Future Energy Scenarios for African Cities

Unlocking Opportunities for Climate Responsive Development

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Acronyms and abbreviations

AEEP	Africa-EU Energy Partnership
AfDB	African Development Bank
AREI	Africa Renewable Energy Initiative
BMUB	The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
BPO	Business process outsourcing
cCR	carbon*n*® Climate Registry
CDKN	Climate and Development Knowledge Network
COP	Conference of the Parties (to the United Nations Framework Convention on Climate Change)
CHOICES	Community and Household Options in Choosing Energy Services
EIB	European Investment Bank
ESCO	Energy service company
EU	European Union
EUEI PDF	EU Energy Initiative Partnership Dialogue Facility
GCF	Green Climate Fund
GHG	Greenhouse gas
GDP	Gross domestic product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
ICLEI	Local Governments for Sustainability
ICT	Information and communication technology
IDE-E	Institute for Development, Environment and Energy
IEA	International Energy Agency
IFI	International financial institution
IIED	International Institute of Environment and Development
IKEM	Institut für Klimaschutz, Energie und Mobilität (Institute for Climate Protection, Energy and Mobility)
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contributions
IPCC	Inter-governmental Panel on Climate Change
IPP	Independent Power Producer
KCCA	Kampala Capital City Authority
KfW	Kreditanstalt für Wiederaufbau (Reconstruction Credit Institute)
KPO	Knowledge Process Outsourcing
MUSCO	Multi-utility service company
M&E	Monitoring and Evaluation
NAZCA	Non-State Actor Zone for Climate Action
NDC	Nationally Determined Contributions
OECD	Organisation for Economic Cooperation and Development
PV	Photovoltaic
SDG	Sustainable Development Goal
SEforALL	Sustainable Energy for All
Sida	Swedish International Development Cooperation Agency
UCCRN	Urban Climate Change Research Network
UCLGA	United Cities and Local Governments of Africa
USD	United States Dollars
UNHCR	United Nations High Commissioner for Refugees
WWF	World Wide Fund For Nature

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Foreword

In Africa, the Paris Agreement in 2015 marked a new era not only for the national governments submitting climate commitments, but also for sub-national governments since two thirds of the Nationally Determined Contributions (NDCs) submitted envisage climate action in cities and regions.

As almost 80 % of greenhouse gases emanate from urban areas, city governments will be playing an increasingly important role in achieving global energy and climate goals. In Africa in particular, the growth in urban population of almost 800 million inhabitants up to 2050 puts cities at the centre of development planning as energy demand increases, whilst climate change threatens to deepen social urban vulnerabilities. About two thirds of the city landscapes that will house this population have not yet been built. How these urban areas will be constructed will have a fundamental impact on the environmental, and economic growth situation.

At a time when cities in Africa are functioning at less than 30 % of the capacity needed to service their citizens, much more effort needs to be put into long-term climate planning backed up with innovative municipal financing to enhance the implementation capacity of municipal governments.

Given that about 70 % of the urban population of sub-Saharan Africa lives in informal settlements and slums, urbanisation can only turn into an opportunity for African cities if stakeholders' needs are addressed in a participatory process and the relevant actors are placed in the driving seat. This includes sub-national actors such as municipal governments as well as civil society, men and women in informal settlements, academia and the private sector.

Authoring this study, the EU Energy Initiative Partnership Dialogue Facility has experience in sustainable energy development since 2004. The Swedish International Development Cooperation Agency (Sida) is proud to be both an initiator and main donor of this Facility. Sida supports sustainable cities through different initiatives such as UN-Habitat, which is developing an important joint African approach to urbanisation under the leadership of the African Union; the African Centre for Cities in Cape Town, as well as the Climate and Development Knowledge Network. Furthermore, Sida supported a comprehensive urban assessment in Addis Ababa, Ethiopia, and is preparing a programme to support the country's urban policy implementation.

The scenario analysis provided in this study shows that megatrends such as population growth, increased energy demand and climate risks will shape the future resilience and development of African cities. The environmental and economic challenges for African cities could be turned into opportunities for development if environmental and smart energy urban planning guide the policy framework at national level and action at city level. To this end, we hope this publication provides a good leadership product with insights and examples.

Torbjörn Pettersson
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About this study

The future development of African cities entails a high level of complexity and uncertainty, particularly in relation to energy and climate change issues. A scenario-based strategic foresight methodology has been used in order to provide a basis for long-term strategic visioning and planning. This study applies this methodology to support decision makers, by identifying risks and opportunities in present and future trends, which can assist in the planning, implementation and evaluation of projects, as well as informing the policy debate.

This study contains:

- an analysis of the main megatrends that will shape the future of African cities;
- four alternative scenarios of African cities until 2050 with a focus on the implications for energy; and
- recommended areas for action for decision makers including policy makers, the private sector, civil society and the donor community.

How do I apply the study outcomes?

Planning:

- The scenarios can be adapted for the local context and used in local strategic planning, long-term need assessments and option appraisal.

Implementation:

- The scenarios can be used during programme and project implementation as a reference point or indicator to identify potential risks (for example wild cards). This analysis then serves to develop mitigating actions to overcome identified challenges,
- Strategic foresight methods are widely used globally in infrastructure planning, including in sectors such as energy, water and transport.

Monitoring and evaluation:

- Indicators can be drawn from the scenarios and integrated into monitoring and evaluation frameworks.

What are its limitations?

- The study is focused on macro urbanisation patterns. City specific scenario building is required to identify context specific actions and policies.
- Secondary and smaller cities face significant resource constraints. Capacity development and further support for these cities may be required before actions recommended here can be implemented.
- Implementing the study outcomes requires substantial stakeholder participation as well as cross-sectoral cooperation.

Executive Summary

Cities currently consume up to 80 % of total energy production and release 75 % of global CO_2 emissions.[1] Africa's urban population is projected to rise from 400 million to 1.34 billion between 2010 and 2050, which represents nearly half of the projected rise in numbers of urban dwellers globally.[2] Urbanisation in sub-Saharan Africa has not, for the most part, been matched with improvement in service delivery and economic growth, which hampers development opportunities. In a time when sub-Saharan Africa is experiencing the most severe impacts of climate change, local governments in Africa have great interest and incentives to take action on energy and climate issues. There is an opportunity in many African cities, as they urbanise over the next three decades, to meet existing and future needs of its economy and citizens while avoiding being locked-in to unsustainable patterns of growth.

Purpose of this study

The objectives of this study are to:

- break down the complexity of urban infrastructure planning by presenting four scenarios and strategic policy choices, which are integrated across sectors;
- identify the megatrends that will shape the future of African cities;
- classify uncertain drivers for change and wild cards in order to improve risk management in strategic policy-making; and
- identify short, medium and long-term opportunities and challenges of urbanisation in African cities.

The study aims to provide an input to shape the policy dialogue around the role that African cities can and should play in the implementation of their countries' Nationally Determined Contributions (NDCs).

A scenario-based strategic foresight methodology was used in order to support medium to long-term strategic visioning and planning. Such a method can be applied to enhance the effectiveness and design of plans, programmes and projects at a city level by complementing and informing city-level energy scenario modelling, carbon inventory and climate risk modelling.

1) Kamal-Chaoui and Robert, 2009
2) UN Population Division, 2016

Complementarity with other international initiatives and programmes

Cities are increasingly recognised as critical actors on energy and climate issues. Principles of the UN HABITAT New Urban Agenda include access to physical infrastructure and environmental sustainability through, amongst other approaches, promotion of clean energy.[3] Cities are taking a critical role in climate negotiations and commitments – around 50 % of the Intended Nationally Determined Contributions (INDCs) submitted envisage climate action in cities and regions.[4] UN HABITAT even counted over two-thirds – 110 out of 163 – of the submitted NDCs showing clear urban references and content.[5] It can therefore be expected that the focus of technical assistance will shift to enabling action at local level.

The outcomes of this study compliment the objectives of a number of ongoing initiatives supporting energy and climate action at city level including Global Covenant of Mayors for Climate & Energy, ICLEI's (Local Governments for Sustainability) global and Africa focused sustainability programmes, Cities Alliance Country Programmes, Sustainable Energy Africa city portfolio, C40's Cities Programme, the Transformative Actions Programme and the carbon*n*© Climate Registry. Many initiatives and organisations such as technical assistance agencies and international financial institutions (IFIs) are increasing their focus on cities.

This study also bears relevance to broader energy and climate-focused initiatives in Africa, such as the Africa Renewable Energy Initiative (AREI), Sustainable Energy for All (SEforALL), the Africa-EU Energy Partnership (AEEP) and Power Africa.

Target audience

The research conducted provides strategic directions to the following four stakeholder groups, to inform specific entry points for energy action in cities in sub-Saharan Africa:

- African public institutions at national, provincial and municipal level, as energy and climate policy mandates tend to be dispersed across different levels of government;
- the private sector, responsible for scaling-up energy and climate investments;
- Civil society, responsible for implementing urban development strategies and representing the needs of citizens as well as providing research and insight; and
- the donor community, focusing on energy and urban development.

3) Habitat III, 2016

4) ICLEI, 2015

5) *https://unhabitat.org/books/sustainable-urbanization-in-the-paris-agreement/*

Table 1 Scenario 1

Reliance on a centralised energy model

Core scenario dimensions:

- Weak government implementation capacity
- Centralised energy supply

Local government implementation capacity is weak, typified by a lack of or limited mandate, inadequate skills, lack of staff and financial resources. This is due to centralised models of governance and infrastructure provision. The pursuit of a growth-focused, climate neutral policy results in a 'locked-in' energy and transport system, which does not meet local needs and undermines the ability of cities to meet climate, energy and other objectives.

Table 2 Scenario 2

Weak enforcement of ambitious climate commitments

Core scenario dimensions:

- Strong climate policy commitment
- High informality

Local governments make a strong commitment to climate change mitigation and adaptation and develop plans and policies accordingly. Interventions however fail to account for informal settlements and the informal economy. This means policies cannot be enforced and programmes do not deliver, resulting in significant costs for those in the informal sector. Progress on climate change action is achieved through cooperation and partnerships, including with informally settled communities and the informal economy.

Table 3 Scenario 3

Growth-driven climate action

Core scenario dimensions:

- Increased installed renewable energy capacity
- Emerging middle class

Strong local governance, rising incomes and education lead to increased capacities and public support for a sustainable model of urban planning and development, including renewable energy generation at the local level. A green growth[6] model underlines the path of development in this scenario.

Table 4 Scenario 4

Technology-enabled growth

Core scenario dimensions:

- Technological innovation
- Increased decentralised energy supply

Technological innovation facilitates investment in decentralised systems and the emergence of new solutions for economic growth. Governments also draw on this technology to improve urban services, including management of energy infrastructure.

6) The Organisation for Economic Cooperation and Development (OECD) defines green growth as fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our wellbeing relies. See OECD, 2011 for more information.

Current and future drivers for change in African cities

The scenario development exercise identified five main megatrends that will influence the future of energy and climate-responsive development across sub-Saharan African cities:

- The urban population of sub-Saharan Africa is expected to grow by 800 million people from 2014 to 2050. West and East Africa will witness the largest increases.
- It is expected that rates of economic growth in sub-Saharan Africa will remain above that of G7 economies in the coming decades.
- Due to population and economic growth, it is likely that energy demand in cities will increase until 2050 and beyond. Under the IEA New Policies Scenario, Sub-Saharan Africa's energy demand will increase by about 45% by 2040. West Africa and Southern Africa will witness the largest increases.
- In the period to 2050, Africa will experience some of the most severe impacts of climate change including heat extremes, changes to rainfall patterns and water availability as well as sea-level rises.
- Finally, improvements in education and health can support economic development and consequently the creation of higher value employment opportunities most likely located in cities. According to the African Development Bank (AfDB), literacy rates are expected to reach around 92 % to 94 % in 2050 from 67 % in 2010. Similarly, the average life expectancy is projected to reach 70 years in 2060 compared to 56 years in 2010.

While it is possible to make informed estimates regarding the identified megatrends described above, there are many highly significant factors for the future development of African cities characterised by uncertainty. These factors represent 'critical uncertainties' and were used to form the scenarios. These include factors related to the economy, society, technology, environment, natural resources, infrastructure and governance.

The scenarios

The four scenarios in this study are not the only potential scenarios which could unfold; however, they reflect the range of views of consulted stakeholders regarding the fundamental factors which are likely to influence the future of energy in African cities. The scenarios represent a broad range of potential outcomes and stages of a city's development. It may therefore be the case that different scenarios are relevant to the same city in different time periods and sectors. While no scenarios are considered to

necessarily be more probable than the others, *scenarios 1* and *2* are believed to be closer to the current experience of many African cities, whilst *scenarios 3* and *4* are more likely to become relevant to cities in the future.

Conclusions

All four scenarios describe possible strategic directions towards sustainable urban planning and development in sub-Saharan Africa. This analysis breaks down the complexity of urban infrastructure planning, identifies the megatrends that will shape the future of African cities; it classifies uncertain drivers for change and wild cards in order to improve risk management and identifies opportunities and challenges of urbanisation in African cities.

In *table 5* is a summary of the key recommended areas of action identified in the study. They show how local and national governments, the private sector and utilities, civil society and the international donor community can enhance the effectiveness of action and progress towards achieving the global Sustainable Development Goals (SDGs) and Nationally Determined Contributions.

Table 5 Key areas of action for specific target groups

Sub-national governments:

- Undertake a diagnostic analysis to assess the cities' current position and address gaps and opportunities for development.
- Develop a clear view of priorities, for example through an energy and climate change strategy development process, which outlines a coherent approach to project identification, development and delivery. This process should be based on the diagnostic assessment.
- Lead the way in setting city-level ambitions, commitments and targets on climate change, which can contribute to national and international objectives.
- Review cities' own operations and assets for opportunities to make progress on energy and climate change goals.
- Use cities' convening power to create partnerships between stakeholders (including private sector) to deliver climate and energy objectives.

National governments:

- Integrate energy action planning into national urbanisation strategies.
- Put in place a regulatory framework to allow cities to meet their energy needs autonomously, including liberalisation of energy markets to allow local and community power utilities or power producers to meet energy needs.
- Support the decentralisation of finance and revenue-raising mandate / powers and responsibilities.
- Enable more finance to cities, particularly from international funds.
- Hold cities partially accountable for the implementation and achievement of national and international climate and energy objectives and commitments.
- Explore and encourage strategic public-private partnerships.

The private sector:

- Engage with local government and local city partnerships to provide technical expertise and advice in decision-making, as well as seek guidance on how the private and public sector can work together to enable climate action locally.
- Enter into dialogue with national and local governments to shape policies and regulation, with the aim of de-risking private investment.
- Support delivery of and develop technical capabilities for a resource management model based around the water-energy-food nexus.

  For private/public utilities:

  - Explore opportunities for the provision of decentralised networks.
  - Align investment in distribution networks with government planned urban development and transport investment.

Civil society:

- Engage with and ensure representation of marginalised groups, which public bodies may find hard to reach and engage.
- Bring technical and scientific capacity to assist in analysing local needs, and provide skills development and training to municipalities.
- Work with informal communities to deliver new solutions, such as decentralised energy, which support livelihoods.

The international donor community:

- Support knowledge management, for example by supporting local academic institutions to develop research programmes relevant to city decision-maker needs and establishing city data observatories to equip city decision makers with the data they require.
- Support municipalities in developing capacities, particularly with senior leadership teams, as a critical step to support city action. Particularly secondary cities might require additional support to enable action.
- Target action at utilities and municipalities as well as a wide range of stakeholders involved in urban development, for example public sector land holders, housing finance institutions and infrastructure or real estate developers, as well as civil society organisations.
- Assist national and municipal institutions in enhancing the enabling environment and market readiness for city-focused energy and climate solutions. Support packages could cover the legal framework and regulatory reforms required to support change, such as reviewing financing mechanisms, climate finance readiness, incentive structures and subsidies.
- Create project preparation facilities to support the creation of bankable projects at sub-national governmental level, including M&E requirements post award.
- Strengthen municipal finances for energy and climate action, for example through:
  - use of city-level multi-sector finance windows to enable transformational programmes;
  - improving creditworthiness;
  - additional revenue raising fiscal measures, fees and charges; and
  - land-based financing as a mechanism to support infrastructure costs.

1 Introduction

1.1 Project context

Africa is the last continent to urbanise. However, the speed and scale of urbanisation will differ vastly from other continents. The rate of urban population growth in sub-Saharan Africa between 1980 and 2014 amounted to 4.4 % per year, distinctly higher than in other regions. By 2050, sub-Saharan Africa's cities will have grown by almost 800 million people. This represents nearly half of the projected rise in numbers of urban dwellers globally.[7] The Africa's New Climate Economy Report considers that:

'[...] urbanisation in sub-Saharan Africa has been something of a missed opportunity so far. Urban growth has not, for the most part, been accompanied by economic transformation – a phenomenon sometimes called 'urbanisation without growth'. This appears to be due to policy and institutional weaknesses that failed to provide an enabling environment for rapid economic growth in cities [...]' [8]

There is a significant body of work on urbanisation, economic development and climate change on a global scale. Nonetheless, this is an emerging area of research and significant gaps remain. Therefore, there is a pressing need for engagement and research specifically addressing the needs of African cities to identify approaches and actions that enhance progress towards achieving the global Sustainable Development Goals (SDGs).

This study focuses in particular on SDG 7 on ensuring access to affordable, reliable, sustainable and modern energy for all, whilst recognising the interdependency between energy goals and other SDGs, including those regarding economic growth (SDG 8), infrastructure (SDG 9), making cities and communities more resilient and sustainable (SDG 11) and climate change (SDG 13).

Principles of the New Urban Agenda agreed at UN Habitat III include access to physical infrastructure and environmental sustainability through, amongst other approaches, promoting clean energy.[9] Cities are becoming a relevant voice in climate negotiations. The Lima Climate Change Conference of the Parties (COP20) in 2014 launched a Non-State Actor Zone for Climate Action (NAZCA) to register commitments on climate change mitigation by cities and regions, amongst others. At COP21 and COP22 there have been strong calls for action on climate change mitigation from the Climate Summit for Local Leaders. Around 50 % of the INDCs submitted envisage climate action in cities and regions[10]. UN HABITAT even counted over two-thirds – 110 out of 163 – of the submitted NDCs showing clear urban references and content.[11] It can therefore be expected that the focus of technical assistance will shift to enabling action at the city level.

7) Brahmbatt et al, 2016

8) ibid

9) Habitat III, 2016

10) ICLEI, 2015

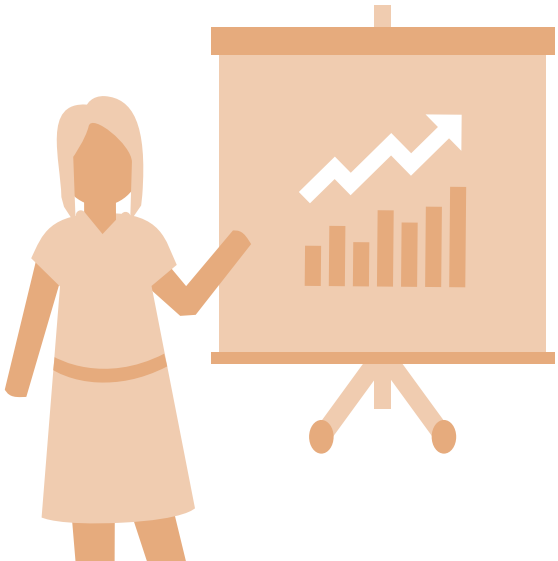
11) *https://unhabitat.org/books/sustainable-urbanization-in-the-paris-agreement/*

1.2 Purpose of this study

A scenario-based strategic foresight approach has been used in order to support medium to long-term strategic visioning and planning. Such a method can be used to enhance the effectiveness and design of plans, programmes and projects by complementing and informing energy scenarios modelling, carbon inventory and climate risk modelling work at city level.

The objectives of this study are to:

- break down the complexity of urban planning by presenting four scenarios and strategic policy choices, which are integrated across sectors;
- identify the main drivers for change that will shape the future of African cities;
- classify uncertain drivers for change and wild cards in order to improve risk management in strategic policy-making; and
- identify short, medium and long-term opportunities and challenges of urbanisation in African cities to avoid lock-in to unsustainable patterns of growth.



1.3 Complementarity with other international initiatives and programmes

The outcomes of this study compliment the objectives of a number of ongoing initiatives supporting energy and climate action at city level. These include, but are not limited to, the Global Covenant of Mayors for Climate & Energy, ICLEI's (Local Governments for Sustainability) global and African focused sustainability programmes, Cities Alliance Country Programmes, Sustainable Energy Africa city portfolio, C40's Cities Programme, the Transformative Actions Programme and the carbonn© Climate Registry.

As the focus of this study is sub-Saharan African cities, it also bears relevance to broader energy and climate-focused initiatives in Africa, such as AREI, SEforALL, the AEEP and Power Africa.

Other initiatives and organisations such as technical assistance agencies and IFIs are increasing their focus on cities. Initiatives from agencies with bilateral portfolios include Deutsche Gesellschaft für Internationale Zusammenarbeit's (GIZ) Sustainable Development of Metropolitan Regions Programme[12] and the Swedish International Development Cooperation Agency's (Sida) Symbiocity integrated city diagnostic[13]. The UK's Department for International Development's (DFID) Cities and Infrastructure for Growth programme, Infrastructure and Cities for Economic Development and Managing Climate Risks for the Urban Poor address these issues. These programmes recognise energy as a cross-cutting issue; other programmes target energy in cities specifically such as DFID's Supporting African Municipalities in Sustainable Energy Transitions programme. Among the IFIs, the AfDB is developing an urban programme and the European Investment Bank (EIB) is developing a new programme focused on housing with Shelter Afrique. Additionally, the Green Climate Fund (GCF) is exploring city-focused support and business models.

12) See *https://www2.giz.de/urbanet/focus/metropolises.asp*

13) See *http://www.symbiocity.org/*

1.4 Target audiences

The research conducted provides strategic directions to the following four stakeholder groups to inform specific entry points for energy action in cities in sub-Saharan Africa:

African public institutions

African public institutions at national, provincial and municipal level, as energy and climate policy mandates tend to be dispersed across different levels of government

Civil society

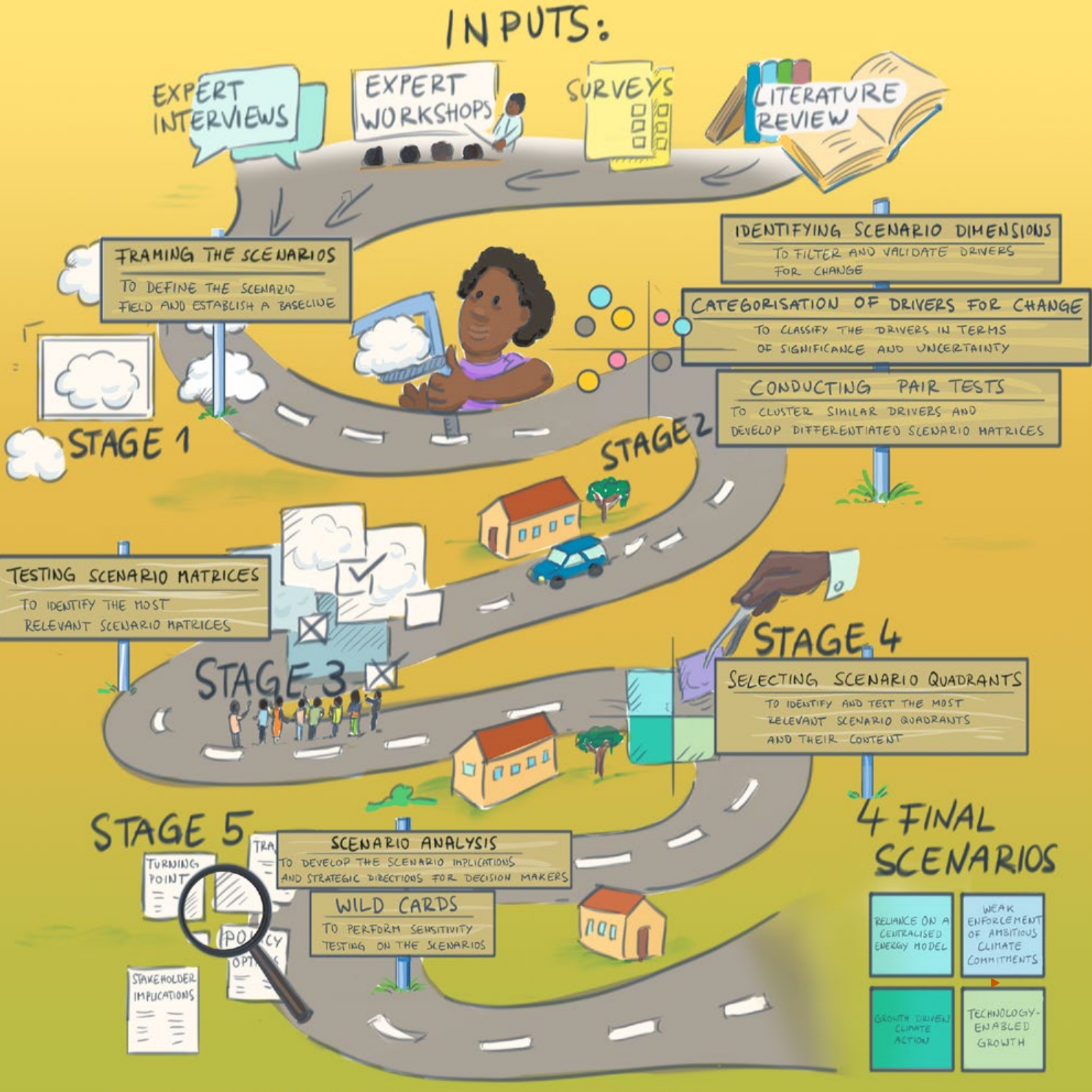
Civil society, responsible for implementing urban development strategies and representing the needs of citizens as well as providing research and insight

Private sector

The private sector, responsible for scaling-up energy and climate investment

Donor community

The donor community, focusing on energy and urban development


INPUTS:
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EXPERT WORKSHOPS
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GROWTH DRIVEN CLIMATE ACTION
TECHNOLOGY-ENABLED GROWTH

2 Methodology

The future is uncertain. It is not the aim of this scenario analysis to predict future trends or events. Instead, it is to identify and present critical uncertainties relevant to the future of African cities[14].

Within the context of this study, critical uncertainties are factors that will have a highly significant impact on energy and urban development in African cities but are subject to a high degree of uncertainty regarding their development. These include issues such as income distribution or government implementation capacity.

Different possible combinations of critical uncertainties were assessed to generate four potential scenarios of African cities. However, the analysis of scenarios goes beyond these uncertainties to focus on a wide range of other drivers of energy and climate responsiveness in African cities. The methodology used is elaborated in *section 2.1*.

Strategic directions for decision makers were drawn by reviewing the range of potential actions which could be taken and how they would apply within the context of the scenario environment. Key messages were then identified by comparing these strategic directions across scenarios, identifying areas of commonality and highlighting scenario-specific critical messages. These conclusions are presented in *chapter 5*.

14) This analysis draws on the scenario development methodology outlined by Schwartz, 1996.

2.1 Scenario development stages

Stage 1: Framing the scenarios

1.1: Framing the scenarios

Objective: To define the scenario field and establish a baseline

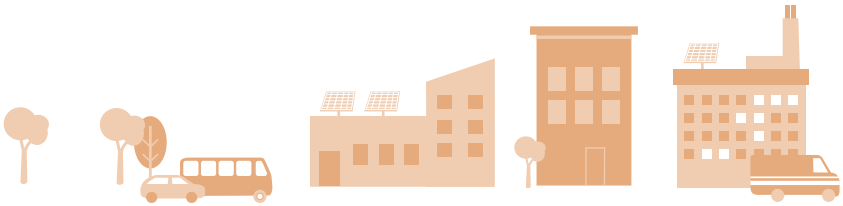
Methodology: Literature review

Details: The literature review focused on the current state and potential future development of African cities including six categories:

- natural resources and the environment;
- governance;
- society;
- economy;
- infrastructure; and
- technology.

The review generated a list of 56 drivers for change in African cities. Information on the possible future trajectory of each driver was identified[15]. The 56 drivers were selected according to their relevance to the development of African cities up until 2050, in terms of the six categories listed above. At this stage, no judgement was made on the magnitude of their impact or probability.

15) This list is included in the appendix.



Stage 2: Identifying scenario dimensions

2.1: Expert review and validation

Objective: To filter and validate the drivers for change

Methodology: Expert interviews, survey, peer review and workshops

Details: Throughout the scenario development process, consultation activities took place to seek validation and knowledge from various experts. This enabled an interdisciplinary perspective, drawing on ten interviews, fifteen survey responses, fifteen peer reviews and six interactive validation workshops.[16] This allowed for qualitative and quantitative inputs from the perspective of stakeholders in the public and private sectors, civil society as well as academia, and from both Africa and Europe. Experts were selected to ensure that contributions reflected expertise across a wide range of sectors related to cities and urban development in Africa, including but not limited to issues directly related to energy.

The organisations and institutions consulted include Accra Metropolitan Assembly, Addis Ababa city administration, Atkins, AVSI foundation, the German Federal Ministry for the Environment (BMUB), C40, Climate and Development Knowledge Network (CDKN), Cities Alliance, Covenant of Mayors, Ethiopian Ministry of Urban Development, the EU Energy Initiative Partnership Dialogue Facility (EUEI PDF), GIZ, ICLEI Africa, the Institute for Development, Environment and Energy (IDE-E), the International Energy Agency (IEA), the International Institute of Environment and Development (IIED), Kampala Capital City Authority (KCCA), Kreditanstalt für Wiederaufbau (KfW), Mozambican Ministry of Land, Environment and Rural Development, the municipalities of: Dakar (Senegal), Drakenstein (South Africa), Nampula (Mozambique), Accra (Ghana), Dire Dawa (Ethiopia), Chefchaouen (Morocco) and Jinja (Uganda); the Urban Climate Change Research Network (UCCRN), United Cities and Local Governments of Africa (UCLGA), Uganda National Planning Authority, and UN-HABITAT, amongst others.

At this stage, feedback from the expert consultation was used to filter and validate the selection of relevant drivers, or suggest additional drivers to be considered.

2.2: Categorisation of drivers for change

Objective: To classify the drivers for change

Methodology: Expert interviews, surveys and workshops

Details: As the next step, expert consultation was conducted through the interview, survey and workshop approaches described above to classify the drivers in terms of significance and uncertainty with regards to the future of African cities.

16) European Development Days 2016 in Belgium; Two GIZ internal workshops with energy, urban, climate and transport experts in Germany; Cities Alliance Africa Strategy Workshop in Ghana; IKEM Summer Academy 'Energy and the Environment' 2016 Sustainable Cities in Germany; Workshop at COP22 in Morocco.

Significance refers to the potential scale of impacts of the driver on African cities. For example, population growth is likely to be more significant for urban development than vehicle energy efficiency.

Uncertainty refers to the future development of that driver. For example, there are scientific predictions of the effects of climate change which give us a degree of certainty within specified parameters, whereas the future of social stability in African cities is less certain.

The following categories of drivers were identified:

1. **Megatrends:** Significant and relatively certain factors assumed to be common across all scenarios (e.g. population growth or increasing energy demand).

2. **Critical uncertainties:** Significant and relatively uncertain factors, which form the main driving forces of the scenarios (for example decentralised energy systems or urban informality).

3. **Wild cards:** Low probability and high impact factors, which could lead to radical change in African cities in the future (for example civil conflict or an oil price shock). These were used at a later stage for sensitivity testing of the scenarios and their policy implications.

The drivers considered to be insignificant were retained; they are neither critical uncertainties nor megatrends and may feature within certain scenarios. See *figure 1* for an overview of the full categorisation of the drivers for change.

2.3: Conducting pair tests

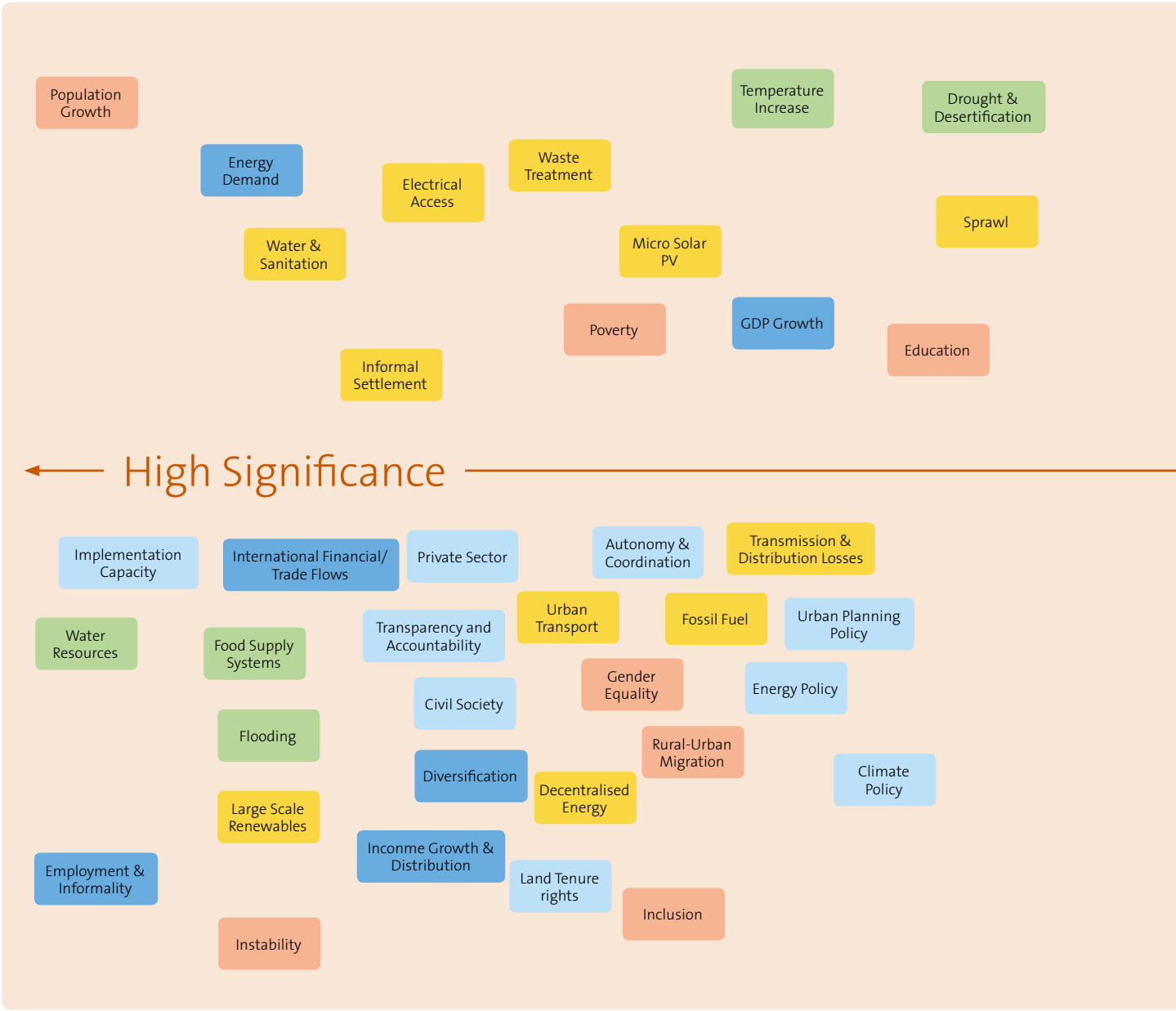
Objective: To cluster similar drivers and develop differentiated scenarios

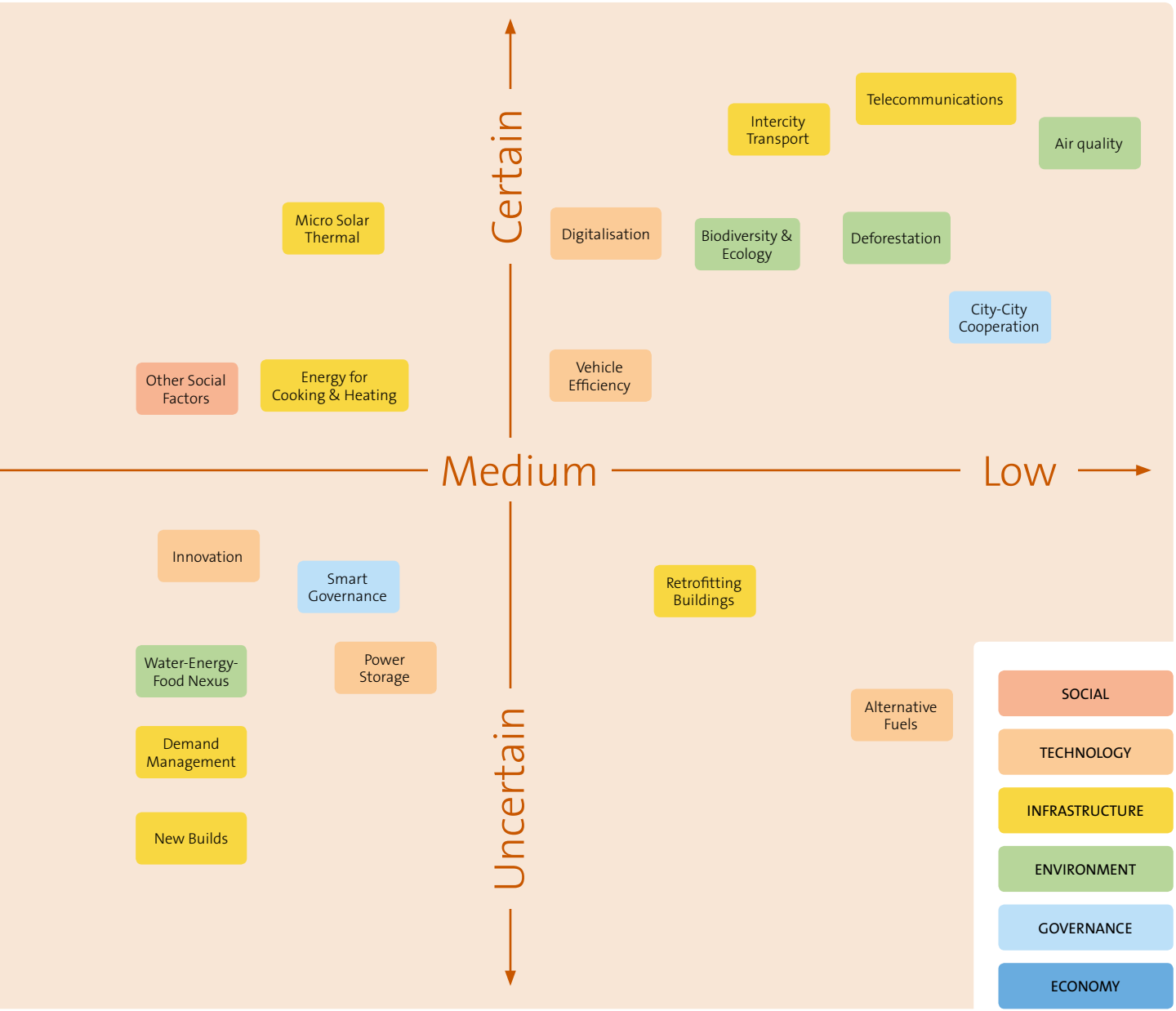
Methodology: Analysis of combinations of drivers for change

Details: Each driver for change categorised as a critical uncertainty was provided with opposite hypotheses of their development. For example, for decentralised energy, these were a decentralised energy system consisting of micro-grids and small scale generation technologies (high degree of decentralisation) or a centralised energy system based on large-scale generation and nationally administered transmission and distribution networks (low degree of decentralisation). Pairs of critical uncertainties were combined in a workshop session to form matrices of four quadrants, each giving rise to a possible scenario.

Drivers which – when considered together – had the same or a similar effect on scenarios were clustered together. The most significant drivers were selected to describe the cluster (for example 'income distribution' describes the cluster of economic diversification, employment growth and income growth). Alternatively, a general category label was used to summarise a range of related and interlinked issues (for example 'implementation capacity'). Through this process, twelve scenario matrices were identified resulting in 48 draft scenarios.

Figure 1 Categorisation of drivers for change




Certain
Uncertain
Medium
Low
Telecommunications
Intercity Transport
Air quality
Micro Solar Thermal
Digitalisation
Biodiversity & Ecology
Deforestation
City-City Cooperation
Other Social Factors
Energy for Cooking & Heating
Vehicle Efficiency
Innovation
Smart Governance
Retrofitting Buildings
Water-Energy-Food Nexus
Power Storage
Alternative Fuels
Demand Management
New Builds
SOCIAL
TECHNOLOGY
INFRASTRUCTURE
ENVIRONMENT
GOVERNANCE
ECONOMY

Stage 3: Testing scenario matrices

3.1: Testing scenario matrices

Objective: To identify the most relevant scenario matrices

Methodology: Criteria-based selection

Details: In this stage the matrices were subjected to an assessment based on the following **key criteria**[17]:

- **Plausibility** – the selected scenarios must be capable of happening;
- **Differentiation** – the scenarios should be structurally different and not simple variations on the same theme;
- **Consistency** – the combination of logics in a scenario must ensure that there is no built-in internal inconsistency that would undermine its credibility;
- **Decision-making utility** – each scenario should contribute specific insights into the future; and
- **Challenge** – the scenarios should challenge conventional wisdom about the future.

From the 48 scenarios draft scenario quadrants, the 16 that performed best against these criteria were taken to the next stage as draft scenarios.

Stage 4: Selecting four scenarios

4.1: Selecting scenarios

Objective: To identify and test the most relevant scenarios

Methodology: Expert validation, scenario analysis

Details: The 16 draft scenarios were further developed with an outline narrative for each. They were then presented in an additional workshop to international experts on energy, urban development and other relevant issues for further analysis and validation through group discussions of scenarios. Here, the scenarios were specifically validated in terms of the plausibility and relevance of their narratives to the work of experts in and for African cities.

This led to the final selection of four scenarios for which trajectories up to 2050 were then developed internally for each.

17) These criteria are those suggested in Wilson, 1998.

Stage 5: Identifying scenario implications

5.1: Wild cards

Objective: Sensitivity testing of the scenarios

Methodology: Application of identified wild card events

Details: At this stage, the implication of each wild card event identified in *stage 2.2* was analysed according to the impact and relevance to each scenario trajectory in terms of the systemic changes and/or turning points they could cause. The wild cards used in this study are:

4 °C warming

The IPCC's most severe projections suggest that, without intervention, global temperature could increase by 4 °C before 2100. This wild card explores a world in which this point is brought forward to 2050. Severe impacts include sea-level rises, changes to fresh water availability and natural disasters (for example storm surges). These impacts are likely to be most severe in lower latitudes, including many African countries.

Energy technology breakthrough

Breakthroughs in research could result in game-changing technologies coming to market by 2050. For example, the development of highly efficient power storage technologies, commercially available synthetic fuels, artificially photosynthesised fuels and significant improvements in solar photovoltaic (PV) efficiency.

Oil price shock

The oil price shocks of the 1970s had far-reaching and long-term implications. Given ongoing depletion of finite resources and the prevailing market structures, it is not inconceivable that such a shock could re-occur. Recent research suggests there is little spare capacity in production and supply constraints are likely to arise before demand peaks[18]. This wild card considers a very severe oil price shock – for example a price greater than USD 200 per barrel.

18) Fustier et al, 2016

Civil conflict

Civil conflict is a major threat to development. Whilst economic growth typically reduces the risk of conflict, it is always a possibility, particularly where the model of economic growth creates social divisions and grievances.

5.2: Scenario implications

Objective: To develop the scenario implications and strategic directions for decision makers

Methodology: Implication analyses

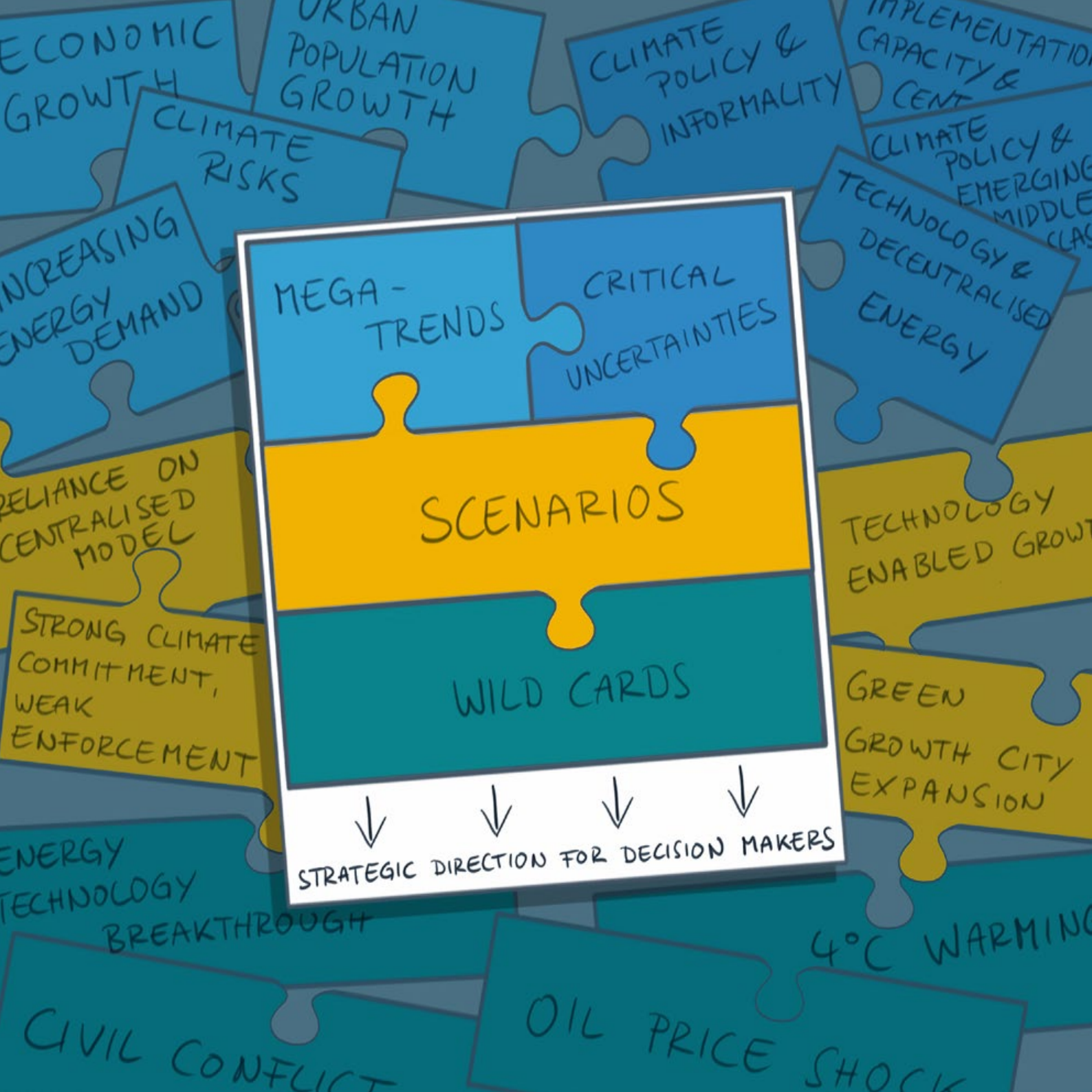
Details: The trajectory towards 2050 of each scenario was considered in detail, by reviewing a long list of potential interventions informed by the literature and expert reviews. This allowed the identification of key implications and relevant strategic policy directions for reaching energy and climate mitigation and adaptation goals in African cities. These goals would ideally be drawn from the countries' Nationally Determined Contributions, however in some cases they might be part of a City Climate Strategy and not reflected at national level.

In each scenario a list of recommended areas for action was tailored for each of the following stakeholder groups:

- African public institutions, both at national and sub-national level, as energy and climate policy mandates tend to be dispersed across different levels of government;
- the private sector, working in the provision of goods and services in the energy sector;
- civil society, representing citizens and implementing urban development strategies; and
- the donor community working on energy and energy and urbanisation.

An overview of the components that make up each scenario is shown in *figure 2*.

Figure 2 Scenario components ▶


MEGA - TRENDS
CRITICAL UNCERTAINTIES
SCENARIOS
WILD CARDS
STRATEGIC DIRECTION FOR DECISION MAKERS
ECONOMIC GROWTH
URBAN POPULATION GROWTH
CLIMATE POLICY & INFORMALITY
IMPLEMENTATION CAPACITY & CENT
CLIMATE RISKS
CLIMATE POLICY & EMERGING MIDDLE CLA
INCREASING ENERGY DEMAND
TECHNOLOGY & DECENTRALISED ENERGY
RELIANCE ON CENTRALISED MODEL
TECHNOLOGY ENABLED GROWT
STRONG CLIMATE COMMITMENT, WEAK ENFORCEMENT
GREEN GROWTH CITY EXPANSION
ENERGY TECHNOLOGY BREAKTHROUGH
4°C WARMING
CIVIL CONFLICT
OIL PRICE SHOCK

3 Current and future drivers for change in African cities

3.1 The impact of African cities on energy and climate change

In 2014, only 37 % of the entire population of sub-Saharan Africa lived in cities, making it the world's least urbanised region. By 2050 it is expected that this number will rise to 55 %,[19] an increase of almost 800 million people. This represents nearly half of the projected rise in numbers of urban dwellers globally.[20] Urban population growth across Africa has been – and will continue to be – significant, as demonstrated in *figure 3*. This is driven in part by rural-urban migration but also high rates of population growth within cities and their expansion into previously rural areas. The speed and scale of urbanisation in sub-Saharan Africa will therefore differ vastly from Asia and Latin America. The growth rate of the urban population between 1980 and 2014 amounted to 4.4 % per year, significantly higher than in other regions. No western city has ever increased in population as quickly as sub-Saharan African metropolises are doing at the moment.[21]

These population projections show that the urban transformation of Africa has begun but is set to continue rapidly through the early 21st century. Around two thirds of the infrastructure required to support Africa's urban population in the next three decades is yet to be built.[22]

This represents a leap frogging opportunity whereby urban development in Africa can target a more energy efficient, low carbon growth pathway.

The economies of scale and productivity gains brought by urbanisation can make infrastructure provision more cost-effective[23]. However, as centres of economic and population growth, the concentration of human populations and physical assets such as infrastructure means cities are also more vulnerable to climate and environmental risk. Cities are typically more vulnerable to specific climate risks, such as increased temperatures and heat waves due to heat island effects, as well as to flooding resulting in increased surface run-off.

Cities are centres of economic growth and many people migrate to cities in search of a better quality of life. However, the rapid pace of population growth in African cities has often outstripped the ability of sub-national governments to manage growth and provide services. Research done by Cities Alliance shows that cities in Africa are currently functioning at less than 30 % of the capacity needed to service their populations, with particular gaps in planning and finance[24].

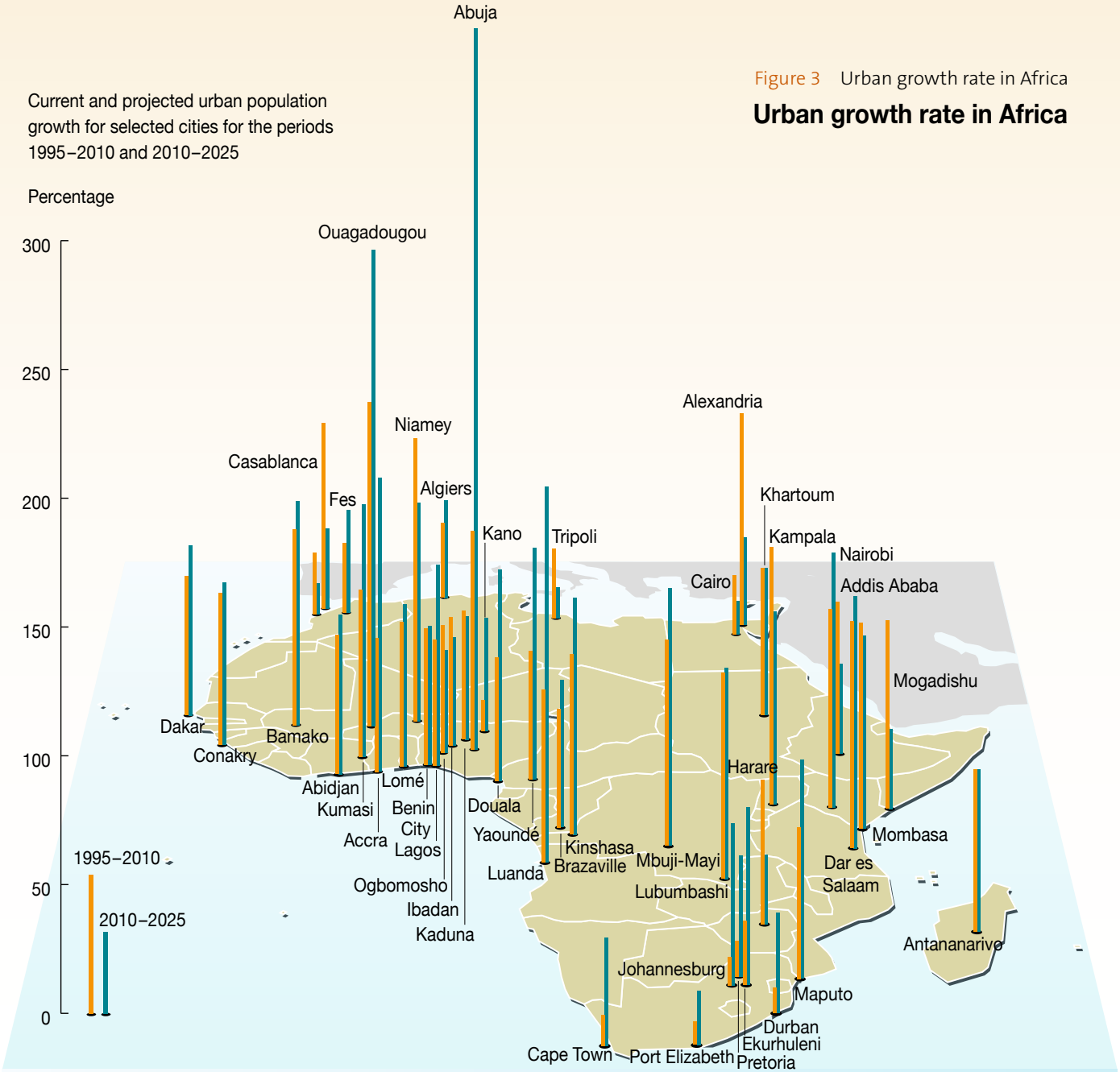
The growth of African cities has historically not been guided by comprehensive urban policy planning. It is estimated that only one in three African countries has a

19) Brahmbatt et al, 2016
20) ibid
21) The Economist, 30 July 2016
22) Gurría, 2016
23) Foster and Briceño-Garmendia, 2010
24) Cities Alliance, 2017

Figure 3 Urban growth rate in Africa

Urban growth rate in Africa

Current and projected urban population growth for selected cities for the periods 1995–2010 and 2010–2025



Source: UNDESA, The World Urbanisation Prospects, The 2009 Revision, 2010.

Implementing plans at a city level:

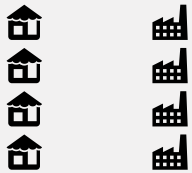
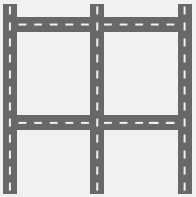
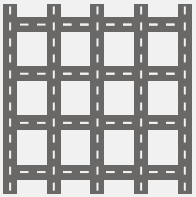
- Leadership is a key requirement necessary to bring together and engage stakeholders and to ensure both horizontal and vertical governance cooperation across different municipal departments and stakeholder groups.
- Engaging stakeholders to shape and review the diagnostic and participate in action planning is necessary to reach alignment on priorities and identifying the sequencing and geographic targeting of action.
- Establishing a 'local champion' to make the case for action both to national government and to build support and capacities for implementing the plan from the bottom up is also required.
- A dedicated delivery unit or task force has been used successfully by some cities in order to provide an effective basis for translating priorities into actions.
- Establishing dedicated city climate action and green funds to help finance projects.

national urban policy.[25] Though planning codes are in place across most African countries, most are poorly designed giving rise to multi-layered land ownership structures and, in many cases, they have not been well enforced. In Uganda, for example, illegal construction in residential and environmentally sensitive areas in Kampala were commonplace due to poor government capacity or political interventions in the past.[26]

Cities are centres of energy demand. However, only 63 % of urban residents in sub-Saharan Africa reported having a grid connection which worked most or all of the time.[27] Energy use in cities is strongly influenced by urban structures and morphology (see *table 6*). Over several decades, a pattern of urban sprawl has emerged in sub-Saharan Africa, fuelled by informal settlements, weak urban planning, lower land rates, lack of transparent systems of land rights and ownership, and ineffective land markets and development regulations. In Accra, for example, the population increased by 50 % between 1985 and 2000, and was accompanied by a 153 % increase in urban land cover.[28] Urban sprawl, particularly when poorly integrated with infrastructure provision, tends to make cities more energy intensive despite energy access being poor. Density therefore reduces carbon intensity and supports infrastructure provision, but needs to be combined with sustainable urban design to ensure climate resilience and quality of life.

25) Ivan Turok, 2015
26) Goodfellow, 2013
27) Oyuke et al, 2016
28) Angel et al, 2011

Table 6 Dimensions of low-carbon city planning

Dimension	Related concepts and metrics	High Carbon	Low Carbon
Density	High density reduces carbon intensity. Density can be measured as population (dwelling unit, persons) or activity (commercial, employment) per area unit, or as floor-to-area ratio (FAR).		
Land use	A high mix of land-use functions and walkability reduces travel demand for for example employment, supply, and leisure of city residents.		
Connectivity	Low-carbon urban form is characterised by small blocks with a high density of crossings, intersections and high street density, and well-dimensioned pavements.		
Accessibility	High accessibility of urban functions (short distances and availability of mass or active transport options) reduces private travel demand and related congestion and energy use.		

These issues are compounded by the fact that in sub-Saharan Africa, an estimated two-thirds of all new city inhabitants settle in informal settlements or slums (WBGU, 2016). In West Africa, East Africa and Central Africa more than 70 % of the urban population lives in slums.[29] Many of these urban and peri-urban dwellers make up displaced populations. Around 82 % of persons of concern to the United Nations High Commissioner for Refugees (UNHCR) worldwide live outside refugee camps, usually in informal settlements in urban and peri-urban areas.[30]

Examples of options for city-level energy interventions include:

- solar PV and LED street lighting projects;
- use of renewable energy to power water operations (for example use of biogas generation to provide power for feed pumping);
- waste-to-energy initiatives;
- deployment of roof top solar on schools and public buildings;
- influencing the energy needs of the transport sector, for example, by establishing CNG supply infrastructure on government land and establishing the market through procurement of municipality vehicle fleets (buses, light vehicles), taxi licensing of CNG vehicles;
- establishing local multi-utility service companies (MUSCOs) to provide decentralised energy systems and access and energy efficiency schemes;
- building and construction – using green procurement guidelines for infrastructure and buildings. Mandating eco-neighbourhood and green building codes within planning and development control guidelines;
- land management – using mechanisms for the assembly and consolidation of land so that infrastructure can be effectively integrated and coordinated at scale in line with sustainable urban development principles;
- green transportation including public transport, walking and cycling, demand management and integrated land use and transportation; and
- urban form and transport planning.

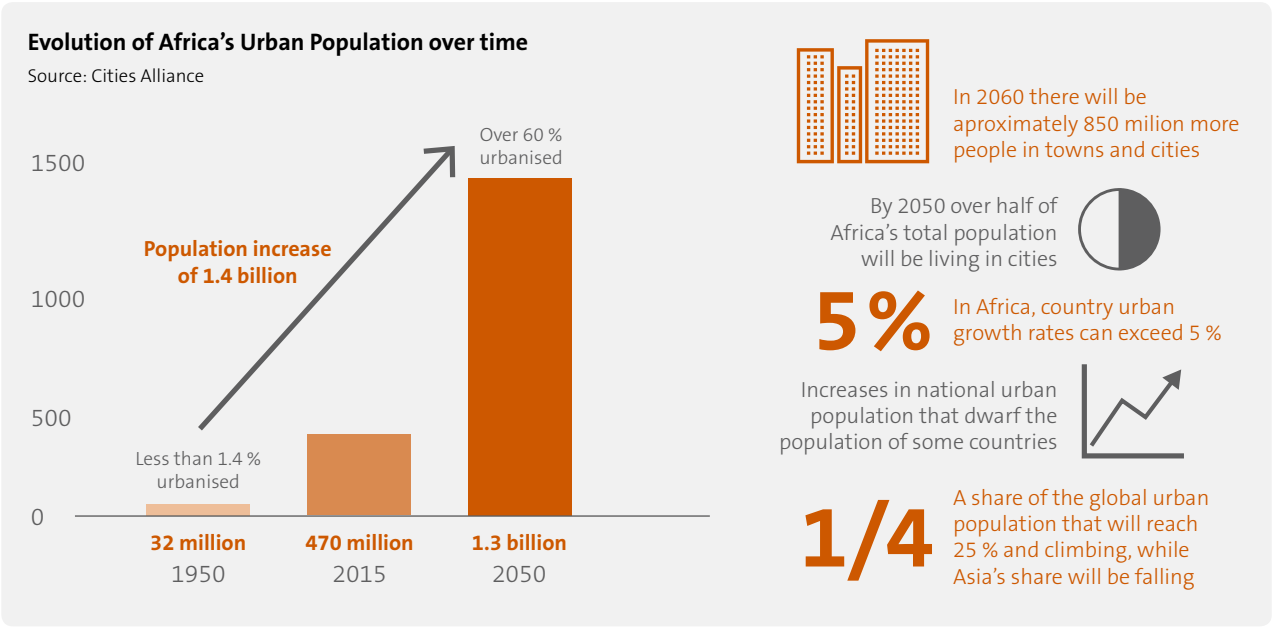
29) Cities Alliance, 2010.

30) Lahn and Grafham, 2015

In many residential areas, settlement is excessively dense and takes place without integrated infrastructure investment, including in energy utilities. For example, the average population density of Kibera, one of the largest urban slums in Africa located on the periphery of Nairobi's central business district, was estimated in 2009 at around 87,500 inhabitants per km^2.[31, 32]

Rapid population growth has also resulted in predominance of the informal economy due in part to a lack of alternative employment opportunities. Only a sixth of Africans under the age of 35 are in formal employment and it is estimated that 93 % of new job creation is in the informal sector.[33, 34]

Figure 4 The speed and scale of urbanisation in sub-Saharan Africa



31) Desgroppes and Taupin, 2011

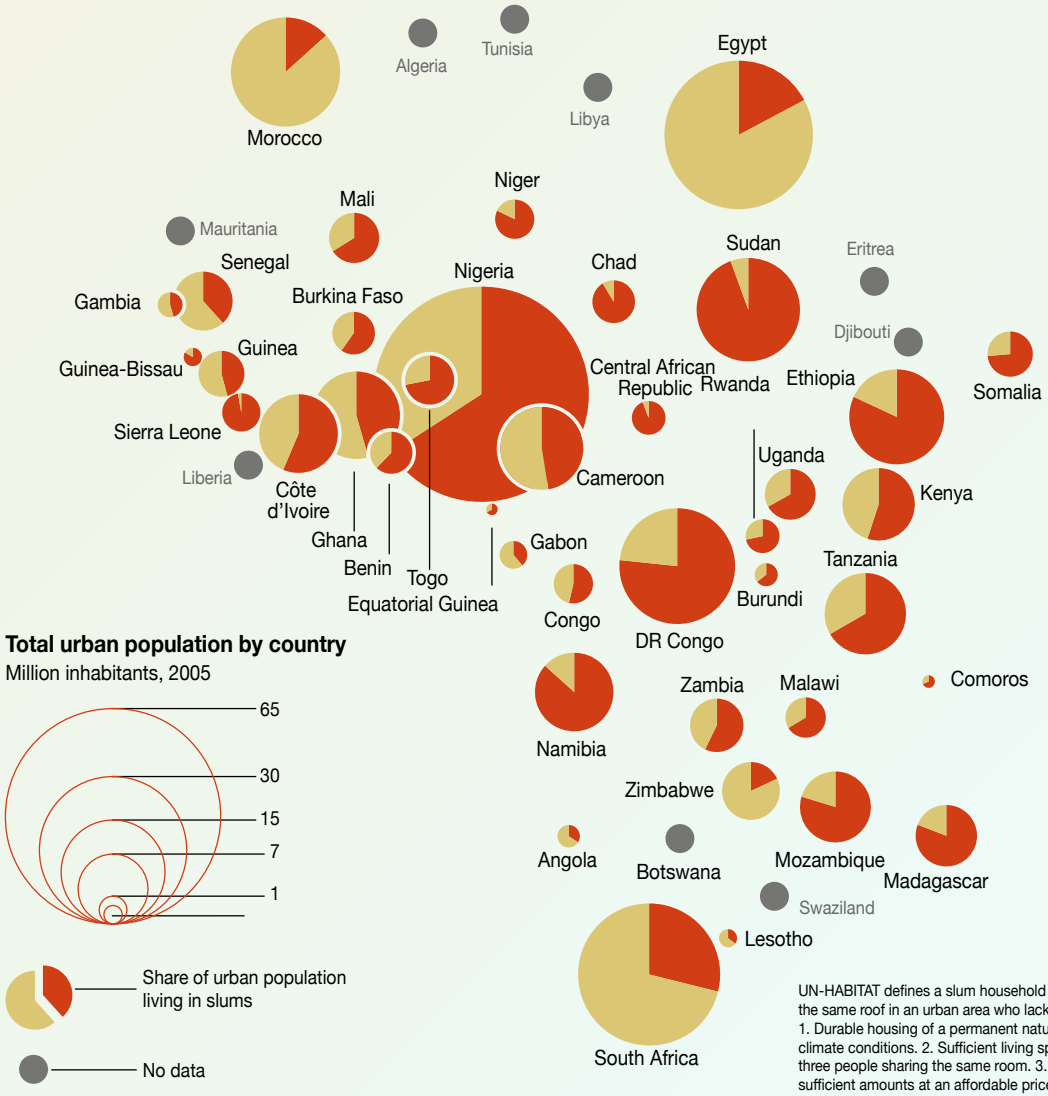
32) Kenya National Bureau of Statistics, 2010

33) The Economist, 2 February 2017

34) Cities Alliance, 2006

Figure 5

Slum population in urban Africa



Source: UNDESA, *The World Urbanisation Prospects, The 2009 Revision*, 2010.

UN-HABITAT defines a slum household as a group of individuals living under the same roof in an urban area who lacks one or more of the following: 1. Durable housing of a permanent nature that protects against extreme climate conditions. 2. Sufficient living spaces, which means not more than three people sharing the same room. 3. Easy access to safe water in sufficient amounts at an affordable price. 4. Access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people. 5. Security of tenure that prevents forced evictions.

Table 7 Comparison of data in selected sub-Saharan African cities[35]

Region	City	Population (millions, 2015)	CO_2 emissions per capita (metric tons, national, 2013)	Access to electricity (% of national urban population, 2012)	Energy use per capita (kg of oil equivalent, 2013)	Human Development Index (national, 2014)	GDP per capita (USD, 2015)
West Africa	Accra, Ghana	2.3	0.56	85%	344	0.58	6,885
	Lagos, Nigeria	13.1	0.55	84%	773	0.51	4,044
Central Africa	Lubumbashi, DRC	2.0	0.04	36%	292	0.43	932
	Kinshasa, DRC	11.6	0.04	36%	292	0.43	1,070
East Africa	Dar es Salaam, Tanzania	5.1	0.21	46%	470	0.52	4,022
	Mombasa, Kenya	1.1	0.30	58%	492	0.55	4,445
Southern Africa[36]	Johannesburg, South A.	3.9	8.86	91%	2,656	0.67	18,559
	Matola, Mozambique	0.9	0.15	55%	407	0.42	2,321
OECD average			9.65	99.9%	4,183	0.88[37]	35,886[38]

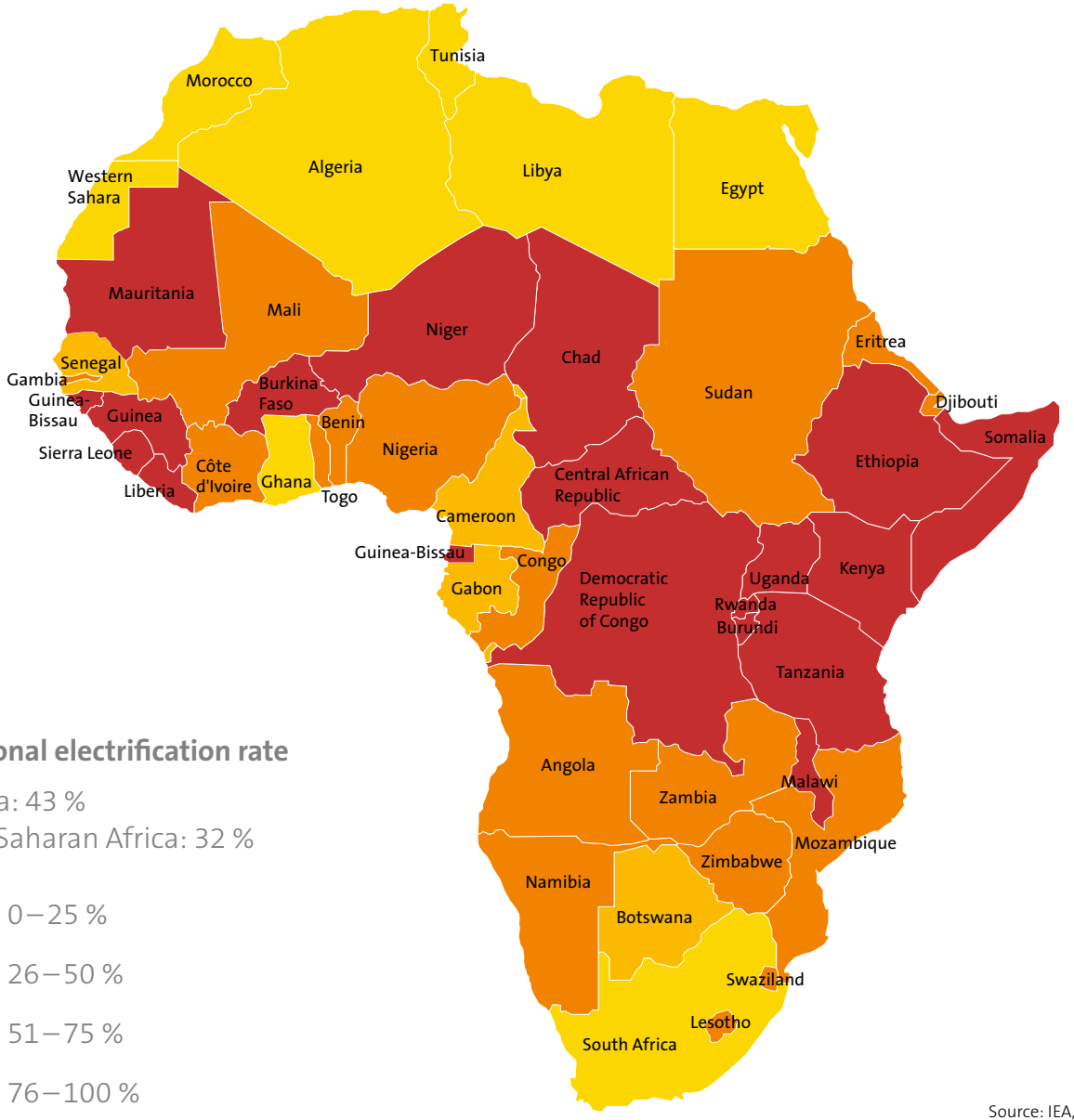
35) Population data is taken from UN Department of Economic and Social Affairs, Population Division, 2014. CO_2 emissions per capita, access to electricity as a proportion of the urban population and energy use per capita are taken from the World, 2016. The Human Development Index is taken from UNDP, 2015. GDP per capita data at the city level is taken from C-GIDD, 2016.

36) Sustainable Energy Africa, 2015 provides figures for per capita GHG emissions for Johannesburg and Durban of 5.7 and 7.3 tCO_2e respectively.

37) Unweighted mean

38) World Bank World Development Indicators

Figure 6 Urban electrification rates in sub-Saharan Africa (2012)



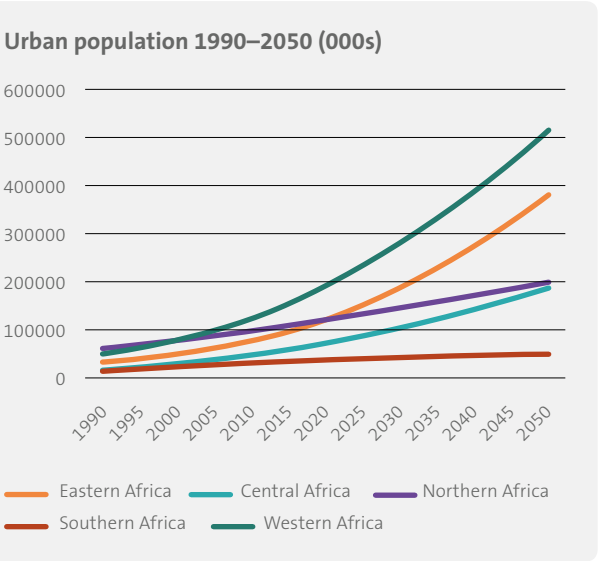
Source: IEA, 2014

3.2 Megatrends

Based on the review of drivers for change, this section highlights the five megatrends, which are relatively certain and significant and will influence the future of energy and climate-responsive development across sub-Saharan African cities.

3.2.1 Urban population growth

Description: Urban population is expected to increase significantly until 2050. The population structure will also change, with an increase in the proportion of the working age population over the period.



Relevance to energy: As urban population grows, so will the energy demand of cities. As a minimum, this will take the form of the energy required to satisfy basic needs such as cooking. Economic and income growth, and the characteristics of urban development, will also influence energy demand per capita and may place further pressure on energy systems.

Scale and patterns: The UN Population Division estimates that the urban population of sub-Saharan Africa is expected to more than triple between 2015 and 2050. Growth will occur in all African regions but is particularly significant for East and West Africa. Every single African country is projected to experience continuous urban population growth until 2050. Even in Southern Africa, where relatively low absolute growth is projected, the urban proportion of the population is projected to rise from under 50 % in 1990 to over 70 % in 2050. Across sub-Saharan Africa, the proportion of those aged 20–64 is expected to increase between 2015 and 2050. There is a significant variation in fertility, migration and life expectancy rates which will continue to fluctuate and influence the outcome for individual cities.

Implications: Increasing urban populations will place significant pressure on resources, economic systems and urban services. It will therefore create an imperative for urban policymakers to ensure the sustainable growth of cities. The increasing proportion of the working age population may lead to a demographic dividend and corresponding economic growth, or lead to underemployment. This could create the conditions for instability and unrest.

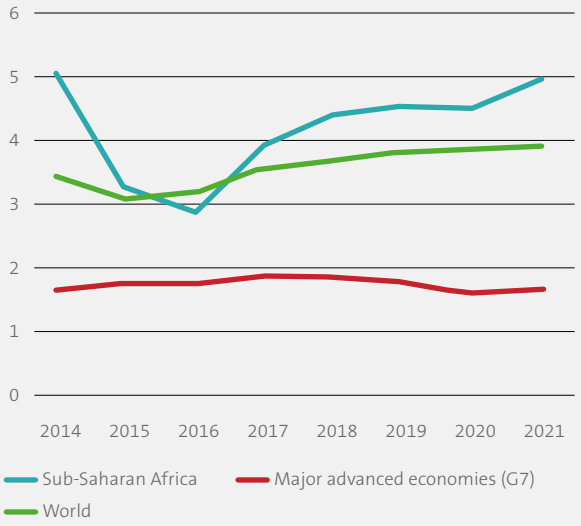
Assumption: It is assumed that rapid urban population growth will continue until 2050 and that the proportion of the population of working age in cities will increase.

3.2.2 Economic growth

Description: Sub-Saharan Africa has, on aggregate, experienced generally continuous gross domestic product (GDP) growth since the early 1990s. Though recently the rate of growth has declined, it remains above that of the G7 economies. Current projections suggest higher rates of economic growth will return in the short-term future.

Annual GDP growth, constant prices (%)

Source: IMF World Economic Outlook 2016



Relevance to energy: Economic growth will be dependent on improvements in energy supply, both in terms of overall volumes but also with regard to the resilience and reliability of energy systems. The increase in demand created by economic growth will also increase pressure on energy systems and increase the economic costs of energy system failures.

Scale and patterns: International Monetary Fund (IMF) forecasts on GDP are only available until 2021. Sub-Saharan Africa is projected to return to strong rates of economic growth in this period, exceeding those of both the world economy and of the major advanced economies. However, Africa's population is also rapidly growing and, historically, total GDP growth has substantially outpaced per capita GDP growth. Individual city economies will differ by economic structure and level of diversification, which influences their economic resilience. Factors influencing city-level economic development include the level of dependency on natural resource endowments, productivity and efficiency of agriculture, significance of industrialisation and premature de-industrialisation, growth of the service economy, scale of the informal economy, and formal sector employment growth linked to education.

Implications: Economic growth has the potential to improve the lives of urban residents through increased employment and income. Many conditions are required for economic growth to take place in cities, particularly the business environment, human resources and skills and infrastructure. The distribution of economic growth will also have significant implications for development and society in African cities.

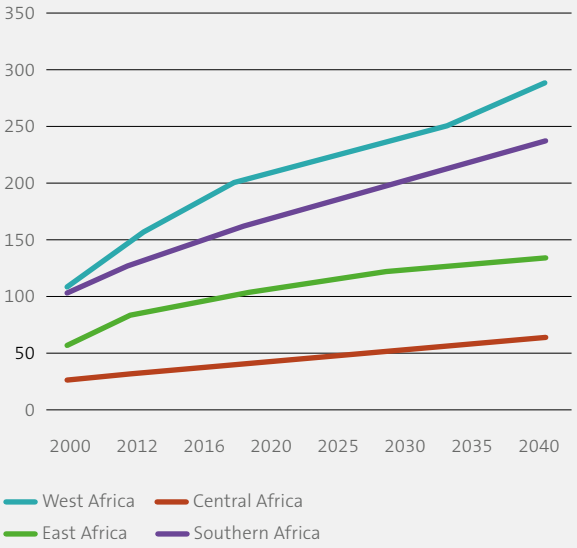
Assumption: It is assumed that total GDP growth will remain positive until 2050 for sub-Saharan Africa on aggregate. However, this does not necessarily mean that continued growth will translate into increased GDP per capita within urban areas.

3.2.3 Rising energy demand

Description: Due to population and economic growth, it is likely that energy demand in cities will increase until 2040 and beyond. This will also be driven by improvements in access to energy.

Total final energy demand (Mtoe)

Source: IEA Africa Energy Outlook 2014



Relevance to energy: Despite potential for reduced losses and improved efficiency, demand is still likely to increase across industrial, residential and transport uses. Strategic decisions about the decentralisation of energy production and about the source of energy will need to be made in order to meet this increase in demand in an inclusive, effective and climate responsive manner.

Scale and patterns: Authoritative data on energy demand is only available until 2040. The IEA estimates that total energy demand in sub-Saharan Africa will be over 70 % greater in 2040 than in 2012 under their medium scenario. This is due to both economic and population growth. There is considerable regional variation in energy use per capita, which on aggregate actually declines slightly and remains low. Economic growth facilitates and is driven by an increase in energy access, with 75 % of the population having access to electricity in 2040 compared to 40 % in 2015. In urban areas, current levels of access are 65% expected to increase to 93 % by 2040.

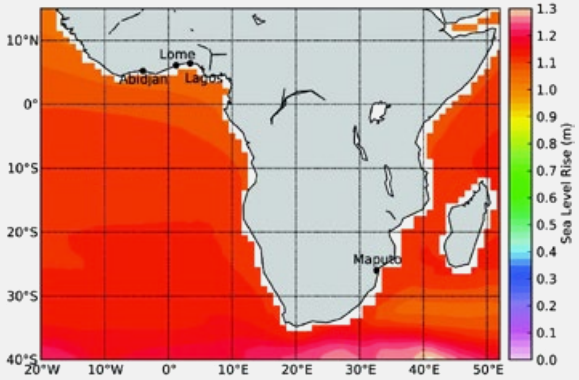
Implications: The increase in energy demand, though substantial, is less than the projected population growth. This suggests that per capita energy savings will be achieved through economic and industrial strategies, investments in energy-saving infrastructure such as public transport, demand management and energy efficiency. Alternatively, lower energy intensity per capita could also result from the type of economic structure, the persistence of informal settlements, or from a lack of access or poor affordability, for example.

Assumption: It is assumed that total energy demand will almost double by 2040.

3.2.4 Climate risks

Description: Climate impacts have already become evident in parts of the world. However, there remains the need to understand their distribution, severity and interaction with impacts which could accentuate cascade effects. Key climate risks for African cities include unprecedented heat extremes, changes to rainfall patterns and water availability, and sea level rise. These impacts are likely to drive rural-urban migration.

Regional sea level rise in 2081–2100 under the highest IPCC AR5 scenario (RCP8.5)



Source: World Bank. 2013. Turn Down the Heat.

Relevance to energy: Climate change impacts may increase demand for electricity, for example through demand for cooling in response to heat extremes, further amplified by the urban heat island effect. Water and food production are likely to become more energy intensive as agricultural areas become more arid. Additionally, floods and extreme heat events can damage or affect the functioning of energy infrastructure, such as transmission networks. Hydropower generation may also be adversely affected by changes in precipitation patterns, particularly relevant for some African energy systems heavily dependent on hydropower.

Scale and patterns: The World Bank projects that under a 2°C warming scenario there will be a risk of severe drought in southern and central Africa, increased risk in West Africa and decreased risk in East Africa, with the West and East African projections slightly more uncertain. At the same time, the area of hyper-arid and arid regions will grow by 3 %. This will impact on the food systems serving cities – cropping areas for stable grains could be reduced by 40–80 % by the 2040s under a 1.5–2°C scenario – which will further increase the energy intensity of food production and distribution. Sea-level rise is expected to reach 30 cm by the 2040s, with levels higher in the south. This will impact on livelihoods and infrastructure systems in coastal cities, which could prompt internal migration.

Implications: The availability of power from hydropower schemes, – which currently provide 22 % of electricity in Africa – are especially vulnerable to climate change. This is exacerbated by a shortfall in energy supply and poorly developed energy transmission networks. Water availability and food production and distribution, are also expected to be affected. In addition, health could also be affected due to reduced availability of food as well as extreme heat and floods.

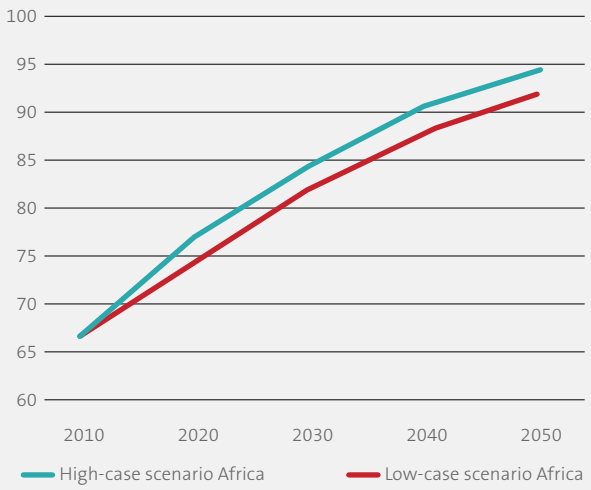
Assumption: It is assumed that climate risks will continue and will increase in severity in the future, raising issues of the vulnerability of urban systems and their growing population.

3.2.5 Health and education

Description: Important progress in improving health and education levels in the continent has already been made and is projected to continue. This represents investment in the 'human capital' of Africa's population.

Projected Africa Literacy Rate (%)

Source: AfDB. 2011. Africa in 50 Years Time



Relevance to energy: Improvements in health and education will influence the demand for energy as life expectancy increases and labour force participation and productivity is enhanced. Rising education in the medium to long term is likely to underpin economic diversification, which could stimulate demand for energy linked to production and consumption. A more informed population could help to enable a take-up of energy efficiency measures.

Scale and patterns: According to the AfDB, investment in education should see the current trend in literacy rates continue, reaching around 92–94 % in 2050 from 67 % in 2010. Similarly, the average life expectancy is projected to reach 70 years in 2060 compared to 56 years in 2010, based on investment in health systems and interventions (for example reducing impact of communicable diseases) as well as new technologies.

Implications: Improving the educational level of the population would increase the likelihood of advancing economic development and consequently the creation of higher value employment opportunities most likely located in cities. Raised health levels and income levels would increase the demand for services. Improved economic opportunity for Africa's youth may also reduce the likelihood of social conflict and migration.

Assumption: Continuous improvements in both education and health levels will generally prevail across the continent, with variation between countries. Educational improvements in urban areas can be expected to continue to outperform rural areas due to economic factors. Urban residents will, on aggregate, lead continuously longer and healthier lives. This will lead to improved 'human capital' for Africa's economy.

3.3 Uncertainties

It is possible to make informed estimates regarding the future of population and economic growth, energy demand, education and health and climate risks. However, there remains significant uncertainty regarding the interaction and implications of these trends in African cities. This section provides a brief overview of the key areas of uncertainty which inform the scenarios.

3.3.1 Economy

Table 8 Critical uncertainty: Economy

Area of uncertainty	Description
Economic modernisation	**Referring to the structural transformation of the economy, this includes economic diversification (for example away from resource dependency and into manufacturing), increased labour productivity and high-value employment opportunities. This process has typically been associated with urbanisation – though this link has been disputed in Africa[39, 40].** *Baseline:* There are marked differences between the economic bases of African cities. Investment and exports tend to drive government expenditure and consumption in other sectors of the economy. Many African countries remain dependent on resource exports: low commodity prices in recent years have demonstrated the potential vulnerability of this economic model. Manufacturing and service activity has developed, particularly in primary cities, but is hampered by energy supply. Improvements have been made in health and education, but they are not on target to meet the SDGs.[41] The economic model (for example whether manufacturing or services become dominant) will influence energy demand.
Income growth and distribution	**The extent of income growth and its distribution across society (i.e. growth of middle class).** *Baseline:* The AfDB defines the African middle class as those earning $4–$20 per day. This represented around 13 % of the continent's population in 2010. A further 21 % of the population represent a 'floating' middle class earning $2–$4 per day.[42] This group is vulnerable to slipping backwards into poverty. 61 % of Africa's population earned less than $2 per day. A lack of energy access can reinforce poverty and socio-economic divisions.

39) For discussion of this issue see Fay and Opal (2000) and Henderson et al (2013)
40) Brahmbatt et al, 2016
41) OECD, 2016
42) AfDB, 2011a

Finance	**The enabling environment for investment, the level of private investment, regional or national capital markets and aid funding made available for African cities. Municipalities, especially those in secondary cities, typically have less power to raise finance than national governments and may lack sufficient capacity to, for example, collect tax revenue.** *Baseline:* Africa attracted over $200 billion (USD) of external finance in 2015, a 1.8 % decline from 2014 levels. Flows of finance have however remained broadly stable over the past ten years whilst finance has been volatile globally.[43] The Infrastructure Consortium for Africa shows that $83.5 billion (USD) was committed in 2015 to the development of Africa's infrastructure. $28.4 billion came from African national governments. Major sectors for investment were transport and energy, together accounting for over 80 % of committed investment.[44] Municipalities face difficulties in accessing funds from IFIs and international sources. In December 2016, out of the 41 accredited entities for the GCF, 56 % were international, 17 % regional and 27 % national.[45] No municipality is currently accredited, likely as municipalities lack the capacity required for the accreditation process. Local governments are calling for a specific financing window for cities in the GCF.[46] In turn, bilateral and international development banks face obstacles around local currency risks with the direct financing of projects, thus tending to prefer sovereign loans to governments or guarantees by governments.[47]

3.3.2 Society

Table 9 Critical uncertainty: Society

Area of uncertainty	Description
Instability and inclusion	**The degree of social inclusion and cohesion within cities characterised by gender, ethnic, religious and social equality, as well as political or economic shocks may result in social or political instability.**  *Baseline:* UN-HABITAT describes African urban dwellers as highly segregated by class and ethnicity.[48] This is reflected in slum and informal settlement incidences. Protests and riots due to food and fuel price shocks occurred in many countries in 2008 and 2010. Ethnic and religious based violence has also been occurring more frequently in many African cities such as in Addis Ababa (2016), Johannesburg (2006) or Bujumbura (2015). Data suggest that demonstrations and riots in urban areas have risen in recent years.[49]

43) OECD, 2016
44) Infrastructure Consortium for Africa, 2015
45) As of March 2017, a directory of accredited organisations can be found on the GCF website: *http://www.greenclimate.fund/partners/accredited-entities/ae-directory*
46) Barbière, 2015
47) Citiscope, 2017
48) UN-HABITAT, 2014
49) UN-HABITAT, 2014

3.3.3 Technology

Table 10 Critical uncertainty: Technology

Area of uncertainty	Description
Technological innovation	**Extent of domestic technological innovation and adoption of imported energy technologies. Improvements in education and economic growth should in principle facilitate technological innovation and adoption of new technologies. However, uncertainty around energy supply, economic development models, distribution of income and inclusion create uncertainty regarding the uptake and generation of technology. This includes certain key areas for potential breakthroughs such as power storage, new renewable energy developments and information and communication technology (ICT) solutions such as smart grids.**  *Baseline:* Currently, African cities experience shortages in access to technologies and services. However, technological innovation is increasingly taking place domestically on the continent. Technology hubs, such as those supported by the World Bank, are being developed across the continent where cities like Nairobi have become centres for technological innovation. Mobile technology in Africa has been on the rise with an estimated penetration rate of 56 % in 2014. Mobile subscription was 480 per 1,000 inhabitants in 2010 and expected to rise to 1,405 per 1,000 by 2060. A 10 % increase in mobile phone usage is linked to an increase in a middle/low income country GDP of 1.2 %. ICT broadband usage has also picked-up in the last five years, from 0.1 % of the population in 2005 to 7 % in 2010. Projections reveal a sharply rising trend to 99 % of the population in 2060.[50] Investment in technology has been driven by the private sector and consumers with government being a relatively late adopter in most countries. The Global Entrepreneurship Monitor has reviewed the conditions for innovation across 60 countries including a small number in Africa and highlighted Botswana and South Africa as showing the best environment to support innovation. Other countries not included in the survey have made technology a driver of their national economic plans such as Rwanda and Kenya. In contrast, less open economies such as Zimbabwe, the Democratic Republic of Congo and Sudan have shown relatively slow uptake of technology. One of the constraints on improving ICT penetration in Africa is low electrification.

50) AfDB, 2011

3.3.4 Environment and natural resources

Table 11 Critical uncertainty: Environment and Natural Resources

Area of uncertainty	Description
Natural resource nexus management	**Ensuring the sustainability of energy, water and food supply systems and the implementation of water-food-energy nexus approaches to natural resource management. Increasing climate risks and the projected increase in urban population means that, although uncertain, the costs of climate risks to African cities will grow significantly up to 2050. Climate risks can be reduced through climate adaptation measures across sectors and effective, nexus-based natural resource management.**  *Baseline:* Consumption and population growth is placing increasing pressure on Africa's natural resource systems. Africa's ecological footprint, the amount of land required to sustain its consumption, increased by 240 % from 1961 to 2008.[51] This has direct relevance to the energy sector given that in some developing countries biomass accounts for more than 90 % of primary energy consumption.[52] Biomass, whether in form of wood or charcoal, is the most extended cooking fuel in Africa and its use has large negative effects related to deforestation. Though more prevalent in rural areas, biomass fuels represented over 50 % of the fuels used for cooking in urban areas in East, Central, West (excluding Nigeria) and Southern (excluding South Africa) Africa.[53]

51) WWF and AfDB, 2015
52) EUEI PDF and GIZ, 2014
53) IEA, 2014

3.3.5 Infrastructure

Table 12 Critical uncertainty: Infrastructure

Area of uncertainty	Description
Decentralisation	**Whether future infrastructure systems, particularly energy, will make use of centralised or decentralised networks. A move towards decentralisation will also require complementary political decentralisation and local autonomy.**  *Baseline:* Centralised energy networks currently do not provide power to all, and where it is provided energy supply may be highly intermittent. Surveys across 36 African countries found that on average 40 % of households nationally were not connected to the national power grid, 35% had an intermittent connection and only 25 % had a connection that always worked.[54] Whilst urban households are more likely to be connected, only 63 % of urban residents reported having a connection which worked most of or all of the time.[55] Additionally transmission networks have average losses of 18 % (excluding South Africa).[56] Given the limitations of centralised power provision, decentralised technologies are often coping mechanisms, for example the use of diesel back-up generators.
Urban form and transport	**How land use policy and transport interventions determine urban form given urban population growth.** *Baseline:* Urban form defines the energy intensity of urban development. African cities are becoming increasingly characterised by both sprawl and excessive densification as urban populations grow. Public transport has typically been of low quality and motor vehicle ownership has been rising significantly.
Renewables and fossil fuels	**The mix of renewable and fossil fuel sources of energy generation.** *Baseline:* Coal-fired generation currently accounts for 45 % of large-scale generation capacity in sub-Saharan Africa, oil and gas 31 % and hydro 22 %. Other renewables account for less than 1 %. Though data on decentralised technologies are not available, these could be solar PV or thermal technologies but rather, are mostly biomass or oil-based generators.[57]

54) Oyuke et al, 2016
55) ibid
56) IEA, 2014
57) IEA, 2014

3.3.6 Governance

Cities are limited in their capacity by their competencies and resources. The level of power and accountability devolved to local government differs significantly between country and governance systems. Therefore, the capability of African cities to raise finance, manage and implement change is highly variable and normally requires the support of national government. *Figure 7* highlights the differences between the institutional environment for cities in Uganda and South Africa. The KCCA in Uganda is controlled by the national government and national agencies are in charge of the electricity infrastructure. In contrast, South African municipalities tend to have a formal electricity policy mandate and local departments of electricity purchase and sell power to end users. In South Africa, for example, local authorities are responsible for the administration of newly introduced green building regulations[58].

Table 13 Critical uncertainty: Governance

Area of uncertainty	Description
Role of private sector	**The role the private sector has in supporting economic growth and infrastructure provision.** *Baseline:* The policy environment in Africa has become more supportive of markets and the private sector over the past 25 years. State-owned utilities continue to dominate power generation infrastructure, but the private sector is engaging in investment. The private sector provided $7.2 billion (USD) of investment in energy infrastructure in Africa in 2015, 21 % of the total.[59] About 4 GW of capacity is produced by independent power providers (IPPs) in Africa.[60] 
Transparency, engagement and accountability	**The transparency and accountability of local, regional and national governments as well as the role of civil society in governance.** *Baseline:* The Economist Intelligence Unit's Democracy Index, recorded from 2006 to 2015, suggests that sub-Saharan Africa has seen very modest improvements in its level of democracy. Regular elections and the peaceful transfer of power are now common in most sub-Saharan countries. However, political participation, civil liberties and transparent functioning of government remain weak. The Index classed 23 countries in the continent as authoritarian regimes.

58) For more on energy in South Africa see *www.sustainable.org.za*

59) Infrastructure Consortium for Africa, 2015

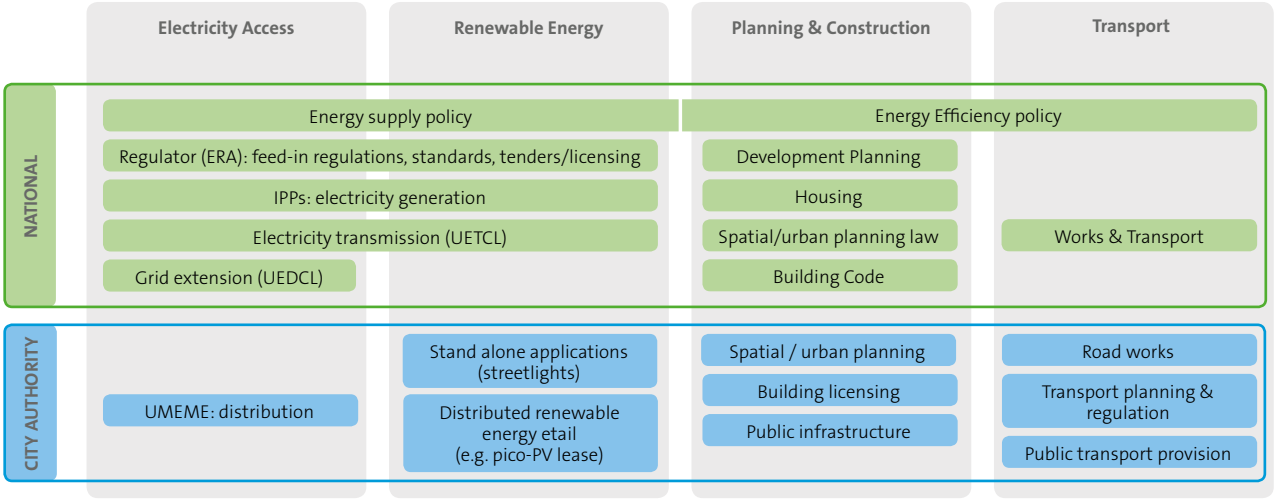
60) Eberhard, 2013

Implementation capacity	**The jurisdiction, resources and organisational processes and structures available to or used by local governments to effectively implement policies and solutions. Four dimensions of city power are suggested: ownership/operation of assets; the ability to set and enforce policies; control of budgets and the ability to set visions.**[61] *Baseline:* Research into factors that enable local government has highlighted that, across African countries, particular weaknesses exist in financial transfers, revenue raising powers, human resources and citizen participation.[62]
Informality and land rights	**Informal settlement and the governance structures which determine the nature and extent of land rights and enforcement (particularly of legal systems).** *Baseline:* In many African cities more than half of the urban population lives in informal settlements, this may even be as high as 70 % to 80 % in some cities, such as Dar es Salaam.[63] The AfDB suggest 80 % of Africa's labour force and 5 % of GDP is in the informal sector.[64] Key factors that drive both informal settlement and the informal economy are poorly enforced and overlapping systems of land rights. More than two thirds of Africa's land are under customary tenure, with land ownership rooted in communities and typically neither written down nor legally recognised.[65] That means that most of the land in sub-Saharan Africa has no registration of ownership or use rights.[66] This affects the capacity to plan development and infrastructure effectively.
Climate and energy policy	**International, national and local policies relating to climate change and energy systems, including the structuring and regulation of energy markets.** *Baseline:* There is increasing recognition of the role of cities in delivering climate responsive development. The Stockholm Environment Institute found that 80 % of emissions reductions achievable in cities are not currently being addressed by national efforts.[67] Around 50 % of INDCs submitted as part of COP21 have a focus area at local and subnational level.[68] There has also been increasing engagement from city governments in Africa, particularly regarding climate adaptation. Cities are undertaking various interventions, such as coastal protection and improving public transport. However, international attention has tended to focus on capital cities or those in more developed economies (such as South Africa), rather than secondary cities.[69]

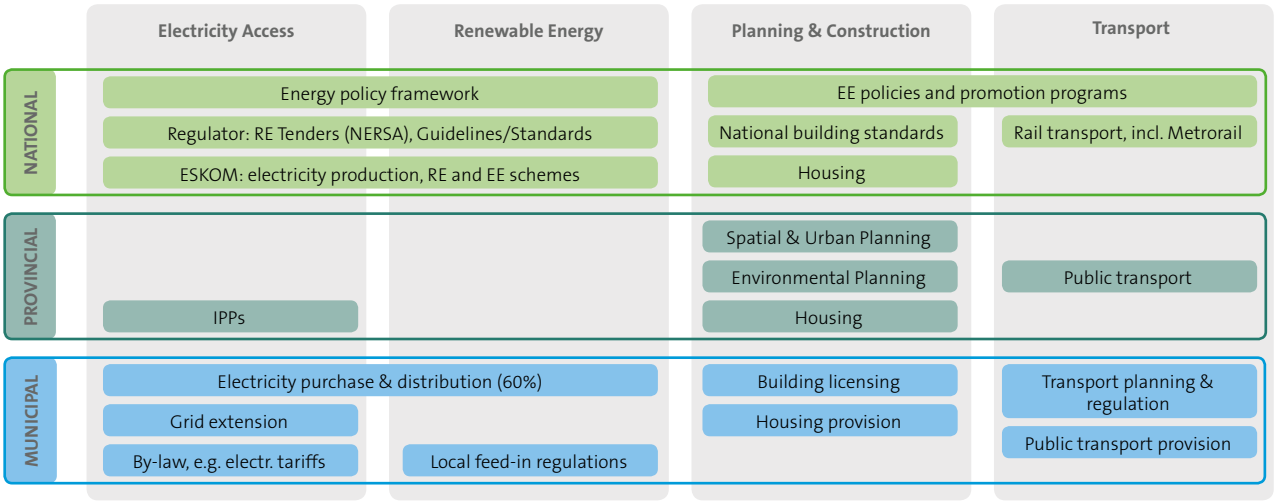
61) C40 & Arup, 2015
62) UCLGA & Cities Alliance, 2013
63) Dodman et al, 2015
64) AfDB, 2013
65) The Economist, 16 July 2016
66) Toulmin, 2009
67) C40 Cities & Arup, 2015
68) Leskelä, 2016
69) C40, 2014 and C40, 2015

Figure 7 Institutional environment for cities in Uganda and South Africa

Urban policy landscape: Kampala, Uganda



Urban policy landscape: South Africa



4 Future energy scenarios

4.1 Introduction

The scenarios focus on fundamental factors influencing the future of energy in African cities. They are not specific to an individual city, but instead address issues common to several cities in sub-Saharan Africa. The scenarios represent a broad range of potential outcomes and stages of a city's development. It may therefore be the case that different scenarios are relevant to the same city in different time periods and sectors. Though the scenarios take 2050 as their end-point, they reflect current and emerging trends and issues, as discussed in *chapter 3*. This section describes the four selected scenarios that outline alternative futures for African Cities, these are:

- **Scenario 1** – Reliance on a centralised energy model;
- **Scenario 2** – Weak enforcement of ambitious climate commitments;
- **Scenario 3** – Growth-driven climate action; and
- **Scenario 4** – Technology-enabled growth.

Each scenario includes the elements described in *table 14*:

Table 14 Summary of scenario elements

Section	Description
Scenario overview	A description of each scenario and of the two key dimensions explaining why the scenario might occur. It includes the dynamics, influences and causality underpinning each scenario as well as its key implications.
Trajectory 2050	A narrative of how the scenario could develop until 2050, identifying key events and turning points, while also considering the impact of wild cards on the scenario.
Key issues	A summary of the key issues identified in the scenarios which require a response from stakeholders. The identified issues form the basis of the recommended strategic directions in the summary matrix on *page 76* at the end of the chapter. The recommended strategic directions aim to mitigate the identified key issues in the scenarios.
Strategic direction for decision makers	For each scenario, broad recommendations for different stakeholders operating within a city to mitigate negative or strengthen positive scenario outcomes are suggested. These are also presented in the summary matrix.

Scenario 1

Reliance on a centralised energy model

4.2 Scenario 1 – Reliance on a centralised energy model

Local government implementation capacity is weak as a result of centralised models of governance and infrastructure provision. Pursuit of a growth-focused and climate-neutral policy results in a locked-in energy and transport system which does not meet local needs and undermines the ability of cities to meet climate and energy objectives.

Key scenario dimensions

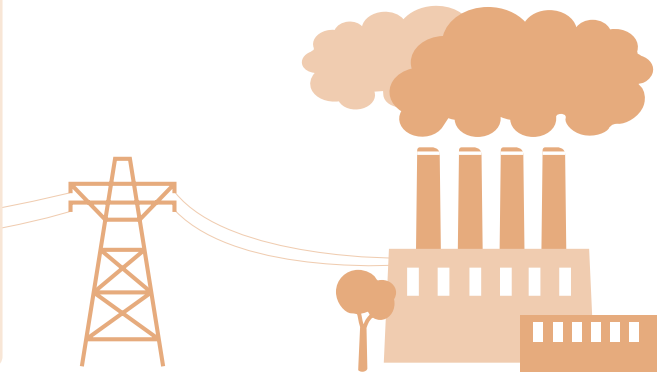
Centralised energy supply: Centralised energy supply is typified by large-scale, grid connected generation. This is coordinated at a national or regional level. Under the traditional regulation scheme, vertically integrated utilities are awarded territorial franchises where they supply electricity with a regulated monopoly business model.[70]

Weak implementation capacity: Insufficient jurisdiction, resources and organisational processes and structures are available to or used by local governments to effectively implement policies and solutions. Four dimensions of city power, which relate closely to implementation capacity, are ownership/operation of assets; the ability to set and enforce policies; control of budgets; and the ability to set visions.[71]

4.2.1 Scenario description

Urban growth: The municipal government has limited resources and is dependent on central government. Rapid urban growth therefore results in urban poverty, inadequate infrastructure and environmental degradation (such as deforestation and air pollution). Local implementation capacity is weakened as the city sprawls and expands into other jurisdictions and resources are spread more thinly.

Centralised investment: As the city grows, a centralised energy supply and weak local capacity is not able to respond to demand, particularly from informal settlements. However, a centralised system is the lowest-cost electricity provision for an urban population and is more attractive to energy providers and international finance partners. Investment also reflects natural resource endowments[72].



Investment in centralised energy infrastructure creates lock-in and prevents adoption of a decentralised system. There is little incentive for private providers to set affordable tariffs for low-income and marginal groups. Investment in centralised energy infrastructure therefore does not significantly improve energy access. Local solutions are limited as resources are tied to implementing central government policy.

Centralised provision of other infrastructure, such as transport, which takes place without involvement of local governments, leads to poor investment choices. Increased sprawl leads to high demand for private motor transport, increasing energy demand and carbon emissions. Fuel subsidies follow.

Energy-dependent growth: Improved quality of energy supply benefits users with a grid connection, such as existing industrial or commercial users. This supports investment in energy-intensive technology and economic growth. Where growth is not supported by local government (for example, insufficient provision of infrastructure for employment land) entry barriers for new businesses emerge. Where grid connections are not possible, larger firms invest in their own largely-scale fossil fuel based generation facilities. Small businesses cannot and do not grow.

70) Pérez-Arriaga, 2013

71) C40 and Arup, 2015

72) For example, countries following this path at present include Mozambique (coal) and Ethiopia (hydro).

Constrained economic growth results in under- and unemployment and poverty. Low-income households and informal businesses use small scale biomass or charcoal for cooking and heating, with negative impacts on health. For power, they use expensive off-grid systems based on fossil fuels (for example diesel generators) or renewable energy (for example PV systems). Weak local government is unable to address this through inclusive energy or economic policies. This may lead to social instability.

Climate change: Climate migrants may exacerbate unplanned urban expansion, settling on marginal land, isolated from economic opportunities and infrastructure.

Scenario 1: Key issues

1. Urban growth and policy enforcement is poorly managed due to weak government capacity.
2. Investment in major infrastructure by centralised government creates lock-in to unsustainable development paths and does not address urban and peri-urban specific needs.
3. The model of economic and urban development is very energy intensive and inefficient.
4. Social and economic inequalities are tied to energy inequality and are concentrated in informal settlements posing a risk of civil conflict.

4.2.2 Trajectory 2050

2010s

1. The city population grows and the city expands. A growing workforce drives economic growth and total energy demand.
2. **Turning point:** In response to increased energy demand, central government pursues investment in large-scale fossil fuel and hydropower generation as there is an established investment and delivery model for these facilities, they provide a reliable base load supply and may utilise domestic resources.

Oil price shock:

- High fuel costs drive energy efficiency measures, including the provision of (greater) public transport
- In an oil producing country, central governments may reinvest royalties or provide high subsidies
- Shift to large-scale renewables would reduce oil and gas consumption and energy costs

2020s

3. Energy investments improve the quality of supply for those with an existing connection, and access is gradually increased for those able to pay and with land titles.
4. Local governments do not have jurisdiction or resources to improve distribution networks and land rights issues mean many informal or low-income residents do not have a connection. They use decentralised coping solutions, including biomass for cooking and illegal connections, or use affordable, basic solar technology for power.

Energy technology breakthrough:

- Decentralised energy supports small businesses
- Job creation in the tech industry
- Low-cost solutions reduce burden of energy on poor households

5. Central government implements a major programme of highways investment in and between cities to support economic growth. Limited priority is given to public transport and non-motorised modes.
6. Highways shape a sprawling urban form, spatially separate communities and increase the demand for private motor vehicles, increasing the energy intensity of development.

Figure 8 Trajectory of scenario 1 until 2050

2030s

7. The sprawling metropolitan area now covers multiple jurisdictions. Coordination between local governments is poor, weakening collective ability to plan urban growth.
8. Central government blocks efforts to promote decentralised energy systems to avoid making existing large-scale investments redundant.
9. Rainfall patterns become unpredictable and temperatures rise. Crops fail and rural-urban migration rises.

4 °C warming:

- Centralised infrastructure vulnerable to climate risk
- National government transfers powers to municipalities to ensure infrastructure is resilient
- Impacts on water and food systems increase energy demand
- Climate migration causes wide-scale unrest, leading to economic and societal destabilisation

10. Climate migrants settle along highways on city outskirts, isolated from economic opportunities and with little or no infrastructure provision.

2040s

11. National government begins energy efficiency campaigns as a main strategy to ensure security of energy supply.
12. Local implementation is weak, and the policy is counteracted by the energy-intensity of the established urban form and transport infrastructure.
13. The continued lack of action by local government to address socio-economic disparities fuels unrest amongst unemployed youth. Occasional outbreaks of violence target city institutions and rural-urban migrants.

Civil conflict and instability:

- Disruption of centralised infrastructure cuts off energy supply
- Energy inequality, climate change impacts and socio-economic disparities can fuel conflict
- Rising oil costs could drive social conflict

Scenario 2

Weak enforcement of ambitious climate commitments

4.3 Scenario 2 – Weak enforcement of ambitious climate commitments

City governments make a strong commitment to climate change mitigation and adaptation through international mechanisms such as NDCs and develop plans and policies accordingly. However, interventions fail to properly account for informal settlements and the informal economy. Therefore policies cannot be enforced and programmes are not delivered, resulting in significant costs for those in the informal sector.

Key scenario dimensions

Strong climate policy commitment: A strong climate policy commitment by the local government could include engagement with national CO_2 emission targets and NDCs, membership of the Global Covenant of Mayors and other international climate-focused city collaborations and the adoption of a dedicated city-level climate change strategy.

High informality: Large shares of the population migrate from rural areas and settle in peri-urban slums. Many city residents living in informal settlements are also employed in the informal sector. Informal transport systems and infrastructure services such as water become more widespread. This arises for a number of reasons, including poorly enforced and overlapping systems of land rights and planning policies.

4.3.1 Scenario description

Commitment to climate action: The city government has jurisdiction over several policy areas and benefits from regular fiscal transfers. It is strongly engaged with national climate policy and international collaboration on climate action. However, most informal activity is neglected in policy design as it cannot be easily addressed due to legal structures.

Widespread informality: High informality results principally from the speed of urban population growth, driven by economic opportunity. Weak land management policy, perceived costs of economic formalisation and inadequate citizen engagement by government prevent formalisation. In this scenario, women are more likely to work in the informal sector, less likely to have a legal claim to land and therefore bear a high proportion of the costs of informality.

Climate policy compromised: Solar micro-grids may not be feasible in informal urban settlements as land rights issues prevent private sector involvement and access to finance. Residents of informal areas may be subject to environmental risk. Simple off-grid energy solutions such as diesel generators and biomass, informal waste, transport and water services are widely used.

Faced with various risks, informal businesses are not able to grow significantly and support urban economic growth. Informal service providers may oppose interventions intended to support climate objectives, such as introducing energy efficient public transport or reforming waste systems, fuelling social instability. It may be possible to develop 'mixed' public transport and waste systems, including informal providers, but sustainable water and energy infrastructure is likely to remain a significant issue.

Climate risks: Low-income informal residents are likely to settle in flood risk areas or are increasingly spatially separated from economic opportunity. Density and informality of these settlements also make them particularly vulnerable as it is difficult for emergency services to enter or exit. Fires or floods can therefore quickly impact a large number of people. Under this scenario, low-income informal residents also spend large parts of their income on basic services. Also, attempts to remove or relocate informal settlers may not provide adequate compensation due to lack of land rights.

Increasingly frequent and intense heat waves and droughts mostly affect low income citizens more severely (for example those living in illegal buildings which do not meet regulations and lack cooling appliances). Climate impacts also increase the prices of food, biomass fuel and water. This weakens energy access and disproportionately affects low income groups, who spend a greater share of their incomes on these necessary goods.

Scenario 2: Key issues

1. Citizen engagement and participation in governance is weak, preventing implementation of local and national policies.
2. There are significant policy gaps regarding access to land and housing for urban residents.
3. The government does not provide energy as a service to all citizens, particularly to informal settlements in urban and peri-urban areas.
4. There are significant vulnerabilities concerning the impacts of climate change that affect mostly low-income informal residents.

4.3.2 Trajectory 2050

2010s

1. The city government begins creating a carbon inventory and mapping climate risks.
2. The city government identifies climate mitigation and adaptation actions, informed by international examples of best practice.

4 °C warming:

- Inability of government to enforce policies leaves population vulnerable to climate change consequences
- Use of decentralised technologies rather than centralised infrastructure reduces city's exposure to climate risks
- Informal settlements are more vulnerable to the shock

2020s

3. **Turning point:** The city government produces a development vision and strategy, but does not include implementation plans which account for the informal sector.
4. Policies emphasise decentralised private or community-led mini-grids and solar generation.

Oil price shock:

- Improved energy efficiency through slum upgrading and retrofits can reduce exposure to energy price shocks
- System of decentralised renewables also supports resilience
- Residents are more likely to use biomass or charcoal rather than LPG (for example for cooking) or start using more renewable technologies. Use of renewables may still require expensive diesel back-up generation or batteries

5. The city encourages formal development around key transport corridors through planning policy prohibiting development in flood-risk areas and selling public land to private sector developers.
6. Higher income groups locate around these corridors as they become centres of economic activity.

Figure 9 Trajectory of scenario 2 until 2050

2030s

7. Private-sector led micro-grids prove successful among formal settlements, but are rarer in the informal sector. Some community-led grids develop amongst higher-income informal areas.

Energy technology breakthrough:

- Technology for improving decentralised energy access
- New technologies are used in pilots in order to reach marginalised communities in informal settlements
- May not address risks which prevent community investment, such as the risk of eviction

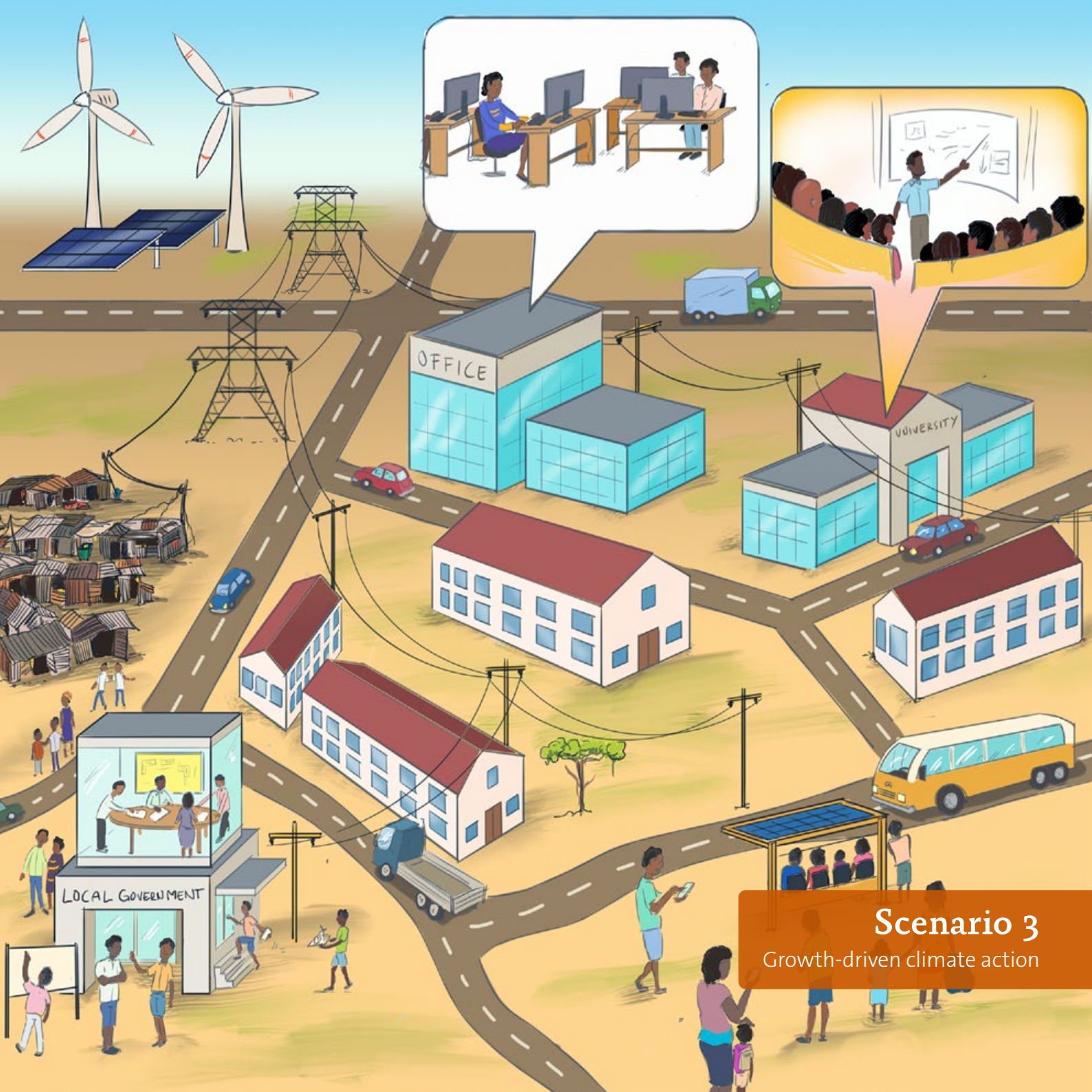
8. Efforts to introduce energy efficient public transport and waste systems meet resistance from informal service providers.
9. Low-income residents settle in flood-risk areas, increasingly spatially separated from economic opportunity. Attempts to remove or relocate informal areas create social tension.
10. Heat waves and droughts increase the prices of food, biomass fuel and water. Energy demand rises due to increased use of air conditioning

2040s

11. Floods cause displacement and significant damage to human life, health and livelihoods, particularly amongst low-income residents in informal areas.
12. Interventions by civil society and international donors create a patchwork of decentralised energy systems or improvements to water and sanitation infrastructure for informal communities, but these do not amount to a system change. High quality infrastructure remains inaccessible to many.
13. ↻ **Turning point:** In response to social tension and action by the civil society, the city begins to develop mixed public transport and waste systems, including informal providers.

Civil conflict and instability:

- Decentralised systems are more resilient in a conflict situation
- Private sector and international investment in infrastructure is unlikely during conflict.
- Civil conflict and instability could result from the growing divide between the informal and formal sector and heightened by economic imbalance
- Inclusion and engagement, such as through community partnerships, may reduce the likelihood of conflict



Scenario 3

Growth-driven climate action

4.4 Scenario 3 – Growth-driven climate action

This scenario highlights the pathway towards a green model of expansion and development, where human resources are increasingly enabled through an emerging middle class. Strengthening of local governance, rising incomes and education lead to public support for a sustainable model of urban development, including renewable energy generation at the city level.

Key scenario dimensions

Increased renewable energy generation: A shift from fossil fuels to renewable sources takes place in energy generation. Renewable energy resources are harnessed at the national level through the grid. Cities also seek to utilise their own locally accessible renewable energy resources as a basis to minimise dependence, ensure reliability and diversity of supply.

Emerging middle class: The changing distribution of income results in an emerging middle class in African cities, coming to represent a significant proportion of the population.

4.4.1 Scenario description

Economic growth and energy: As economic growth takes place, energy demand is rising across residential, commercial, industry and transport uses. In response, city governments may actively seek to develop renewable energy resources to ensure security of supply, increase use of local, natural resources and maintain low GHG emissions to comply with international targets.

Decentralised renewable energy improves energy access, which plays an important role in supporting educational attainment and income growth.

An increasingly skilled workforce can access higher-value employment opportunities in the formal sector. Investment supports economic diversification with growth in services and manufacturing. Cities are incentivised to take action to address their energy needs to sustain their economic growth.

Formal and more secure employment leads to income growth and increased consumption. This is partly directed towards improved housing, education and health.

Cities seek to promote a hybrid model of energy provision, also in informal settlements, combining grid connected access with opportunities for decentralised generation. Significant long-term planning and investment in new grid infrastructure is required to achieve this. Cities also give priority to energy efficiency and reducing energy intensity, which is incentivised by national energy resource constraints or economic concerns.

Strengthened governance: A better-off and well-educated population engages with government to ensure urban problems of energy access, congestion, pollution and quality of life are addressed. They also provide skilled staff for local governments, improving implementation capacity. Policies do not only benefit the middle class but recognise and actively target lower income groups and informal stakeholders which still represent relatively large shares of the population.

Accountability of local government officials is high, emphasising delivery and results. This leads to a widening of their mandate over time with support of national government. A strong tax base is enabled by the growing private sector and affluent citizens, further supporting local capacity.

Familial connections with agriculture in current or recent generations mean many city dwellers have a tacit awareness of environmental and climate risks. Environmentally responsive policies in line with a water-energy-food nexus model can be promoted.

Urban form: The lack of available land close to the urban core leads to suburbanisation, where land is cheaper. However, development is guided to locations that are well connected to employment and services.

The pattern of urban form is strongly guided by effective planning and management, including land management policies, coordination of infrastructure and integrated transport accompanied by an appropriate mix and density of activities.

Rising incomes mean increasingly formal development. Land values close to the centre remain high. This could lead to the cascading and more intensive use of existing property or potentially redevelopment of high density areas.

Scenario 3: Key issues

1. Economic growth results in high energy demand, requiring urgent action to improve efficiency, expand generation and keep the size of urban pollution low.

2. An increased penetration of renewable energy to the grid poses technical challenges to the existing transmission and distribution infrastructure. Large amounts of new grid infrastructure need to be built to satisfy increased power needs.

3. Fast urban growth requires management to ensure climate resilience and work with the informal sector to ensure inclusive growth.

4. Local mandates and activities require strong local government capacity, particularly in accessing finance and managing programmes.

4.4.2 Trajectory 2050

2010s

1. **Turning point:** The city takes action on energy by creating a Multi-Utility Service Company (MUSCO) or Energy Service Company (ESCO), covering a development programme of waste-to-energy plant as well as small-scale renewable energy and energy efficiency initiatives.

Oil price shock:

- Need for energy cost savings accelerates development of MUSCOs/ESCOs
- Renewable electricity producing areas export to oil-dependent areas
- Hybrid model of energy generation protects consumers from price shocks
- Bring large energy users (such as hospitals) into networks to anchor the viability of local/municipal energy networks and explore opportunities for district cooling/heating

2. The city establishes green building standards and puts incentives and delivery mechanisms in place, though these are not yet mainstreamed.
3. There is an incentive for energy providers and municipal utilities to pursue policies for informal settlements and extend access to underserved areas, but this is not necessarily financially viable.
4. The city views itself not only as a service provider, but enabler with room for bottom up solutions and partnerships.

2020s

5. The city undertakes investment in transport infrastructure underpinned by effective and integrated land-use transport planning.
6. High frequency public transport corridors link informal communities and new neighbourhoods at the urban fringe with the centre to support inclusive growth.
7. New mixed income neighbourhoods are planned and developed in climate resilient areas. While the area is grid connected, renewable energy generation (for example, solar PV) is integrated with new residential development and surplus energy is fed back to the grid.

4 °C warming:

- Nexus-based resource management mitigates impacts on energy, water and food systems
- Established local finance models are used for climate resilient investment
- Impacts limited where development is planned or retrofits have taken place

8. Action is taken to coordinate infrastructure provision in advance of development through regulation, partnership and investment structures. Land is preserved for agriculture.

Figure 10 Trajectory of scenario 3 until 2050

2030s

9. Incremental upgrading takes place in slum areas to extend electricity, municipal water and sanitation networks.

Civil conflict and instability:

- Emissions, environment and education become a lower priority for citizens and governments
- Effective regulatory frameworks, institutional strengthening and accessing finance becomes challenging
- Decentralised micro-grids and local energy companies enhance the resilience of the energy system

10. ↻ **Turning point:** As access becomes more widespread, there is a greater emphasis on retrofit and improving energy efficiency.
11. The standards and policies for new buildings are strengthened over time and through partnerships with developers and the construction sector. A high density cluster including public buildings, shopping centres and hotels has developed a localised district cooling network.

2040s

12. Decentralised networks are linked and integrated to create city-wide energy networks and enhance operational efficiencies, requiring significant grid investment. Energy storage solutions have become affordable at scale. The combination of grid, decentralised energy solutions and energy storage allows energy costs to be optimised for the benefit of end users.
13. The city has become a generator of electricity, competitive with national providers. The revenues gained from locally generated energy have repaid the initial investment and the system is self-sustaining with surpluses reinvested locally to support community initiatives.

Energy technology breakthrough:

- Increased electricity production creates a windfall for the city as an electricity generator, supporting further investment
- New technologies further improve efficiency, access and reduce emissions of energy systems
- Renewable energy becomes a growth sector for the city

Scenario 4

Technology-enabled growth

4.5 Scenario 4 – Technology-enabled growth

Technological innovation facilitates investment in decentralised systems and the emergence of new solutions. This leads to economic and income growth for large parts of the population. Governments need to draw on this technology to improve urban services and infrastructure, including management of energy infrastructure and disaster warning systems.

Key scenario dimensions

Technological innovation: Increasing adoption, innovation and adaptation of technologies and business models to directly respond to local needs. Relevant technologies include data digitalisation, mobile devices, the internet, cloud-based storage, reducing cost of satellite communications and the internet of things. The impact of mobile access is very significant, for example, in mobile banking, agriculture and efficiency of local trade in the formal and informal sector.

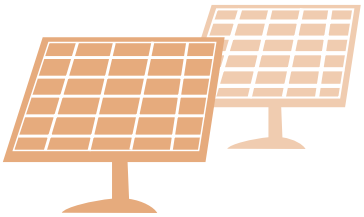
Increased decentralised energy supply: The ranges of energy solutions which can be developed independently of large-scale energy generation, transmission and distribution networks for example off-grid renewable energy generation. These solutions may be developed at different scales (building, cluster or community) and be open or dedicated networks connected via micro and smart grid systems.

4.5.1 Scenario description

Technological take-up: Market openness allows technologies to be taken up. African cities have the opportunity to benefit from and influence global innovation and the reduction of technology costs.

Small-scale renewable energy generation and grid technologies can be combined with digital technology to develop new business models covering generation, distribution, storage as well as payment and operating systems. These reduce barriers to energy access while enhancing proximity to payment and addressing challenges such as measurement and revenue collection, improving the case for investment. Resource efficient 'sharing economy' solutions could also emerge.

Vertically integrated utilities relying on fossil-fuel generation are affected by new technologies and slowly diminish share of market power. Take-up and commercialisation of new technologies is led by the private sector, which may outpace improvements in city government implementation capacity. This is underpinned by user demand from a young and entrepreneurial urban population. Due to the rapid success of these models in improving access, governments look to enable further technological progress and integrate new technologies with future infrastructure investment. These fast expanding decentralised solutions are poorly coordinated by governments and may not be accessible.



Education and employment: Investment in education takes place to support skills development. Large parts of the population benefits from these improvements, however the public sector needs to intervene to strongly support low-income residents. Improvements in education and employment are facilitated by better energy access provided by decentralised solutions. Low-cost technologies and open source technologies enable access to information and new solutions to emerge across multiple sectors including education, health, media and retail.

The economy moves into higher value sectors. Increased power availability supports manufacturing. Increasing education attainment in cities and fixed/mobile broadband access allows the development of knowledge-based services among the better educated. Nigerian, South African and Kenyan cities are already active in exporting IT enabled services including call centres, business process outsourcing (BPO) and knowledge process outsourcing (KPO). Amongst the less-educated, an informal service-based economy prevails.

Government and regulation: National government can establish a regulatory environment which stimulates inward technology investment, providing lower cost domestic technology. This requires relevant technology standards including those relating to interoperability, protection of IP and procurement guidelines for government entities. Governments implement low-cost solutions but need to develop capacity to implement smart governance solutions. IT enabled platforms can also be used to enhance services and improve transparency.

Infrastructure: Cities represent a series of electronically well connected neighbourhoods, but physically isolated due to poor transport networks. Clear economic demand can facilitate investment in the roll out of broadband internet networks (fixed and mobile) to increase connectivity. Rapid uptake and use of technology has the potential to lead to leapfrog transformation and more rapid transition towards low carbon climate responsive solutions.

Scenario 4: Key issues

1. National and sub-national governments require strong support to create an enabling environment for technological progress, in terms of physical infrastructure, skills, investment and regulation.

2. The emergence of decentralised solutions leads to a fast changed or diminished role of vertically integrated utilities.

3. There is little coordination of urban development, which may result in an unsustainable urban form and poor physical infrastructure, especially for lower income groups.

4. Under strong influence of the private sector for development, little coordination of climate action, particularly regarding adaptation, is taken by the government.

4.5.2 Trajectory 2050

2010s

1. **Turning point:** Driven by lack of access to grid connected power within informal settlements, a technology enabled business model to deliver energy emerges. These are frugal innovation solutions combining technologies such as mobile banking, apps and other solutions. Decentralised networks do not displace investment in grid connected power but have the effect of accelerating access.

Energy technology breakthrough:

- Improved, affordable technologies catalyse innovation and the spread of information
- Rapid uptake supports economic development in formal and informal economies
- Role of vertically integrated utilities diminished

2020s

2. A range of parallel solutions emerge covering a range of urban services for example water, transportation and waste management.

Oil price shock:

- Decentralised energy systems likely to be more resilient in the event of conflict
- Progress in energy regulation or infrastructure investment stalls
- Damage to infrastructure or network interruption may undermine the digital economy

3. Social media is used as a communication channel for sharing information and mobilising action, which strengthens governance and accountability.
4. **Turning point:** As capacity of government grows it adopts technology as a basis to enhance the efficiency and transparency of its operations and to improve service delivery.
5. Technology is used in government as a complimentary good to available human capacity and financial resources.
6. Government facilitates the roll out of broadband internet networks (fixed and mobile) to increase the connectivity and speed of sending/receiving of data.
7. Government tries to avoid lock-in and remain flexible as demands and available technologies change and costs reduce. Full impact requires sustained investment over 15–20 years.

Figure 11 Trajectory of scenario 4 until 2050

2030s

8. **Turning point:** As the enabling environment for investment improves, ICT has a more transformational impact, as it acts as a multiplier and accelerator within the formal economy. ICT network-based business models reinforce informal activities.

Civil conflict and instability:

- Renewable energy investments reduce the energy costs and support access
- Innovation challenges can be used to support a shift from oil products
- Smart metered, efficient energy systems reduces energy costs for consumers

9. Investment takes place in communications interfaces.

10. **Turning point:** Use of sensors and connected devices linked to the internet of things provides a basis to improve the control and management of infrastructure systems (energy demand management, traffic, safety and security, disaster warning systems). New low-cost energy storage solutions become viable.

11. Technology is embedded with new capital investments rather than retrofitted later where there is an effective business case. Open interoperable systems are used to enable flexibility.

2040s

12. Operations and control centres become useful in integrating sources of information and to provide a basis to act on real time information.

13. Software is used to improve city operations where it is accompanied by human resource investment and institutional change management. IT enabled solutions provide information to assist decision-making and operational improvements.

4 °C warming:

- Smart governance solutions identify and manage climate risks to energy systems
- Damage to energy and telecommunications infrastructure disrupts technology-led economy and services
- Persistent governance gaps, for example coordination between levels of government, inhibit climate responses

4.6 Strategic directions for decision makers

Thematic areas for action						
Governance	Informality	Finance	Technology	Skills/capacity building	Partnerships and dialogue	Complimentary measures in transport and urban planning

Scenario 1		
National Government 	Governance	Support a more pluralistic approach, for example by allowing IPPs or community-led micro-generation. Central to this is the regulatory reform of the energy sector, which would also be to allow other service providers to make use of the grid infrastructure.
		Mandate green building standards to enhance energy efficiency. Establish accreditation schemes, trainings and incentives to promote the up-take of standards. Incentivise the creation of ESCOs in order to lead the energy efficiency transition. Working with industry could be prioritised at the beginning to achieve effective results fast.
		Align energy policies with climate, social and environmental goals, for example by telescoping tariffs based on consumption to favour low users of energy who tend to also be the poorest.
	Informality	Work with local governments and civil society organisations to develop innovative, technical and financing solutions for energy provision to informal settlements. This could include legalisation of residential status in order to ensure that connections are not illegal and payments for service are collected.
	Finance	Use emerging international climate funding to de-carbonise power provision. In order to meet the criteria of climate funding, efforts should be made to enhance the enabling environment and re-risk investment at municipal level.
		Develop a national financing facility targeted at cities and local municipalities to support the roll-out of packaged solutions for cities.
	P. & D.	Integrate energy issues in other portfolios, such as Ministries of Environment or Urban Development, to ensure energy policy is aligned with climate and urban plans. National government should take a nexus-based approach to energy and water infrastructure and natural resource management.

Local Government 	Partnerships and dialogue	Offer targeted support to national government, both in terms of financial and human resources, to address local energy and climate issues. For example, cities should work with national government to develop a central support facility for cities.
Private Sector 	Partnerships and dialogue	Implement action on energy and climate issues throughout supply chains through the collaboration between industry and private sector infrastructure providers.
Civil Society 	S/C	Play a stronger role in knowledge sharing and supporting the replication of successful solutions.
	P. & D.	Support action by organising community-led energy generation initiatives as well as bringing communities into energy planning. This has been successfully practiced by initiatives such as the Community and Household Options in Choosing Energy Services (CHOICES) programme in South Africa
	P. & D.	Set the agenda at the national level, particularly if participation in local governance is weak. Civil society must be able to hold central and local government accountable for performance against social and environmental objectives.
International donor community and finance 	Finance	Use programmes to provide finance for more innovative projects at local level, as well as scaling-up solutions which are successful.
	Finance	Mobilise climate finance and other financial models to support municipalities, infrastructure providers and the private sector directly.
	P. & D.	Promote dialogue between national governments and sub-national governments to create national frameworks and local action and enforcement.
	P. & D.	Involve civil society – locally and nationally – by ensuring that investments and policies meet distributional and broader socio-economic objectives, including action in informal settlements
Complimentary measures in transport and urban planning	Comp. meas.	Regulate motor vehicle efficiency and reform fuel subsidies with priority given to investment in public transportation, while ensuring active and public transport options in urban areas to reduce energy intensity.
	Comp. meas.	Develop a national urbanisation policy to guide development of energy and climate policies, particularly promoting polycentric development and utilising existing transportation network servicing trade routes.

Scenario 2		
National Government 	Governance	Ensure regulatory alignment to permit development of a municipal energy fund and other local actions.
		Consider use of concessions of public land for social housing or for privately developed mixed income, climate resilient housing projects. These can then be used for relocation of those in at-risk areas. Concession terms can guarantee provision of energy infrastructure.
	Infor.	Use a consultative approach to manage the issues of informal settlements including seeking to promote formalisation of rights and enabling upgrades in building quality and improving energy access. Schemes to enable relocation are very relevant for high-risk areas.
	S/C	Support the public sector in their capacity to structure projects in order to leverage private financing and increase lending impact.
Local Government 	Governance	Make use of the city's mandate on energy efficiency and focus action on municipal buildings in their property.
		Develop a municipal energy fund, following regulatory alignment at national level, to support private sector supply of energy generation and grid technology. This could be delivered through private sector loans and microfinance.
		Promote private-sector business models which do not require land titles to enable access to renewable electricity, such as pico-PV appliances.
	Informality	Develop energy efficient solid waste management systems, including recycling and use of waste-to-energy plants and integration of informal services.
		Mobilise support for slum upgrading and building retrofit programmes focusing on low cost measures, which reduce energy demand and climate responsiveness (for e.g. passive solar building design). This could be supported by microfinance schemes.
	P. & D.	Work together with the national government to support connectivity and feed in to the grid of renewable micro generation solutions.
		Develop partnerships with industry to support renewable mini-grids and small and medium scale IPPs where the national regulatory framework permits.
		Start a dialogue with communities to decide whether a grid connection or a decentralised approach to electrification is more suited. Similarly city governments should focus on a shift from biomass cooking to more modern forms of cooking, for example LPG or electric stoves.

Private Sector 	P. & D.	Align the capacities of private electricity distribution companies with city government to access opportunities for power provision in low access areas.
		Implement low-risk projects, such as small-scale renewable appliances or pico-PV, through community partnerships.
Civil Society 	Infor.	Engage with local government in order to exchange knowledge and find possible solutions to tackle climate and energy issues in informal settlements and peri-urban areas.
	Fin.	Explore social enterprises, cooperatives and microfinance solutions as an option for the management and operation of community-based energy access, renewable energy and micro grid schemes.
	P. & D.	Raise awareness of climate impacts and environmental risks in urban and peri-urban areas and facilitate dialogue between all government levels and communities.
International donor community and finance 	Gov.	Target gaps in vertical governance in order to align national priorities with effective action at city level.
	Infor.	Support inclusive processes of urban development, by ensuring technical support considers informal urban sectors.
	S/C	Provide large capacity building programmes for municipal governments, especially for those in smaller secondary cities. Focus should be on the provision of skilled personnel to manage projects as well as on training programmes for the provision of energy access for urban and peri-urban areas, renewable energy for local production and energy efficiency in buildings and appliances.
		Target practical support to strengthen the enabling environment including regulation that deals also with informal settlements.
Complimentary measures in transport and urban planning	Comp. meas.	Promote low-cost options, for example, using energy efficient and alternative fuel buses and promoting non-motorised transport, working with the private sector and informal operators and ensuring access to economic centres.
		Incentivise settlement in climate resilient areas through the development of well-located informal settlements, including pro-poor housing, slum upgrading and retrofit programmes. Addressing the issue of land rights and strengthening land management systems along with legal, policy and financing frameworks to guide urban upgrading and expansion is needed to coordinate delivery of infrastructure including energy infrastructure.

Scenario 3		
National Government 	Governance	Deregulate to enable the financing and growth of municipal energy networks. This includes access to the grid and framework systems for feed-in tariffs.
		Support holistic energy planning which calculates how much renewable energy can be included in the mix as well as the specific costs, dimensions and locations of transmission and distribution networks.
	Tech.	Invest in energy storage combined with distribution network upgrades to establish a smart grid in order to enable appropriate balancing of the grid and respond to peaks and troughs.
Local Government 	Governance	Support enforcement of green building standards developed by national governments to enable delivery of green buildings and eco-neighbourhoods in cities.
		Identify potential opportunities for nexus solutions together with MUSCOs and link municipal water and energy needs through, for example, water storage and gravity-fed release linked to small-scale power generation.
		Pursue opportunities for renewable energy generation and energy efficiency in public sector energy use, including schemes such as solar-powered public buildings and street lighting.
	Finance	Work with national government to mobilise finance for low carbon investment. Options may include municipal bonds, climate finance, user charges, local levies and charges, land based financing, parking charges, a municipal levy on fuel and congestion charging. A city focused investment model is likely to require strengthening of revenue generation and collection at local level as well as support and guarantees from national government.
		Forge partnerships with Distribution Network Operators focused on community based action to enhance effective implementation in informal communities, for example through Corporate Social Responsibility (CSR) initiatives.
		Establish an energy fund to enable investment in building and community scale renewable energy including solar PV, biogas and waste-to-energy schemes. For example, municipal energy funds have proven successful in North American cities such as Ann Arbor. As an alternative Cape Town has developed an initiative with local financing institutions for household solar hot water, PV and energy efficiency projects.
	S/C	Develop the capacity of city government and support the preparation and programming of projects, for example in planning, project and asset management and financing. This can help to facilitate horizontal and vertical integration and coordination of action.

	S/C	Build and strengthen the capacity of distribution network operators to manage access to the grid. City government should establish a platform to link producers and community based prosumers to support the emergence of MUSCO/ESCO.
Private Sector 	Infor.	Enter into partnerships with informal sector businesses or civil society representatives to explore opportunities to explore opportunities for the provision of solutions to the informal sector.
	P. & D.	Cooperate with municipalities in guiding and implementing the development of city level energy strategy.
Civil Society 	Fin.	Enter into partnerships to support action in informal areas including establishing finance for upgrading and energy access, applying technical expertise gained in working with formal sector.
	P. & D.	Develop partnerships with academia and local government focusing on strengthening the overall capacity of the city.
		Promote active citizen engagement to ensure ownership is sustained.
International donor community and finance 	S/C	Target action to a variety of urban-enablers including public sector land holders, housing finance institutions and infrastructure or real estate developers as well as civil society organisations.
		Support institutional strengthening and capacity building at city level to enable city led planning, asset management, investment and finance and operations across energy, transport and urban development.
Complimentary measures in transport and urban planning	Comp. meas.	Align land use and transport planning to guide urban growth, reducing energy intensity. Local levies, municipal bonds and climate finance should be used to finance low carbon transport investment, this may support investment in high volume, high frequency public transport corridors aligned with development to minimise the number and energy intensity of trips.
		Develop mixed use urban areas to support energy efficient urban form and promote regulation to avoid urban sprawl. Options including green public sector procurement guidelines and initiatives to establish a green buildings supply chain should be considered.

Scenario 4		
National Government 	Governance	Deregulate to enable access to the grid and a system of feed-in tariffs for decentralised energy networks and renewable microgeneration.
		Provide the investment and business climate for technology take up to establish a market. This includes establishing relevant energy-related technology standards including those relating to interoperability, protection of intellectual property, and procurement guidelines for government entities.
		Review infrastructure and green building standards to include relevant reference to the use of technological solutions (for e.g. building management systems to improve the efficiency of air conditioned buildings).
	S/C	Support science and technology education, training and skills development to enable uptake of technological solutions.
Local Government 	Governance	Develop financing models together with the private sector for investment in community scale renewable energy with the use of smart metering technology as well as energy efficiency measures.
		Develop the regulatory frameworks and support the creation of public private partnerships with technology providers focused on addressing energy access, energy efficiency and wider municipal needs.
	Technology	Use an innovation competition amongst selected stakeholders to encourage the emergence of new solutions.
		Explore low cost big data solutions including satellite, mobile and digital payment systems. These can improve planning for energy (satellite data) and enhance viability of solutions by enhancing security of revenue.
		Use technology as a basis to enable integrated action, for example by developing a city dashboard which allows key issues to be identified and information shared.
		Manage climate and environmental risks such as pollution and natural hazards such as flooding and landslides by utilising ICT enabled early warning systems.
Private Sector 	Gov.	Mobilise private finance including social impact investment to support ESCOs to meet energy needs and improve energy performance.
	Tech.	Bring commercial expertise in partnerships with the city government to establish local solutions and business models as well as support local capacity development.

	S/C	Invest in skills development to help implement programmes and bridge the gap in available skills and resources. This could be done by investing in training staff or through providing specialist mobile and digital education platforms and trainings such as Eneza Education.
Civil Society 	S/C	Use open platforms and social media to enhance accountability, provide skills and training and advocate action.
	P. & D.	Partner with city government to initiate development of decentralised energy systems in areas not served by the grid.
	P. & D.	Act as a delivery partner by organising community-led initiatives which may include microfinance, cooperatives and small business development, skills and training.
International donor community and finance 	Finance	Provide finance to more innovative or experimental projects, particularly those which support use of local technology and skills, as well as scaling up solutions which are successful in their business models and objectives.
	S/C	Target enhancement of the enabling environment and emergence of city level and bottom-up solutions by providing finance and technical expertise.
Complimentary measures in transport and urban planning	Comp. meas.	Facilitate efficient digital business models for car sharing and para transit whilst use of big data by local governments or transport agencies. This should support effective traffic management solutions which reduce the energy intensity of transport.
	Comp. meas.	Develop local government mobile platforms to support efficient service delivery and citizen engagement, and integrate sensors and the internet of things with infrastructure to optimise efficiency and deliver savings in operating costs.

5 Conclusions – Key messages for decision makers

This section draws together the findings across all four scenarios outlining the implications for energy in African cities and reflecting feedback from expert workshops. Concretely these conclusions highlight key messages identified from the strategic directions for decision makers depicted in *section 4.6*. The identified conclusions are presented in six thematic areas of action: governance, informality, finance, technology, developing skills and capacity locally as well as partnerships and dialogue. Though strategic directions that were relevant to multiple scenarios are discussed here, the conclusions also highlight scenario-specific critical messages.

5.1 Thematic areas for action

Governance

Vertical integration of governance between national and sub-national governments opens up the opportunity for a wider range of actions to be implemented within cities.

While implementation capacity needs to be developed at the municipal level, the key enabler for change is the cooperation between municipalities and the national government. *Scenario 1* shows how centralised governments with weak local governments can pursue certain actions; however they will struggle to address all issues. Simultaneously, municipal action will be limited without regulatory change at the national level. For example, the provision of universal affordable and sustainable energy access in Africa will largely depend on national well-designed policies that are successfully implemented by sub-national governments in urban settlements. Nationally developed but locally implemented standards on energy efficiency in green buildings are another example of the importance of vertical integration. Regulation on national building codes should be adapted to the regional and municipal climate realities and enforced locally.

The liberalisation of energy markets by national governments to enable local and community scale power production and distribution is a low-cost option, which enables city level actors to take greater ownership in meeting their energy needs.

Scenarios 3 and *4* reveal that permitting cities and sub-national government authorities to generate and distribute energy, to take ownership of needs and increase the share of own source revenues, results in scaled-up action to meet not only city's needs, but also contribute to national and international climate and energy objectives. Specifically *scenario 4* implies that allowing the private sector and community enterprises to become licensed as energy companies with powers to generate and distribute energy to customers, would help unlock action at local level.

Integrated planning that considers horizontal co-ordination and integration of sectors (energy, water, climate, housing and transport) in decision-making will pay off in terms of the benefits which can be delivered.

The similarities between *scenario 1* and *2* indicate that, even with a clear commitment to climate action, challenges cannot be successfully addressed without integrated action across sectors. For example, the provision of energy access is often poorly reflected in slum upgrading or social housing programmes. Energy efficiency is often planned by energy experts with insufficient coordination with housing departments. Making green building codes mandatory for housing programmes, for example, would enhance integrated planning.

Greater benefits and transformational impacts can be delivered in the future through integration of energy with other urban issues. As featured in *scenarios 3* and *4*, large opportunities exist where a systematic approach is used and action on energy is aligned with urban development, reducing energy in transport land use and urban form.

Cities should align energy related investment with economic development opportunities

Across all scenarios, energy infrastructure is a critical enabler of economic development. Similarly economic growth sustains city economies and provides resources and capacities, which can be used to address energy needs and climate risks. In *scenarios 1* and *2*, weak energy infrastructure acts as a barrier to business growth which prevents inclusive economic growth. Conversely, aligning energy and economic policies can enable:

- a green growth transformation, through ensuring renewable energy provision and low carbon urban form (as in *scenario 3*);
- technology and knowledge based industries, through providing energy and ICT services. These can then support deployment of renewable energy solutions (as in *scenario 4*); and
- all scenarios show that a reliable supply of energy at a competitive price is a necessary condition for almost all economic activities.

The scenarios indicate the importance of spatial planning to achieve this. In *scenario 1*, insufficient supply of energy to businesses as well as a lack of infrastructure-serviced employment land prevents businesses to grow. *Scenario 3* benefits from integrated land use planning, as employment location in relation to home is the single most important factor influencing travel demand and energy demand in the transport sector.

Informality

Solutions to address energy and climate vulnerability need to acknowledge informality, both in urban and peri-urban areas.

Informality is prevalent in African cities, with more than 70 % of the urban population in sub-Saharan Africa living in slums. Land claims which are not legally recognised represent a too-high-to-bear risk for private developers and investors. This will remain a barrier to the provision of basic infrastructure to informally settled communities. Many slum dwellers do not have a legal status, and have difficulties obtaining a legal electricity connection due to land tenancy issues. Simultaneously, a large number of businesses operate informally and therefore may have trouble in accessing services. In all the scenarios, low income, informally settled groups face the greatest risks from climate change impacts. Given the large share of population living in slums, tackling issues in informal settlements will have the greatest climate adaptation and mitigation impact.

The issue of informality must be addressed and considered in the design and delivery of solutions for energy and climate action. This should involve partnerships, with municipalities and civil society working with informal communities and businesses to identify innovative, workable solutions. It will be important to understand the social, financial and cultural barriers of communities in order to choose the appropriate technology solutions. In the past large efforts have been invested to bring energy solutions to non-electrified rural areas. In the future, greater understanding of specific conditions and solutions for people living in urban slums will be needed.

Addressing the issue of cultural differences between communities, land rights and instituting land rights and instituting land management systems along with legal, policy and financing frameworks to guide urban expansion will be needed to coordinate delivery of infrastructure. This will also be important as cities grow into previously rural areas.

Finance

Financing for renewable energy and energy efficiency in municipalities still needs to be unlocked.

For cities to deliver promising energy and climate change projects, they will need financing mechanisms and instruments specific to municipalities, such as municipal energy funds and municipal bonds along with support to structure projects. Accessibility of subnational governments to climate financing instruments (such as the GCF) is extremely difficult (see section on Finance in *page 45*).

Municipal financing mechanisms exist but there may be barriers to their use, such as the lack of guarantees by national governments or weak credit rating of cities, often secondary cities.[73] IFIs need to show more commitment to open these mechanisms for cities and supporting in accessing finance. Investments in domestic infrastructure projects with a transformative effect in the economy could also start to be attractive for African domestic pension funds.

National government should support decentralisation of finance and revenue raising powers and responsibilities.

In all four scenarios, financing of local initiatives represented a potential constraint to action. A national finance window can support upfront capital to finance micro-generation and other district- or community-scale energy projects. Raising the fiscal capacity of local governments is also essential to ensure that they have room for manoeuvre to implement projects in their constituency. Lack of tax revenues from the informal economy also undermine municipal financing. National governments can mandate housing and finance institutions to include provision of sustainable energy and green building solutions in their lending criteria.

73) The African Development Bank (AfDB) and the Global Environment Facility (GEF) announced in November 2016 that they will redouble their efforts to support African cities towards meeting the cost of climate change adaptation, which is estimated to be in the range of $28–67 billion per year by 2030. Africa's Power Journal 16 November 2016 'AfDB and GEF confirm commitments in Africa'.

Technology

There are benefits of decentralised solutions but it remains open to debate whether grid extension or decentralised energy infrastructure will serve the needs of informal urban and peri-urban settlements.

All four scenarios show that African cities will clearly see a widespread emergence of decentralised solutions. The 'energy technology breakthrough' wild card improves decentralised energy provision in all scenarios by offering modular technology that requires less up-front investment than centralised infrastructure. In the case of informal settlements, it remains open whether grid extension or decentralised solutions will be the predominant and most effective method of electricity access provision and enhancement.

In *scenario 4*, there are strong arguments for a decentralised approach that allows for mobile business models and more reliable payment. Decentralised solutions reduce system vulnerability because they are more resilient to climate and conflict risk. In contrast, as shown in *scenario 1*, centralised infrastructure such as large-scale oil and gas extraction fields, energy transport networks and telecommunications infrastructure are particularly at risk of climate and conflict threats. For utilities, the provision of services in informal settlements is a risky business and therefore, decentralised and/or off-grid solutions might be best suited for the given environment. Finally urban

slum dwellers are becoming increasingly mobile (changing residence very often[74]) and therefore off-grid solutions that can be moved easily might be the most practical choice.

However, the upfront cost of off-grid solutions for households in urban areas tends to be higher than the connection to the existing grid infrastructure. Furthermore, continuous supply provided by the centralised grid might be preferred instead of intermittent renewable off-grid generation units that will require an investment in batteries in order to ensure continuous supply. Given the megatrends related to progress in health and education leading to an increased middle class in African cities (*scenario 3*), the demand and expectations of African citizens to receive a secure and continuous supply of electricity might be higher in the future.

Technological innovation can be used to improve access and efficiency of city energy systems but requires skills, governance and business environment for benefits to be fully delivered.

Scenario 4 highlights the opportunities and impediments linked to a future where households, business and government harness technology to help overcome gaps in energy and infrastructure provision. Creation and diffusion of new technologies (for e.g. mobile technologies, which facilitate new business models suited to decentralised provision) can help to accelerate and extend the impact of action on energy.

74) The State of African Cities, 2010

Developing skills & capacity locally

Additional support staff as well as training and capacity building with municipal staff as well as municipal institutions, particularly in secondary cities, is needed to drive the technology transformation of energy supply.

Scenario 1 explored the consequences related to weak capacity of local stakeholders in terms of human, financial and institutional resources. Municipalities, especially those in secondary cities often lack the capacity to coordinate and implement projects, especially if these are related to 'newer' renewable energy and energy efficient technological solutions. Ensuring that municipalities are able to draw on skilled staff and robust institutional structures should be a priority for national governments and international partners. While providing specific technical support, training and information sharing are important, support will be needed in the long-term in order to ensure sustainability of institutional capacities.

Specialised training and capacity building for engineers and technicians in the private sector are needed.

Training targeted to technicians, engineers and entrepreneurs at the local level is essential in order to ensure marketing of new technologies as well as

sustainability of projects in the long-term. Specialised skills in energy audits, energy efficiency applications and renewable energy technology will be critical. The public sector will also benefit from being able to access these skills in the local private sector.

Partnership & dialogue

Cities are critical actors in guiding the policy framework at national level and action at local level.

Local and municipal governments have a first-hand view of needs, gaps and impacts as well as they are also being responsible for delivery of a range of urban services. Therefore cities can lead in diagnosing city problems and identifying priorities, act as innovation hubs for pilot projects and inform and guide policy making, for example on achievement of commitments and targets related to climate change (NDCs). Dialogue between both levels of government needs to happen more often and in more structured ways. Initiatives such as the Global Covenant of Mayors for Climate and Energy and platforms like the cCR[75] could provide the means for dialogue not only among cities, but also between local and national levels. Locally, cities can achieve action towards their climate objectives through benchmarking with other similar cities as well as establishing partnerships with other actors and stakeholders. Potential partners could include power generation and distribution companies, major industrial consumers, housing finance organisations, community organisations and knowledge partners in academia and training centres.

The private sector has the opportunity to lead change, but public sector support is required to create an environment to promote sustainable and inclusive action.

Scenario 4 demonstrates that there is potential for the private sector to lead progress on energy and outpace action in governments. As currently seen in the telecommunications sector, this has the potential to disrupt conventional energy industry structures. In particular, the widespread emergence of decentralised solutions may see the role of existing vertically integrated utilities (public and private) changing or diminished. Rapid technological development could result in stranded centralised, fossil-fuel based assets. However, the scenarios show that private-sector led technological progress does not guarantee greater benefits. In order to ensure that the full benefits of economic and technological progress in the private sector are shared by all, including informal communities and businesses, targeted local public sector support and appropriate national regulation will be required. For progress to be made on energy and climate change issues, strong engagement will be needed with industry and private utilities.

75) *http://carbonn.org/*

Civil society has a critical role in ensuring citizen engagement, providing guidance to decision makers and supporting innovative initiatives.

Across all scenarios, civil society organisations have a similar role to play, in engaging with policy makers, communities, the private sector and international research and best practice. This can be summarised as:

- ensuring marginalised groups are represented in governance processes and shaping agendas and informed;
- providing guidance, either through their research or knowledge sharing, to decision makers and to communities on energy and climate issues; and
- supporting the implementation of innovative energy initiatives and championing successful examples.

5.2 Recommendations for decision makers

Key recommendations for public institutions:

Sub-national governments:

- Undertake a diagnostic analysis to assess the cities' current position and address gaps and opportunities for development.
- Develop a clear view of priorities, for example through an energy and climate change strategy development process which outlines a coherent approach to project identification, development and delivery. This process should be and based on the diagnostic assessment.
- Lead the way in setting city-level ambitions, commitments and targets on climate change which can contribute to national and international objectives.
- Review cities' own operations and assets for opportunities to make progress on energy and climate change goals.
- Use cities' convening power to create partnerships between stakeholders (including private sector) to deliver climate and energy objectives.
- Adapt regulations on national building codes to the regional and municipal climate realities and also enforce locally.

National governments:

- Integrate energy action planning into national urbanisation strategies.
- Put in place a regulatory framework to allow cities to meet their energy needs autonomously, including liberalisation of energy markets to allow local and community power utilities or power producers.
- Support the decentralisation of finance and revenue-raising mandate/powers and responsibilities.
- Enabling more finance, particularly from international funds, to cities.
- Hold cities partially accountable for the implementation and achievement of national and international climate and energy objectives and commitments.
- Explore and encourage strategic public-private partnerships.

Key recommendations for the international donor community:

- Support knowledge management, for example by supporting local academic institutions to develop research programmes relevant to city decision maker needs and establishing city data observatories to equip city decision makers with the data they require.
- Support municipalities in developing capacities, particularly with senior leadership teams, as a critical step to support city action. Particularly secondary cities might require additional support to enable action.
- Target action at a wide range of stakeholders involved in urban development, for example public sector land holders, housing finance institutions and infrastructure or real estate developers as well as civil society organisations.
- Assist in enhancing the enabling environment and market readiness for city-focused energy and climate solutions, in cooperation with national and municipal institutions. Packages of support could cover the legal framework and regulatory reforms required to support change, such as reviewing financing mechanisms, climate finance readiness, incentive structures and subsidies.
- Create project preparation facilities to support the creation of bankable projects at sub-national governmental level, including M&E requirements post award.
- Strengthen municipal finances for energy and climate action, for example through:
  - use of city-level multi-sector finance windows to enable transformational programmes;
  - improving creditworthiness;
  - additional revenue raising fiscal measures, fees and charges; and
  - land-based financing as a mechanism to support infrastructure costs.

Key recommendations for the private sector:

- Engage with local government and local city partnerships to provide technical expertise and advice in decision-making as well as seek guidance on how the private and public sector can work together to enable climate action locally.
- Enter into dialogue with national and local government to shape policies and regulation, with the aim of de-risking private investment.
- Support delivery of and develop technical capabilities for a resource management model based around the water-energy-food nexus.

For private/public utilities:

- Explore opportunities for the provision of decentralised networks.
- Align investment in distribution networks with government planned urban development and transport investment.

Key recommendations for civil society:

- Engage with and ensure representation of marginalised groups, which public bodies may find hard to reach and engage.
- Where possible, bring technical and scientific capacity to assist in analysing local needs, and provide skills development and training to municipalities.
- Work with informal communities to deliver new solutions, such as decentralised energy, which support livelihoods.

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Appendix – Drivers for change

Category	ID No.	Key driver of change	Description
Governance	**1**	Local government autonomy and vertical coordination	The autonomy of municipal governments in designing, financing and implementing policies and interventions and the coordination between local and regional/national governments involved in the delivery chain of a service or programme. This includes scope of political mandate and powers over budgets and revenue-raising powers.
	2	Transparency and accountability	Transparency prevents corruption and the abuse of power by government officials and organisations by allowing public scrutiny of governance. Accountability refers to the ability of citizens to ensure policy makers and governments are held to account for their decisions (for example through democratic systems).
	3	Government and role of private sector	The performance and operations of the private sector are dependent on the regulatory and legislative environment. This is particularly relevant in partnerships between the private and public sector.
	4	Government and role of civil society	The ability of citizens and communities to engage with governments. The role of community based action can be important in service delivery and influencing policy.
	5	Smart governance	The use and management of technology and information to design and implement policies and solutions. For example, using technology to gather data on traffic patterns and resource use which can then inform the design/selection of policies and projects, or the use of technology to engage citizens in policymaking.
	6	Urban planning policy environment	The purpose of urban planning systems and policies and the integration of planning across multiple sectors (e.g. land use, infrastructure, and transport).
	7	Implementation capacity	The resources available to sub-national governments to design and implement policies and projects and enforce/deliver decisions. Capacity refers principally to human resources but also access to financial resources – however this latter point is dependent on 1 – Decentralisation of Power and 23 – International Financial Flows.

	8	City to city cooperation	Cooperation of municipalities across metropolitan agglomerations and regions, within nations and internationally.
	9	Land tenure rights	The system by which legal ownership and access to land is determined and enforced.
	10	Climate change mitigation and adaptation policies	International, national and local policies relating to carbon emissions and climate change.
	11	Energy policy	Structuring and regulation of energy markets including municipal policies relating to energy production, distribution and consumption.
Economy	**12**	Energy demand	Energy demand, driven by households and industry. Relates to the energy intensity of the economy (how many units of energy required per unit of GDP).
	13	Income growth and distribution	The effects of increasing personal or household incomes will likely depend on the distribution of income growth, for example the extent of income inequality or the expansion of the middle class.
	14	Economic diversification	Economic output and employment distributed across a range of sectors. These include: resource extraction; agriculture; industrialisation; and the service sector.
	15	Rate of economic growth	How fast economies grow throughout the period up to 2050
	16	International financial and trade flows	Private investment and aid funding to Africa, as well as national or regional capital markets, and openness to international markets in goods and services
	17	Unemployment and informal employment	Prevalence of informal employment, unemployment and underemployment amongst urban population, particularly regarding long-term and structural unemployment.

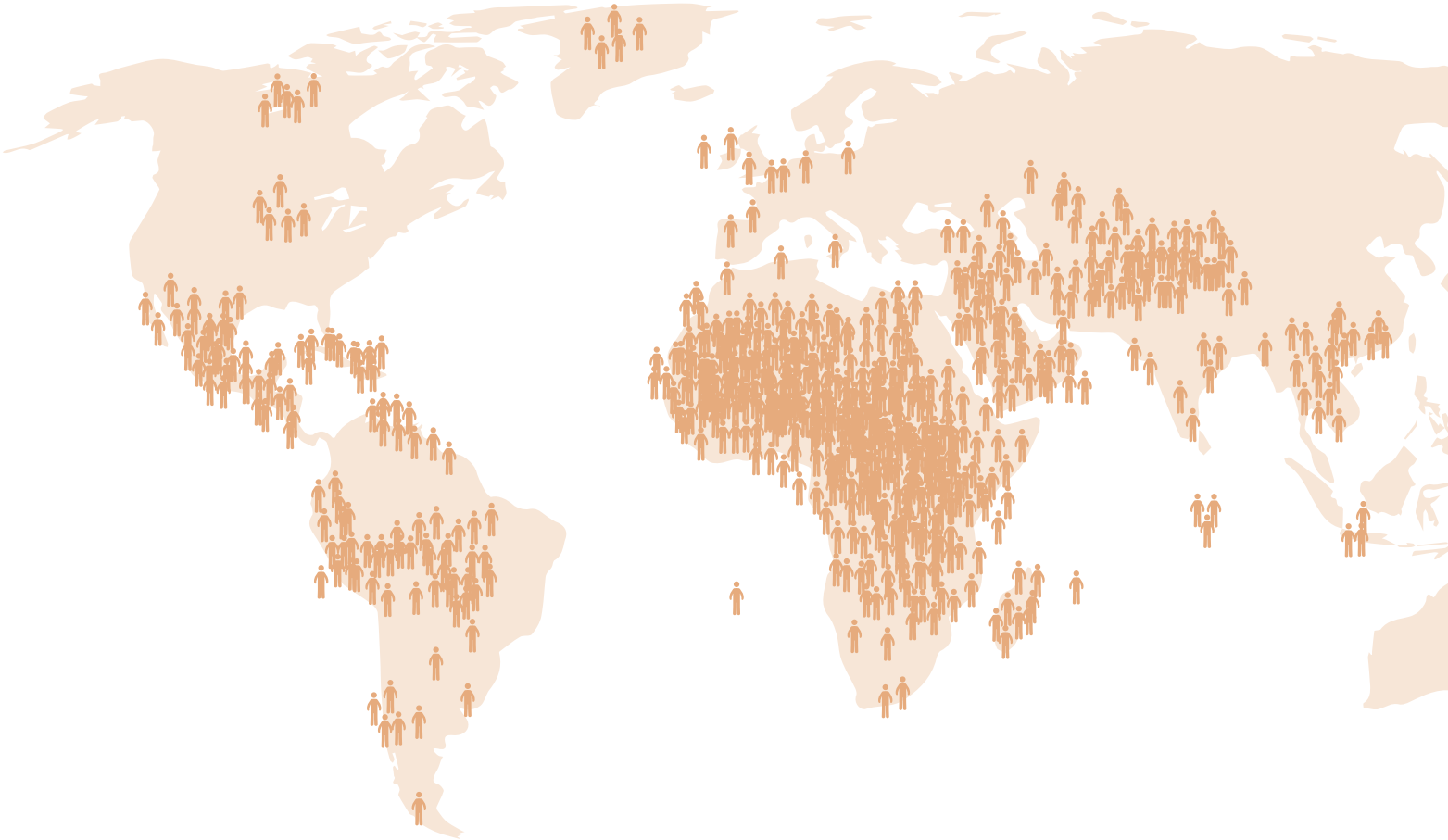
Society	**18**	Poverty	Multidimensional poverty, including income, health, education and living standards
	19	Social inclusion	Refers to instances of exclusion or marginalisation in urban areas arising from tension between groups, particularly those defined by ethnicity, religion or nationality.
	20	Gender equality	Equal economic, political and social status of women and men
	21	Urban population growth dynamics	Natural population growth in urban areas (i.e. excluding migration) and the dynamics of growth in terms of the age profile of the population (particularly the high proportion of people of working age).
	22	Rural-urban migration	Movement of individuals from rural areas to the cities, including circular migration
	23	Education	The educational attainment of the population
	24	Other social factors (disease, political instability)	Other social factors here includes endemic or epidemic diseases, political instability, terrorism and violence. These can all be affected by climate change and have a wide range of indirect impacts.
Infrastructure	**25**	Urban transport	The modal share of public transport and its connectivity and affordability, the modal share of cars and motorcycles and modal shares of non-motorised transport (walking and cycling) and their role in the urban transport system (for example if limited to the urban poor).
	26	New buildings and energy efficiency	Energy efficiency of newly constructed buildings in African cities.
	27	Retrofitting existing buildings	Energy efficient building regulations, and supporting systems of enforcement, materials supply chains and energy and water efficient appliances.

	28	Telecommunications infrastructure	Mobile network provision, including data access and wireless internet, and provision of broadband and fixed telephone line infrastructure.
	29	Water and sanitation infrastructure	Extent of water and sanitation infrastructure provision and accessibility, as well as quality of water and sanitation infrastructure.
	30	Transmission and distribution losses	Loss of energy from distribution infrastructure. This can be due to technical limitations, human disruption or infrastructure damage
	31	Demand management	Policies and infrastructure interventions which manage demand of resources, particularly water and energy
	32	Intercity transport	Includes ports, air transport, intercity and international road network and passenger and freight rail.
	33	Large scale renewable energy generation	Share of renewable energy generation in national, large-scale energy production
	34	Large scale fossil fuel energy generation	Share of large scale energy production based on fossil fuels (oil, gas, coal) in energy production
	35	Electrical access	Extent and accessibility of power infrastructure, whether on/off grid
	36	Decentralised energy	Localised energy production, transmission and consumption. This could refer to a range of scales, such as local generation and transmission networks (mini or micro grids) or household-scale solar technology.
	37	Small scale solar PV technology	Flooding either due to rainfall volatility or sea level rise, largely resulting from climate change

	38	Small scale solar thermal technology	Use of small scale, decentralised solar thermal technology for energy generation, as well as cooking/heating technology integrating solar thermal
	39	Access to energy for cooking and heating	Fuel and cook stove use for cooking and heating for example biomass stoves.
	40	Urban sprawl	Low density andw often ineffectively planned urban development
	41	Waste treatment	Urban waste production requires treatment, with potential for decentralised waste/wastewater treatment and implementation of the 'waste hierarchy': minimisation; reuse; recycling; energy recovery and disposal.
	42	Informal settlement	Informal settlement in cities, relates to availability of affordable land/housing in urban areas
Technology	43	Digitalisation	Access and sharing of information online through digital media and new business models and reduced costs for businesses resulting from adoption of mobile/digital technology. Related to 'big data' generation, with potential implications for energy, transport and water infrastructure in particular.
	44	Electric/alternative fuel vehicles	Proportion of private vehicles which use electric motors or hydrogen rather than fossil fuel-based ICEs.
	45	Motor vehicle energy efficiency	Energy efficiency of vehicles, particularly conventional ICE-based vehicles.
	46	Power storage	Technological development and adoption of batteries as part of electrical infrastructure, for households (for example linked to rooftop solar power generation) and in electric or alternative fuel vehicles.

	47	Creation and adoption of technological innovation	Ability of society to innovate and adopt innovation from elsewhere, in terms of production technology, energy efficient technologies and others. This refers to the general case, rather than the specific examples under other key factors (for example power storage, electric vehicles).
Environment and natural resources	**48**	Drought and desertification	Either events or permanent condition of aridity and water stress, including land degradation, loss of water resources and flora/fauna.
	49	Temperature increase	Average temperature increase resulting from climate change
	50	Flooding	Flooding either due to rainfall volatility or sea level rise, largely resulting from climate change
	51	Food supply systems	Ability to import food into cities , either from the agricultural hinterland, internationally or from fisheries, as well as potential for urban agriculture.
	52	Water resources	Sustainable access to water resources and addressing water pollution arising from urban activity
	53	Air quality	Pollution of air arising from urban activity
	54	Deforestation	Removal of forest for conversion of land use (for example to agriculture, urban).
	55	Biodiversity and ecology	Effects of environmental degradation and climate change on ecological systems
	56	Water-energy -food nexus	Multiple relationships between energy, water, food and land represent opportunities for improved natural resource management.

What will Africa look like in 2050?



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