DESIGNING THE AFRICAN ENERGY TRANSITION

An approach for social and economic transformation in a climate compatible manner

2020 - 2025

AFRICAN UNION

AFREC ENERGY

Agend A 2063 The Africa we Want

October 2019

AFRICAN UNION

AFREC ENERGY

2020 - 2025

DESIGNING THE AFRICAN ENERGY TRANSITION

To order copies of this report, please contact:
African Energy Commission (AFREC)
02 Rue Chenoua, BP791, Hydra, 16035
Algiers, Algeria

Tel: +213 23 45 91 98
Fax: +213 23 45 92 00
Web: www.afrec.au.int
E-mail: afrec@africa-union.org

African Union AFREC
@AUAFREC
African Union AFREC
African Union AFREC

Department of Infrastructure and Energy
African Union
Algiers, Algeria

First printing October 2019

Tittle: Designing the African Energy Transition: An approach for social and economic transformation in a climate compatible manner
Language: English
Available languages: English and French

The designations used and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the African Energy Commission for the African Union Commission concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process.

Photo credits: Cover page: Douw de Jager/Shutterstock; p.5: Asian Development Bank; p.12 Jose Navarro and Ilyas A Abukar; p 20 Photographer unknown no attribution required (CC0 Public Domain); p.23 cogdogblog; p.24 UN Environment; p.28 Photographer unknown no attribution required (CC0 Public Domain); p.29 Photographer unknown no attribution required (CC0 Public Domain); p.30 Turtlewong; p.30 Joshua Doubek; p.33 Albert Gonzalez Farran, UNAMID.

Photos used under creative commons Attribution-Non Commercial 2.0 licensing: https:// creativecommons.org/licenses/by-nc/2.0/ except cover photo (Shutterstock licensed).

Table of Contents

Figures and Tables

Acronyms

AFRETRAP	Africa Energy Transition Program
AfDB	Africa Development Bank
AFREC	Africa Energy Commission
BP	British Petroleum
CESISE	Center of Excellence in Social Innovation for Sustainable Energy
DDP	Deep Decarbonization Pathways initiative
EV	Electric Vehicle
GHG	Greenhouse Gas
IDDRI	Institut du Développement Durable et des Relations Internationales
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
MSE	Medium and Small-scale enterprises
NDC	Nationally Determined Contribution
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
R&D	Research and Development
RE	Renewable Energy
SDG	Sustainable Development Goals
TFC	Total Final Energy Consumption
TOE	Tons oil equivalent
UNCTAD	United Nations Conference on Trade and Development
UNDESA	United Nations Department of Economic and Social Affaires
UNECA	United Nations Economic Commission for Africa

About the African Energy Commission (AFREC)

AFREC is a specialized agency of the African Union (AU), under the Commission for Infrastructure and Energy that is in charge of coordinating, harmonizing, protecting, conserving, ensuring rational exploitation, commercializing and integrating energy resources on the African continent.

AFREC was created by African Heads of States and Governments' decision of the 37th Summit of the Organization of African Unity (OAU) in 2001 in Lusaka, Zambia and was launched by the African Union Ministers in charge of energy in 2008 in Algiers, Algeria. AFREC's mandates include the following among other energy related issues as stated on the AFREC convention: (1) Developing policies, strategies, research and plans based on Member states, sub-regional, regional and continental development priorities and recommend their implementation; (2) Designing, creating and updating an energy continental database and facilitate the rapid dissemination of information and exchange of information among Member States, sub-regional, regional and continental institutions; (3)Providing technical support, mobilize financial and technical support, while providing capacity building to the Member States, sub-regional, regional and continental institutions in the energy sector.

In order to fulfil these mandates, AFREC developed a new strategy that was approved by the Specialized Technical Committee (STC) on Transport, Transcontinental and Interregional Infrastructure, Energy and Tourism (STC-TTIIET) held in Cairo, Egypt in April 2019. The new strategy is based on the following pillars:

African Energy Information System (AEIS): aims to carry out a holistic improvement plan to African Energy Information System (AEIS) that will create a more integrated and comprehensive system while increasing the energy data quality and expanding AEIS to provide more information and indicators for African countries.

Bioenergy program: aims to improve monitoring, reporting and the sustainability of the bioenergy resources in African countries with higher bioenergy production and consumption.

African energy efficiency program: aims to transform the African energy market to higher efficiency lighting and electrical appliances with a strategic integrated energy policy approach at the continental level to significantly reduce final energy demand on the continent and to provide increased electricity access, competitiveness, energy security and economic development.

Oil and gas program: aims to create the African domestic crude oil and petroleum products market by developing the required policies, strategies and promote expansion of refinery production capacity in Africa and associated infrastructure.

African energy transition program: aims to provide a clear understanding of trans-formations of the energy system needed in the short, medium and long term to achieve the

energy transition by identifying frameworks to support the development of sectoral and technological detailed, policy-relevant and country-driven strategies consistent with the national development agenda and the Paris Agreement goal.

Acknowledgements

This document has been commissioned by the African Energy Commission (AFREC) in order to design a dedicated program supporting the transition of the African energy sector based on the aspirations of the African countries and more precisely on the African countries committed shared development pathway Agenda 2063, the United Nations' 2030 Agenda for Sustainable Development, and the Paris Agreement on Climate Change. The work was carried out by Dr Smail Khennas Senior Energy and Climate Change Expert, and Prof. Youba Sokona Senior Advisor for Sustainable Development at South Centre, with the support of Mr Rajesh Eralil Research Assistant at South Centre.

An expert meeting was held in Algiers, Algeria on 08 – 11 July 2019 at the headquarters of AFREC to peer-review the draft "Designing African energy transition: an approach for social and economic transformation". It brought together key experts on energy and development, and climate change, in Africa. The participants were: Mr Rashid Ali Abdallah, Executive Director of AFREC; Ms Walaa Ahmed, AUYVC-Energy Policy Researcher, AFREC; Prof. Lawrence Agbemabiese, Research Associate Professor at the Biden School of Public Policy and Administration, Centre for Energy and Environmental Policy, University of Delaware, United States of America; Prof Chukwumerije Okereke, Professor in Environment and Development, University of Reading, United Kingdom; Mr Abdoulaye Oueddo, Energy Expert, AFREC; Dr Henri Waisman, Climate Program – Lead Coordinator of Deep Decarbonization Pathways, Institut du développement durable et des relations, internationals, Paris, France; Prof. Harald Winkler, Energy Research Centre, University of Cape Town, South Africa. Mr Niclas Hällström, What Next, and Prof. Yacob Mulugetta, University College London, could not participate to the meeting, however both provided written comments and suggestions to the draft document. The meeting also benefited from comments and suggestions from energy experts from the ministry of energy of Algeria: Ms Ait-Said Dalila, Ms Chehat Djaouida, Mr Si Chaib Farid, Mr Medjelled Miloud, and Ms Dormane Naziha.

Disclaimer

Foreword from the Commissioner of Infrastructure and Energy

The Africa Energy Transition Programme is the vision of the African Energy Commission (AFREC) for the energy development in Africa, driven by AU Agenda 2063, Sustainable Development Goals (SDGs) and Paris Agreement on climate change. Access to affordable clean energy for productive uses and households in Africa can be achieved mainly by introducing and implementing comprehensive policy tools that can transform the African Energy Sector to mostly be based on renewable resources through an integrated approach that facilitates the transformation process and attracts the required investment.

AFREC has taken the initiative to develop the Africa Energy Transition Programme to be the main umbrella under which different policies and programmes fall. This Programme aims to fully mobilize Africa's own energy resources and potentials; bringing energy to the top of national and regional agendas; and taking approaches that put Africa directly on to innovative, low carbon energy development pathways, avoiding the fossil fuel lock-in now facing most industrialized and emerging economies.

I am calling on African policy makers, continental leaders, national and international organizations, private and public sectors, experts and development agencies to join hands and partner with AFREC to facilitate the African Energy Transition through different means to build the Africa we want.

Amani Abou-Zeid
Commissioner of Infrastructure and Energy

Foreword from the Executive Director of AFREC

Energy for development is the main agenda and vision of the African Energy Commission (AFREC) for a major Africa-wide energy sector strategy aimed at accelerating the transition of the continent's energy systems to foster meaningful economic well-being, wealth creation, poverty eradication and inequality reduction, in order to realise Africa's development aspiration in a manner that is sustainable and climate compatible.

Africa is rich when it comes to energy resources, both renewables and non-renewables, that can meet the needs of the continent as well as be exported to generate revenues to support Africa's economy. However, the energy sector faces many obstacles, such as inadequate policies, lack of finance, technology, local technical expertise and properly integrated infrastructure within and among countries. Moreover, there is still a huge reliance on fossil fuels as well as traditional and non-efficient biomass that has a direct impact on health and environment, bearing in mind the rapid population growth and demographic changes.

In order to tackle all the challenges faced in the energy sector, we need to adopt our own African solutions driven by inspiring leadership and committed ownership to accommodate the different needs, the cultural barriers and the deviation among regions when it comes to resources, infrastructure, economy and technical capacity.

The African Energy Transition Programme represents AFREC's vision on Energy development in a sustainable manner in alignment with the AU agenda 2063, the UN agenda 2030 for sustainable development goals and the Paris agreement.

For this programme to be implemented successfully, decisions makers should prioritize the issue of energy development in their national agenda. Skilled personnel and specialised institutions are all needed to lead the energy transition process.

This document represents the guiding principles for AFREC to launch and implement its continental programme on Energy Transition that will cover all African member states in phases. AFREC will work closely with different regional research institutes, experts and decision makers and International partners to coordinate the implementation of this programme in order to achieve its main objectives of transforming and developing the energy sector in a way that meets the aspiration of the African people in an environmentally and climate compatible manner.

Rashid Ali AbdAllah
Executive Director

Executive Summary

Energy for development – this is Africa's energy vision. Achieving the vision requires rapid energy transition in the continent to foster meaningful development, poverty eradication, and inequality reduction in a sustainable, climate compatible manner. The Africa Energy Transition Program (AFRETRAP) to be developed under the auspices of the African Energy Commission is an important step in that transformation.

Africa's development aspirations are contingent on making this transition possible. Modern, secure and affordable energy is a crucial input for mitigating poverty, securing prosperous rural livelihoods, building vibrant industries to diversify national economies, and connecting the continent through trade and cooperation. Primarily, Africa has abundant renewable energy sources with potential to cater to all energy needs, but also natural gas reserves that for a period may facilitate the rapid energy transition to renewables while limiting greenhouse gas emissions. The direction of the transition is well spelled out in the major sustainable development commitments that African Governments have signed on to, notably Africa Agenda 2063, the UN 2030 Agenda and Sustainable Development Goals and the Paris Agreement on Climate Change. Governments have also shown their commitment to sustainable low-carbon energy transitions in their national development plans and strategies.

There are of course many challenges to overcome in achieving the energy transition for Africa. These include affordable access to modern energy services, persistent reliance on traditional biomass energy sources; heavy reliance on fossil fuels; poor infrastructure and low rates of electrification; major technical and institutional capacity constraints; inadequate systems and infrastructure for regional energy cooperation; rapid population growth and urbanization; and weaknesses in energy governance. In addition, there are constraints in access to the substantial financial resources and investment security needed – particularly for the broad set of new and much more diversified set of owners that will need to shape the new renewable and more distributed energy systems in the making. Farmers, cooperatives, SMEs, municipalities and other both public and private entities will be active participants and actors in Africa's energy futures.

Successful energy transitions will depend on African leadership and ownership of the process. This will mean fully mobilizing Africa's own energy resources and potentials; bringing energy to the top of national and regional agendas; and taking approaches that put Africa directly on to innovative, low-carbon energy development pathways, avoiding the fossil fuel lock-in dangers now facing most industrialized and emerging economies.

The way forward for an African energy transformation can be defined around seven strategic objectives. These objectives are:

» Building the **energy infrastructure for economic and social development**, starting with agriculture, which employs the largest share of the population but remains at a near-subsistence level of production in most parts of the continent;

» Development of the **renewable energy sector** in alignment with the Paris Agreement, to exploit Africa's great potential for solar, wind, hydropower and other renewable sources, and build African capacity for developing these technologies;

» **Energy efficiency programs** for buildings, industry and transport. Such a program should include local manufacturing of efficient equipment, as well as regulatory and behavioural interventions;

» Careful consideration of the possible role of **national, regional and inter-continental gas pipelines**, where this can be justified from a long-term climate and economic perspective, with recognition of risks of stranded assets and the global need to rapidly move away from fossil fuels;

» Development of an **integrated African electricity network**, which would greatly decrease average electricity costs across the continent and increase energy sustainability and security;

» Decarbonisation of the energy and other sectors, to put countries firmly on a **low- to zero-carbon energy trajectory** as well as fulfil national commitments under the Paris Agreement;

» Implementation of a systematic, continent-wide approach to **innovation** to harness the research and development capacities required to meet all the above objectives.

The Africa Energy Transition Program (AFRETRAP), to be implemented under the auspices of the African Energy Commission, aims to help African countries and regions achieve these objectives. The first 3-4-year phase of the AFRETRAP will focus on:

» Supporting the development of African **human and institutional capacity** to design and steer energy transitions;

» **Sensitizing and mobilizing decision makers** around the need for investment in energy transition;

» Building a **community of practice** for knowledge sharing and mutual learning across countries in Africa.

The program will take a learning-by-doing approach, whereby small teams of selected experts from each of Africa's five regions, working closely with regional research institutions and external experts, will develop roadmaps for regional transitions. The regional roadmaps will form the foundation for the development of concrete national energy transition plans for one or two pilot countries per region.

Appropriate methodologies for country analysis, modelling and mapping will be reviewed, particularly the Deep Decarbonisation Pathways initiative currently active in around 40 countries throughout the world where local researchers and stakeholders have developed their own decarbonisation pathways, with the use of the Long-Term Energy Alternatives Planning model (LEAP). The African-driven and owned AFRETRAP will engage with African energy experts and scholars to develop distinct pathways to be interrogated and further refined through cross-cutting engagement across the African continent.

DESIGNING THE AFRICAN ENERGY TRANSITION

An approach for social and economic transformation in a climate compatible manner

This paper sets out a vision and the approach for a major Africa-wide energy sector strategy aimed at accelerating the transition of the continent's energy systems to foster meaningful economic well-being, wealth creation, poverty eradication and inequality reduction in order to realise Africa's development aspiration in a manner that is sustainable and climate compatible. It also identifies the actions needed to spur a regional energy transformation, consistent with African and global ambitions for a sustainable and prosperous future for all. The paper concludes with a proposal for designing a program – the Africa Energy Transition Program (AFRETRAP) – to undertake analytical work, research, and development of capacity and partnerships needed to implement the vision.

.

1. Energy for development: Realising Africa's energy vision

Energy is a fundamental prerequisite for development and a key requirement for the wellbeing of human society. Energy has been a primary driver of economic growth, wealth creation, and poverty eradication throughout much of the world, but Africa has been largely left behind.

Africa's energy vision is as follows: By 2063, Africa's energy systems will largely be based on renewable energy resources coupled with a strong and to a considerable extent localized manufacturing sector, highly qualified human resources and an integrated energy infrastructure for both centralized (electricity grid, hydrogen systems etc.) and decentralized energy systems (mini- and smart grids, distributed power etc.). The ultimate objective is universal access to affordable modern and clean energy services. There will be energy convergence not only between and within countries and regions, but also between urban and rural areas particularly in sub-Saharan Africa. Likewise, at a global level, there will be a convergence towards sufficiency and responsible well-being where Africa overall increases its energy use, while today's wealthy countries reduce theirs.

Agend A 2063
The Africa we Want

In achieving this vision, the huge potential of Africa's renewable sources of energy must play a central role. Indeed, while industrialized and emerging economies face the challenge of transforming their existing energy infrastructure, African countries have the opportunity to adopt cleaner, flexible, more efficient and adaptable energy systems from the start. Transition to a different mix of energy sources, as clearly articulated by Vaclav Smil (2017), is unavoidable, but such a transition will require important changes and a long period of time (several decades). Smil argues that the energy transition is inherently a complex and very lengthy process encompassing technological, economic, social, cultural, and political challenges. It is therefore advisable that the African nations jumpstart zero to low-carbon energy systems to avoid highly costly and complex searches for the energy transition in the future. It is important to recognise that African populations and their decision-makers do not have the luxury of time. Planning of African urban areas with growing populations and high levels of informality is a major challenge. Indeed, urban concentrations determine many energy needs, for a very long time. It is therefore imperative for policy makers to rapidly move away from business as usual models and design new models to address this challenge.

Africa has abundant, diverse but largely unexploited renewable energy potential (geothermal, biomass, marine, solar and wind) but also non-renewable energy sources that may be considered during the transition for boosting development and improving the livelihoods of the bulk of the continent's population. Major policy shifts in the energy sector – and in other related sectors — are needed to provide reliable, affordable, safe and modern energy services to meet Africa's development needs.

In 2013, at their 50th Anniversary Solemn Declaration, the African Heads of State and Government agreed to a paradigm shift of the continent's development agenda by adhering to a guiding vision "to build an integrated, prosperous and peaceful Africa, driven and managed by its own citizens and representing a dynamic force in the international arena". This vision translated into an agenda for the next fifty years, known as Agenda 2063. Through Agenda 2063, African countries have committed to a shared development pathway. This is an immense undertaking: Africa is in both land area and population the second largest continent, with close to 200 borders that demarcate fifty-five countries. There is great diversity in terms of physical geography, economic conditions, political situations and social structures. However, the geopolitical frontiers seldom reflect actual demarcations in cultural or ecological features. A persistent failure to grasp the broad picture has so far prevented the African nation-state from achieving coherent development aspirations in the region. The continent's fragmentation has obscured the extraordinary potential that trade expansion within the continent, infrastructural interconnection and a greater economic integration could unlock. And when it comes to energy, the potential is indeed immense.

The United Nations 2030 Agenda for Sustainable Development, adopted by the world's leaders in 2015, provides a remarkable common global vision aligned with African aspirations. All its 17 Sustainable Development Goals (SDGs) are closely linked to the 12 goals defined in Agenda 2063. Agenda 2063 and the SDGs, along with the Paris Agreement on Climate Change, provide clear guidance on the direction for the future of Africa's energy systems. However, the transformation must be driven by African countries themselves, working together towards this common vision.

Meaningful development in Africa will remain an illusion as long as energy systems are unable to support even the most basic survival requirements, with the current energy consumption of the entire 1 billion people in Africa amounting to less than that of 20 million residents of the State of New York. With changes in demography, urbanization patterns and a rising need for energy services, policy makers and leaders will need to be bold, imaginative and clearheaded to chart out a new paradigm for transformation. Above all else, leaders will need to have the knowledge to set the agenda and the courage to follow through with their convictions.

The uncritical transfer and absorption of ideas and models from Europe and North America needs to give way so that the questions that Africans ask about their energy challenges (and the solutions to these questions) are internally generated, debated and acted upon. This requires investment in knowledge systems and institutions that enable African analysts, scientists, social scientists and stakeholders in communities, civil society and the private sector to understand, replicate, and organize knowledge within their own socio-cultural context. Unfortunately, the continent continues to suffer a serious leadership deficit in the area of energy development. The tendency is to let development partners set the agenda and control the outcome, instead of working in a genuine partnership with them. Because of this, many of the so-called innovations on energy such as pay-as-you-go (PAYG), feed-in tariffs or Public Private Partnerships are not home-grown, but transferred from elsewhere or controlled by non-Africans. Solutions must be refined, modified, adjusted and applied to the reality of Africa to bring lasting and appropriate transformative change across the continent.

The overall approach hence needs to change. African leaders need to spearhead a more radical vision of modernity and formulate an endogenous, African based notion of "development". This needs to be rooted in 'locally' conceived interpretation of modernity that is grounded in the everyday life experiences of its people. This means transforming the relationship between society and technology where ordinary citizens participate as practitioners and innovators to shape the future in accordance to their reality and in line with their aspirations. This leads to a healthy societal dynamic and paves the way for self-transformation where all individuals contribute to the collective project of development in harmony with nature.

2. The current energy picture: constraints and challenges

It is well documented that Africa is endowed with sufficient energy resources and potentials to meet the needs of the whole continent and to generate significant revenues from exports. At the same time the continent faces a number of challenges and obstacles to achieving its energy vision.

2.1 Persistent reliance on low-quality traditional energy sources

Most sub-Saharan countries still rely heavily on traditional and non-efficient biomass to meet domestic needs and some productive activities. Africa is the only continent which has been experiencing a growth of firewood and charcoal consumption (see Figure 1).

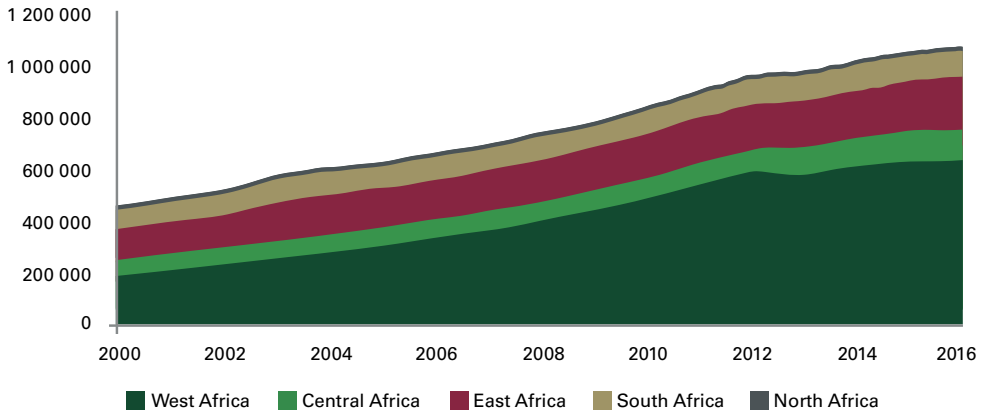

Figure 1: Africa's firewood production by region 2000-2016 in kt
Source: AFREC, 2018 key energy statistics

Firewood and charcoal are widely used for cooking, with widespread use of inefficient stoves and other cooking devices. As a result, many households in sub-Saharan Africa are plagued by smoke from unsafe biomass burning. Poor combustion causes indoor pollution with serious health consequences, especially for women and children who are more exposed to smoke from cooking devices. Children constitute a particularly vulnerable group because their immune systems are ill-equipped to deal with exposure to particulate matter, carbon monoxide and other pollutants emitted by biomass burning. In addition to causing serious health challenges, the 2017 IEA Energy Access Outlook noted that over 0.5 million people in sub-Saharan Africa have prematurely died (higher than malaria) due to biomass combustion during cooking. Firewood harvesting, charcoal production and biomass burning, all of which require significant human labour at the cost of health, are also responsible for greenhouse gas (GHG) emissions, in particular short-lived climate pollutants such as black carbon, and a range of adverse impacts on health and local ecosystems. Deforestation, land degradation and desertification are some of the increasingly visible impacts of unsustainable energy production from biomass in rural Africa.

Harmful energy production and consumption patterns are not confined to the continent's rural areas. Many city dwellers, especially in sub-Saharan Africa, share similar cooking habits and practices as the rural areas, albeit a wider range of fuels are used. Many greenbelt projects

undertaken around the cities in the Sahel have faced major challenges linked to unsustainable and uncontrolled firewood harvesting. It would be inaccurate, however, to claim that household practices are only shaped by a predominant preference for traditional energy. Other factors, such as availability, accessibility and affordability of alternatives, determine the energy choices made at the household level. In sub-Saharan Africa — a region which has the highest incidence of extreme poverty — embracing new technologies and increasing energy consumption have a hefty price, which the overwhelming majority of households cannot afford.

Charcoal commercialization in Ghana and woman cooking in Mogadishu.

2.2 Obstacles to expansion of modern energy production and distribution

Africa relies today heavily on fossil fuels (oil, natural gas, coal) for its electricity generation and domestic energy consumption. Yet, of the hundreds of trillions of cubic feet of proven conventional natural gas resources in sub-Sahara, Africa has only exploited approximately 1%. At the global level, Africa's production of natural gas in 2017 accounts for only 6.1% of total production, of which 53% is exported outside the continent (BP, 2018). The remaining is mainly used for electricity production and to a lesser extent to meet cooking needs, particularly in North Africa. Aside from electricity generation, the use of natural gas for the development of the agricultural sector, infrastructure, chemical industries or residential use is marginal in sub-Saharan Africa.

While being the least polluting fossil fuel, the strategic use of natural gas for economic development has hence been limited on the continent. It may thus be tempting for many African countries to plan for continued or even expanded extraction of natural gas and other fossil fuels for revenue generation. Many African countries are indeed today already heavily dependent on fossil fuel reserves for foreign exchange. Revenues, particularly from oil and natural gas, exceed 90% of total export earnings in some countries.

Continued reliance on fossil fuels however poses significant vulnerabilities for these countries and the continent as a whole, particularly in light of rapid decarbonisation of first the electricity sector and in the longer term all sectors of society.

At current rates of extraction, fossil fuels, particularly oil, may be depleted in a few decades in many countries, and with the escalating climate crisis and a rapidly shrinking carbon budget there will be no room for fossil fuel extraction or emissions at all within just a few decades. Africa hence faces major challenges as well as opportunities to design and plan for a continuously changing energy mix towards renewable energy sources that will provide for energy resource sustainability, and that can provide the foundation for strong and sustainable economies. Hence Africa definitely needs a new model.

This new energy model does not only need to overcome the current dependence on fossil fuels, but must also overcome the prevalent focus on centralized, large-scale and one-directional energy systems. The current electrification systems in Africa have been largely shaped by the traditional centralized power grid model, comprising generation, transmission and distribution.

Africa, and in particular sub-Saharan Africa, has the world's lowest electrification rate, with an average access rate of 40% and only a few countries above 50%. Large parts of rural and peri-urban Africa remain non-electrified, and current generation capacity is often unable to meet the demand from a rapidly growing population and proliferating micro, small-scale, and medium-size enterprises. The supply-oriented approach characterizing the current electrification system is not equipped to provide options or opportunities for universal electricity access in sub-Saharan Africa for the foreseeable future, if ever, and for several reasons.

Dependence on such a centralized power paradigm leads to the requirement of heavy investments and high operations costs. The shortcomings characterizing such systems cannot be handled by poor economies with limited capacities.

There is also a significant deficit in electricity supply and reliability across the continent and particularly in sub-Saharan Africa, resulting in high production and transaction costs, as well as lack of competitiveness for businesses across the continent. Even when electricity is available, the reliability of services is a major issue, particularly for the productive sectors (see Figure 2). The proportion of firms without access to reliable electricity in sub-Saharan Africa is higher than in any other region. This results in a substantial growth of inefficient and expensive on-site self-generation in industrial, commercial, and even residential sectors.

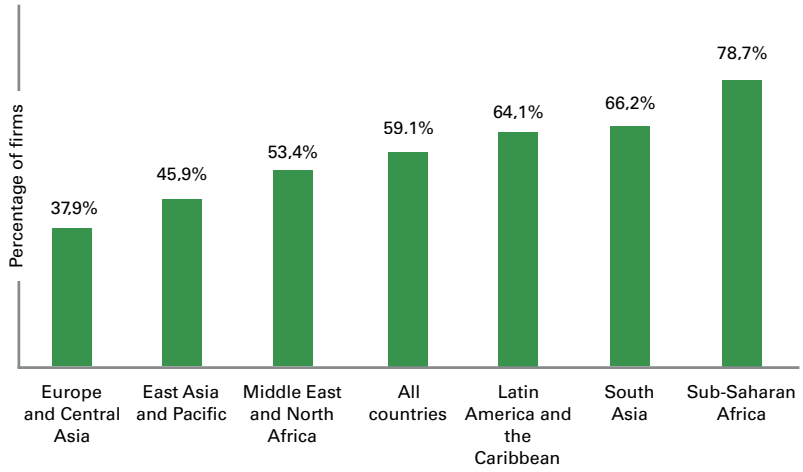

Figure 2: Proportion of firms without access to reliable electricity
Source: AFD, World Bank, Electricity Access in Sub-Saharan Africa Uptake, Reliability, and Complementary Factors for Economic Impact.

Many enterprises resort to backup facilities, mainly diesel generators, thus increasing both costs and greenhouse gas emissions. According to the World Bank, 53.2 % of the businesses

in sub-Saharan Africa own or share a diesel generator, in comparison to 38.2% in Middle East and North Africa and only 17.2% in Europe and Central Asia (AFD and World Bank, 2019).

In areas covered by the current, centralized electricity grid, tariffs are prohibitive for many consumers, creating a vicious circle in which low demand leads to high prices. Average electricity consumption in sub-Saharan Africa does not exceed 23% of the total energy consumption, with rural electrification rates often below 5% and even as low as 1% in some countries. Attempts to increase the use of Liquefied Petroleum Gas (LPG), which is a safer and cleaner alternative to traditional biomass, has largely failed due to lack of affordability for many potential users and various problems related to the inefficiency of the supply chain. Even in fossil-fuel-rich countries such as Nigeria, Gabon or Angola, biomass still accounts for a significant share of the energy consumption. This clearly illustrates the deep infrastructure shortcomings, market failures and ill-equipped energy systems that remain prevalent in sub-Saharan Africa.

2.3 Inequalities between and within countries and regions

Another prevalent challenge is the unevenness in energy production and use. Africa accounts for just 2.9% of the world's primary energy consumption. Within the continent, two countries alone consume more than 63% of the continent's primary energy and four countries account for as much as 88% of the total (see Figure 3).

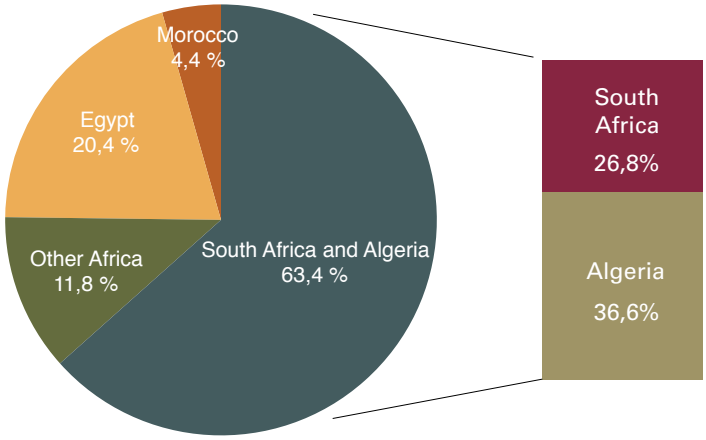

Figure 3: Total primary energy consumption in 2017 (449,5 Mtoe). On average, approximately 40% of the modern energy produced in Africa is used in the Northern sub-region by just six countries. Southern Africa has a similar share, but one country, South Africa, uses over 80% of the sub-region's available energy.

Source: based on BP 2018.

The gross asymmetry in energy use across the continent is in similar ways also the case for the distribution of fossil fuel production, which is concentrated in just 10 countries. Staggeringly, South Africa alone accounts for 96% of the continent's recoverable coal reserves. This skewed distribution both in terms of production and consumption is partly linked to the geographical location of energy sources, but also reflects vastly different conditions of industrial and economic development. In a continent with very limited infrastructure connections, the disparities observed in the energy sector aggravate an already dire situation and further isolate nations with low access to energy.

Africa, and particularly sub-Saharan Africa, is also characterized by high level of inequalities within countries, and above all between urban and rural areas, with huge disparities in access to modern forms of energy and often different energy systems existing side by side.

2.4 Insufficient regional integration

Energy trade within Africa remains marginal, reflecting the low rate of Africa's economic integration and limited exchange of goods and services between African countries. However, there are signs of positive change such as the trend toward power pools in all five African regions. Power pools have contributed to increasing access and improving electricity supply to all sectors as well as a strengthening of Africa's integration, collaboration and exchange of expertise. This trend could be scaled up to interconnect, mainly through electricity interconnection, all African countries and ensure that Africa's energy resources and potentials (renewables and natural gas where applicable during the transition) are primarily benefitting the economy of the continent and its population.

2.5 Capacity constraints

Institutional and administrative capacity remains limited and is a fundamental bottleneck to enabling the required action across all other areas. It is important to understand capacity in non- conventional terms, and recognize that indeed much capacity do exist both in Africa and among Africans living outside of the continent. Africans have huge knowledge and capacity to understand their socio-economic, cultural and ecological contexts. Therefore, capacity must be understood in terms of capacity mobilization – including area-specific local and traditional knowledge – as much as capacity generation. Parallel to capacity mobilization, Africa needs to embark on long-term efforts to foster new generations of practitioners and scholars that are well networked and grounded in dedication to serve their continent for the common good. The energy transition will take time and will require increasing numbers of highly skilled people. This means that any serious program must have a long-term, strategic plan in terms of capacity building and mobilization.

2.6 Rapid population growth and demographic shifts

The African population is growing at an estimated annual rate of 3%. Soaring demographics limit the impact of the sluggish economic growth, particularly since the global economic downturn that began in 2008. Recent estimates are suggesting that, by 2030, Africa may become as populous as China or India, with more than half of the population living in dense urban areas. Land degradation and desertification, exacerbated by the adverse impacts of climate change, are increasingly causing migration from rural to urban areas. In recent years, living standards have deteriorated due to population growth and extreme vulnerability to internal as well as external shocks. This vulnerability is illustrated by the disastrous consequences that spikes in prices on staple food and fuel on international markets invariably have on Africa's poorest nations.

2.7 Commonalities and differences across Africa

The 55 African countries are diverse but share some common characteristics that justify a continent-wide approach to developing an energy transformation strategy. These characteristics include:

- Energy systems across the continent that are still evolving, with currently low emissions intensity and the **potential to avoid a lock-in to carbon-intensive pathways**, rather than later having to decarbonize;
- **For time being a continuing reliance on fossil fuels** as part of the energy mix in order to satisfy Africa's growing energy needs;
- The **predominance of the agricultural sector**, requiring that energy systems and agriculture systems develop in an integrated manner;
- **High rates of urbanization** and population movement, which the development of energy systems must consider;
- The **inability of industrial sectors to fulfil their potential** until current energy challenges are adequately addressed;
- The **role of international cooperation** as a key enabler for regional and/or national transitions given domestic capacity limitations;
- The **uneven quality and availability of relevant data**, which must be considered in defining approaches and methods of analysis.

While the above characteristics apply broadly across Africa, there are also differences between countries based on regions, level of economic development and other factors that suggest the need for developing an understanding of shared characteristics among particular clusters of countries.

Although energy systems in Africa are diverse, some countries or regions share fundamental energy characteristics which justify their grouping into clusters and common approaches. Africa's model of energy production and consumption is characterized by huge disparities across the regions, particularly between North and sub-Saharan Africa. Broadly speaking, inefficient traditional forms of energy, mainly firewood and charcoal, still dominate in most sub-Saharan Africa countries but their share is marginal in North Africa. Furthermore, there is unequal access to modern forms of energy (electricity, natural gas, LPG) between sub-Saharan and Northern Africa. The following clustering of countries is aligned with the Sustainable Energy for All objectives:

Clustering of countries in relation to access to modern forms of energy

A preliminary grouping of countries can be made based on access to modern forms of energy, where for example Northern Africa already has a quasi-universal access to energy. Firewood and charcoal, which account in 2016 for more than 36% of the total primary supply in Africa (AFREC, 2018), will become marginal long before 2063. Detailed modelling over the short, mid, and long-term periods will be carried out to substantiate this transition.

Enabling this transition implies deployment of a large scale of renewable energy in all African countries and a fuel switching strategy in sub-Saharan Africa, particularly in rural areas, from traditional biomass to renewable energy and to an extent LPG and natural gas. Instead of focusing simply on developing oil and gas for export, the focus must be on viable local energy markets with a flourishing of new energy providers, both commercial and public, that will carter to enhanced access and needs of the local productive sectors. Expanding both off and on-grid renewable energy programs while using natural gas as wisely and prudently as possible during the transition are crucial for human well-being and industrial development.

Energy access is a human right, and will need to be attained as fast as possible for the many hundreds of millions of African who currently lack access to energy. Energy as a development imperative, as clearly articulated in the SDGs, combined with the climate crisis calling for rapid transition to renewables calls for ambitious and 'Marshall plan' like public investment approaches into the new, smart, people-centred renewable energy systems of the future.

Such efforts will lift hundreds of millions of people out of poverty (Oxford Institute for Energy Studies, 2019) and also create attractive conditions for domestic as well as international investors.

Clustering of countries in relation to existing use of fossil fuels and decarbonization of the electricity sector

The share of renewable energy, excluding traditional biomass, is still marginal in many countries despite the deployment of a few solar and wind projects, particularly in North Africa and Southern Africa. In some countries, renewable energy accounts for less than 5% of the total primary energy supply despite the sharp decrease of renewable energy costs.

To achieve the continent's energy transition aims, a rapidly increased penetration of renewable energy for all African countries is crucial. A limited number of African countries, particularly in North Africa, rely today on natural gas for electricity generation. In these countries, it will be important to embark on long-term transition plans that gradually phase out fossil fuels towards increasingly smart and resilient renewable energy systems and storage solutions, at a pace and in a manner that secures stability and supply given the intermittent nature of renewables. These transition plans need to ensure infrastructure investments in natural gas as well as storage solutions are optimised so as to avoid excess expenses and stranded assets.

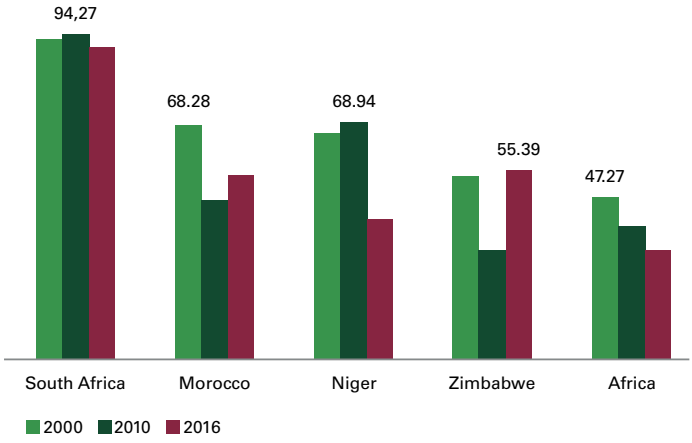

Figure 4: Electricity generation from coal in selected African countries (% of total)

Source adapted from IEA, World Energy balances 2018

In Southern Africa, coal is still an important source for electricity generation. It will be important even for countries with large coal reserves to realise that given the current situation with solar PV and wind already significantly cheaper than new-built coal, from both an economic and climate perspective it will make sense to plan for far-reaching transformations of the existing energy mix in favour of renewables, and to an extent natural gas. The primary role of natural gas will be that of a bridging solution to rapid-fire energy supply at times of peak demand and intermittency of the renewable energy baseload, until solutions such as concentrating solar power (CSP) and batteries are cost-competitive.

The Africa Energy Commission (AFREC) and its current priority themes

The Africa Energy Commission, headquartered in Algiers, was launched in 2008 and serves the African Union Commission. It is tasked to map policies, strategies and development energy plans; design and maintain a continental energy database; identify, develop and launch inter-African cooperative energy projects, promote inter-African cooperation for human resourceps development and training; create technical assistance networks; and support harmonizing of standards, procedures and practices for facilitation of trade within Africa.

AFREC is currently undertaking work across five themes, which are partly interrelated. This paper about the proposed Africa Energy Transition Programme (AFRETRAP) is developed under the theme 'Africa's Energy Transition', and intended to provide a vision for the whole of AFREC's energy programme.

African energy transition

This theme seeks to develop a vision to accelerate the African Energy Transition and transformation required in the continent to foster jointly economic growth, wealth creation, poverty eradication, and inequality reduction in a sustainable climate compatible development manner. It aims to provide a clear understanding of transformations of the energy system needed in the short, medium and long term to achieve these intertwined targets in the specific prevailing conditions of Africa and seek to develop of sectoral and technological detailed, policy-relevant and country-driven strategies consistent with the national development agendas and the Paris Agreement on climate. This document sets out key elements for this vision. The other four current AFREC themes are:

Bioenergy

The objective of the programme is to improve and enhance the capacity of the African countries to measure/collect and analyse bioenergy data and establish a strong system of continuous monitoring through the implementation of the Sustainability Indicators for Bioenergy (GSI) and related FAO best practices. The programme will also propose tailored recommendations and policies that individual countries can implement to improve the monitoring and sustainability of bioenergy production and consumption, including fuel switching from traditional biomass to modern forms of energy such as electricity, LPG, and natural gas.

African domestic market for oil products and natural gas

This programme seeks to promote African oil products and natural gas in the short- and medium-term and reduce extreme exposure to price volatility (experienced by both net exporters and net importers of petroleum) and address the currently significant discrepancy between Africa's oil and gas production and consumption. Most African countries rely on expensive imported petroleum products whereas natural gas consumption in all sectors is low, except for the North African region. This programme will focus on creating better functioning markets for both African domestic crude oil and petroleum products as well as natural gas markets in collaboration with main African stakeholders.

African energy efficiency

The overall objective of the programme is to significantly reduce energy intensity of the final demand and emissions across the continent and to provide increased electricity access, competitiveness, energy

security and economic development by supporting the unlocking of some $ 175 billion in available savings by 2030. A faster market deployment of more efficient lighting and appliances across the African Union Members States can be achieved through a common strategic, harmonized and integrated policy approach applied in each region and country.

African Energy Information System (AEIS)

In order to fulfilling its mandate, AFREC created a first ever comprehensive "African Energy Information System (AEIS)" and database through creation of a series of energy databases of which the "African Energy Statistics Database" (AESD) has already developed, published and disseminated annually since 2012, in addition to the Biomass Database and Hydropower Database. AFREC is currently planning to develop a holistic improvement plan to AEIS, which will support work across all other themes, and serve all African countries.

To successfully address these five key sectoral themes require cross-cutting measures to ensure sound governance, appropriate policies and other proper procedures:

- Pushing for **sound national energy policies** that are conducive to a common sub-regional energy strategy to promote the integration of energy markets to respond to the rising demand through projects/programs that can achieve economies of scale;
- Advocating and fostering **energy sector reforms** towards the enhancement of multi- stakeholder participation, entrepreneurship and value chain gains at national levels;
- Implementing effective **precautionary measures and technology assessment** to ensure that new energy solutions and deployment does not lead to unintended harmful consequences.
- Promoting **diversified ownership of energy** (cooperatives, communities, SMEs, public entities, municipalities and African companies) which allows for rapid flourishing of decentralized and distributed renewable energy investments where consumers are also producers.

3. Guiding principles for the African energy transition

Several landmark African and international agreements already exist that address the many energy challenges Africa faces. Agenda 2063, the Paris Agreement on climate change, the SDGs, the Africa Renewable Energy Initiative and the Least Developed Countries Renewable Energy and Energy Efficiency Initiative for Sustainable Development point to a set of key principles to overcome the challenges described above and guide Africa's energy transition. These include:

- **African leadership and ownership** in setting the energy agenda, with clear policies for the short, medium, and long term;
- **Mobilizing the continent's own, particularly renewable energy resources** and harnessing of energy potentials for development;
- Contributing to the achievement of local (cities, urban and rural areas) national, regional and global **sustainable development goals**, notably Agenda 2063, the SDGs, and the Paris Agreement;
- **Leapfrogging to the best available, smart, modern, distributed renewable energy systems** that enable a transition towards low to zero carbon energy futures in line with the Paris Agreement;
- Placing **energy issues high on the agenda** as a key strategic element for structural transformation;
- Employing **transformative and programmatic approaches** and strengthening the synergies between policies and projects so that experiences from project implementation inform policy-making;
- Moving from natural resources-based economies to **more complex and diversified value chains** and improved terms of trade with other continents;
- **Alignment with national and regional development agendas**, for a transformation rooted in local and national realities;
- **Multi-stakeholder engagement** and social **and environmental safeguards** as essential elements of sustainable solutions.

4. Strategic objectives

In order to address Africa's current energy challenges and successfully implement the far-reaching African energy transition in accordance with the above guiding principles, seven key strategic objectives need to be met.

4.1 Strategic objective 1: Energy infrastructure for economic and social development

Energy infrastructure expansion is urgently needed to drive economic growth and social development across sectors. An important example is agriculture, which is a major contributor to GDP, employment and exports, and the basis for livelihood and well-being among the many small-scale farmers on the continent (see Figure 5).

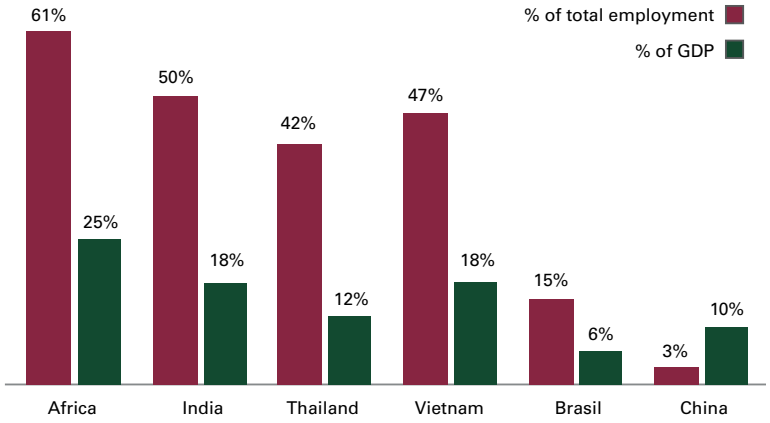

Figure 5: Agriculture's share of total employment and GDP in Africa compared with other developing countries. Source: AfDB, 2016.

However, agricultural productivity in Africa remains very low, much due to continued dependence on low efficiency inputs such as human and animal energy as well as lack of energy and infrastructure along the value chain of e.g. storage, processing, and transportation to markets. As the main source of livelihood in rural sub-Saharan Africa, agriculture, almost exclusively in the form of rain-fed small-scale farming, is the primary engine of rural economic development. Agriculture accounts for only 3% of total electricity consumption – despite employing 60-80% of the working population – and just 3-4% of crop land irrigated (Sokona et al., 2012).

In sub-Saharan Africa a 1% increase in agriculture production pulls 0.41% of population out of poverty (Christiansen et al., 2011). As women comprise half of the labour force in smallholder farming, modern energy access in the agri-food sector can greatly contribute to female economic empowerment and gender equality in the rural labour force. By providing energy for productive use in agriculture and the agri-food chain – solar-power irrigation systems, farm equipment, refrigerated and/or dried storage systems, processing and food transport – output will increase throughout the farm-to-table food chain, resulting in better nutrition and rising incomes.

Along with agriculture, micro- and small enterprises (MSEs) in manufacturing and service sectors are also critically important for increasing rural incomes and providing greater opportunities. Higher quality of life in rural areas also relieve pressure on urbanization and associated challenges. Through access to modern energy, MSEs across different sectors can increase output and improve quality of products and services, thereby increasing incomes and

furthering economic development. Table 1 provides examples of how MSEs can create value from enhanced access to energy services.

Table 1: Energy services and their income generating value

Energy services	Income generating value	Renewable energy services
Irrigation	Better yields, higher value crops, greater reliability	Wind, solar PV, biomass, micro-hydro
Illumination	Reading, extending higher operating hours	Wind, solar PV, biomass, micro-hydro, geothermal
Grinding, milling, husking	Create value-added product from raw agricultural commodity	Wind, solar PV, biomass, micro-hydro
Drying, smoking (preserving with process heat)	Create value-added product, preserve product to enable selling in higher-value markets	Biomass, solar heat, geothermal
Expelling	Produce refined oil from seeds	Biomass, solar heat
Transport	Reaching markets	Biomass (biodiesel)
TV, radio, computer, internet, telephone	Entertainment businesses, education, access to market news, coordinating with suppliers and distributors	Wind, solar PV, biomass, micro-hydro, geothermal
Battery charging	Wide range of services for end-users (phone charging business)	Wind, solar PV, biomass, micro-hydro, geothermal
Refrigeration	Selling cooled products, increasing the durability of the products	Wind, solar PV, biomass, micro-hydro

| Source: AEEP (2015): The Productive Use of Renewable Energy in Africa.

4.2 Strategic objective 2: Alignment with the Paris Agreement on climate change and a strong manufacturing sector for local production of renewable energy technologies

The African energy transition need to respond to the new regional and global agendas that collectively call for a more sustainable and prosperous world, articulating an integrated approach to the economic, social and environmental dimensions of development. Africa Agenda 2063 launched in 2013 seeks to eradicate poverty in one generation by providing access to improved standards of living, health facilities, education and skills. Energy is a basic element for achieving all these objectives. In September 2015, the world's leaders agreed to the 2030 Agenda and SDGs, which provide a remarkable framework for combining global sustainability with human well-being. They also echo the key objectives of Agenda 2063 including poverty eradication, avoidance of child mortality, inclusive growth, gender equality and sustainable land use. The SDG energy goal (SDG 7) aims to close the energy gap and "ensure access to affordable, reliable, sustainable and modern energy for all".

The Paris Agreement on Climate Change adds a critical piece to the new framework with its goal to maintain average global temperature rise to "well below 2° C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial

levels", requiring reaching global carbon neutrality soon after 2050. This ambitious objective aims at limiting the impacts of climate change and preserving opportunities for development, notably in most vulnerable regions and communities. All 55 African countries have committed to the Paris Agreement and have pledged their commitment to meeting their Nationally Determined Contributions (NDCs) towards climate mitigation under the agreement. Although the NDC commitments are non-binding, keeping within the limited carbon budget requires that all countries converge towards zero carbon societies for the second half of the 21st century. In addition, the recent special report of the Inter-governmental Panel on Climate Change on limiting global warming to 1.5° C, shows unambiguously the need for an immediate transition at an unprecedented scale to trigger structural changes compatible with zero GHG emissions, starting with decarbonizing the electricity sector.

This is also true for African countries, despite their current very low collective contribution to climate change of less than 4% of global CO_2 emissions. Looking ahead however, if they do not consider their climate impact as their development accelerates and populations grow in coming decades, they could become major GHG emitters, threatening the achievement of the global climate objective and compromising their sustainable development aspirations. On the other hand, African countries have the legitimate right to satisfy their essential socio-economic development needs and, in particular, the eradication of poverty. The issue for these countries is to build long-term trajectories that reconcile the achievement of very low GHG emissions with the satisfaction of key objectives for the well-being of their populations. The fundamental question for African nations is how to align the imperatives of their development aspirations, Africa Agenda 2063, the SDGs, and global climate mitigation aims, in ways that maximize synergies while minimizing trade-offs.

In short, African countries, as all of the world, need to rapidly increase use of renewable energy sources such as solar, wind and hydropower to eventually become fully decarbonized societies.

While such a transition is a massive undertaking, Africa has many advantages. All African countries are endowed with abundant renewable energy potential, mainly biomass, solar, wind, hydro and geothermal and in most African countries the bulk of the energy infrastructure is not yet built, allowing for rapid leapfrogging to new energy systems. Additionally, while renewable energy systems such as wind farms and utility- scale solar power plants can be land intensive, this is often less of a constraint in most African countries.

Economies of scale, a huge domestic market and the large spectrum of renewable energy options are key drivers for a sustainable energy mix with a large and rapidly expanding share of renewable energy. This huge increase in renewable energy deployment will also provide unprecedented opportunities for development of domestic, African industry for manufacturing and assembly of renewable energy technologies. Developing strategies for increasingly locating the renewable energy technology value chain in African countries will foster wealth creation and a thriving manufacturing sector across African countries. Such strategies may sensibly involve staggered approaches where one can begin with assembly, and move towards increasingly sophisticated production of equipment. This will give great scope for cooperation and manufacturing strategies across the regions and the whole continent.

4.3 Strategic objective 3: Long-term strategic planning towards smart, people-centred, interconnected and distributed renewable energy systems

The rapid development and falling costs of new renewable energy technologies in combination with rapid advances on energy systems development, electric vehicles, and smart grids opens up whole new possibilities for transition to, and designing of, the energy systems of the future.

For countries in Africa with already extensively developed, centralized energy systems based on fossil fuels, these new opportunities require a phased approach over decades where renewables take increasing shares of the energy mix, and where fossil fuels, particularly natural gas, increasingly plays the role of balancing intermittency of renewables until storage and concentrating solar power can fill also these needs. Such a transition requires careful, strategic long-term planning with consideration of infrastructure investments already made, and measures to ensure a successful transition.

It is imperative for countries to avoid locking themselves into new, costly fossil fuel-based infrastructure as the world rapidly moves to zero-carbon futures. Even for countries with own supplies of oil, coal and natural gas, it makes more sense to focus on export (during the transition period) for foreign exchange earnings while creating a modern, smart increasingly renewables-based system domestically. Least-cost scenarios only point to a rapid shift to renewables for both new generation capacity and as replacements for old coal and gas power

plants. Today, solar PV and wind are 40% cheaper than new-built coal and nuclear power in South Africa, and it already starts to make economic sense to decommission existing coal power plants in favour of new wind and solar facilities (Bischof-Niemz and Creamer, 2019).

For the large majority of countries in Africa that are at the very beginning of the construction of their energy systems, who also face huge challenges to meet energy access needs, renewables will need to be at the core of the energy-system expansion from the very beginning. Through their distributed nature renewables present opportunities to build smaller-scale, modular and rapidly constructed energy infrastructure across all communities. This can much easier cater to the needs of both local productive sectors, farming, households and public services than the old centralised model. Energy infrastructure development becomes a direct driver of local economic growth and industrialization, and directly enhance well-being across the populations. These energy systems also allow for a much more diversified landscape of actors involved in energy generation, with numerous entities – communities, cooperatives, small and big companies, utilities and public entities – becoming both producers and consumers of energy. Over time this modern, bottom-up approach allows for increasing interconnection of local micro and medium-sized grids which offers further resilience and means to balance intermittence. New 'virtual power plants' can draw on numerous, dispersed energy generation points to effectively constitute the equivalent of a large power plant, catering to all needs. Large-scale renewables of course also play a key role as part of the increasingly diverse mix of energy sources and sizes from the very local to utility-scale power plants.

It will be important for African development and energy planners to embrace the necessary shift of minds and perspectives that this energy revolution entails, in order to make wise strategic decisions and investments today. One example is how to deal with natural gas, which is often hailed as a 'clean' fossil fuel that should replace high-emitting energy sources such as coal and fuel oil or diesel as baseload energy provider. In the renewable based energy systems of the future, natural gas will rather, during the transition, increasingly play a role to fill the gap when solar and wind cannot meet peak demand. It is technically possible and feasible from least-cost modelling scenarios to design a system that over time, to a large extent rely on solar PV, wind and hydro as baseload, and natural gas, CSP, storage and demand-side management added during the peak demand, corresponding to the remaining load (ibid.). This speaks to an important role for natural gas for some time (but less and less catering to baseload needs), and will merit corresponding infrastructure development and adjustment (including pipelines where it makes economic sense). Such investments will however need to be carefully considered as part of a phased energy transition where fossil fuels related investments are minimized to avoid them becoming stranded assets before long.

In essence, despite vastly differing energy systems today, African countries will over the coming decades transition and converge towards these smart, energy systems of the future.

4.4 Strategic objective 4: Regional and intercontinental gas pipelines

Natural gas is the least polluting and hence most appropriate fossil fuel option to contribute to meeting Africa's domestic energy needs during Africa's energy transition towards increasing limitation of GHG emissions and, eventually, full decarbonisation. In addition to the relative emissions benefits vis-à-vis other fossil fuels, proven natural gas reserves in Africa are much larger than oil and are to a large extent untapped. Africa holds 7.1% of the proven natural gas reserves in the world, with a life expectancy measured by the ratio reserves to production of over 60 years (figure 6).

Much of the natural gas is currently exported either through gas pipelines linking North Africa to Europe or as LNG. Regional gas pipelines have also been successfully deployed in West Africa and North Africa. Enabled by the West Africa Gas Pipeline, part of Benin's current electricity supply is generated from natural gas, with the proportion expected to notably increase as new power plants are currently being built. In North Africa, Algerian pipeline expansion (originally intended for export to Europe) have significantly benefited Morocco and Tunisia, which have increased their natural gas consumption considerably for domestic end uses and electricity generation. Such infrastructure and trade developments underline the potential of natural gas interconnections as part of the energy mix during the transition.

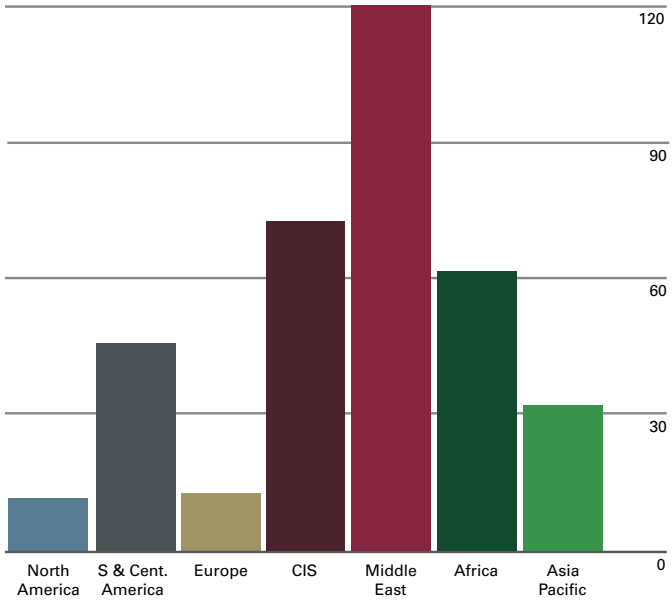

Figure 6: Natural gas reserves to production in 2017 (years)*
Source: BP statistical review of world energy, 2018.

From an environmental standpoint, natural gas has a comparative advantage over coal. A detailed assessment of lifecycle greenhouse gas emissions of gas and coal supply by the International Energy Agency from 2018 finds that gas on average resulted in 33% less emissions than coal per unit of heat used in industry and buildings, and 50% less emissions than coal per unit of electricity generated (IEA, 2019).

Compared with renewables, natural gas may currently be cost-effective particularly for high-temperature heat for industry, and heating for buildings. However, with the rapidly falling costs of renewable energy and storage solutions, renewables are rapidly and increasingly being deployed in these sectors. Natural gas is for example currently the most viable near-term option in most parts of the US for balancing variable renewable energy at scale and providing essential load-following services, but rapidly falling battery costs is bound to soon alter this (ibid.). The phasing out of coal should hence include a detailed assessment of not only natural gas as a replacement, but of other low carbon alternatives and particularly renewables.

In light of this, it will be an important strategic consideration for African countries to determine to what extent it makes sense to, during the transition period towards full decarbonisation in line with the Paris agreement, unlock Africa's natural gas potential and enhance interconnections of African countries through gas pipeline networks.

* The reserves to production ratio shows at a given period the life expectancy of the reserves and may contribute as an indicator for energy planning. There are however limits. It does not consider potential economic and technological factors that could expand the reserves such the rate of recovery and/or possible new fields discoveries, neither does it consider the dynamic of the fossil fuel consumption. For instance, an increase of natural gas consumption will decrease the life expectancy assuming the proved reserves remain the same. Most significantly, in a climate constrained world the very limited remaining carbon budget sets firm limits for extraction long before supplies run out.

It may be argued this would strengthen the continent's economic integration, provide a modern source of energy for productive activities and electricity generation and increase access to modern fuels for Africa's population. The Trans Sahara Gas Pipeline is set to link sub-Saharan Africa with North Africa and would offer opportunities to access supplies of natural gas for transit countries. This is a priority project for the Program for Infrastructure Development in Africa (PIDA). However, countries will need to consider risks of stranded assets and implications of rapidly falling costs of renewables.

Compared with other fossil fuels, Natural gas is clearly the least problematic option in terms of GHG emissions. Energy intensive industrial sectors that may directly depend on natural gas for their energy supply are the chemical industries, heavy and intensive heat users like the cement industry and iron as well as aluminum smelting plants. Analysis of African energy use reveals, however, that natural gas consumption by these industries is very low compared with other continents. Natural gas accounts for only a fraction of the total final consumption (TFC) of energy in Africa. The bulk of this consumption is concentrated in North Africa, and to a much lesser extent in West Africa.

Many long-term energy forecasts show an increase of the relative share of natural gas in the primary energy supply mix, particularly as use of other fossil fuels such as oil and goal decrease. Other scenarios outline future trajectories where natural gas does not increase its share, but indeed remains a relatively cost-effective fossil fuel with less dramatic climate change impact to, as discussed in the previous section, primarily balance peak demand rather than as main source of energy for industrial sectors. Whether natural gas production and consumption will increase in the longer term depends on strategic choices relating to overall energy planning, short- verses longer term supply and investment considerations for other energy sources such as renewables, risk assessments and climate concerns. This may be particularly true for countries that have emerged as new potential sources of natural gas supply and thus need to make decisions on what direction to take.

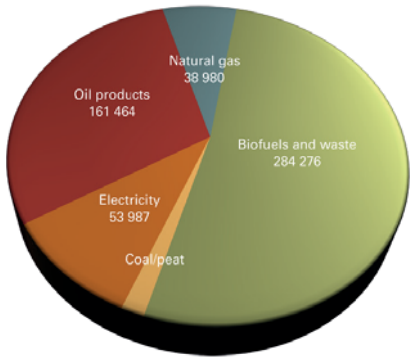

Figure 7: Natural gas accounted for 7% of the total final enery consumption (ktoe) in 2016.

Source: Adapted from AFREC key Africa energy statistics, 2018

Fuel switching to cleaner fossil fuels, primarily natural gas, in energy intensive industries and other sectors such as buildings, agriculture, and transport can contribute directly not only to relative reduction of greenhouse gas emissions but also to increase access to modern energy services. This must, however, be carefully considered in relation to the rapidly increasing capacity of renewable energy to serve also the heaviest industrial demands as well as the risk of stranded assets and rapidly decreasing costs for large-scale storage.

4.5 Strategic objective 5: Integrated electricity market

Currently, the deficits in Africa's electricity infrastructure is resulting in increased production and transaction costs across economies, reduced business competitiveness, and negative impacts on foreign direct investment flows to the continent. This is hindering the rate of economic and social development throughout Africa. Following the same pattern as developed countries, electricity markets in developing countries have evolved vertically within national boundaries rather than horizontally across countries. African energy development can instead pursue a new model across several dimensions simultaneously.

While on the one hand, distributed, decentralized energy production with diversified and often local ownership will play a critical role for energy access, local economic development and environmentally sustainable industrialization, African countries will on the other hand also benefit from the development of enhanced webs of electricity integration. Cross-border electricity trade coupled with market development should dramatically reduce average electricity prices for all African countries and increase the share of renewables and energy security for the whole continent. Decentralized solutions will be key, and in many cases, especially in remote areas, it will only make sense to remain as distinct island grids that may increasingly expand in capacity. Over time, however, the bottom-up, distributed systems that have then already benefitted huge parts of the populations will provide further benefits by expanding interconnections that allow enhanced balancing, load sharing and access to new markets.

4.6 Strategic objective 6: Climate change and decarbonization of the energy sector

Energy plays a fundamental role in addressing climate change. The recent special report of the Intergovernmental Panel on Climate Change on global warming of 1.5° C above pre-industrial levels and related global GHG emission pathways clearly spelt out the need for decarbonisation of the global economy starting with energy systems, and in particular the electricity sector.

Climate change poses a huge threat to development in Africa, as the continent is particularly vulnerable to its adverse impacts, with limited capacity to withstand these impacts. Although Africa has only marginal historical responsibility for GHG emissions and is currently emitting only a small fraction of global emissions, almost all African countries have committed to reducing emissions through their Nationally Determined Contributions under the Paris Agreement.

According to IRENA, the deployment of renewable energy sources and energy efficiency, coupled with deep electrification of end-uses, can provide over 90% of the reduction in energy-related CO_2 emissions needed to maintain a 2° C limit (IRENA, 2018). Although most African countries have set ambitious targets for renewable energy, their share in electricity generation (apart from large hydro) is still below 5%. Energy intensity in Africa compared with other countries is particularly high. Energy efficiency programs in all sectors (e.g. transport, building, industry, energy) must be strengthened. Regulations, incentives and financial transfers will be essential to reach the targets already set by energy efficiency strategies in most of the African Regional Economic Communities.

Switching from high-emitting carbon fossil fuels to less carbon-intensive fossil fuels is, as discussed above, another area that offers decarbonisation options, particularly in countries where coal is widely used for electricity generation. Depending on the region, tackling GHG emissions will imply different strategies compatible with social and economic development. In sub-Saharan Africa, a key priority is a rapid transition away from firewood and charcoal to cleaner and renewable energy sources. This transition will not only limit GHG emissions given the low energy efficiency of the biomass value chain, but also contribute to reaching the target of universal access to modern fuels.

While coal is being used in only a few African countries, it is a major contributor to energy-related greenhouse gas emissions from the continent, with 32% of the GHG emissions mainly due to coal power plants. Indeed, coal is still a major energy source for electricity generation in several Southern African countries, both in terms of relative and absolute values.

Large-scale deployment of renewable energy (solar photovoltaic, wind and geothermal) along with natural gas will dramatically limit coal's share for electricity generation. However, in order to reduce GHG emissions the use of coal must also decrease in absolute terms. Encouragingly, African countries with a high share of coal for their electricity generation have already began deployment of utility- scale renewable power plants and set ambitious targets for renewable energy deployment.

Furthermore, the fact that the largest portion of Africa's energy infrastructure and energy systems are yet to be built, particularly in rural areas, offers a tremendous opportunity to

leapfrog to technologies compatible with climate change mitigation, sustainable development and poverty eradication. In combination with existing energy systems, they will provide options for structural transformation for the continent.

It is important to simultaneously tackle and engage in long-term planning across all sectors, in addition to power generation. Although transport accounts for over 30% of CO_2 emissions in Africa, there is no robust policy to curb these emissions.

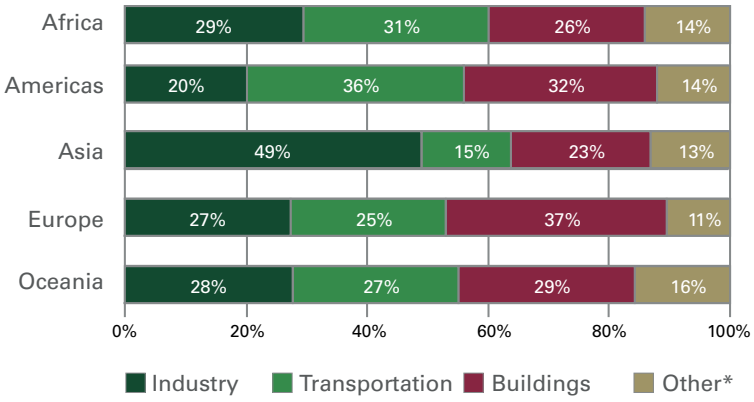

Figure 8: CO_2 emissions from transport and other sectors in Africa and other continents in 2017 (after allocation of emissions from electricity and heat generation to consuming sectors). * Other here includes agriculture, forestry, fishing and other non-specified.

Source: IEA, 2018, CO_2 emissions from fuel combustion

In both short-, medium- and long term, modernizing urban and inter-city public transport through the deployment of transport systems based on cleaner fuels (LPG, biogas, natural gas and, increasingly, electricity) offer major prospects to reduce GHG emissions, urban pollution and increase the overall performance of African economies. In a few African countries, electrification of railways and urban transport systems as well as substitution of gasoline for LPG are already being carried out on at a relatively large scale.

However, mass penetration of electric vehicles (EV) will likely remain an objective for Africa over considerable time given the lack of infrastructure and the currently high initial investment costs in EV. Nevertheless, EV for collective transport (taxis, buses) for large cities only require a limited and quite centralized charging infrastructure. African countries also need to understand

the significant worldwide trend in developed countries where there will be likely bans on light vehicles running on fossil fuels within the next couple of decades if not before, which will likely revolutionize the system and rapidly lower costs. It may be crucial for African countries to have the foresight to set very ambitious strategies for EV deployment despite currently high costs, so as to enable rapid leapfrogging. It may also be wise to develop industrial strategies towards increasing manufacturing of components for the EV value chain within Africa.

Energy efficiency is an important component of this strategic objective. Not only has energy efficiency an important impact on climate change but it also brings significant economic and social benefits. Yet, African countries have barely tackled energy efficiency, even though investments in this area are usually highly cost-effective. In many cases energy efficiency programs and projects offer a significant return on investment in addition to mitigating GHG emissions. Energy efficiency programs must encompass all the components of energy systems, i.e., production, transformation and consumption. At the production level, gas flaring is a major issue in oil producing countries. Immediately mitigating gas flaring at a large scale will substantially decrease wasting resources while reducing GHG emissions.

Electricity systems in Africa are characterized by low energy efficiency for electricity generation and transportation and distribution losses far beyond international standards. Deploying efficient power plants and transportation lines would have transformative effects and contribute to increased profitability of the utilities by reducing fossil fuel inputs per unit of kWh for electricity generation as well as having positive impacts on GHG emissions.

Transformation of firewood to charcoal in sub Saharan Africa is a wide-spread business which is characterized by very low energy efficiency along the whole value chain. Low Income Countries in Sub-Saharan Africa have the highest energy intensity in the world (at 10.3 MJ/2011 PPP$ in 2014) due to their strong reliance on inefficient traditional biomass. This is compared to the SEforALL objective for global energy intensity of 5.5 MJ/2011 PPP$ (Sustainable Energy for All, Global Tracking Framework, 2017). Deployment of available and affordable technologies such as improved kilns and stoves can significantly reduce firewood consumption and GHG emissions. In the longer term the objective is to phase out solid fuel consumption for households through less harmful fossil fuels such as LPG and natural gas, biogas in some rural areas and, ultimately widespread deployment of electricity options powered by renewable energy sources.

With regards to consumption, the potential for energy savings and GHG mitigation is significant in all sectors and particularly buildings, transport and industry. The African energy transition must be guided by a realization that overconsumption and non-efficient energy lifestyles by the high emitting, wealthy part of African populations must be curbed while the overwhelming majority of Africans gain sufficient access to more but efficiently produced and used energy.

In the short term, energy efficiencies measures will have some positive impact on GHG with little investment such as change in behaviour, deployment of energy efficiency appliances in

the building sector, stringent rules to ensure imports are complying with energy efficiency requirements etc.

Energy system transitions require long-term strategies and capital, particularly when energy infrastructure is either non-existent (e.g. natural gas infrastructure, electric transportation and distribution networks) or under-developed. A low to zero carbon energy development strategy will therefore require not only financial transfers but above all the building of a thriving manufacturing industry for energy to increase economic integration and a sustainable energy future for Africa's population.

4.7 Strategic objective 7: Strengthening energy systems innovation and leveraging the potential of social innovation

Successful implementation of both Agenda 2063 and the SDGs will require substantial expansion of renewable energy (RE) infrastructure consistent with low-carbon paths to development. Once considered unrealistic due to their high upfront costs, increasing economies of scale and recent innovations in technology and business models have dramatically driven down the costs of renewable energy generation and storage. These developments offer new opportunities for African countries. To realise the full potential of renewable energy, innovative energy solutions tailored to local, national and continental conditions are needed. The Coalition for African Research and Innovation has identified two major barriers that need to be addressed, namely, inadequate allocation of resources to innovation, and the fragmented nature of available resources. Africa's share of global funding on R&D is only around 1%, and resource fragmentation severely limits any opportunities for collaboration (AAS and NEPAD, 2019).

The individuals, organizations, and governments that fund and conduct R&D on the continent do not have any mechanism for systematic collaboration. A comprehensive continent-wide framework is clearly needed – one specifically designed to integrate currently dispersed renewable energy innovation resources into a more powerful source of innovative solutions that can benefit both communities, public entities and enhance energy democracy/community energy as well as enterprise-led penetration of renewable energy markets in Africa (Pirzer and Meyer, 2016). It will be of crucial importance for the African energy transition to ensure it is contributing to improving the livelihoods of poor people. Workers directly affected negatively by the changing priorities will need to be assured a just transition with access to support and rights to enable re-orientation to other sectors, and particularly the renewable energy sector with its tremendous opportunity for jobs creation.

However, much of the ongoing efforts to achieve this result focuses on technological dimensions of innovation. While this is important, current thinking suggests that in many areas such as energy, mobility and health, "…the social and the technological dimensions of innovation are strongly inter-connected and can hardly be separated from each other in explaining social change" (Howaldt et al., 2014). The technology-centered paradigms currently shaping efforts at strengthening innovation systems in Africa need to give greater prominence to social innovation. In addition to capturing the added value of such innovation as an autonomous field of action, addressing this need would recognize the intimate links between the social and the technical sphere.

Given the relative absence of institutional capacity to integrate social and technological innovation agendas, on-going innovation system development efforts must be complemented by a strong social innovation drive. Given its sustainable energy focus, this paper proposes

creating, or strengthening an existing organization, to coordinate efforts -- a dedicated Center of Excellence in Social Innovation for Sustainable Energy (CESISE). CESISE's purpose will be to identify and work with social economy actors; develop, test and scale up new ideas and solutions (Nwuneli, 2016) to tackle the challenge of decarbonizing energy systems in Africa.

The Center's initial set of actors would include: social enterprises and other actors of the social economy; civil society; social movements; science, universities and research institutes; companies along the energy value chain including industry clusters; renewable energy and energy efficiency customers/users/citizens/beneficiaries; innovative energy system designers; energy poor and marginalized groups (beyond-the-grid); government agencies and other actors. In the short-to- medium term, CESISE will orchestrate actions towards achievement of the following objectives:

» Open up current energy systems to the entry of more radical but proven technologies and business models by empowering existing (or creating new) institutions and common infrastructures – in effect, **nullifying the locked in-nature of current energy systems**;

» Increase and **rebalance government funding for testing, deploying and scaling up** renewable energy generation and storage technology applications in Africa. Such rebalancing will focus on both direct work with pioneering communities, cooperatives and non-profit initiatives as well as on supporting mature and start-up SMEs, enabling them to successfully transition from experimentation and testing to full-scale deployment;

» Assist countries in designing **transparent processes and criteria** for selecting renewable energy technologies aligned with specific goals of each country, as expressed for instance, in NDCs;

» Provide capacity and create platforms for **critical and precautionary assessment of new technologies** to enable the continent to see both risk and opportunities in a rapidly emerging technology landscape and avoid unintended social and environmental problems due to un- critical commercialization;

» **Strengthen the capacity of relevant agencies** – local, regional and national – responsible for evaluation of innovative technology deployment programs.

5. The way forward – Launch of the program

Energy for development – this is Africa's energy vision. Achieving the vision requires rapid transformation in the continent to foster meaningful economic growth, wealth creation, poverty eradication, and inequality reduction in a sustainable, climate compatible manner.

Realizing the African energy vision requires a clear understanding of what is required for each country and cluster of countries in relation to the principles and strategic objectives presented above. Key questions include:

» **What is the time horizon** for Africa's energy system transition, taking into consideration actions in the short-, medium- and long-term?

» **Which sectors** should be prioritized?

» **How to address the fossil fuels dilemma** taking into consideration the current role of the oil and gas sector in Africa and new oil discoveries in many sub Saharan countries?

» **What lessons can be learned** from the outcomes and constraints of various regional, continental and global initiatives for Africa aimed at addressing the challenges in the energy sector and at accelerating access to modern and sustainable energy services? These initiatives include among others Program for Infrastructure Development in Africa, the Sustainable Energy for All initiative, the Africa Clean Energy Corridor, the Africa-EU Energy Partnership, the USAID-supported "Power Africa", the Africa Renewable Energy Initiative and the LDC Renewable Energy and Energy Efficiency Initiative for Sustainable Development.

The structured interrogation of these questions will be facilitated through the activities of the new initiative – the **Africa Energy Transition Program (AFRETRAP)** – presented in this document. The program will be carried out under the auspices of the African Energy Commission (AFREC) in partnership with other relevant institutions and initiatives.

The overall rational of AFRETRAP is to develop a common understanding of the requirements for pursuing Africa's energy transition vision in light of the overall context presented in previous chapters. This involves:

» Supporting the development of African capacity to produce and analyse country and/or regional **long-term strategies** articulating development aspirations and low to zero carbon objectives;

» Constant engagement with **national and/or regional decision makers** and a wide range of **stakeholders** in all stages of the program's research and analysis;

» Building a **community of practice** for knowledge sharing and mutual learning across countries in the region. AFRETRAP will be developed under the auspices of the African Energy Commission (AFREC) and fully anchored in the African Union Commission (AUC) as an important contribution to the energy transformation. AFREC will ensure that the program remains Africa-led, and that all activities contributing to it as well as the outcomes will benefit directly and indirectly the continent as a whole.

Africa faces huge energy challenges, but those challenges also offer tremendous opportunity. Unlike industrialized and emerging economies which face the challenge of transforming their existing energy infrastructure, most African countries can develop cleaner, flexible, more efficient and adaptable energy systems from the start.

6. Elements for the AFRETRAP design and implementation

6.1 Overall program objective

The AFRETRAP is designed to catalyse the African energy transition, informed by a clear and common understanding of the transformations in the energy sector needed in the short, medium and long-term to achieve the intertwined visions of Agenda 2063, the SDGs and the Paris Agreement. This will foster sustainable economic growth in a climate compatible manner through the provision of targeted research, analytic, engagement, and technical advisory services to key stakeholders at local, national, regional and continental levels. The program will identify frameworks and show how they can support the development of sectorally and technologically detailed, policy-relevant and country-driven strategies consistent with national development agendas. This information will highlight the key enablers of the desired transformation and inform decision-making and support action.

6.2 Approach

The program will be African-centred and provide a platform for mobilizing, strengthening and building capacity of African institutions and experts. It will support engagement within countries, across regions, and between sectors and stakeholders. The program will draw on the best and most suitable practices and methodologies that exist both on the continent and elsewhere, and assert the need for Africa to define and lead its own future in line with the programme's ethos of endogenous development. The approach and toolbox will be open-ended and flexible to allow for continuous learning and refinement.

6.3 Building blocks of the program

The program will start by taking stock of goals, lessons and methodologies from various Africa relevant regional, continental and global initiatives aimed at addressing the challenges in the energy sector and at accelerating access to modern and sustainable energy services. The assessment will draw on the knowledge and expertise of the African Energy Commission as well as relevant energy sector bodies such as the regional power pools, the regional centers for renewable energy and energy efficiency, the New Partnership for Africa's Development (NEPAD), the regional electricity regulators association, existing renwable energy initiatives, the African Development Bank and relevant stakeholders and academic institutions.

The stocktaking will also involve a synthesis of existing national strategic and development plans that define pathways for transformation for individual countries or groups of countries. This synthesis will highlight the current convergences and divergences between different strategic plans for a given geographical area, and help in assessing the possible alignment of visions across different countries and regions. It will also identify and assess gaps and to what extent these currently existing plans are compatible and aligned with the requirements of an energy transition aligned with SDGs and the Paris Agreement, as outlined in this paper.

Strengthening local analytical and engagement capacities

To ensure relevance and ownership of the program by local institutions, the AFRETRAP will be led by experts from the African continent. Given the critical lack of capacities on the continent, the strengthening of technical and scientific capacity of local, African experts and institutions will be a core component of the program. The capacity component will include the following areas of activity:

» Mobilization of a critical mass of **African experts** on energy transition;

» Identification and mobilization of **research centres and think-tanks** to provide sustainable institutional hosts for the development of regional and/or country-oriented analyses;

» Support **capacity building** for researchers and students from these research centres and think-tanks focusing on the common good to produce, access, and communicate evidence that informs policy-making;

» **Training of experts on methodologies** developed and identified as relevant approaches for the analysis of pathways towards achieving development, sustainability and climate objectives;

» Support and facilitate **enhanced knowledge sharing** among African institutions;

» Active and regular engagement of stakeholders on, inter alia, the **monitoring and evaluation** of progress and achievements of all dimensions of the program.

Building concrete transition pathways within countries

The formulation of possible concrete transition pathways for African countries constitute a core building block of AFRETRAP. Such efforts will begin with a set of pioneering countries.

Mandate

It will be crucial to in each selected country identify one or several champions within the government (in energy, environment, economy, treasury, forestry or other key ministries/ sectors) that can provide a high-level mandate for the undertaking. Such mandating is not necessarily a once-off process, since there may be need to renew mandates (e.g. after an election, or to reconcile different views among Ministries) to ensure the continuity of the implementation of the program.

Establishing Scenario Building Teams and facilitation

» The next step involves establishing a **scenario building team** (SBT) for each selected country and identify the key strategic actors from a range of government ministries, academia, local authorities, businesses (including major emitting companies), labour unions, civil society and any other key stakeholder groups;

» Engage with individuals in their own capacity or as representatives of institutions to ensure **appropriate mix of skills and diversity** and secure their entry into the process;

» Identify **facilitators** well equipped to run stakeholder processes and provide training as necessary to build such capacity.

Analytical work and research

Mobilizing and/or strengthening of local capacities as described above will enable the development of concrete roadmaps towards transition for the five African regions (North, West, Central, East, and Southern). These roadmaps will take the form of detailed narratives with a common format and structure, but reflect the heterogeneities of energy transitions in the different African regions as well as within countries. The narratives will provide qualitative and quantitative considerations of possible key transformations needed in relation to the seven key strategic objectives discussed earlier, identify challenges and opportunities, and highlight the key local, regional, and international enablers for these transformations to materialize effectively. These regional roadmaps will be designed based on results of stakeholders' consultation process, and multiple roadmaps may be considered to reflect the key divergences that may exist regarding the future of the energy systems in each region.

The AFRETRAP recognizes that diversity of transition pathways is conceivable and that the strategic and political choices for long-term planning of the energy transitions will need to be informed by active engagement and interrogation of the various alternatives, assumptions, values and understanding of power and vested interests. One important component of the program will therefore be the introduction of qualitative systems mapping methodologies as a means to build common understanding of key variables, actors, dependencies, and leverage points, drawing on the expertise of all involved in participatory manners.

Organizing in-depth, in-country discussions and pathways

These regional narratives will guide the elaboration of country-specific transition pathways in at least one country per region, where the relevant methodology of flexible and country-specific approaches may be applied. These pathways will support in-country stakeholder engagement. These frontrunner countries will be selected according to the availability of analytical and engagement capacities as well as government buy-in and mandates to organize participatory stakeholder consultation processes. Over time, more countries may be added. The programme anticipates several staggered phases where the "Strengthening local analytical and engagement capacities" building block and lessons learned from experiences of frontrunner countries facilitate the additions of more country pathways over time.

Development of strategic partnerships

Strategic partnerships with the very best knowledge institutions both inside and outside of Africa will help accelerate transfer of skills, knowledge, and know-how. These partners will be involved in the capacity building activities and in the design of the regional and national transformation pathways. Themes to be considered for such strategic partnerships include i) modeling and transition pathways; ii) energy and development infrastructure; iii) policy and governance; iv) energy finance and investment; and v) innovation and technology.

6.4 Organisation

AFREC will establish a logistical and scientific secretariat with dedicated staff to coordinate research, organize program activities such as work plan preparations, reports, internal workshops or public outreach conferences, and provide any relevant support as needed.

A program steering committee will be established to provide program oversight with responsibility for monitoring program implementation, providing guidance and advice across implementation stages, and supporting outreach and engagement. The steering committee will be composed of representatives of African research centres and energy sector stakeholders, who will bring their expertise on Africa-relevant approaches to decarbonisation. Some representatives from international partner institutions such as research networks, civil society organizations, development banks and international foundations will be invited as observers.

A team of 10 African experts (2 per region) will be carefully selected and offered training as needed in the relevant, identified methodologies and approaches. These experts will constitute the ambassadors of the program in each region, and be engaged in all activities of the program such as identification of local research partner institutions, review of existing initiatives and strategic plans, definition of regional transformation roadmaps, and coordination of the pathway design in the pilot countries and in the regional engagement.

Local research partner institutions in the pilot countries will be largely responsible for designing country-specific deep decarbonisation pathways and for conducting national engagement.

International research partners will support the design of regional roadmaps and the country energy transition pathways. Some key potential partners such as IDDRI have already in principle agreed to offer training to the experts and support in the reviewing of plans, regional roadmaps and to provide guidance for the elaboration of each country's energy transition pathways. Other relevant potential partner organizations will be approached to play complementary roles on for example qualitative mapping methodologies, energy scenarios modelling and participatory action research methodologies.

6.5 Preparatory activities and work packages

The program will start with a technical inception meeting at AFREC. A feasibility process will be initiated after the inception meeting and include consultations and missions to identify individuals and organizations to be actively involved in the program as well as interaction with potential partners. The consultations will be followed by a scoping meeting to identify the various components of the program and to prepare a detailed budget and work plan.

The initial technical inception meeting will bring together African experts from each of the 5 regions and a limited number of non-African experts, as well as African energy policy makers and senior officials from within the five Regional Economic Communities to provide the required political support.

6.6 Preparatory phase activities

The initial, preparatory phase involves on-going deliberations and the organizing of two meetings to build further on this document:

» **2-days scoping meeting** with core partners to identify the various elements of the program and to elaborate an initial budget and work plan.

» **2-3 days technical inception meeting** at AFREC with core partners and 10 African experts as identified to be considered becoming ambassadors, with further discussion and concretisation of the work plan and detailing of the budget.

6.7 Core activities – work packages

The work plan and time line for the core activities as elaborated in the meetings during the initial preparatory phase will be continuously updated as the programme becomes implemented. The core activities will be further detailed and organized into several Work packages:

- **Work package 1:** Program management and coordination
- **Work package 2:** Identification of local research partners (ambassadors/experts), one focal institution in each sub-region and partner in other countries
- **Work package 3**: Synthesis of existing initiatives and strategic plans
- **Work package 4:** Training of ambassadors/experts on a range of relevant methodologies
- **Work package 5:** Development of regional roadmaps and regional engagement (ambassadors/experts)
- **Work package 6:** Development of national pathways and national engagement in pilot countries (local research partners, with the support of international research partners, under coordination of the ambassadors/experts)
- **Work package 7**: Awareness raising, stakeholders' consultation and participation throughout the whole process

6.8 Time horizon and phases

It is envisaged that the AFRETRAP will, to begin with, have a time horizon of 6-7 years. The initial core activity phase of will run for 3 to 4 years, (2021-2024) with activities and networks for each of the five regions operating in parallel. A staggered approach will allow for the gradual expansion and introduction of additional countries with a second core activity phase allowing for a significant boost of countries undertaking transition pathway planning by drawing and benefitting from the experiences of the pioneering countries.

Phases	Time horizon
Phase 1: Preparation and resource mobilization	2019-2020
Phase 2: Implement in five countries	2021-2024
Phase 3: Implement in broader set of countries:	2023-2026

| Table 2: Implementation phases

7. References

1. AAS&NEPAD, (2019, April 8). Coalition for African Research and Innovation. Retrieved from Alliance for Accelerating Excellence in Science in Africa (AESA) Website: https://aesa.ac.ke/cari/coalition-for-african-research-and-innovation/
2. AFD and World Bank, 2019, Electricity Access in Sub-Saharan Africa Uptake, Reliability, and Complementary Factors for Economic Impact.
3. AFD, 2016, Speed up energy transition in Africa
4. Africa-EU partnership, 2015, the productive use of renewable energy in Africa
5. AfDB, 2017, Industrialize_africa_report-strategies_policies_institutions_and_financing
6. AFREC, 2018, Africa energy database
7. AFREC, 2018, key Africa energy statistics
8. Africa Union, agenda 2063 linkages with the sustainable development goals
9. Africa Union, PIDA, 2108, PIDA progress report
10. Bierbaum, R. and Fay, M. World Development Report 2010: Development and Climate Change. World Bank, Washington, DC, 2010.
11. Bischof-Niemz, T. and Creamer, T. 2019. South Africa's Energy Transition. A Roadmap to a De- carbonised, Low-cost and Job-rich Future. Routledge: London
12. BP, 2018, Statistical review of world energy, 67th 2018
13. Casillas, Christian, and Daniel Kammen. The Energy-Poverty-Climate Nexus. vol. 330, SCIENCE, 2010, The Energy-Poverty-Climate Nexus.
14. Christiansen L., Demery L. and Kulh J. 2011. The (evolving) role of agriculture in poverty reduction – Am empirical perspective. Journal of Development Economics; volume 96, Issue 2, pages 239-254
15. Daly, Hannah, and Molly A. Walton. Energy Access Outlook 2017: From Poverty to Prosperity. The International Energy Agency, 2017, Energy Access Outlook 2017: From Poverty to Prosperity.
16. Eberhard, Anton; Gratwick, Katharine; Morella, Elvira; Antmann, Pedro. 2016. Independent Power Projects in Sub-Saharan Africa: Lessons from Five Key Countries. Directions in Development-Energy and Mining; Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/23970 License: CC BY 3.0 IGO."
17. Ganguly, Sourav and Sen, Souvik, Opportunities, barriers and issues with renewable energy development – A discussion, Elsevier Ltd. 2016.
18. Gielen, Dolf, et al. The Role of Renewable Energy in the Global Energy Transformation. Elsevier, 2018, The Role of Renewable Energy in the Global Energy Transformation.
19. Gouridis, S., Abdullah, A., Griffiths, S., Saygin, D., Wagner, N., Gielen, D., et al. 2016, RE-map- ping the UAE's energy transition: An economy-wide assessment of renewable energy options and their policy implications. Renewable and Sustainable Energy Reviews,
20. Howaldt, J., A. Butzin, D. Domanski and C. Kaletka. 2014. Theoretical Approaches to Social Innovation - A Critical Literature Review. A deliverable of the project.
21. Intergovernmental Panel on Climate Change (IPCC), Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, 2014 [Core Writing Team, Pachauri P.K. and Meyer, L.A.
22. International Energy Agency, United Nations Development Program, United Nations Industrial Development Organization, 2010 Energy poverty: How to make modern energy access universal?
23. IEA and IRENA, 2017. Perspectives for the Energy Transition: Investment needs for a low-car- bon energy system
24. IEA, 2014, Africa energy outlook

25. IEA, 2018, CO_2 emissions from fuel combustion

26. IRENA, 2018, Global energy transformation, a roadmap to 2050

27. IRENA 2018, Off-grid Renewable Energy Solutions. IRENA, 2018 https://www.irena.org//me- dia/Files/IRENA/Agency/Publication/2018/Jul/IRENA_Off-grid_RE_Solutions_2018.pdf.

28. IRENA 2017, Renewable Power Generation Costs 2017. IRENA, Abu Dhabi 2018 https://www.irena.org/publications/2018/Jan/Renewable-power-generation-costs-in-2017.

29. IRENA, 2017). Synergies between Renewable Energy and Energy Efficiency

30. IRENA, 2017, Accelerating the Energy Transition through Innovation

31. Jebli, Mehdi and Youssef, Slim, the role of renewable energy and agriculture in reducing CO_2 emissions: Evidence for North Africa countries. Elsevier Ltd, 2016.

32. Nwuneli, O. N. (2016, April 7). Social Innovation in Africa: A Practical Guide for Scaling Impact. New York: Routledge. Retrieved from Stanford Social Innovation Review: https://ssir.org/articles/entry/creating_a_level_playing_field_for_social_innovators_in_afric a

33. Oxford Institute for Energy Studies, January 2019, Issue 117

34. Pasten, Cesar & Santamarina, J. (2012). Energy and quality of life. Energy Policy. 49. 468-476.

35. Pirzer, C., & Meyer, C. (2016, October 28). Scaling Innovation at the Energy-Agriculture Nexus in East Africa. Retrieved from endeva Web site: https://endeva.org/blog/scaling-innovation- energy- agriculture-nexus-east-africa

36. Rehfeuss, Eva. Fuel for Life: Household Energy and Health. World Health Organization, 2006, Fuel for Life: Household Energy and Health.

37. Scott, V, Haszeldine, S, Tett, S & Oschlies, A 2015, 'Fossil fuels in a trillion-tonne world.' Nature Climate Change, vol. 5, pp. 419–423. DOI: 10.1038/nclimate2578

38. Sgouridis, S., Csala, D., & Bardi, U. 2016. The sower's way: quantifying the narrowing net-en- ergy pathways to a global energy transition. Environmental Research Letters, 11(9), 1–8. http://doi.org/10.1088/1748-9326/11/9/094009

39. Shahsiah, Ahmad. "Evolution of the Traditional Power System." The Power Grid: Smart, Se- cure, Green and Reliable, Academic Press, 2017.

40. Situmbeko, S.M. (2017) Decentralised Energy Systems and Associated Policy Mechanisms—A Review of Africa. Journal of Sustainable Bioenergy Systems, 7, 98-116. https://doi.org/10.4236/jsbs.2017.73008

41. Smil, V. 2017. Energy and Civilization: A History. Cambridge, MA: MIT Press

42. Sokona,Y., Y. Mulugetta and H. Gujba, 2012. Widening energy access in Africa: Towards energy transition. Energy Policy 47 (2012) 3-10. Practical Action. 2012. Poor People's Energy Outlook 2012: Energy for earning a living. Practical Action Publishing: Rugby, UK

43. Somanski, D., Kaletka, C., & Dhont, S. (2014). Theoretical Approaches to Social Innovation - A Critical Literature Review. Brussels: European Union.

44. Sovacool, Benjamin K. How long will it take? Conceptualizing the temporal dynamics of energy transition, Energy Res. Soc. Sci. 13 (2012).

45. Szabo, S, et al. Energy Solutions in Rural Africa: Mapping Electrification Costs of Distributed Solar and Diesel Generation versus Grid Extension. IOP Publishing, 2011, Energy Solutions in Rural Africa: Mapping Electrification Costs of Distributed Solar and Diesel Generation versus Grid Extension.

46. World Bank (2018), Africa's pulse, an analysis of issues shaping Africa's economic future

47. World Bank Africa Renewable Energy and Access Program (AFREA), Energizing Africa: Achieve- ments and Lessons from the Phase I

48. World Bank, 2017 Double Dividend: Power and Agriculture Nexus in Sub-Saharan Africa

49. World Bank and IEA, 2017, Sustainable Energy for All, Global Tracking Framework, progress towards sustainability.

Published by African Energy Commission October 2019

02, Rue Chenoua, Bp 791, Hydra, 16035, Algiers, Algeria
Tel.: + 213 23 45 91 98 / Fax: +213 23 45 92 00
Web: www.afrec-energy.org
E-mail: afrec@africa-union.org
Social Media: @African Union AFREC
@ AUAFREC