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AFRICA SCIENCE PLAN

Sustainable Energy

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for the benefit of society

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Authors

Dr Chrispin Kowenje, Maseno University, Kenya
Prof Albert Julio Tsamba, Eduardo Mondlane University, Mozambique
Prof Romeela Mohee, University of Mauritius, Mauritius
Dr David Tinarwo, University of Venda, South Africa
Dr Adam Sebbit, Makarere University, Uganda
Dr Clement Shonhiwa, University of Zimbabwe, Zimbabwe
Dr Thomas Senganimalunje, University of Malawi, Malawi
Prof Cuthbert Francis Mhilu, University of Dar es Salaam, Tanzania
Dr Mamadou Fall, Cheikh Anta Diop University, Senegal
Dr Winnie Waudo, Mt. Kenya University, Kenya
Dr Daniel Nyanganyura, ICSU Regional Office for Africa, South Africa

All correspondence concerning this Africa Science Plan should be addressed to:
Dr Richard L.K. Glover *r.glover@icsu-africa.org* *and*
Dr Daniel Nyanganyura *d.nyanganyura@icsu-africa.org*

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Preamble

The first Science Plan for Sustainable Energy in sub-Saharan Africa was published in 2007. Much has happened since then. Apart from implementation that has been consistent, including the writing of a book by the same consortium that authored the Science Plan, several developments in the energy space have taken place. Most notable among these is the Africa-EU Energy Partnership (AEEP), structured as a long term framework for political dialogue and cooperation between Africa and the European Union (EU). The partnership aims to increase the effectiveness of African and European efforts to secure reliable and sustainable energy services in the coming decades on both continents, and to extend access to modern energy services and expand the use of renewable energy in Africa.

The Future Earth initiative, developed by a global partnership that includes the International Council for Science (ICSU), necessitated that the sustainable energy sphere be re-examined to include energy issues on the agenda of integrated research and sustainable development. The area of energy is also unique among the regional Science Plans in that, despite being one of the priority areas for all three ICSU Regional Offices, it was not on ICSU's global agenda before the Future Earth initiative.

Considering these developments, the Africa Science Plan for Sustainable Energy is in some sense overdue. Also topical was whether its scope should be limited to sub-Saharan Africa, or extended to the entire continent, with the consensus view that it should be the latter. The Plan comes at an opportune time, considering the adoption of the Sustainable Development Goals (SDGs) by world countries in September 2015. Goal 7 directly addresses access to affordable, reliable and sustainable modern energy for all. In describing this goal, the United Nations (UN) makes the assertion that:

- Energy is central to nearly every major socio-economic challenge and opportunity the world faces today. Be it for jobs, security, climate change, food production or increasing incomes, access to energy for all is essential.
- Sustainable energy is an opportunity that will transform lives, economies and the planet. [1]

Moreover, the UN has led a Sustainable Energy for All initiative to promote universal access to modern energy services, improve efficiency and increase the use of renewable natural resources. This is an indication of how this world body has put increased emphasis on issues of sustainable energy.

[1] http://www.un.org/sustainabledevelopment/energy/

Source: http://www.shutterstock.com stock-photo-solar-panels-with-blue-sky-97115633

The Future Earth initiative emphasises the interconnectedness of global food, energy and water security, and asserts that environmental sustainability calls for joint global responsibility and cooperation among scientists and policy makers to mediate trade-offs and explore synergies. This is further indication that issues of sustainable energy have been placed on the global research agenda.

This Africa Science Plan for Sustainable Energy starts by giving an overview of energy as part of the sustainable development agenda and highlights energy issues pertinent to the African continent. An analysis of key energy challenges for the continent is described at length, demonstrating how these challenges are compounded by environmental and socio-economic factors, as well as issues related to energy access and security. An overview is given of known energy projects in Africa to illustrate progress and to highlight gaps and challenges. While there is considerable private sector activity in the field, this at times may defeat good intentions and contribute to the fragmentation of efforts. At the same time, such activity has brought forth opportunities to use synergies and to combine existing efforts to ensure sustainability in the provision of clean energy.

Finally, this document proposes a plan of action in three focal areas. It is an ambitious action plan with timelines proposed, funding arrangements explored and implementation strategies devised. This is a commendable attempt to ensure that the Science Plan can be operationalised in the face of limited resources and competing basic needs. As aspects of implementation have already been in motion for the past few years without any solid research projects, we remain optimistic that this reviewed Africa Science Plan will give new impetus that speaks to current realities, and thereby open new possibilities to strengthen implementation.

Dr Daniel Nyanganyura
Regional Director, ICSU Regional Office for Africa

Executive Summary

The Africa Science Plan for Sustainable Energy considers energy to be pivotal to and an essential ingredient for socio-economic development at all levels of society. It takes cognisance of the growing evidence that renewable energy has a positive ripple effect throughout society, simultaneously advancing economic, social and environmental goals. A well-designed framework for a regional science-based energy policy would offer a good opportunity to identify potential complementarities among the objectives of energy security.

With the focus on the African continent, the Science Plan gives an overview of the energy situation and highlights the major energy challenges faced by the region. It describes the basic research required to support cogent decisions about energy production, storage, distribution, and use. The Plan also discusses the potential to provide reasonable options for support structures and the resources required to facilitate and implement collaborative energy research in Africa. It is not a blueprint or framework for all energy-related work in Africa, but rather a guide as to where the particular strengths of stakeholders and experts on the continent can be brought to bear on this important issue.

The Plan considers, from a regional perspective, the most pressing sustainable energy-related research needs, the unique opportunities offered, and the capabilities to potentially conduct world-class energy research. This energy research would focus on exploiting and using Africa's abundant renewable energy power potential, as well as on developing a better understanding of the available resources that would be vital to help governments establish ambitious yet realistic targets and effective supporting policies. The work would lead to a proposal for a select number of large-scale, integrative action plans, in three broad areas:

- The development of energy models and scenarios for Africa
- Increase in access to high quality, reliable and affordable energy in a sustainable manner on the continent
- The strengthening and retention of human and institutional capacities in the energy sector in Africa.

The implementation of this Science Plan will involve regional and international energy networks, stakeholders, the ICSU Regional Office for Africa (ICSU ROA) regional partners, and ICSU associated international programmes (such as Future Earth), as well as international donor agencies across the spectrum of research and development. It is estimated that the full implementation of the Plan will require considerable funding, with a significant contribution expected to come from within Africa. The catalytic, coordination and synthesis activities to be undertaken by ICSU ROA will include mobilising the knowledge and resources of the energy scientists in the region.

Source: www.http://breakingenergy.com/2014/04/04/tackling-energy-poverty-with-renewables/

Contents

Source: https://pixabay.com/en/solar-panel-roof-straw-hut-solar-241903/

1. Energy for Sustainable Development

Sustainable energy remains pivotal to and an essential ingredient for socio-economic development globally. Most if not all social and economic activities require the use of energy in various forms and quantities. Communities who have no access to energy also lack basic services such as clean water, food security, sanitation, and access to education and improved healthcare facilities. Discussions held by forums at regional and international levels have led to different definitions of the term 'sustainable energy'. In this Plan sustainable energy is taken in its broadest context to include important factors such as resource endowment, existing energy infrastructure, and meeting development needs. Sustainable energy is therefore defined as

> *providing affordable, accessible and reliable energy services that meet economic, social and environmental needs within the overall developmental context of the society for which the services are intended, while recognising the centrality of equitable distribution in meeting those needs.*

Currently it is estimated that as much as half of the energy generated is reported to be lost in the processes of energy production and energy use, due to inefficiencies in the generating, distribution, conversion, storage and consumption systems. A combination of these system inefficiencies will have serious and significant adverse impacts on the environment, with lasting effects. Some of the environmental burdens include pollution, deforestation and biodiversity loss, climate change and the depletion of water resources, as well as energy use rendering spaces inhabitable. It is estimated that the energy sector accounts for about two-thirds of global greenhouse-gas emissions. This makes it crucial to understand the underlying principles of energy systems and use in order to address climate change (Davidson, 2002), as well as the impact of energy use on local, regional and global environments. Hence the ongoing debate about renewal energy and the sustainability of energy systems.

Over the past few decades, the issues of energy supply, access and security, as well as issues related to the impact of the consumption and production patterns of energy on world sustainability, have been objects of international discussions and debates. In Africa, which is a large and diverse continent with a vast energy potential, it is recognised that energy plays a pivotal role in socio-economic development as a domestic necessity, and as a factor of production, with the cost of energy directly affecting prices of other goods and services, and the competitiveness of enterprises. From an African perspective, commitments, targets and goals made by the various actors can be clustered into the following four issue-based categories:

- Improving energy accessibility for poverty reduction, based on a thorough analysis of existing efforts and capabilities.
- Changing energy consumption/production patterns for environment and resource sustainability, with the emphasis on improved energy management.
- Facilitating the adoption of advanced and cleaner energy technologies and diffusion through engagement and knowledge exchange with experts from other regions of the world.
- Introducing cross-cutting energy measures, including measures on international/continental finance, trade, capacity development, technology transfer and gender equity.

In recent years, Africa has experienced rapid population growth, as well as sustained economic growth and diversification. In order to sustain these developments, it is critical that the continent invests in the exploitation of its vast resource base and use its renewable energy resources to fuel the bulk of its future growth. The continent would need to establish with the support of key stakeholders in the region joint research and development (R&D) initiatives that would foster interactions between international, regional and national

partners. Such initiatives would need to provide science-based analysis and strategic guidance in developing coherent continent-wide strategies for advancing sustainable renewable energy policies, and at the same time, enhance research and development capacity in Africa.

Since the oil crisis in the early 1980s, energy research and development in Africa have largely concentrated on renewable energy resources as alternatives to fossil fuels, except in a few countries that have significant projects on fossil fuels. These research and development efforts are, to a large extent, externally funded, small-scale and uncoordinated in nature, and generally have weak economic and policy links. Hence, these activities have failed to cope with the identified energy challenges, a reality which underscores the need for local innovative thinking through intense research and development activity. As a way forward, it would be vital to convince national, regional and international financial institutions to invest more in local renewable energy research and development efforts, and to link targeted research and development efforts to existing economic development and technology projects or programmes at national levels.

IN SUMMARY:
In order to exploit and effectively use Africa's abundant renewable energy power potential, which is substantially larger than the continent's current and projected power consumption, a better understanding and mapping of the available resources is essential in order to help governments establish ambitious yet realistic targets and effective supporting policies.

Although Africa has a substantial new and renewable energy resource base, most of this remains under-exploited and the energy production and consumption on the continent remain considerably low, compared to other regions of the world. As a way forward, greater national, regional and international investment that targets energy research and development is essential.

2. Overview of Energy in Africa

Africa has a landmass of just over 30.3 million km^2, an area equivalent to the landmass of the United States of America (USA), Europe, Australia, Brazil and Japan combined. There are about 1.1 billion people in Africa (World Bank, 2015), in 54 countries that are varied and diverse in size, socio-cultural entities and resource endowments, including fossil and renewable energy resources. Most of these energy resources are yet to be exploited, which is a contributing factor in making the continent the lowest consumer of energy, as illustrated in Figure 1. Access to electricity, a generally accepted indicator of any country or region's socio-economic development, is low in Africa and particularly in sub-Saharan Africa. In 2015, for example, Africa used about one eleventh, one sixth, and one half respectively of the energy used by North American, Europe and Latin America.

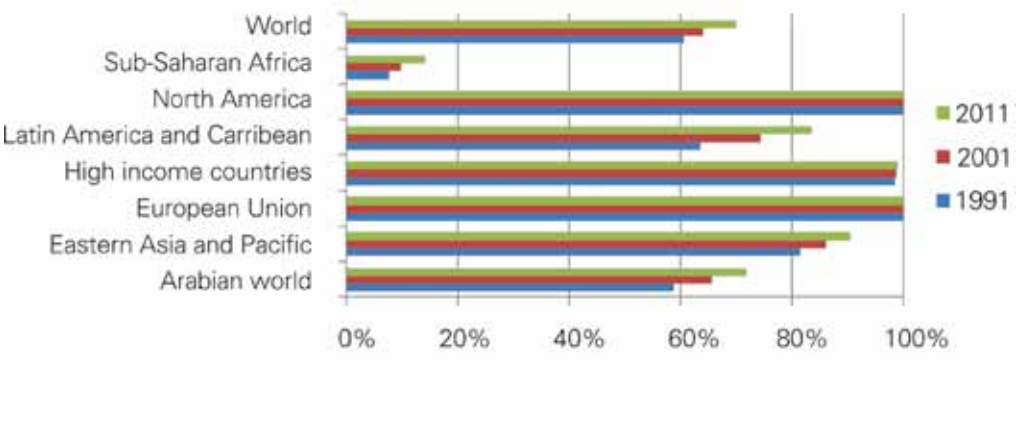

Figure 1. Evolution of electrification rate through the world (World Bank, 2015).

There is an urgent need for substantial increases in energy consumption in Africa if the continent is to be competitive with other developing regions of the world. Equally, there is an urgent need substantially to increase access to energy sources for sustainable socio-economic development across all levels of society.

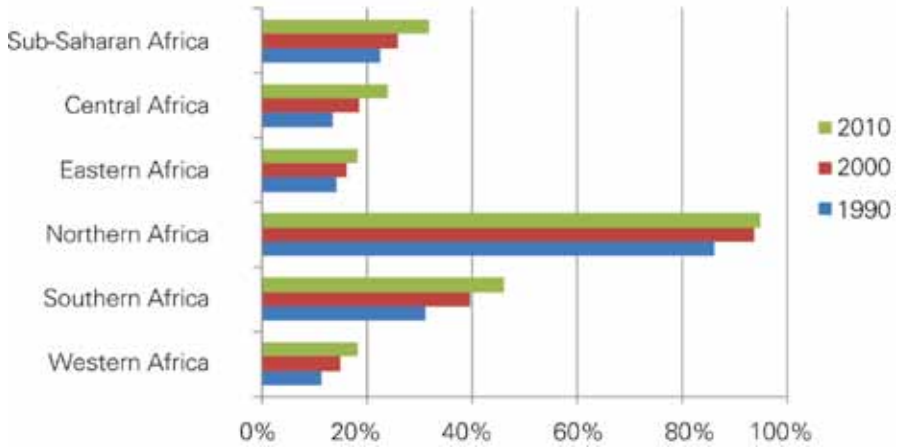

Figure 2. Per capita electricity use by regions of Africa (World Bank, 2015).

Figure 2 shows that in sub-Saharan Africa, only 53% of urban and 8% of rural populations have access to electricity, compared to 99% and 88%, respectively, in northern Africa (World Bank, 2015). A few countries in Africa, such as Ghana, Mauritius, South Africa and Zimbabwe, are above these averages. All the developing regions of the world, apart from South Asia and Africa, have managed to narrow the gap between urban and rural areas in terms of accessibility to electricity. The rural areas of Africa pose specific challenges, mainly because of their low population density and remoteness, both of which result in high costs of production, transmission and distribution of electricity.

Africa's crude fuel reserves at the end of 2014 were 129 billion barrels, equivalent to 7.6% of the world total and enough to last 42 years at current production levels. The current African reserves are more than double those at the end of 1994. African countries with the largest reserves are Libya and Nigeria, followed at a distance by Angola and Algeria. The major African producers are Nigeria, Angola, Algeria and Egypt. The average African oil consumption by 2014 was 3.8 million barrels per day, up by 4.2% to stand at 4.3% of the world total. Egypt, South Africa and Algeria were Africa's largest consumers. 48% of African consumption was middle distillates compared to a world average of 37%. Total African oil refining capacity in 2014 was 3.5 million barrels per day, similar to the 2013 level and just 3.7% of the world total (BP, 2015).

Africa's natural gas reserves at the end of 2014 were 14.2 trillion cubic metres, 7.6% of the world total and sufficient to last 70 years at current production levels. Nigeria and Algeria hold the bulk of African natural gas reserves, followed by Egypt and Libya. In 2014 African natural gas production was 202 billion cubic metres. African natural gas consumption in 2014 was 120 billion cubic metres, 3.5% of the world total. Africa's major consumer nations are Egypt and Algeria with South Africa coming a very distant third. At the end of 2014, African coal reserves stood at 32.9 billion tonnes, 3.7% of the world total and enough to last 122 years at current rates of production. South Africa is the only African country with significant coal reserves. In 2014 African coal production was 268 million tonnes, 1.2% up on 2013 and 3.9% of world production. South Africa, the world's seventh largest producer, accounted for about 97% of African production with Zimbabwe at the opposite extreme, contributing less than 1%. African coal burning in 2014 was equivalent to 98.6 million tonnes of oil, 2% up on 2013 and 2.5% of the world total. South Africa, the world's sixth largest user of coal, accounted for more than 90% of coal burned in Africa, a number likely to increase significantly as major new coal-fired power stations come into operation (BP, 2015).

Significant geothermal resources exist along the Rift Valley in eastern Africa, in Djibouti, Eritrea, Kenya, Malawi, Mozambique, Tanzania and Zambia. The geothermal energy potential on the continent has been estimated in the range of 2.5–6.5 GW, but at present only Kenya has exploited this resource with an installed capacity of 129 MW. Plans are at different stages aimed at advancing this Kenyan experience in several countries in the Rift Valley area. Also, Africa has the world's best solar resources. For centuries, several countries in the region have exploited solar energy for water heating, crop drying, medical applications, and telecommunications, among other uses. The wind potential estimated for Africa is currently at 10 600 TWh/yr, assuming that 10% of the land area has average wind speeds exceeding 5.1 m/s at a height of 10 m. However, useable wind energy occurs in highly localised areas and therefore requires detailed assessment.

Traditional biomass in the form of firewood and charcoal is widely used in Africa for providing heat energy in households. This use is inefficient and in some areas puts pressure on biomass resources. Residues from agriculture and forestry can provide major opportunities for modern biomass energy in the region. Mauritius, Kenya, Tanzania and Egypt are exploiting bagasse for the generation of electricity. Ethanol from sugar cane is produced as an additive to gasoline in some African countries. There is also potential for biodiesel production and use.

Over 70% of oil consumed in Africa is by six countries, namely Tunisia, Morocco, Egypt, Algeria, Libya and South Africa, and over 60% of the natural gas consumed in Africa is by Algeria, Libya, Egypt, and Nigeria (Figure 3).

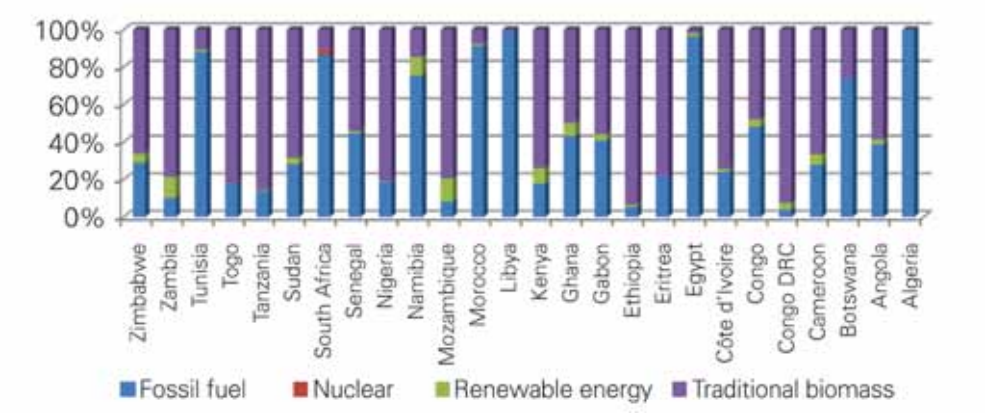

Figure 3. Percentage energy utilisation in Africa by country (World Bank 2015).

Figure 3 shows that the region still depends heavily on inefficient traditional biomass (used in particular for cooking in households), which accounts for over 80% of primary energy demand. With the exception of South Africa, where about 15% of the population depends on traditional biomass energy, almost 80% of the population in sub-Saharan Africa depends on biomass resources for cooking (World Bank, 2015).

Firewood and charcoal burn inefficiently, resulting in major energy losses (up to 15%). Furthermore, when burned indoors, they emit pollutants such as carbon monoxide, small particulates, nitrogen oxides, benzene, butadiene, formaldehyde, poly-aromatic hydrocarbons, and many other health-damaging substances. It is estimated that 393 000 deaths in sub-Saharan Africa in 2002 were due to indoor air pollution from the burning of biomass fuels (WHO, 2006). Women and children are particularly vulnerable as they do most of the cooking.

IN SUMMARY:
Electricity in Africa comes mainly from fossil fuels and hydropower, but the average electricity consumption is the lowest in the world, at 515 kWh/yr, compared to a world average of 2 326 kWh/yr (Karekezi, 2006). Furthermore, energy consumption is skewed: about 40% is consumed in the northern region, 40% in South Africa, and the remaining 20% by all the other African countries (Davidson and Sokona, 2002). Traditional bio-mass remains the major energy type for Ethiopia, Democratic Republic of the Congo (DRC), Tanzania and Togo.

For the African region to improve its developmental status, its energy research and development (R&D) capacity must be strengthened and integrated with energy policies and implementation strategies. This Science Plan will therefore discuss some proposals for energy R&D that are intended to address the key challenges in the energy sector. As background, these challenges are enumerated below, along with a brief discussion of relevant energy projects in the region, and a review of some of the progress achieved in the energy sector.

Source: http://blog.worldagroforestry.org/index.php/2013/10/03/unpacking-the-evidence-on-firewood-and-charcoal-in-africa/

3. Energy Challenges in Africa

Energy is a basic prerequisite for economic and social development, health, education and several other aspects of human life. The energy challenges in Africa are many, and it is clear that these challenges have a negative impact on the region's overall social and economic performance. Improving the added value of African products will require modern and sustainable energy provision for manufacturing, processing, storage and transportation. So too will the region's relatively poor health and education standing, measured against global indicators, be greatly improved with the provision of modern energy services.

While Africa's contribution to global greenhouse gas (GHG) emissions is only about 3%, the continent is the most vulnerable to the impact of climate change, a global threat that is primarily due to the concentration of such gases in the atmosphere. It would be important for African countries to embark on energy development paradigms that are less carbon intensive than those of the past. Such ventures will need innovative thought and planning. An additional factor that would need to be considered is that international financing of projects, on which most African countries depend, often stipulate certain environmental criteria that must be adhered to if countries wish to access such finances. Hence, reconciling global and/or local environmental concerns with Africa's energy development needs will require new thinking and funding, including local funding.

Scaling up the use of energy for growth must overcome the complexities and challenge of energy issues. In addition to the various dimensions related to socio-economic development, such challenges include the extremely low generation, transformation and transportation capacities; low access to and supply of sustainable sources of modern energy, particularly in poor rural areas; weak institutional capacities, especially related to governance in the energy sector; lack of adequate tools for effective energy planning and policy formulation; and a weak energy demand base.

Overcoming these challenges will need intensive and organised R&D activities to facilitate informed energy decision-making. This means that energy R&D needs to be strengthened in Africa, especially in sub-Saharan Africa, despite existing capacity building efforts by several universities and research institutions in the region and some coordinating networks such as the Environmental Development Action (ENDA) and the African Energy Policy Research Network (AFREPREN).

Furthermore, the energy production-to-consumption ratio is high in Africa, largely due to poor regional and sub-regional networks, as well as the heavy reliance on external financing. An important contributing factor to the poor energy demand base is Africa's low levels of industrialisation. Also, most countries have not mobilised local finances for energy resource development. At the same time, external private investments and official development assistance (ODA) are declining. Consequently, energy investments are far below the required level to satisfy the region's needs. Unfortunately, although foreign direct investment (FDI) to the region has shown some increase, it is mainly confined to upstream oil extraction development and limited to less than 10% of the countries in the region (Davidson and Conteh, 2006). An urgent need, therefore, is to identify innovative means of financing the development of fossil and renewable energy resources.

3.1 Main Energy Challenges

Four main sources of energy and energy use in Africa are described to illustrate specific challenges and opportunities:

Traditional biomass

Traditional biomass use refers to the use of wood, charcoal, agricultural residues and animal dung for cooking and heating in the residential sector. It tends to have low conversion efficiency (10% to 20%) and often an

unsustainable supply. The share of traditional biomass is over 50% in many countries, and as noted earlier, accounts for over 80% of households' energy balance (Figure 4).

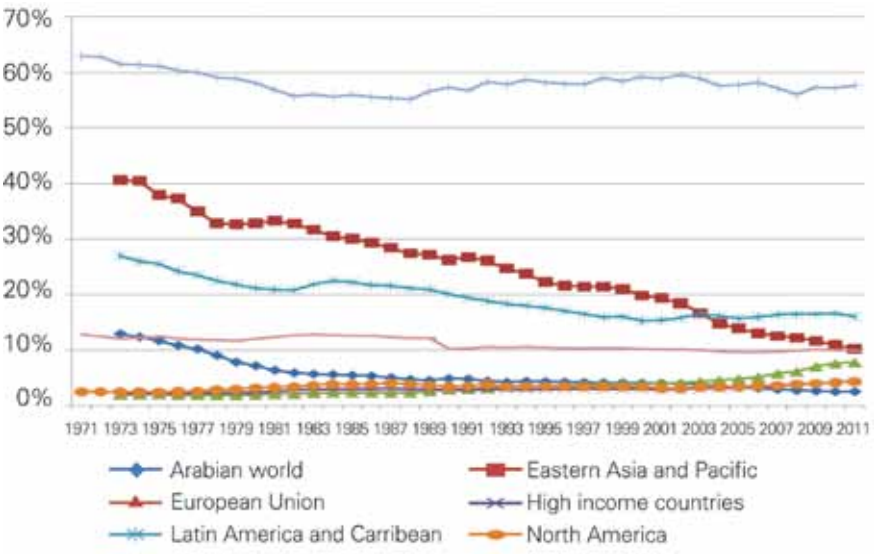

Figure 4. Evolution of the share of traditional biomass energy from 1971 to 2011 (World Bank, 2015).

High oil prices, unfavourable currency exchange rates, and persistent poverty explain the reason why wood-based fuels consumption remains high. The high quantity of wood burnt to meet energy needs inevitably leads to deforestation. Deforestation and unsustainable forest management lead to ecosystem degradation, with negative repercussions on the overall potential for a wide range of ecosystem services. It is reported that forests play an essential role in mitigating climate change and providing products and ecosystem services that are essential to the prosperity of humankind. Studies show that sustainably-sourced wood fuels are carbon-neutral, so their replacing fossil fuels can contribute to climate change mitigation.

Traditional biomass widely used by households as fuel is the main origin of indoor air pollution which has a negative impact on health. The direct burning of agricultural waste such as harvested residues and manure (cow dung) also leads to decreased cropland fertility and increased pressure on forest for new agricultural land. The challenge in the use of traditional biomass energy is to promote sustainable forests management and perennial energy crops in order to harness and increase woody biomass resources. In addition, it will be important to improve the technology of biomass energy conversion and use.

Fossil fuel

Fossil fuel in the form of oil products, coal and natural gas is the second most important source of energy consumed in the world. In many countries in Africa the share of fossil fuel in the energy balance is around 20%. Oil products contribute between 50% and 98% of all fossil fuel used, with oil consumption in Africa remaining the lowest in the world (Figure 5).

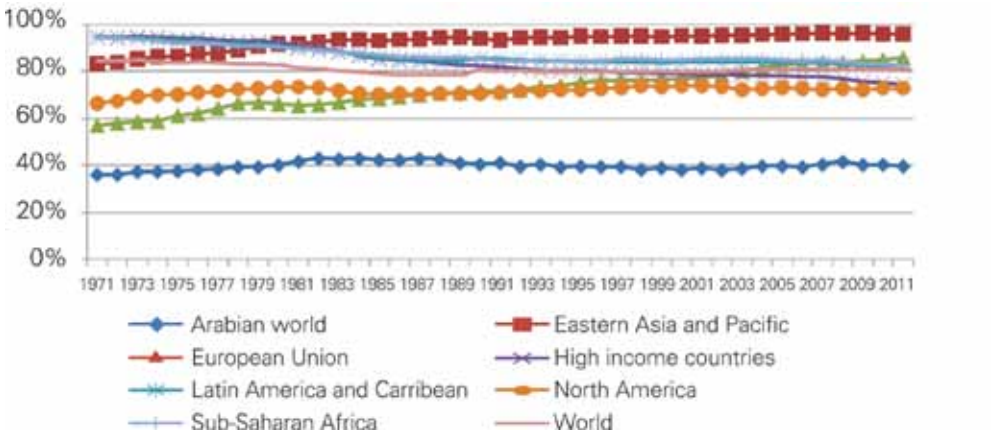

Figure 5. Evolution of the share of oil consumption (% of the final energy consumption) (World Bank, 2015).

Fossil fuel combustion is primarily responsible for the exponential increase in atmospheric CO_2 concentrations since the industrial revolution, and the principal cause of anthropogenic climate change. The environmental challenge is to substitute fossil fuel with low carbon energies as soon as possible in the sectors where this can be achieved at acceptable costs. This would mean keeping fossil energies for the sectors where no competitive alternative fuel is available at the levels required, such as aviation and transport, or when the fuel is vital to ensure economic growth and energy access.

Renewable energy sources

The African continent has vast renewable energy potential which comprises solar, wind, modern biomass conversion to bio-energy, hydropower, geothermal and wave and tidal energy from the oceans. However, Figure 6 underlines the modest exploitation of these renewable resources. It is estimated that Africa's abundant renewable energy resource can provide 100 times the present global energy consumption. Renewable energy is correctly perceived as inherently more environmentally-sound and increasingly cost-effective. Therefore, increasing the share of renewable energy is a fundamental driver for the transformation of Africa's energy systems. Supporting rapid advances in renewable energy technologies and their deployment will be critical in accelerating this transition that can dramatically reduce greenhouse gas emissions, insulate countries from fuel price volatility, and thus benefiting hundreds of millions of people.

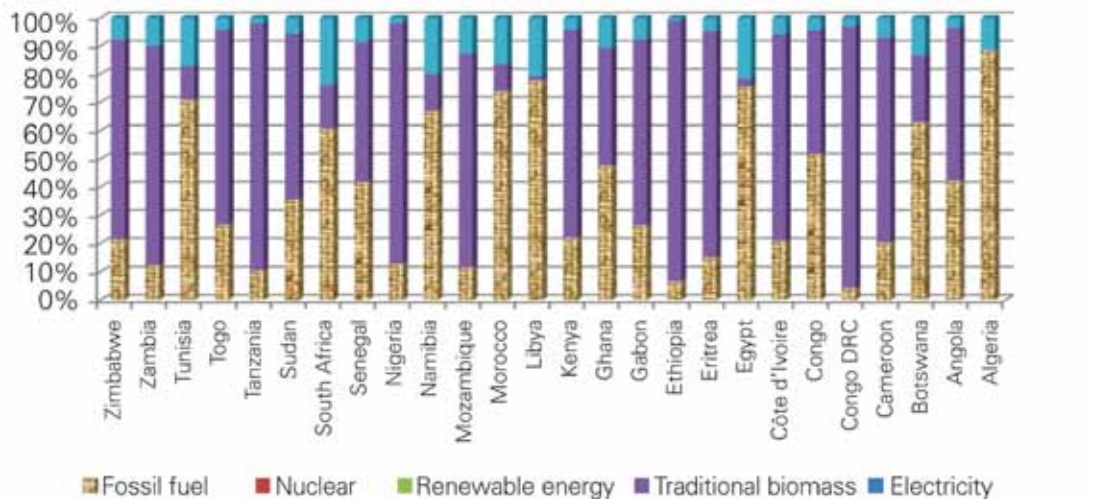

Figure 6. Energy consumption by type of energies in some African countries in 2012 (World Bank, 2015).

Within the ambit of renewable energy, the system of 'waste-to-energy', especially by using natural materials (Kowenje and Onyango, 2015), is a viable waste management and energy producing solution. Waste-to-energy prevents the release of greenhouse gases. It is also a good alternative to coal and depletes less of Earth's natural resource than fuel. On the African continent, proven experiences on waste-to-energy are noted in agro-based industries and in cases of municipal solid waste management. Several agro-based projects, such as wood based industries, vegetable oil factories (palm and groundnut), rice mills, sugar, paper and pulp industries, use their waste to produce both heat and power. Most of these industries can produce significant power that can be used either by nearby settlements or sold to the national grid. Recently, waste-to-energy has been extended to liquid waste with vast power potential, compared to solid waste. Relevant experiences have been recorded with palm oil effluent, wastewater from slaughterhouses, distilleries, the dairy industry and tanneries.

Nuclear energy sources

Nuclear power has historically been an important contributor to both the security of electricity supply by providing a base load source of energy, and reducing CO_2 emissions. It is considered a base load source of energy, especially in the Organisation for Economic Cooperation and Development (OECD) countries where new hydropower projects are very limited. However, many environmental and management concerns do not promote nuclear energy as a valuable alternative source of energy, despite the potential noted on this continent. Key factors impede and limit the use of nuclear power, which include waste disposal, accidents and nuclear failure that could release enough radioactivity to make many spaces uninhabitable or not suitable for agricultural activities, the contamination of water resources, and also technological challenges.

3.2 Additional Challenges

In broad terms, Africa is facing three energy challenges: environmental and socio-economic challenges, as well as challenges related to energy access and security. The first two sets of challenges have already been

described and are briefly re-emphasised here. This is followed by a description of the challenges related to energy access and security.

Environmental challenges

Energy consumption has serious and significant impact on the environment. Air pollution, climate change, deforestation, inhabitable spaces and indoor air pollution are the main consequences of and environmental burden related to unsustainable forms of energy use. The energy sector accounts for around two-thirds of global greenhouse gas emissions (GHG). Considering appropriate and sustainable energy sources is therefore central to tackling climate change.

Socio-economic challenges

Access to reliable sources of modern energy is generally accepted as an indicator for the overall socio-economic development of a country or region. The energy sector therefore has a critical role to play in providing universal access to energy. This means access to modern energy sources for almost 1.1 billion people living in Africa, and particularly for those in rural areas without access to electricity who rely on the traditional use of biomass for cooking and heating purposes.

Limited and unreliable energy access is a major impediment to economic growth. Access to energy is directly related to income and poverty. For example, the lack of purchasing power in rural communities to pay for the cost of services, insufficient technical capacity and the shortage of a skilled workforce aggravate the situation of poverty and affect the context of industrial productivity and competitiveness.
An analysis of the final energy consumption by sectors in Africa (Figure 7) shows that the productive use of energy (referring to the economic sector, including industries, commerce, agriculture and the fishing sector), has the lowest energy consumption, compared to the household and transport sectors.

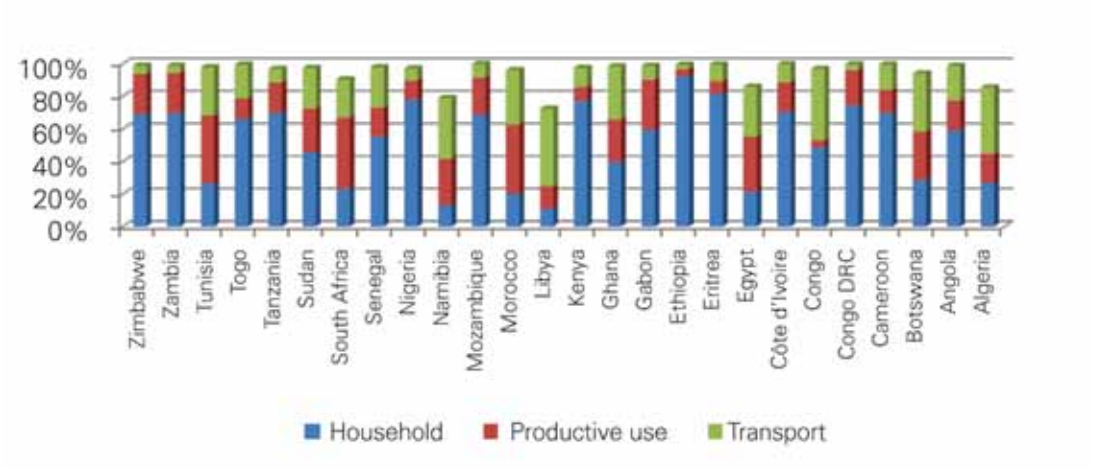

Figure 7. Energy consumption by sectors in Africa in 2012 (World Bank, 2015)

Developing a competitive energy sector requires large numbers of highly skilled people in many specialised areas. Some skills do exist in Africa, but not in sufficient quantities to meet the demand. Improving skills to

achieve optimal human resource capacity, and strengthening institutions to compete internationally, are urgent concerns. A related problem is the retention of human capacity. Unfortunately, many of the functions that are needed in Africa are carried out by foreign personnel, which result in significant financial and capacity drain. The areas most affected include oil and gas exploration and development; power generation, transmission and distribution; and financial investment decision-making related to energy. These areas encompass energy planning, analysis and modelling based on national, sub-regional and regional data.

In the region, some countries such as South Africa, Cote d'Ivoire and Kenya, which do not produce oil, have more efficient refineries than oil-producing countries such as Nigeria, Angola and Gabon. As a result, countries with efficient refineries have become regional suppliers of oil products. There is a need to create a more rational basis for oil production, refining and use. Joint procurement of oil and gas will result in gains from the benefits of economies of scale, and eliminate or reduce expensive third-party financing. Greater use of joint oil refining will reduce losses and improve the continent's overall refining capacity. Several power interconnection facilities exist within the region, but improving these and introducing several more will improve the region's power supply reliability. However, to benefit from the gains of international energy cooperation and trade, standards and policies need to be harmonised and economic cooperation enhanced. Furthermore, greater cooperation for sharing relevant experience among the various sub-regions of Africa will lead to optimal benefits.

Energy access and security challenges

Addressing energy access and security should be aimed at increasing access to modern and diversified energy for the majority, and to respond to the increased burden related to the high cost of fossil fuel compounded by power shortages, and frequent electricity outages. Addressing these challenges would necessarily lead to the up-scaling of new energy developments in Africa, to enhancing wider access to modern forms of energy, and to strengthening the continent's energy security (AUC, 2015).

Access to new energy involves technology transfer and adapting new technologies and systems to suit local needs. It is therefore important to strengthen and expand existing regional networks that bring together national, sub-regional and regional institutions working on new energy, and promoting the exchange and sharing of experience and skills, so as to support enterprises involved and interested in local manufacture and maintenance, or the servicing of new energy.

In addition, special efforts are needed to mobilise sustainable local funding for energy projects, so as to reduce the reliance on external sources of funding. Additional areas that would need special attention to reduce the cost of energy projects include: investigating ways of reducing the long lead times between project/programme conceptualisation and implementation, and developing the downstream energy sector. Increasing energy demand in the industrial and commercial sectors is crucial to ensuring that a large share of energy produced will be used within the continent, as that will yield associated economic benefits.

The sustainable development of a viable energy sector will require decisions and actions by multiple institutions and stakeholders, including the public and private sectors, non-governmental organisations, international bodies, and user groups. The effective participation of all these groups will need a strong and adequate policy, and firm legal, regulatory, institutional frameworks, and at times government subsidies which are conducive to both domestic and foreign investors. An additional area that needs urgent attention is the development of capacity so as to negotiate effectively with the private sector, and with bilateral and multilateral organisations and international agencies. In particular, the growing interest in the oil and gas resources of the region will require the development of new negotiating skills to cope with experienced external investors. The current inadequacies further increase the transaction costs of energy projects and programmes.

IN SUMMARY:
To conclude this section, the African Union Commission (AUC, 2015) points to several energy challenges in Africa, which include: low generation capacity and efficiency, high costs, unstable and unreliable energy supplies and low access rates, low levels (or in some cases a lack) of effective policies, and of regulatory and institutional frameworks, and small energy markets which are not attractive to energy investors.

In turn, the Future Earth (2015) vision links an improved energy situation in Africa to the following:

- Deliver water, food and energy for all and manage the synergies and trade-offs among them, by understanding how these interactions are shaped by the environmental, economic, social and political changes.
- Decarbonise the socio-economic systems to stabilise the climate by promoting the technological, economic, social, political and behavioural changes enabling transformations, while building knowledge about the impacts of the climate change and adaptation responses for people and systems.
- Encourage sustainable consumptions and production patterns that are equitable by understanding the social and environmental impacts of consumptions of all resources, opportunities for decoupling resource use from growth in well-being, and the options for sustainable development pathways and related changes in human behaviour.

Taken together, the two positions sum up the challenges and what ought to be accomplished. The section below provides an overview of substantial achievements at different levels across the continent.

4. Overview of Energy Projects in Africa

For several decades now, many energy projects have been undertaken and others planned both for direct developmental purposes, and for research and development. According to the African Union Commission Initiatives for Africa's energy sector (AUC, 2015), there will be a 6% increase in annual demand to the year 2040. To keep pace, generating energy also needs to increase annually by over 6%, equivalent to 140 GW in 2012, to about 700 GW by 2040. With modern energy demands continuously on the rise, there is the need to develop large scale energy infrastructure at the continental, regional and national levels to meet the current and future demands. These projects are carried out by external as well as internal organisations on either a regional, sub-regional or national scale, though some overlaps occur among the projects. The projects are briefly discussed along regional, sub-regional and national lines.

4.1 Regional Projects

The African Union (AU) is premised on African states making commitments to good governance, democracy and the preservation of human rights. The AU has an energy initiative that aims at developing vast African energy resources in a sustainable manner to ensure increased productivity, wealth creation and improved quality of life for all Africans. This initiative is articulated in the New Partnership for Africa's Development (NEPAD), which is a holistic and comprehensive strategic framework for the continent's socio-economic development.

AU/NEPAD is based on self-development and self-reliance, using collective means to exploit opportunities in Africa. This involves facilitating and ensuring constructive partnerships between African countries and the

developed world, based on mutual interest and benefits, and shared commitment – driven by African ownership and leadership. Among the energy projects and plans within AU/NEPAD are: the formulation of suitable energy policies aimed at cooperation for sub-regional development; electricity grid interconnection among countries, and a possible pan-African electricity grid; oil and gas pipeline projects; resource development (especially major hydropower sites); solar power initiatives, and the energy information development project. All these projects are at different levels of development, with the Energy Information Project well-advanced and collaborating with the World Energy Council (WEC) and the International Energy Agency (IEA). It is being run by the Energy Commission of AU/NEPAD, that is, the African Energy Commission (AFREC). Another project that is relatively advanced is the study of regional energy integration.

The Forum for Energy Ministers in Africa (FEMA), which advocates for major energy security and infrastructure projects, has undertaken two situation analysis studies. One is focused on identifying the key challenges facing the continent and possible policies to overcome them. The other has looked at energy and poverty reduction with the hope of identifying key energy targets for achieving the Sustainable Development Goals (SDGs). The African Ministerial Conference on the Environment (AMCEN) is interested in the environmental challenges facing the African energy sector and searching for and investigating ways to overcome these challenges.

4.2 Sub-Regional Projects

Currently, several sub-regional economic bodies are conducting numerous energy initiatives. In the western sub-region, the Economic Community of West African States (ECOWAS) has two main ongoing energy projects: the West African Power Pool (WAPP) that aims at connecting all the electricity grids of member countries, and the West African Gas Pipeline Project (WAGPP) that aims at connecting three countries to Nigeria's natural gas supply. In addition, the West African Solar Energy Project (CILES) undertakes several renewable energy projects in nearly all the countries in the Sahel.

The Economic Community of Central African States (ECCAS) has set up a power pool, *the Pool Energétique d'Afrique Centrale* (PEAC) that connects the various countries in the sub-region. There is also a mini-pool connecting Burundi, the Democratic Republic of Congo and Rwanda, and the countries in Eastern Africa have formed a pool known as the East Africa Power Pool (EAPP). An oil pipeline connecting Tanzania to Zambia has been constructed, and crude oil flows from Dar es Salaam harbour to Zambia.

The inter-connection in the Southern African Development Community (SADC) is far advanced. The Southern African Power Pool (SAPP) is well-established and some countries are now benefiting from the optimisation of power sharing. They have also embarked on a sub-regional project in energy efficiency and a biofuels programme, which aim to promote efficient technologies and reduce reliance on petroleum fuels. The gas pipeline between Mozambique and South Africa has been commissioned and is fully operational. There is also the Nile Basin Initiative (NBI) involving Burundi, DRC, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda.

4.3 National Projects

Most countries in Africa have initiated numerous national energy projects. Prominent among these are the following:

- Several solar power generation projects in the Sahel and parts of South Africa and Kenya.
- The reduction of natural gas flaring in Nigeria along with demand stimulation projects to utilise the gas.
- Capacity building projects with formal training ranging from short courses to undergraduate and postgraduate programmes. Ghana, Nigeria and South Africa are among those involved.

- The South Africa-Botswana methane gas pipeline project.
- Biofuels as alternative fuel projects in several countries.
- Ethanol production in Zimbabwe and Malawi.
- Land Fills to Bio Gas projects in South Africa and Tunisia.
- Geothermal generation of power in the Greater Rift Valley of Kenya.

4.4 Multi- and Bi-Lateral Projects

Various United Nations bodies have energy projects on the continent. The United Nations Development Programme (UNDP) has projects in several countries. These include the promotion of liquefied petroleum gas (LPG) as alternative cooking fuel in some countries. The UNDP is assisting rural women in Mali to produce biofuel for productive activities. The United Nations Environment Programme (UNEP) is working with several countries to study the relationship between energy systems and the environment. In addition, the United Nations Economic Commission for Africa (UNECA) is coordinating a UN system-wide collaborative mechanism involving other African regional organisations, such as the African Development Bank (AfDB), the AU, AU/NEPAD, and others, in support of NEPAD programmes, including the energy programme.

The World Bank has also initiated several energy projects in its member countries. They fall mainly into three groups: power sector reform; development of energy infrastructure and energy services provision; and poverty reduction. The World Bank recently joined other donors to form an Energy Infrastructure Consortium that could jointly fund energy infrastructure in Africa.

Energy development and R&D projects feature among several bilateral programmes with the Development Assistance Countries (DAC) in the region.

- The German government, through its funding agency, the German Federal Enterprise for International Cooperation (GIZ), is running energy projects in selected countries. These include energy advisory services in Uganda, rural electrification and household fuel management in Senegal, renewable energy development in Tanzania, household energy in Ethiopia, promotion of biomass conservation in eight SADC countries, and sustainable biomass energy supply in Madagascar, among others.
- Similarly, France has several energy projects with its former colonies, mostly in West Africa. These projects involve power and renewable energy projects.
- Denmark has renewable energy projects in Burkina Faso, Ghana, Kenya and some countries in southern Africa. The projects range from power plants to renewable energy projects.
- Norway is working with a few countries on oil development projects.
- Sweden, through the Stockholm Environment Institute, is working on several renewable energy projects in selected countries in southern Africa, Zambia and Tanzania.

In addition to bilateral projects, some regional energy networks undertake energy research development and design (RD&D) work relevant to the projects discussed below. The Global Network on Energy for Sustainable Development (GNESD) Type II initiative from WSSD is working with three energy centres in the region, namely, AFREPREN in the east; the Energy Research Centre (ERC) at the University of Cape Town in the south; and ENDA in the west. They are identifying suitable pro-poor policies for power sector reform and renewable energy development. The Global Village Energy Partnership (GVEP), another Type II initiative, is at present working with Senegal on a rural electrification project; in Ghana on an Energy for Poverty Reduction Action Plan; and in Kenya on energy data collection and analysis. The African Rural Energy Enterprise Development Training Programme (AREED), which is funded by UNEP, is working with Senegal and Zambia to train small and medium-sized enterprises in business development within the energy sector with the aim of increasing their productivity.

There are also regional RD&D centres that are working on a wide range of projects covering power sector development, transport energy, and renewable energy development. These include AFREPREN, which is located in Kenya and works with most of the countries in eastern and southern Africa; ENDA, which is located in Senegal and works with most of the former French countries in West and Central Africa; and the Kumasi Institute of Technology and Environment (KITE), which is located in Ghana and works with selected West African countries.

5. Progress in the Energy Sector in Africa

Modern energy demand is continuously on the rise in Africa. As noted earlier, the indication is that energy output in Africa needs to grow annually by 6% to 3188 TWh/year by 2040 (AUC, 2015). To meet the growing energy demand, to promote power trading between countries and regions, and to improve energy security, the following programmes and initiatives were proposed by the AUC:

- In 2012, the Programme for Infrastructure Development in Africa (PIDA), which by 2040 will cost about USD 360, was initiated to facilitate continental integration, and socio-economic development and trade, through improved regional infrastructure. This is expected to increase electricity access to 70%, by enabling an additional 800 million people power access.
- The hydropower 2010 initiative to harness the power potential in major river basins on the continent.
- The Eastern African regional geothermal programme, to encourage the public and private investors in geothermal energy development by providing grants.
- Solar energy potential assessment in the Sahara and Sahel regions and in high solar intensity regions.
- The renewable energy cooperation programme under the African-EU energy partnership.
- The sustainable energy for all (SE4ALL) initiative in Africa aimed at ensuring modern energy access, as well as doubling the use of renewable energy and efficiency by 2030.
- The power Africa initiative.

Still, modest progress has been made in the energy sector in Africa, with progress mainly attributed to internally- and externally-funded national, regional, and international energy and energy-related initiatives. Access to modern energy services in both rural and urban areas (household and productive sectors) has grown. Recent efforts to improve off-grid energy systems, largely based on renewable energy, have been developed in the rural areas of many countries and are slowly being accepted by authorities as an important option for greater access to energy. The development of indigenous energy resources has increased mainly due to Foreign Direct Investment (FDI), although this has essentially been on upstream projects (such as oil and gas). Energy cooperation and trade among African countries, including developments within sub-regional economic groups, have increased significantly. The number of well-trained energy professionals has risen, and the performance of energy decision-making institutions has improved.

Access to modern energy has increased modestly in sub-Saharan Africa in the past few years, from 17% to 24% as in the years 2000–2002 and from 3% to 9% in rural areas (IEA, 2004). These increases which are due to many national initiatives, such as the ongoing power sector reform programmes, are still insufficient to improve the region's competitive position, compared to other developing regions of the world. However, externally initiated power sector reform programmes have produced mixed results. Improved road and pipeline networks have led to better distribution of petroleum products. Greater attention paid to rural areas, especially by non-governmental and international organisations, has also facilitated access to modern energy services in these areas, though more action is needed to improve the sustainability of such endeavour. Energy cooperation and trade have grown in many of the sub-regions. The Southern African Power Pool (SAPP) is a clear example of how countries can cooperate effectively to ensure optimal benefits. The Western African Power Pool (WAPP), although not as developed as SAPP, has started showing positive results. The other power

pools are EAPP in Eastern Africa and PEAC in Central Africa. In addition, several bilateral power agreements among countries have been signed and most of them are now in operation. The pipeline project between Kenya and Burundi through Uganda, and the gas pipeline between South Africa and Mozambique are examples of successful bilateral agreements in the oil and gas sectors. The West African Pipeline Project will, on completion, be an example of effective cooperation between four West African countries.

Botswana, Ghana, Senegal and Sudan have successfully benefited from both locally initiated programmes and externally funded projects to replace the use of traditional fuels with Liquefied Petroleum Gas (LPG) in their urban areas, and to increase the use of this fuel in rural areas. The biofuels programme in Mali, which is being replicated in a few other countries in the region, is a promising case for substituting petroleum fuels for productive activities in land-locked oil importing countries. A few relatively large-scale renewable energy projects in the region have shown some success, such as, for example, the Global Environmental Facility (GEF) sponsored projects in Zimbabwe, the Western African Solar Energy project (CILES) in West Africa, and the Eskom/Shell project in South Africa.

There have been advances in the training of energy professionals, within and outside the region, although the retention of staff is still a problem for many countries. Undergraduate and postgraduate energy programmes are on offer at certain universities and other training institutions. Research and development capacity has grown due to many local and international efforts, especially in the postgraduate training domain. Programmes such as that of the Global Network on Energy for Sustainable Development (GNESD) and some bilateral assistance projects have contributed to the overall effort. In many countries, small and medium-sized energy service enterprises have been established, especially in renewable energy. South Africa, for example, has developed integrated energy centres that are one-stop shops providing energy solutions to rural communities and access to affordable, safe and sustainable energy services.

National capabilities in energy agencies for energy planning and policy development have improved in many countries through energy projects and related programmes such as national communications for climate change. Capability in energy modelling has increased, although not substantially because of data limitations. In addition, information sharing on modern energy technologies and the services associated with technologies has improved substantially. The growth of many energy network activities such as GNESD, Renewable Energy and Energy Efficiency Partnership (REEEP), the Global Village Energy Partnership (GVEP), and others, have, as a result of the World Summit for Sustainable Development (WSSD), contributed to greater knowledge and capacity building in several African countries.

Despite all these efforts and modest progress in the region, many gaps remain. Some of these can be filled if the necessary R&D initiatives and programmes are undertaken in a sustainable manner, as this will result in providing the science-based information needed for effective policy-making in the energy sector. The following are among the gaps identified:

- There is a need for the substantial increase in guaranteed energy supplies, and for sustainable rural and urban access to energy.
- Energy models and scenarios for Africa need to be developed.
- Timely energy demand growth needs to be stimulated. Realising that progress has been made in some of these areas, however, and also taking into consideration the strength and capability of ICSU ROA in terms of both funding and technical capacity, priority is given to three key areas, namely–

    · the development of energy models and scenarios for Africa;
    · increasing access to high quality, reliable and affordable energy in a sustainable manner; and
    · the strengthening and retention of human and institutional capacity in the energy sector.

Source: https://pixabay.com/en/forestry-logging-deforestation-960806/

Source: https://pixabay.com/en/pot-fire-cook-lit-wood-fired-oven-1248616/

6. Proposed Action Plan

The analyses of the energy situations in Africa presented in the sections above provide the context for the three major action plans, and for what needs to be achieved in 2017 and beyond.

All action plans would run until the next review of this document. The modelling project, in particular, would require at least five years for meaningful outcomes to be achieved.

Action Plan 1

Development of Energy Models and Scenarios for Africa

Effective energy management and planning in Africa is difficult for several reasons. Among the reasons are the lack of much needed reliable, adequate and relevant energy and energy-related data, and the absence of a coordinated energy planning structure. In addition, the few national and sub-regional efforts in this area are insufficiently organised to be used effectively for conducting a regional activity. It is important, therefore, that an organised data collection and management information system, and a strategy for coordinating development plans and aspirations, be established. These are pre-conditions for scientists, engineers, and technologists to apply their analytical skills in mapping out possible energy futures for the region.

At present, many countries in the region lack an adequate and fully developed energy infrastructure needed to provide the foundation for developing future energy perspectives based on sound and up-to-date science and technology. There exists an opportunity for these countries to try out both conventional and bold new options in mapping out their future energy requirements. To embark on such ventures will require them to have the necessary scientific and technological tools in the form of models and scenarios, so that they can visualise their energy futures effectively. This pursuit will also allow countries in the region to select from a broad range of models and scenarios now globally available that will ensure a more technically and economically efficient, environmentally sound, climate-friendly, and socially responsible energy future. Repeating the adverse impacts of past paradigms could be avoided with the proper selection and adaptation of existing tools. This type of exercise is already being carried out in many parts of the world, and has resulted in the generation of a range of energy scenarios and models with different levels of scientific and technological sophistication. They range from those based on spreadsheet analysis with minimum data, to third-generation equilibrium models that need detailed techno-econometric information. Hence, this project creates an opportunity for competent Africans to customise models and tools to visualise their energy future in ways that will fully reflect regional perspectives and realities.

In other developing regions of the world, such teams exist and are working on similar exercises. In Africa, there are few countries with national activities or ad hoc efforts that are capable of investigating energy futures, and the work undertaken is far from comprehensive and coherent. There is a need, therefore, to set up a coordinating mechanism that will not only harness existing skills and human resources, but also develop these to the required standard so that the region becomes more competitive in the energy sector. Strengthening this research and skills base will also provide a basis for collaboration with similar structures in developing countries and other parts of the world.

The various sub-regional power pools, including the SAPP the WAPP, and the EAPP, demonstrate clearly the region's capacity to coordinate energy development, even though these initiatives are at different stages of development. In addition, there are several cooperating energy activities, such as bilateral and multilateral energy agreements in both the power and the petroleum sectors, which can form the basis for further cooperation. All these efforts demonstrate the willingness to cooperate and to investigate in the future energy scene of the continent.

General foci

The plan is to develop energy models and scenarios with related activities for optimising, managing effectively, and planning energy production, distribution and use in Africa. The implementation of the plan will seek, among other issues, to identify capacity needs for the effective development of models and scenarios for the region through:

- Harmonising national, sub-regional, and regional plans, models and scenarios in the region;
- Developing a harmonised energy database useful for scenario-building and modelling;
- Strengthening human and institutional capacity in scenario-building and modelling for energy and energy-related sectors;
- Developing knowledge networks and other collaborative links among specialists in energy modelling and scenario-building; and
- Keeping track of developments in scientific and technological advances in the energy sector.

Action Plan 2

Increase in Access to High Quality, Reliable and Affordable Energy in a Sustainable Manner in Africa

Africa currently constitutes 14% of the world's population, but accounts for only 2% of the world's gross domestic product (GDP). Although the continent produces 7% of the world's total energy, it consumes only 3% of it. Furthermore, energy intensity in Africa is twice the world average (WEC, 2002). The use of modern energy services is closely linked to economic development, poverty reduction, and the provision of vital services, but consumption of modern energy sources in Africa is extremely low (WEC, 2005a and b) owing to the region's reliance on traditional biomass.

Electricity, the most important energy source in the delivery of the all-important modern functions such as health, education and social services, accounts, for example, for only 4% of sub-Saharan Africa's total energy consumption. Moreover, in sub-Saharan Africa, between 1980 and 2000, electricity consumption declined from 132.6 kWh to 112.8 kWh per capita, even as the world average energy consumption increased substantially (World Bank, 2004). For rural Africa, where the majority of the population lives, the reality is worse. Energy-intensive projects should include improved efficiency for economic activity and production/mobility. Africa also has significant amounts of renewable energy resources yet to be exploited. Furthermore, renewable energy technologies (RETs) have demonstrated a growing potential to meet energy needs where conventional energy supply options have failed. The costs of many RETs are also declining with technology improvements and economies of scale in production. For instance, solar and wind power costs are now half of what they were in the mid-1990s (REN21, 2005). There is also the potential to develop modern biomass technologies in several areas outlined below.

Energy intensity – the ratio of energy consumption to a measure of the demand for services (e.g. constant dollar value of GDP for services) – is a measure of the energy efficiency of a nation's economy. It is calculated as units of energy per unit of GDP. Hence there is a need to search for ways that ensure greater use of RETs in Africa. Overall improvement in quality of life is needed in both rural and urban communities if the true potential for development is to be realised across Africa. Energy projects in the region will therefore need to focus on providing secure and reliable energy supplies at affordable prices, while at the same time building up a sustainable demand. The region is rich in energy resources, however, and needs to use them largely within regional boundaries to create sustainable growth. Such development will be needed by each country, although links among countries will assist in the economic viability of specific development and encourage regional interdependence, trade and development.

African urban populations are growing at rates about twice their national average population growth rates, thus exacerbating the problem of sustainable urban energy access. Current projections indicate that Africa will still, in 2030, host the highest percentage of the world's population without access to modern energy services, and that the size of the population without electricity will increase steadily until 2025 (IEA, 2006).
This trend can and must be reversed, and calls for innovative technological and policy approaches. For example, in the case of electrification, it is estimated that, at the rate of power connections of the past decade, it would take more than 80 years to electrify Africa (IEA, 2002). A model that links the transition to modern fuels with the time when the per capita income reaches US$1 000–1 500 (Toman and Jemelkova, 2003) illustrates this view. Under a business-as-usual scenario, therefore, it will take a long time to realise full access to modern energy technologies in Africa.

International development partners as well as other energy stakeholders at regional and national levels should therefore view the energy access problem as inseparable from poverty reduction efforts and economic growth strategies. However, two major challenges – namely, weak policies and inaccessible financing – hamper efforts aimed at accelerating access to reliable and affordable modern energy options in Africa. It is conceivable, therefore, that the role of energy in achieving the Sustainable Development Goals (SDGs) can only be played out if these key barriers are eliminated.

Inefficient institutional, regulatory, and policy frameworks characterise the energy sector in most African countries. There is a need for African policy-makers to pay special attention to measures that clarify the roles of various stakeholders, improve the investment climate in general through more favourable legal and regulatory reforms, strengthen the role of independent energy regulatory bodies, and remove barriers to the realisation of regional integration energy projects (UNECA, 2006).

Since Rio+20, a number of energy projects have been implemented in the region with varying degrees of success. These, however, are not well documented and it is therefore unclear what useful lessons exist for taking projects to scale across countries in the region.

The need is thus paramount urgently and significantly to improve access to modern energy services in urban and rural Africa. The challenge is to determine how this can be achieved.

General foci

The plan seeks to promote energy research through providing information and knowledge for ensuring a substantial increase in the supply of and access to reliable and affordable energy in both rural and urban areas in a timely manner, so as to promote economic growth and sustainable development through stimulating energy

demand while maximising the use of all local energy resources. Identification of research and knowledge gaps – and of useful lessons for scaling up and financing strategies for the energy sector – are of special interest to the region. Emphasis needs to be placed on the stimulation of modern energy demand for both productive and household activities, improvement of technical and economic efficiency of energy generation, distribution, delivery and usage, as well as the identification of barriers to modern energy technology access and to scale up both policy and financial commitment through private-public partnerships. There is a special need for establishing channels that would be used to make policy recommendations with respect to the options for the increase in supply and access to sustainable energy services.

Action Plan 3

The Strengthening and Retention of Human and Institutional Capacities in the Energy Sector in Africa

As is emphasised in this Science Plan, strengthening and retaining human and institutional capacities in the energy sector is of great importance to sustainable development and environmental conservation. Africa currently suffers a high deficiency in human and institutional capacity. Most countries in the region have limited tertiary-level training opportunities in fields of science and technology (S&T) related to the energy sector. Where such capacity exists, it is difficult to retain skilled personnel for several reasons, which include unfavourable working conditions. Similarly, institutions mandated to build capacity in S&T related to energy are often poorly equipped, and may lack the facilities required for training and access to data sources and information. Furthermore, institutions may have insufficient numbers of qualified and experienced teaching and research staff and are often poorly funded by central governments.

The need to provide and improve access to modern energy for people living in both rural and urban areas, and the need to develop alternative energy sources, constitute a driving force to the creation of skilled individuals and efficient institutions by strengthening and retaining human and institutional capacities.

The key capacities required include trained researchers, technicians, lecturers, policy-makers and managers capable of planning and managing programmes in the public and private sectors. The institutional strengths required include, among others, analytical instruments, regular funding to sustain programmes, networking capacity (information and communications technology connectivity), and supportive policy frameworks. The process of strengthening and retaining human and institutional capacities should be contextualised within a broader base that takes cognisance of activities in diverse countries in the region at governmental and private sector levels. These activities should promote and stimulate literacy in energy matters at all levels of education. A priority is also, the exchange of information and knowledge among individuals and different African organisations dealing with energy and energy-related matters in the region (for example, AU/NEPAD, SADC and ECOWAS).

The proposed project will endeavour to generate knowledge aimed at informing strategies for strengthening and retaining energy and energy-related human and institutional capacities in the region.

General foci

The activities should contribute to the strengthening and retention of energy and energy-related human and institutional capacities in Africa through:

- Identifying human and institutional capacity needs in the energy sector of the region;
- Developing a critical mass of skilled people and institutions required in energy and energy-related disciplines in the region; and
- Strengthening networks of energy experts and institutions within the region and outside the region.

Attention should also be given to enhance collaboration, to stimulate the creation and promotion of centres of excellence in energy, and to develop partnerships between the public and private sectors for energy investments, financial negotiations, and technical development and management.

7. Funding Arrangements

Possible sources

Addressing the energy issue will require the participation of several players, as well as enormous resource mobilisation. In addition, a well coordinated approach, for both the mobilisation of resource and the implementation of strategies, is required in order to realise the goals. Therefore funding will be sourced from, but not be limited to, the following:

- African governments: governments should show their interest and commitment by making financial and material support available.
- Bi- and multilateral funding resources: bilateral resources fall within the mandate of many ODA programmes and could be a major source of funding. Multilateral sources are also important in view of the recent trends in forming consortiums and establishing trust funds through multilateral bodies.

Development partners

Addressing the energy challenges in Africa will need strong and committed development partners, including but not limited to:

- AU/NEPAD and UNECA initiatives
- African Economic Communities (e.g., SADC, ECOWAS, ECCAS, EAC)
- The African Development Bank (AfDB)
- The European Union Energy Initiative (EUEI) programme
- EU/Africa Collaborative Programmes (e.g., Horizon 2020)
- Private sector sources, for example, to enlist the participation of local banks in funding renewable energy projects
- Joint projects, such as: ICSU Unions, for example, IYPE (Geo-Unions), IUGS, INQUA; UNESCO; GECAFS; TWAS/NASAC/AAS; and Energy and Environment Partnership (EEP).

8. Implementing Strategies

The role of ICSU ROA

ICSU ROA activities will include mobilising the knowledge and resources of the energy scientists in the region to:

- Identify gaps in knowledge, and competences that needs to be developed
- Facilitate interaction among scientists to ensure multidisciplinary and transdisciplinary collaboration and strengthened institutional support
- Promote the participation of energy scientists and establish human resource needs

- Host a local energy network in the region with appropriate links to other regions of the world
- Provide independent, authoritative advice to stimulate constructive dialogue between the energy experts in the region and governments, civil society, and the private sector
- Promote dialogue and share understanding between the energy community, policy makers and society
- Provide organisational support and host workshops to involve existing training institutions and relevant experts
- Facilitate and foster links energy experts in the region with the relevant communities in the ICSU Scientific Unions
- Ensure that regional programmes and activities are aligned with existing ICSU global programmes and initiatives, such as Future Earth
- Identify obstacles to attaining sustainable energy access, and foster the technological progresses needed to overcome these challenges.

General strategies

General strategies would include:

- The involvement of local social scientists to assist with the full integration of the three action plans into society and localised contexts.
- The establishment of regional nodes to coordinate proposal formulations, and to improve on the visibility of ICSU ROA.

In addition, the proposed plans will enable the development of context-appropriate energy access systems that are high-quality and reliable, affordable, timely, and that will have the minimum impact on the environment. Participants in these activities must include senior scientists with expertise in energy and energy-related systems analysis, energy and energy-related technology assessment, and in the history of technology developments. Participation is also required from energy and energy-related experts in the developed world. Major audiences will be policy-makers, business leaders, universities and training institutions, administrators for technology and innovation management, and related scientists and technologists.

Source: https://nuancefinancial.com/cumulus-499176/

9. Conclusion

The three R&D Action Plans presented here, and any activity that can be derived from this Science Plan, seek to address the key challenges in the energy sector of Africa. Their implementation will provide the information needed by African policy-makers and investors to make informed decisions that will lead the region towards satisfying the growing energy demand, and serve as catalysts for the rapid growth and development urgently needed in all economic and social sectors in Africa.

There are many regional and global initiatives in Africa aimed at addressing the barriers in the energy sector in order to accelerate access to modern and sustainable energy services in the region. Energy experts in the region have organised themselves in consortia with meetings held at regular intervals that involve energy scientists and key actors from within and outside Africa. Such meetings continually review the existing energy activities on the continent. So, for example, the necessity of developing a GIS-based visualisation system for energy data has been identified, as well as the need to involve GIS experts and institutions in the region. This will come into effect from the early stages of developing the projects.

Also, a series of books on challenges and successes in energy technology and use in Africa will be published to showcase African success stories on issues of scientific research and its development to serve society. It is envisaged that by highlighting energy success stories in Africa, the visibility of SETI scientists and consortia can be strengthened as key actors in the development and provision of sustainable energy for sustainable development. Importantly too, such publications would document achievements and serve as catalysts for further processes of change that would be required in the energy sector.

Source: https://pixabay.com/en/drops-of-water-water-nature-liquid-578897/

Source: http://maxpixel.freegreatpicture.com/Field-Farm-Sky-Nature-Windmill-Landscape-Wind-1911608

Source: https://pixabay.com/en/the-sun-way-street-man-470317/

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Source: https://pixabay.com/en/wind-farm-energy-green-sustainable-1209335/

Acronyms and Abbreviations

AAS	African Academy of Sciences
AEEP	Africa-EU Energy Partnership
AfDB	African Development Bank
AFREC	African Energy Commission
AFREPREN	African Energy Policy Research Network
AMCEN	African Ministerial Conference on the Environment
AREED	African Rural Energy Enterprise Development Training Programme
AU	African Union
AUC	African Union Commission
CILES	West African Solar Energy Project
DAC	Development Assistance Countries
DRC	Democratic Republic of the Congo
EAC	East African Community
EAPP	East Africa Power Pool
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
EEP	Energy and Environment Partnership
ENDA	Environmental Development Action
ERC	Energy Research Centre
EU	European Union
EUEI	European Union Energy Initiative
FDI	Foreign Direct Investment
FEMA	Forum for Energy Ministers in Africa
GDP	Gross Domestic Product
GECAFS	Global Environmental Change and Food Systems
GEF	Global Environmental Facility
GHG	Green House Gas
GIS	Geographic Information System
GNESD	The Global Network on Energy for Sustainable Development
GIZ	German Federal Enterprise for International Cooperation
GVEP	Global Village Energy Partnership
GW	Gigawatts
ICSU	International Council for Science
ICSU ROA	International Council for Science Regional Office for Africa
IEA	International Energy Agency
INQUA	International Union for Quaternary Science
IUGS	International Union of Geological Sciences
IYPE	International Year of Planet Earth

kWh/yr	Kilowatt hours per year
KITE	Kumasi Institute of Technology and Environment
LPG	Liquefied Petroleum Gas
NASAC	Network of African Science Academies
NEPAD	New Partnership for Africa's Development
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
PEAC	Pool Energétique d'Afrique Centrale
PIDA	Programme for Infrastructure Development in Africa
R&D	Research and Development
RD&D	Research Development and Design
REEEP	Renewable Energy and Energy Efficiency Partnership
REN21	Renewable Energy Network for the 21st century
RETs	Renewable Energy Technologies
Rio+20	The United Nations Conference on Sustainable Development, Rio de Janeiro, Brazil
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SDGs	Sustainable Development Goals
SE4ALL	Sustainable Energy for all
SETI	Science, Engineering, Technology and Innovation
S&T	Science and Technology
TWAS	The World Academy of Sciences
TWh/yr	Terawatt-hours per year
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US(A)	United States (of America)
WAGPP	West African Gas Pipeline Project
WAPP	West African Power Pool
WEC	World Energy Council
WHO	World Health Organization
WSSD	World Summit for Sustainable Development

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INTERNATIONAL COUNCIL FOR SCIENCE
REGIONAL OFFICE FOR AFRICA

ICSU Regional Office for Africa
1st Floor Block C, The Woods
41 De Havilland Crescent
Persequor Technopark 0020
Pretoria
South Africa
+27 (12) 349 7731
www.icsu.org/africa