel and footwear activities and basic metals, iron and steel contributed to the growth of the industrial sector during this period (Nigerian National Bureau of Statistics, 2014). The GDP for 2016 was estimated at -1.5%, and a moderate recovery was expected in 2017. This is as a result of a series of shocks, including the continued decline in oil prices, foreign exchange shortages, power shortages, disruptions in fuel supply and sharp reduction in oil production, and insecurity in some parts of the country, as well as low capital budget execution rate (51%) (AEO, 2017). Managers of the economy responded to the recession with a package of monetary, fiscal and exchange rate policies. The government has also developed the Nigeria Economic Recovery and Growth Plan (NERGP) framework of 2017-20. The plan focuses on five key areas: (i) improving macroeconomic stability; (ii) economic growth and diversification; (iii) improving competitiveness; (iv) fostering social inclusion; and (v) governance and security.

#### *5.5.3.1 The Case of Lagos*

Lagos is one of the largest cities in Africa and a report by Price Waterhouse Coopers (2013) states that it is expected to be the twelfth-largest city in the world by 2025. Fani (2012) termed Lagos as the second most populous and fastest-growing city in Africa after Cairo. Lagos currently ranks as the seventh fastest-growing city in the world (World Urbanization

Prospects: The 2011 Revision). It has a vision of becoming a climate smart city in the long run.

It is projected that there will be 7 million tonnes of municipal solid waste in Lagos State by 2030; an 80% increase on current levels (Fani, 2012) presents an opportunity for long term planning for biogas. Between 16,000 – 27,000MW of new generation capacity will be required in Lagos State by 2030 (Fani, 2012).

In 2003 Nigeria adopted a home-grown poverty reduction strategy referred to as the National Economic Empowerment and Development Strategy (NEEDS). A year later this strategy was decentralised to the state level in 2004. Following this example, Lagos State formulated and adopted the Lagos State Economic Empowerment and Development Strategy (LASEEDS) in 2005. It is "a poverty reduction strategy aimed at achieving cohesive coordination of the development process through adoption of a bottom-up approach and inclusiveness of stakeholders" (Ehingbeti 2008).

The urban rail network planned for Lagos will have seven rail lines spanning 264 kilometres. Once complete, the network is expected to ease traffic congestion and provide employment for the growing population. Another plan set in place by the Lagos state government is the Lagos Metropolitan Area Transport Authority (LAMATA), signalling its intention to re-orient the way in which transport services were managed and implemented (Mobereola 2006). LAMATA, created in 2013, is responsible for the formulation, coordination and implementation of urban transport policies and programmes.

Lagos State has identified Power, Agriculture, Transport and Housing (PATH) as the "Quickest drivers for post-recession economic recovery and poverty eradication", noting their enabling capacity to accelerate inclusive development in Lagos (LSG, 2014). Below are some of the key issues identified by the state government and the proposed solutions in relation to the energy sector:

a. 60% LIVE IN INFORMAL SETTLEMENTS: Energy access is an important part of the 'enabling' approach to integrating informal settlements into the city
b. 80% OF HOUSEHOLDS RELY ON DIESEL GENERATORS:

i. Households spending 50N/kWh for diesel generation compared with 13N/kWh for grid electricity
ii. Lack of access to power results in use of generators and hardwood fuel resulting in air quality problems and increasing risk of respiratory disease

c. 40% OF POPULATION HAVE NO ACCESS TO POWER GRID:
   i. Human capital and wellbeing improved with access to utilities
   ii. Limited street lighting enables crime and impacts on personal safety
   iii. Infant mortality reduced through provision of reliable power to hospitals
   iv. Building regulations support energy conservation and efficiency

d. LAGOS ENERGY SECTOR TODAY. HIGH RISK AND VULNERABLE:
   i. Power deficit equal to 9,000-10,000MW and low utilisation of generating capacity
   ii. 40% have no access to the electricity grid and inadequate transmission capacity
   iii. 150kWh/yr average annual energy consumption
   iv. 80% population relying on diesel generators
   v. Governance challenges Federal – State ownership / management of assets
   vi. Minimal renewable energy in Lagos State energy mix
   vii. Fossil fuel subsidies in place

e. FUTURE PROOFING LAGOS ENERGY SECTOR – POTENTIAL INTERVENTIONS
   i. Development of offshore gas
   ii. Embedded generation – Independent Power Projects (conventional and renewable)
   iii. Municipal Energy Fund to finance rural and urban solar projects
   iv. Community biogas projects
   v. Offshore wind
   vi. Compressed Natural Gas transportation
   vii. Promotion of energy efficient appliances
   viii. Building regulations

f. LAGOS ENERGY SECTOR 2030. INCLUSIVE, RESILIENT AND ADAPTABLE
   i. 100% access to electricity
   ii. State has control and accountability for energy infrastructure
   iii. Independent Power Projects result in stable and reliable power supply, lower air pollution and carbon emissions
   iv. Renewable energy accounts for at least 20% of state energy mix
   v. Incentives and education programs support energy conservation
   vi. Building regulations improve energy performance
   vii. Street lighting covers 100% of commercial and residential areas
   viii. Fossil fuel subsidies reformed and investment in sustainable energy

g. DAILY TRIPS DEMAND ESTIMATED TO REACH 30M/DAY IN 2030 LAGOS IS THE LARGEST MEGACITY IN THE WORLD WITHOUT INTEGRATED MASS TRANSIT NETWORK
   i. Mass transit supports modal shift, reducing car dependency
   ii. Air quality and public health will be improved
   iii. Lagos State Strategic Transport Master Plan dependent on c.200MW of additional capacity to power rail and metro lines 200MW New generation capacity required for planned mass transit infrastructure
h. 7% ANNUAL INCREASE IN CAR OWNERSHIP 1 MILLION REGISTERED CARS
   i. Rising incomes correspond to rising car ownership exacerbating congestion
   ii. Integrated land use planning and transport can avoid car dependency Reliable, secure, affordable power provision is an essential element of infrastructure for Lagos State's SPAAG (Strategic Programme for Accelerated Agricultural Growth).
i. UP TO 60% OF FRESH PRODUCE WASTED IN SUPPLY CHAIN
   i. Energy will enable cold storage and distribution networks, improving access to market, reducing waste and improving food hygiene
   ii. Stronger interstate trade links with reliable power
   iii. Higher temperatures resulting in greater evapo-transpiration and a larger water demand for crops can be managed
j. 70% OF RURAL POPULATION EMPLOYED IN AGRICULTURE
   i. Addressing energy deficit in rural economy supports food production and processing investment
   ii. More rural opportunities reduces migration
   iii. Provision of power will support technological innovation and production efficiencies (LSG, 2014).

Another provision for Lagos' future energy resilience is the Lagos Energy City initiative (Eyo, E., et al., 2008). According to Eyo et al., (2008) this initiative is envisioned to be the first fully integrated business hub for the oil and gas industry on the Africa continent. It will also provide life, work, and play elements to non-energy companies as well. It is a 763-hectare development strategically located in Badagry Town of Lagos comprising two zones:

- Zone 1 aims to be the region leading convention and tourist destination;
- Zone 2, or the Energy City Zone, will provide a world class business and residential environment that will cater for the entire energy industry and all companies in its value chain (Lagos Energy City, 2007).

### *5.5.4 Climate Change Measures*

Nigeria's Vision 2020 sees climate change as a potential driver of "damaging and irrecoverable effects on infrastructure, food production and water supplies, in addition to precipitating natural resource conflicts." Nigeria's NDC recognizes this as an important first step towards a climate change adaptation strategy and action plan. Maintaining a BAU growth scenario, consistent with a strong economic growth of 5% per year, translates to a growth of emissions to around 900 million tonnes per year in 2030, which translates to around 3.4 tonnes per person. Alack of adaptation would be very costly for Nigeria's overall economic development especially in the energy and agricultural sectors. According to a 2009 DFID study, if no adaptation action is taken, between 2-11% of Nigeria's GDP could be lost by 2020. Following the major floods of 2012, the Post Disaster Need Assessment (PDNA) report revealed that the total damage caused by the disaster amounted to USD16.9billion, representing 1.4% of real GDP growth in that year.

In 2000, Nigeria contributed about 214.21 million tonnes (Mt) of CO2 equivalent (CO2e) of GHG to the atmosphere; 155.34 MtCO2e was from the energy sector. Carbon dioxide was the largest contributor (114.72 MtCO2e) at a percentage of 74% of the total energy sector emissions. Energy-related activities have the dominant share of GHG emissions which are classified into two main categories: (i) emissions from fuel combustion, and (ii) non-combustion (fugitive) emissions (FME, 2014). Emissions from the industrial sector are mainly from mining and the construction sector, showcasing an indication of the weak industrial capacity utilization in Nigeria.

*Table 11: Emissions in Nigeria*

| Sector | Emissions ($MtCO_2e$) | Emissions (%) |
|---|---|---|
| Energy: | | |
| • Fuel Combustion | 133.01 | 60.32 |
| • Fugitive Fuel Emissions | 22.33 | 10.13 |
| Agriculture | 60.69 | 27.52 |
| Industrial Processes | 2.10 | 0.95 |
| Waste | 2.38 | 1.08 |
| **TOTAL** | **220.51** | **100** |

*Source 37:( FME, 2014)*

With regards to energy, climate change will have significant effects on the energy sector in particular, rising temperatures would result in increased energy demand for refrigeration, air conditioning and other household uses. This is within a context of severe shortages of energy supply.

With regards to agriculture and food security, a sector that is most sensitive to climate change, agricultural productivity could decline between 10 to 25% by 2080 under a BAU scenario. In some parts of the north, the decline in yield in rain fed agriculture could be as much as 50%. This in turn would impact GDP, reducing it by as much as 4.5% by 2050, even though the share of agriculture in GDP will decline from 40 to just 15%.

#### *5.5.4.1 The National Adaptation Strategy and Plan of Action for Climate Change Nigeria (NASPA-CCN)*

The NASPA describes Nigeria's adaptation priorities, bringing together existing initiatives and priorities for future action. Also the NDC explores on them as a global commitment. The table below is a summary of the actions.

*Table 12: Climate Change Adaptation Measures for Nigeria*

| **A. Strategies For Agriculture (Crops And Livestock)** |
|---|
| 1. Adopt improved agricultural systems for both crops and livestock (for example, diversify livestock and improve range management; increase access to drought resistant crops and livestock feeds; adopt better soil management practices; and provide early warning/meteorological forecasts and related information).<br>2. Implement strategies for improved resource management (for example, increase use of irrigation systems that use low amounts of water; increase rainwater & sustainable ground water harvesting for use in agriculture; increase planting of native vegetation cover & promotion of re-greening efforts; and intensify crop and livestock production in place of slash and burn).<br>3. Focus on agricultural impacts in the savanna zones, particularly the Sahel, the areas that are likely to be most affected by the impacts of climate change. |
| **B. Strategies For Energy** |
| 1. Include increased protective margins in construction and placement of energy infrastructure (i.e. higher standards and specifications).<br>2. Undertake risk assessment & risk reduction measures to increase resilience of the energy sector.<br>3. Strengthen existing energy infrastructure, in part through early efforts to identify and implement all possible 'no regrets' actions.<br>4. Develop and diversify secure energy backup systems to ensure both civil society and security forces have access to emergency energy supply.<br>5. Expand sustainable energy sources and decentralize transmission in order to reduce vulnerability of energy infrastructure to climate impacts. |
| **C. Strategies For Transportation And Communications** |
| 1. Include increased protective margins in construction and placement of transportation and communications infrastructure (i.e. higher standards and specifications).<br>2. Undertake risk assessment and risk reduction measures to increase the resilience of the transportation and communication sectors.<br>3. Strengthen existing transportation and communications infrastructure, in part through early efforts to identify and implement all possible 'no regrets' actions.<br>4. Develop and diversify secure communication backup systems to ensure both civil society and security forces have access to emergency communication methods. |
| **D. Strategies For Industry And Commerce** |
| 1. Increase knowledge and awareness of climate change risks and opportunities<br>2. Undertake and implement risk assessments and risk reduction measures<br>3. Incorporate climate change into ongoing business planning<br>4. Review and enforce land use plans in industrial areas in light of climate change |

| |
|---|
| 5. Encourage relocation of high risk industries, facilities and markets<br>6. Promote and market emerging opportunities from climate change<br>7. Encourage informal savings and insurance schemes, and arrange for the availability of medium term credit (especially for industries in crisis). |
| |

*Source 38: (FRN, 2014)*

Adaptation in Nigeria's context has looked into energy and industrialization under the motivation that they are major drivers towards alleviating the impacts of climate change. Policy dissemination is largely decentralized as has been seen in the case of Lagos, thus an assumption can be deduced that that the adaptation measures shall also be urbanized even though there is no specific mention in the climate change policy.

## 5.6 Discussion

*Energy*

- Except for South Africa, the rest are still grappling with energy poverty at very high levels with above 80% of the population still relying on biomass. It also has the lowest electricity costs and costs of doing business.
- Despite both Nigeria and South Africa being endowed with numerous fossil fuels ranking highly globally, Nigeria has high population living under the poverty line as well as a weak and underutilized industrialization potential and yet South Africa is the biggest investor in Africa.
- Except for South Africa, the rest have energy as the major issue affecting the cost of doing business, e.g. Nigeria's huge power outages and Kenya's too especially during droughts
- When completed the Grand Renaissance Dam will rank Ethiopia highest in hydropower
- When completed the geothermal plans will rank Kenya highest
- When completed the Turkana Wind Project will rank Kenya highest in wind power
- Recent completion of South Africa's Concentrated Solar Power ranks her highest

- Kenya and Ethiopia have greater potential in renewable energy whereas South Africa is only beginning to tap into it having relied on coal for more than 80% of the time.
- Both Kenya and Ethiopia have huge endowments of renewable energy that will drive forward their sustainable development. However, their energy systems will face higher risks from the impacts of climate change, if they do not embark on making them climate resilient, whether directly (e.g. making their hydro dams resilient to floods) or indirectly (e.g. by implementing their robust afforestation programmes).
- Most of the energy consumed in Nigeria is used for residential purposes as against South Africa whose major percentage goes for industrial purposes, hence the Nigerian market is service driven.
- Nigeria has the highest reserves of oil and natural gas
- Renewable Energy, biomass potential and urban solid/liquid waste has been largely underutilized
- Only Nigeria and South Africa have made considerable progress in their urban energy planning.

*Demographic changes*

- Nigeria is facing the fastest population growth, while Ethiopia's is lowest and South Africa is already having high levels of urbanization
- South Africa has the least population with lack of access to electricity at 8%.
- 1/10 of the natural growth of the rural popn is absorbed by urban areas in Ethiopia, against 2/3 in West Africa

*Structural transformation*

The strategies for structural transformation differ from one country to another given their individual state of each of their economies, policy formulation and present drivers driving their economic growth. For instance, agricultural is the main stay for Kenya and Ethiopia whereas mining and energy is the mainstay in South Africa. Rapid urbanization is witnessed more in Kenya and Nigeria majorly driven by the search for better jobs and a degrading environment, whereas in Ethiopia the government's pro poor industrial segments

and highly decentralized governance tends to mitigate the migration by providing employment at other decentralized SEZs in different federal sub states. Whereas Ethiopia plans showcase that rural-urban migration might be slowed following their huge investments in both light manufacturing and agro-industrial processes in the outskirts, Nigeria and Kenya's migration might be much more rapid. This is majorly because of the geographical dispositions they both possess (they both have bigger chunks of arid lands affected by climate change) and there still lies some elements of centralisation despite their devolved functions.

Both climate change and energy has had a huge impact on all the four economies in one way or another, especially those that heavily rely on agriculture as a source of their GDP. Industrialization still remains a slow progress for Kenya and Ethiopia as it may take some time before labour shifts from the low productivity agricultural sector towards manufacturing as both governments are still setting up grounds for this. South Africa is way ahead, even into investing across the continent and has a great opportunity to take the lead in influencing relevant policies in the countries she is operating in. All eyes are on Nigeria's Lagos city, as it is growing into one of the world's largest cities and a majority of the national functions have already been decentralized. Lagos and Kenya's county governments may as well borrow lessons from South Africa and Ethiopia's strategies identified in their key policies in devolving national functions in order to accelerate development functions and in order to achieve the goals stipulated in their economic blue prints.

- All have a desire to transform their countries as can be seen within their economic blueprints
- Only Ethiopia has a robust green economy approach within her Climate Resilient Green Economy (CRGE) action plan. She has also had the highest GDP growth of up to 10% ever recorded.
- Ethiopia's robust approach towards greening her economy while taking advantage of the opportunity of not being 'locked-in'. There is better investor confidence in this country than in the other three.

- In Africa, Ethiopia is highest exporter of coffee, Kenya of tea and flowers, South Africa of gold, platinum & chromium and Nigeria of oil
- South Africa utilized her rapid urbanization (agglomeration economies) by combining it with economic development in a timely manner
- Economic transformation will not be possible without industrialisation; need to reallocating resources from low-productivity sectors to higher ones. South Africa ranks highest in implementing industrial policies
- All are vulnerable to oil price shocks.
- Nigeria is facing the fastest urbanization.
- Despite both Nigeria and South Africa being endowed with numerous fossil fuels, Nigeria has high population living under the poverty line as well as a weak and underutilized industrialization potential and yet South Africa is the biggest investor in Africa.
- Nigeria and Kenya may as well borrow lessons from South Africa and Ethiopia's strategies identified in their key policies in devolving national functions in order to accelerate development functions and in order to achieve the goals stipulated in their economic blue prints.
- Although all have decentralise implementation functions in their strategies, Nigeria and South Africa have had better National Urban Development Plans (NUDPs) than Kenya & Ethiopia.
- All have Special Economic Zones (SEZs) within their plans.

*Climate change measures*

Following the global combined efforts to response towards the changing climate, all the four countries followed suit and submitted their adaptation and mitigation plans and strategies to the UNFCCC via their Nationally Determined Contributions.

- All have Nationally Determined Contributions (NDCs) as per the UNFCCC requirements
- Acknowledge that Climate Change has a huge impact on their economy having experiences negative impacts on their GDP

- All their adaptation action plans are in line with their National Development Plans (NDPs)
- All their climate policies factor in adaptation, mitigation, vulnerabilities and resilient measures.

*Emissions*

They are also taking measures to reduce and mitigate their emissions as has been seen in their national green house inventories and plans to manage them. Each of the countries is contributing emissions but not as much as South Africa's. Whereas majority of the emissions in Kenya and Ethiopia are majorly attributed to agriculture and land use changes, those emanating from South Africa and Nigeria are majorly as a result of fossil fuels. Noteworthy, each of the four countries put a heavy focus on their efforts to curb emissions as well as adapting and mitigating their energy sectors.

- South Africa is the largest emitter and 11$^{th}$ globally
- All have National Greenhouse Inventories, Business As Usual (BAU) and proposed scenarios for their projected emissions
- South Africa & Nigeria's energy sectors are the highest emitters whereas agriculture & Land Use Changes (LUCs) are Ethiopia & Kenya's
- Only South Africa has conducted a deep decarbonization study

*Thus*:

All the four countries have a deliberate and robust approach towards alleviating energy poverty and climate change adaptation, mitigation and measures across all the relevant sectors of their economies.

Main insights include that African countries require a structural transformation approach in their energy, urbanization and industrialization policies, strategies and actions, alongside climate change adaptation and mitigating measures. Also, there are costs associated with

(or without) adaptation to climate change. Economic transformation will not be possible without industrialisation. Industrialisation is necessary for Africa to transform its economies by reallocating resources from low-productivity sectors to higher ones, and within an energy secure economy. Only industrialisation can bring about unconditional convergence with the more advanced economies.

Agglomeration economies are powerful but underperforming in Africa cities, hence improving the economic functioning of the largest cities holds potential benefits. Policymakers have a wealth of opportunities to link urbanization and industrial development under the umbrella of a national development planning framework. However, they must make hard choices in prioritizing the policy focus and investments.

Of the four countries, South Africa has the most robust and ambitious strategy for its residents moving forward, whereas Ethiopia and Kenya can borrow lessons from the numerous opportunities. All the four countries have immense opportunities to position themselves for industrial opportunities that may be no longer viable for China in the short term. The fourth industrial revolution cannot go unmentioned, thus there is a dire and urgent need to heavily invest in human capital in all the four countries in preparation for the eventualities of the future.

The propositions below thus fit to hypothesize this analysis. That:

i. The use of energy that is clean, affordable, available, accessible and reliable will increase Africa's resilience towards her urbanization and industrialization processes.
ii. Adequate transformation in Africa is as a result of a nexus approach of sustainable energy provision, climate change preparedness, urbanization and industrialization.
iii. There exists energy and climate change measures that are adaptive to climate change.

# CHAPTER VI

# CONCLUSION, POLICY IMPLICATION AND FUTURE DIRECTION

The research has delved deep into the interlinkages of energy, climate change, urbanization and industrialization. It has sought to influence the theories within these four sectors and to investigate their current status in Ethiopia, Kenya, South Africa and Nigeria. The journey has been towards responding to the following key questions:

1. Will Africa's future inhabitants be able to have access to Energy that is clean, affordable, available, accessible and reliable?
2. Is there an existing nexus between energy, climate change, urbanization and industrialization? If such exist how well do they gel in together?
3. How do the measures towards climate change and energy impact on Africa's urbanization and industrialization?

The research was able to find answers to the research questions. In summary:

*Energy*: All the four countries have a deliberate and robust approach towards alleviating energy poverty and climate change adaptation, mitigation and measures across all the relevant sectors of their economies. A majority of the states identified the energy sector as their primary area of focus within their NDCs. Except for South Africa, the rest are still grappling with energy poverty at very high levels with above 80% of the population still relying on biomass.

*Climate change adaptation*: All the four cases have taken steps towards re aligning their economic agenda alongside the demands that climate change has pressed upon them. They recognize that their energy systems, rapid urbanization and industrialization have to adapt and become resilient towards the impacts of climate change. Of the four countries, South Africa has the most robust and ambitious strategy for its residents moving forward, whereas Ethiopia and Kenya can borrow lessons from the numerous opportunities Nigeria has missed and South Africa has harnessed. Ethiopia's outlook is one much more holistic as per their Climate Resilient Green Economy strategy.

*Structural Transformation*: South Africa will continue to dominate SSA economies. It is not quite clear yet when exactly a full shift of labour from the low productivity agricultural sector to the high productivity manufacturing sector will occur in Ethiopia, Kenya and Nigeria.

*Emissions*: All the four countries have inventories of their emissions with Ethiopia and Kenya's largest emissions emanating from agricultural sectors whereas South Africa and Nigeria's emissions are largely from fossil fuels.

*Green Economy*: Ethiopia has a more robust approach towards greening her economy while taking advantage of the opportunity of not being 'locked-in'. There is better investor confidence in this country than in the other three. In effect, majority of the ongoing policy implementation are re-awakened by the renewed perspectives of African countries compared to the past. It would be an enlightening approach for South Africa, Kenya and Nigeria to have a 'green-economy' policy driven approaches in the development schemes in order explore wider and to challenge their process of transformation from a more holistic perspective other than just climate change.

Policymakers have a wealth of opportunities to link urbanization and industrial development under the umbrella of a national development planning framework. However, they must make hard choices in prioritizing the policy focus and investments.

The propositions below thus fit to hypothesize this analysis. That:

i. The use of energy that is clean, affordable, available, accessible and reliable will increase Africa's resilience towards her urbanization and industrialization processes.
ii. Adequate transformation in Africa is as a result of a nexus approach of sustainable energy provision, climate change preparedness, urbanization and industrialization.
iii. There exists energy and climate change measures that are adaptive to climate change.

Noteworthy, all the cases have great policies and considerable well integrated climate change adaptation plans. However, they will require huge investments for initiating a

majority of them. Thereafter the costs may become well manageable, for instance, investments in afforestation programmes would reduce the frequencies of drought which would then lead to a more reliable hydropower system that would ward off economic losses. In spite of the fact that there has been stakeholder involvement and that bottom up approaches have been utilised in arriving at these policies, the trends have been that during implementation phase, not many of these previous resources are integrated back into the process. Also, however much their mode of implementation is time bound within manageable time frames such as Ethiopia's 5- year implementation frameworks, there is still need to break down these time frames up to the local level either within the same 5-year plans and/or into smaller ones. A national framework is not enough to serve well as a guide for a municipality.

Overall, African countries need to hasten their efforts in providing energy to the people and for their economic development. They can also utilise the rapid urbanization and growing population to better their leverage towards accelerating their efforts in industrialization. The recent efforts towards adapting to climate change also presents them with numerous opportunities such as deploying renewable energy technologies, energy conservation and efficiency.

*Policy Implication & Way forward*

1. Policy approach for all sectors require rapid implementation, especially from a green economy perspective and a decentralized approach.
2. Nigeria and Kenya may as well borrow lessons from South Africa and Ethiopia's strategies identified in their key policies in devolving national functions
3. Ethiopia's rurbanism is a good example of managing R-U migration and shifting labour dynamics to more high productive ones.
4. Nigeria may borrow lessons from South Africa's past and current management of the energy sector, whilst deliberately making steps to curb corruption alongside upgrading her ports
5. South Africa, Kenya and Nigeria can explore on Ethiopia's 'green-economy' policy driven approach

6. South Africa serves as a benchmark for excellent implementation of industrial policies
7. Hard and difficult choices in prioritizing the policy focus and investments are required by all, especially following the Addis Ababa Action Agenda (AAAA) of 2015. E.g. via subsidies, soft loans and Public Private Partnerships (PPPs).

**In Summary**

- Energy is the *golden thread* that connects economic growth, increased social equity & an environment that allows the world to thrive.
- Economic transformation in Africa will not be possible without industrialisation; need to *reallocate resources* from low-productivity sectors to higher ones.
- South Africa utilized her rapid urbanization (agglomeration economies) by combining it with economic development in a timely manner.

**Way Forward**

- Africa should focus on rapid implementation of policies from both a green economy and structural transformation perspective, and a decentralized approach.
- The continent should embark on a more integrated planning & management of the energy, urbanization and industrial sectors via a nexus approach.

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