ENERGY MARKETS IN AFRICA

FIESP

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ENERGY MARKETS IN AFRICA

The Federation of Industries of the State of São Paulo (FIESP) is proud of its partnership with Eletrobras and the African Development Bank (AfDB) for the study **"Energy Markets in Africa"**.

Within this publication, we outline that promoting access to energy is a fundamental condition to eradicate dehumanizing poverty, unfortunately still found in many African nations. This access is also essential to economic and human development, but still is scarce in most of these countries.

In contrast, there is enormous potential for hydropower development in Africa, expansion of the renewable energy and biofuel market, and integration of power systems. All of these opportunities could result in a quantum leap in the quality of life for the African people.

The Brazilian experience in building a clean energy mix puts us in a prominent position to cooperate with the advancement of the sector on the African continent.

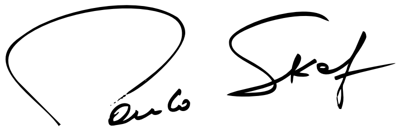
The same can be said on public policy for income distribution, which is changing the social profile of the Brazilian people, and programs that guarantee access to energy to the poorest population, such as Light for All, which made 10 million power connections between 2003 and 2009.

Within this context, Brazil offers to be an African strategic partner. The Brazilian government and private sector are already working jointly in technology transfer towards sustainable development, with policy from assisting in the production of drugs to professional education projects. The latter is how the Brazilian industry places itself as an effective instrument of social change

The National Service of Industrial Learning through Senai-SP, sponsored by São Paulo industry, has on-going projects in Angola and Guinea-Bissau in training and sharing theoretical and technical knowledge, in the fields of civil construction, building and industrial electricity, baking, refrigeration, metalwork, computers, crafts, industrial sewing and diesel mechanics.

Investing in social development - in people – and in infrastructure, is the commitment of São Paulo industry within Brazil and with its cooperation with countries around the world, always with the goal of changing the framework of public services that is preventing social welfare.

Energy scarcity is undoubtedly one of the main obstacles that Africa is facing in its goals to reduce poverty and social inequality on the continent. FIESP is ready to expand its contributions in order to achieve these goals.



Paulo Skaf
President of the Federation of Industries of the State of São Paulo (FIESP)

Africa has vast undeveloped energy potential – potential that creative, experienced entrepreneurs can put to use. Brazil's strong background in sustainable energy development should enable her to become a major partner in the development of Africa's energy markets. Working together benefits both - Brazilian firms can seek new spheres for doing business, and African economies can benefit from Brazil's experience and responsible investment in green economies.

There is huge demand. Although Africa has significant energy resources, energy production remains low – at about 9.5% of the world's total output. The entire installed generation capacity of 48 sub-Saharan African countries is 68 gigawatts, no more than that of Spain. And 92% of the rural population does not have access to modern energy.

There is a large supply. Africa has significant energy resources, including renewable resources, waiting to be untapped. This study of Africa's energy markets puts the essential information for each country at your fingertips.

At the African Development Bank, our overarching objective is to reduce poverty on the African continent.

There is a direct link between access to energy and poverty. Without energy, health services, access to clean water and sanitation, and education all suffer. Rural industries struggle to grow. Nor can rural communities easily access global information networks, including telephones, radio, television and the internet. Women and children, especially girls, spend significant amounts of time gathering primary biomass, limiting the time they can spend studying or improving their lives.

Over the next 3 years, the AfDB intends to invest more than $3.5 billion in improving energy access, with more than a third of it going to renewable energy under its new energy strategy. With these resources and more, we seek a new deal for Africa – a new deal for a clean future that includes job creation, technology development and environmental sustainability – a new deal that includes tailored financing to reduce investment risks, jumpstart clean growth businesses, and encourage new technologies.

The possibilities continue to grow. Cell phones with built-in solar PV chargers made in Africa, the use of hybrid, low-fuel vehicles and transport systems running on clean energy, waste treatment systems, and renewable energy versus costly diesel backup generators are just a few examples.

Brazil has a strong domestic track record in energy development, especially in advanced biomass fuels. She has already put that expertise to work in Africa. With so much potential, now is the time to do more. We hope Brazilian businesses will take advantage of the opportunities to build strong, clean African economies and their own bottom lines. The African Development Bank stands ready to assist with the many tools at our disposal.

Donald Kaberuka
President of African Development Bank Group

Africa is a fascinating continent! With a population of more than one billion and a GDP of near US$ 1.73 trillion, the continent is amazing due to its contrasts and challenges. In spite of the vast mineral deposits (gold, diamonds, copper and uranium) and oil and natural gas reserves, it has always had a hard time to increase social and economic standards.

Gathering and providing valuable information for professionals from various sectors, the study **"Energy Markets in Africa"** depicts the African continent in all its rich resources and different energy alternatives, much needed to face its enormous challenges; reducing internal imbalances, improving quality of life and generating wealth for the population.

The chapter **Power Integration**, which Eletrobras had the pleasure to write, shows in particularly the high complexity of the power interconnection between African countries and also to Europe, which enables energy exports from the Desertec Industrial Initiative (Dii) in North Africa.

This high interconnection complexity also shows the countries' long-term vision and policy alignment to search for solutions for the continent.

By showing Africa in all its richness of features, the publication presents the many opportunities that exist, becoming one more important contribution from Brazil to the development of this remarkable continent.

I hope you enjoy your reading!

José da Costa Carvalho Neto
President of Eletrobras

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Acknowledgments

Coordinators

Carlos A. Cavalcanti and Carolina M. Lembo

Authors

Antonio Augusto Gonçalves (Eletrobras)

Brasil Geraldo Filho (Eletrobras)

Carlos A. Cavalcanti (FIESP)

Carlos Eduardo da Silva Pacheco (Eletrobras)

Carolina M. Lembo (FIESP)

Ignacio Tourino Soto (AfDB)

João Gabriel Rizk Ramires (FIESP)

Kurt Lonsway (AfDB)

Natalie Kehle (FIESP)

Paulo Roberto Freitas Fonseca (Eletrobras)

Sebastian Veit (AfDB)

Victor Magalhães Feleppa (Eletrobras)

Collaborators

Claudio Machado (AfDB)

Gustavo Borges (FIESP)

Lucas Alves (FIESP)

Luiz Salomão (Triver - Illustration/ Maps)

Maria do Carmo Figueiredo de Almeida (FIESP)

Mariane Fonseca Fagundes (FIESP)

Roberto Moussallem (FIESP)

Silvia Dias (FIESP)

Sinval Zaidan Gama (Eletrobras)

Sylvie D'Apote (Gas Energy)

Tanja Faller (AfDB)

Graphic Design

Maria Regina Knoll (FIESP)

Pedro Maia Nogueira (FIESP)

Art Team (AME/FIESP)

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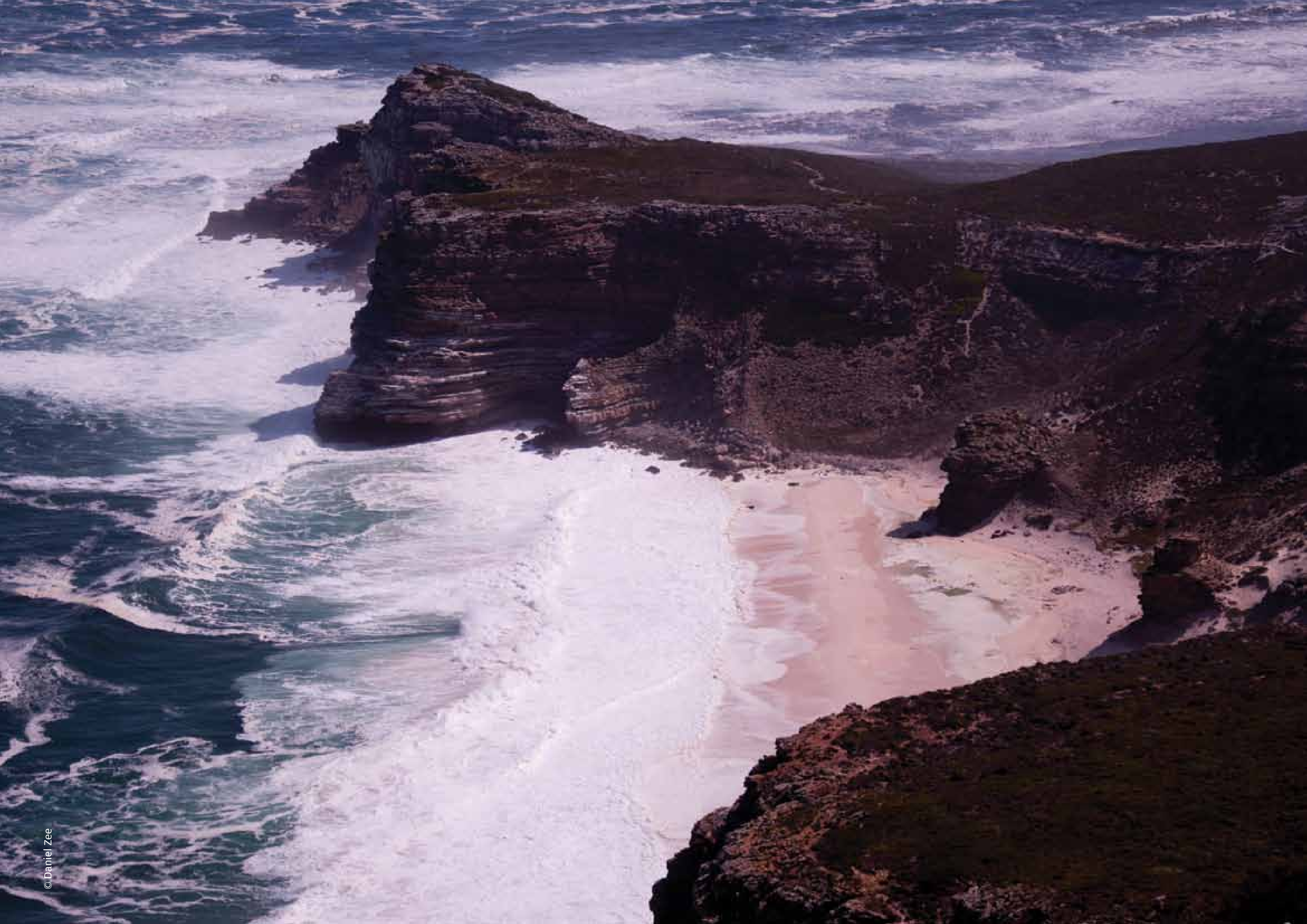
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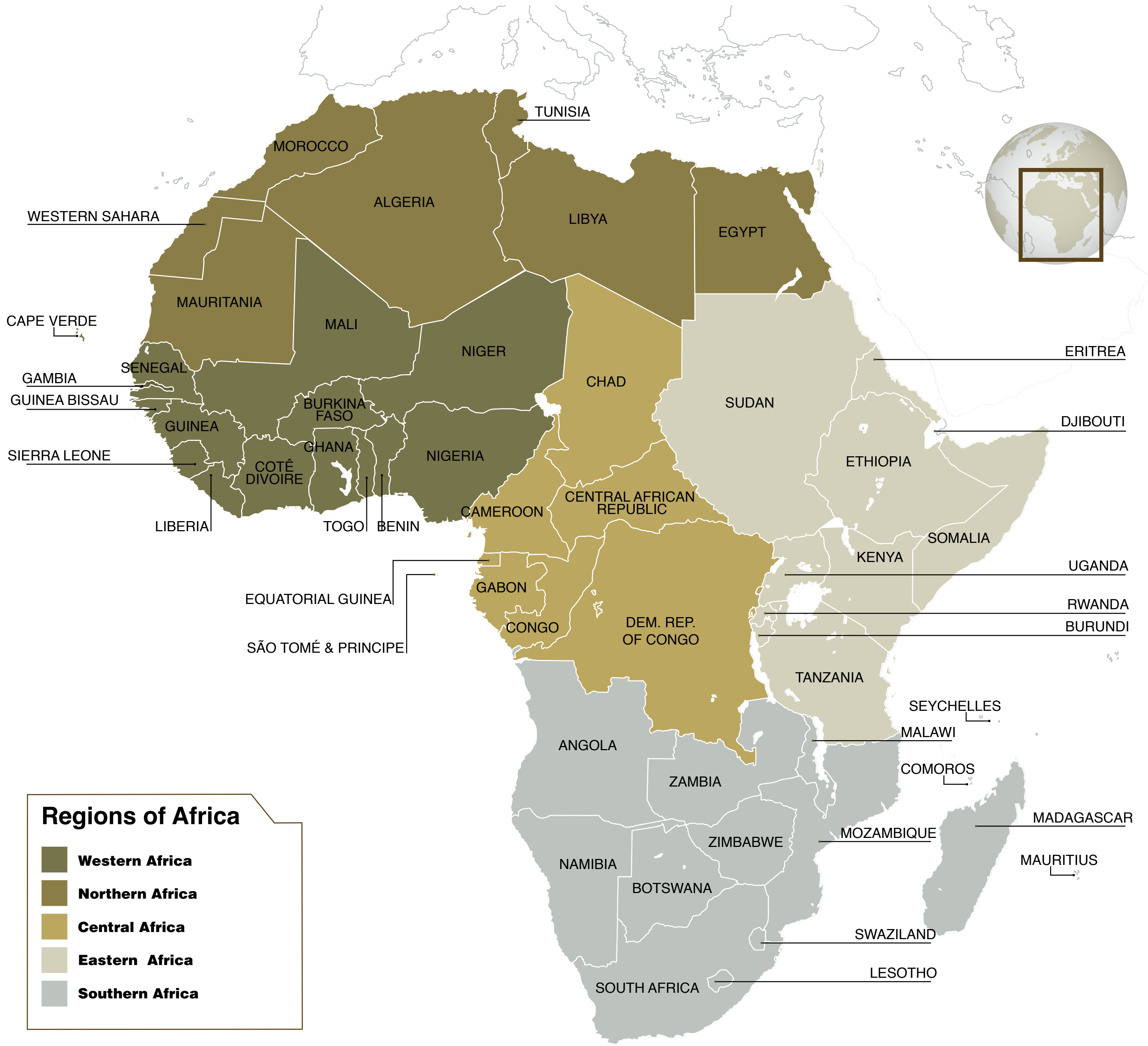
Acronyms

AfDB - African Development Bank
ARGeo - African Rift Geothermal Facility
CAPP - Central African Power Pool
CBM - Coal Bed Methane
CC - Combined-Cycle Power Plant
CCGT - Combined-Cycle Gas Turbine
CFBC - Circulating Fluidized Bed Combustion
CO_2 - Carbon Dioxide
COMELEC - Maghreb Power Committee
CSP - Concentrated Solar Power
CTF - Clean Technology Fund
Dii - Desertec Industrial Initiative
DNI - Direct Normal Irradiance
DRC - Democratic Republic of Congo
EAPP - East African Power Pool
ECOWAS - Economic Community of West African States
FIESP - Federation of Industries of the State of Sao Paulo
GDP - Gross Domestic Product
GEF - Global Environment Facility
GNI - Gross National Income
GWh - Gigawatt Hour
GWh/year - Gigawatt Hour per Year
HDI - Human Development Index
HVDC - High Voltage Direct Current
IEA - International Energy Agency
ISCC - Integrated Solar Combined Cycle
$kWh/m^2/year$ - Kilowatt Hour per Square Meter per Year
LCOE - Levelised Cost of Energy
LNG - Liquefied Natural Gas
MDG - Millennium Development Goals
MENA - Middle East and Northern Africa
MW - Megawatt
MW_p - Megawatt Peak Power
OPEC - Organization of the Petroleum Exporting Countries
PCC - Pulverized Coal Combustion
Pro-Renova - Structured Program for Support to Other Developing Countries in the Area of Renewable Energy
PV - Photovoltaic
SADC - Southern African Development Community
SAPP - South African Power Pool
SENAI - Brazilian National Service of Industrial Learning
TFC - Total Final Consumption
toe - Ton of Oil Equivalent
UN - United Nations
UNEP - United Nations Environment Programme
UPDEA - Union of African Producers, Transporters & Distributors of Electricity
US$ - US dollar
WAEMU - West African Economic & Monetary Union
WAPP - West African Power Pool
Westcor - Western Power Corridor Project



TUNISIA
MOROCCO
ALGERIA
LIBYA
EGYPT
WESTERN SAHARA
MAURITANIA
MALI
NIGER
CHAD
SUDAN
ERITREA
DJIBOUTI
ETHIOPIA
SOMALIA
CAPE VERDE
SENEGAL
GAMBIA
GUINEA BISSAU
GUINEA
BURKINA FASO
GHANA
SIERRA LEONE
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BOTSWANA
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LESOTHO
SOUTH AFRICA
Regions of Africa
Western Africa
Northern Africa
Central Africa
Eastern Africa
Southern Africa

1. PROLOGUE: ENERGY AND POVERTY

Prologue: Energy and Poverty

In 2000, 189 heads of government from North and South, and from wealthy and developing countries, signed the Millennium Declaration at the United Nations (UN) Millennium Summit in New York. The mission: to free the citizens of the world from dehumanizing extreme poverty by 2015.

The Declaration sets eight anti-poverty goals to achieve the mission, called Millennium Development Goals (MDG).

Even though energy is not mentioned as a separate MDG, energy services are an essential element in economic development and poverty reduction.

The close correlation between economic growth and poverty reduction is well illustrated by the experience of countries like China, Brazil and India, which have experienced sustained economic growth and significant poverty reduction in recent years.

Investing in infrastructure is undisputedly the first step for a country to substantially reduce poverty.

Today around one and a half billion people worldwide do not have access to the electricity grid and three billion rely on primary biomass for cooking and heating. Indoor air pollution from primary biomass combustion in open cooking stoves is a leading cause of adult, infant and child mortality in developing countries, ahead of malaria and tuberculosis combined.

The poorest people, i.e. the one billion who live on less than one dollar a day, spend up to a third of their budget on poor-quality energy for cooking, heating and lighting in the home.

These findings have major policy implications for developing countries that aim to achieve the MDGs while expanding their energy infrastructure.

Eradicate extreme poverty and hunger is one MDG that can be met by decreasing energy poverty.

Foraging for fuel to use in the home takes up a disproportionate amount of time, especially for women and children, who are thereby prevented from engaging in more productive and/or leisurely activities.

A number of health and safety issues are related to cooking with fuelwood, such as indoor pollution, the risk of fires and burns, neck and back injuries associated with wood collection and carrying heavy loads and the risk of attack and rape while out collecting.

Such issues mainly affect women and children since they are most often exposed to smoke and other effects of polluting fuels in the home. These problems also relate to MDG 3 and 4, **Reduce child mortality** and **Improve maternal health**. Reliance on fuelwood for use in the home is also to blame for the alarming deforestation rates seen in Africa which could also compromise MDG 7, **Ensure sustainable development**.

Other examples of the importance of energy access in achieving the MDGs are listed in **Table 1.**

Table 1: Examples of the link between energy a access and attaining the MDGs

Millennium Development Goals	Link to Energy Access
Eradicate extreme poverty and hunger	• Enables enterprise development & job creation • Increases industry/ food productiveness at lower costs
Achieve universal primary education	• Creates a healthy & safe learning environment • Access to educational media/ equipment at home & schools
Promote gender equality and empower women	• Frees girls' and young women's time from fuel gathering activities • Street lighting improves women's safety • Home lighting facilitates home learning
Reduce child mortality	• Fuel switching diminishes indoor air pollution • Enables better food preparation • Helps provide pumped clean water
Improve maternal health	• Provides access to better medical facilities • Decreases manual labour for pregnant women
Combat HIV/AIDS, malaria and other diseases	• Access to health education media • Energy to develop, manufacture and distribute drugs, medicine and vaccines
Ensure environmental sustainability	• Reduces traditional fuel use that contributes to erosion, reduced soil fertility, deforestation and desertification
Develop a global partnership for development	• Fosters knowledge sharing and helps build bridges between developed, developing and least developed countries • Increases global resource use efficiency/effectiveness

Source: Elaborated by FIESP using data from the World Bank 2009.

Energy scarcity reduces opportunities for industrialization and undermines competitiveness in national, regional and international trade systems. In short, lack of energy security prolongs poverty.

Access to electricity and "modern fuels" plays a significant role in a country's Gross Domestic Product (GDP) and Human Development Index (HDI), and hence development in general. It is important to note that according the U.N. definition of "modern fuels" for cooking, refers to the use of kerosene, natural gas and electricity. The HDI is a composite index introduced in 1990 to measure a country's average achievements in three basic aspects of human development: health, knowledge and income.

The following schema presents the new and main factors in the HDI for 2010: life expectancy at birth, mean and expected years of schooling, and Gross National Income (GNI) per capita.

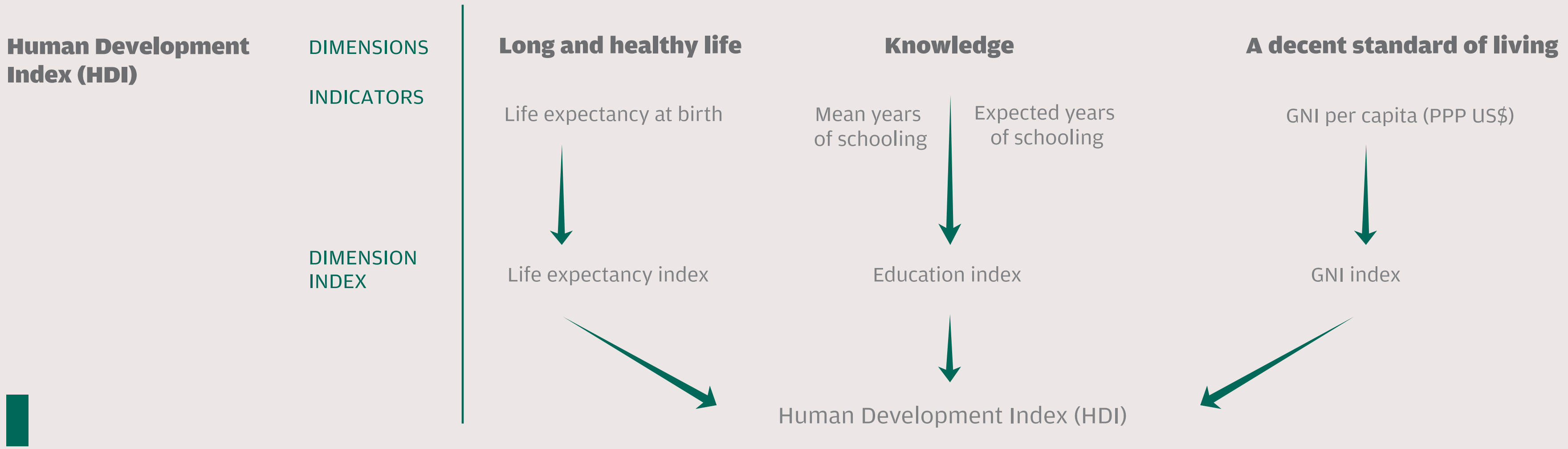
With energy access being so closely linked to the MDGs, it is hardly surprising that access to "modern fuels" is linked to HDI, as seen in Graph 1, which illustrates primary biomass use and HDI levels in African countries.

The percentage of primary biomass in total final consumption (TFC) is a good indicator of access to "modern fuels" and electricity.

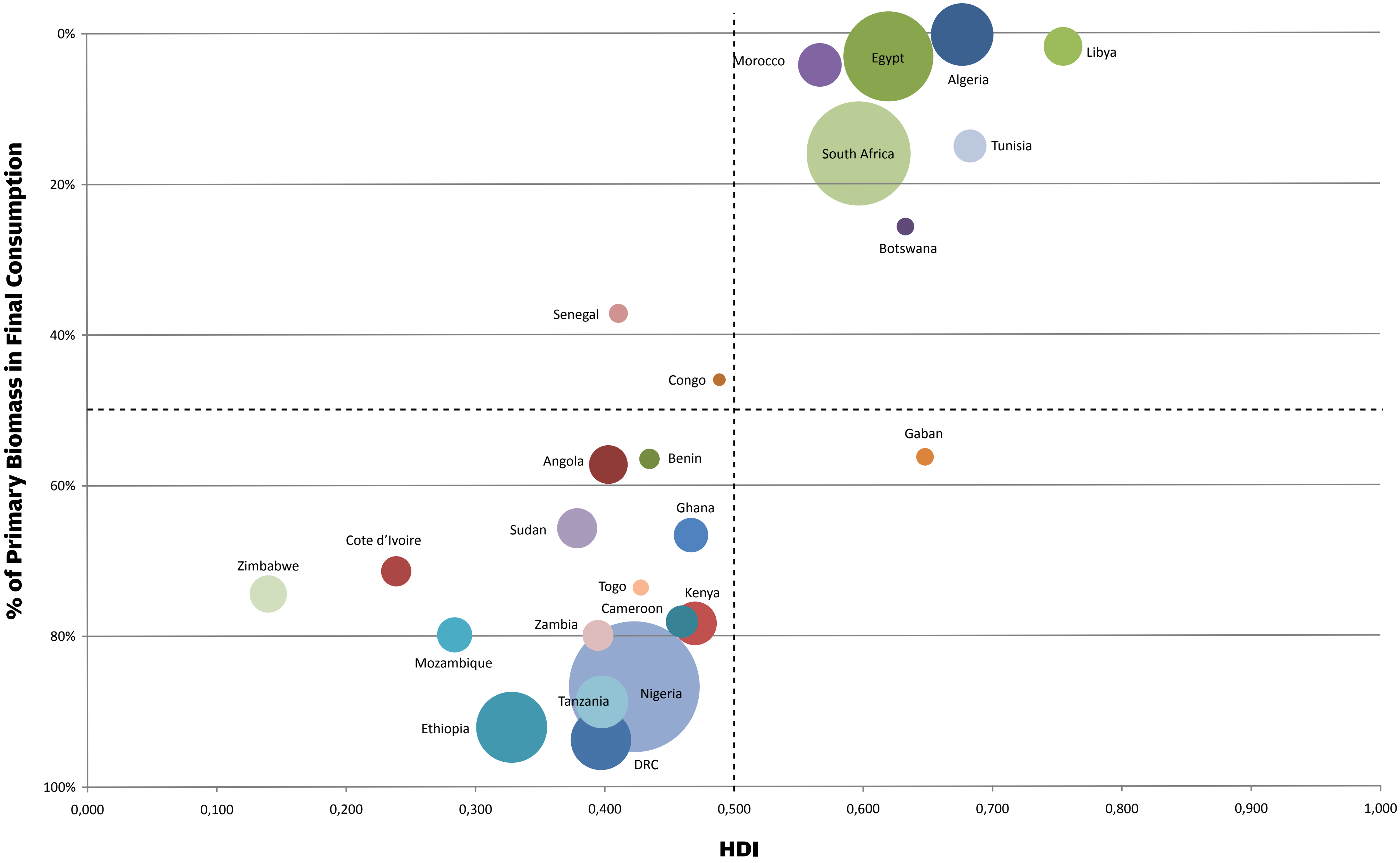
Countries with high primary biomass use generally suffer from energy poverty, with low access to safe efficient fuels and electricity affecting the quality of life in various ways, such as life expectancy, years of schooling and GNI.

It is no surprise that countries with the highest use of wood for cooking and heating also have the lowest HDI. As mentioned earlier, foraging for wood is mainly performed by women and children, and the effects on health associated with primary biomass combustion in the home are severe.

In 2008, over 410,000 premature deaths occurred throughout sub-Saharan Africa from pneumonia and chronic obstructive pulmonary disease due to the use of primary biomass for cooking.



Graph 1 - Percentage of primary biomass in final consumption & HDI in relation to total final comsumption of energy

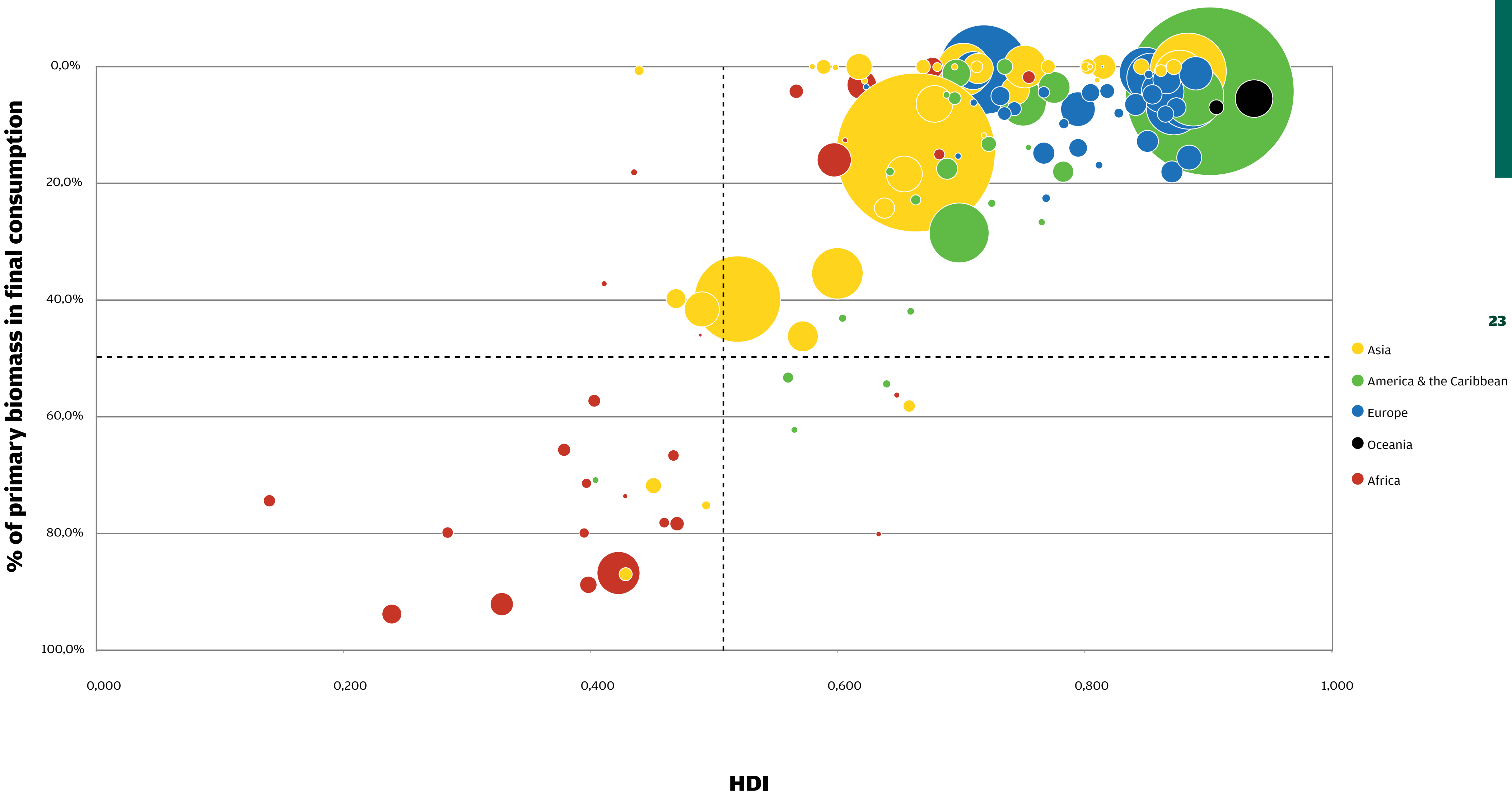


Source: Elaborated by FIESP using data from UNDP 2010, IEA 2008.

Graph 2 also plots the correlation between primary biomass use, HDI and total energy consumption but covers 126 countries worldwide grouped by continent.

It shows the global importance of access to “modern fuels” and electricity as a driver of development. With the exception of Haiti, Cambodia, Myanmar and Nepal only African countries appear in the lower left-hand quadrant, corresponding to an HDI of less than 0.5 and primary biomass consumption at more than 50% of final energy consumption.

Graph 2 - Percentage of primary biomass in final consumption & HDI in relation to total final consumption of energy (world)



Source: Elaborated by FIESP using data from UNDP 2010, IEA 2008.

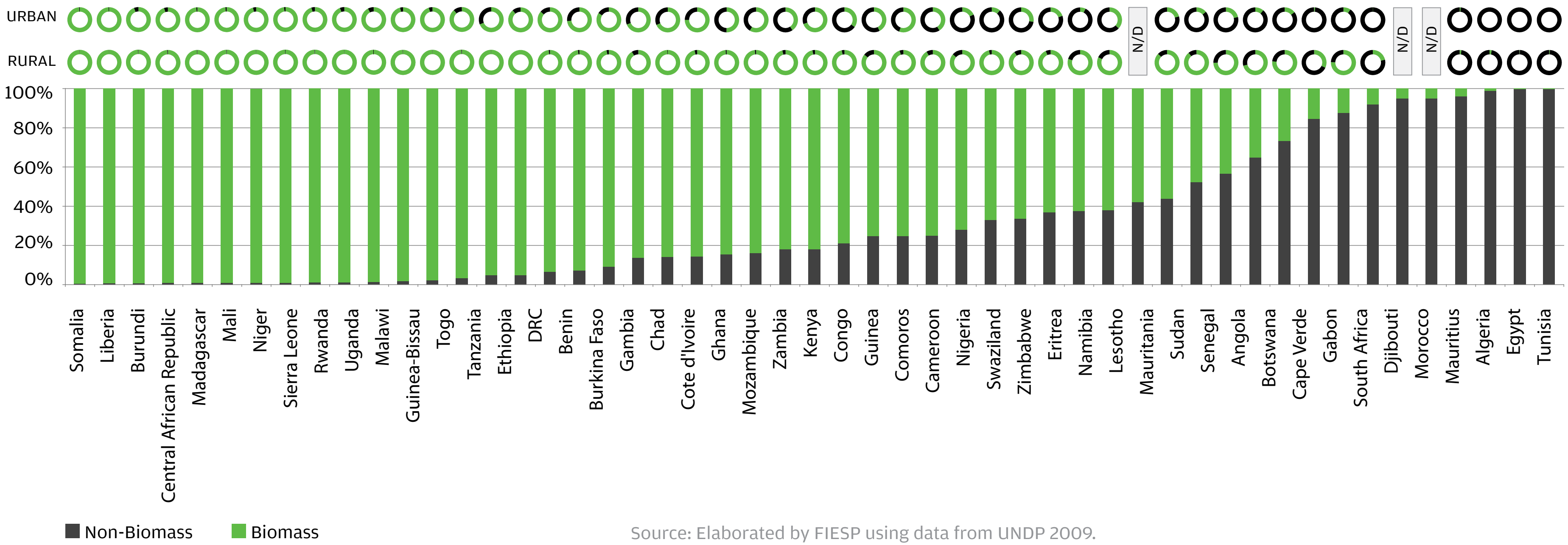
A closer look at energy use at the household level shows that access to "modern fuels" varies significantly across Africa.

It is clear from **Graph 3** that most of the African continent is highly dependent on biomass for cooking. The graph shows fuels used for cooking by energy type, categorized into biomass and non-biomass energy (oil, gas, kerosene etc.).

Northern Africa has the lowest share of wood for cooking, preferring available "modern fuels" such as oil, gas and even electricity.

Sub-Saharan Africa, on the other hand, is exceedingly dependent on wood for cooking, with some countries relying on it almost entirely. A comparison of rural and urban wood use shows that rural Africa is even more helplessly dependent on wood for its cooking needs.

Graph 3 - Fuels used for cooking - percentage of primary biomass use - national population [%]

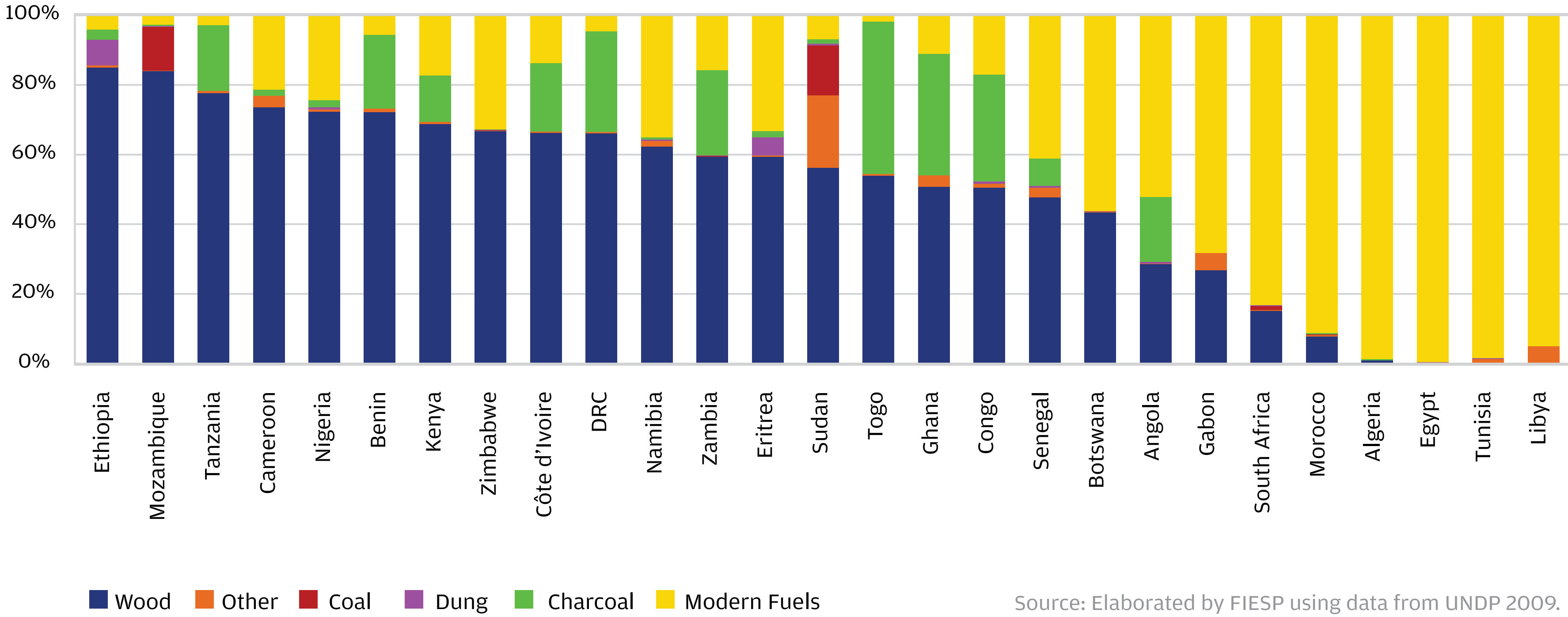


Source: Elaborated by FIESP using data from UNDP 2009.

An analysis of the same cooking fuels data but with a more detailed breakdown by fuel type is shown in **Graph 4**. The graph shows the same predominance of primary biomass across Africa while highlighting the different types of biomass being used.

One important conclusion can be drawn: wood is widely used in most countries, increasing deforestation rates significantly in the medium and long-term and contributing to greenhouse gas emissions.

Graph 4 - Fuels used for cooking - national population [%]



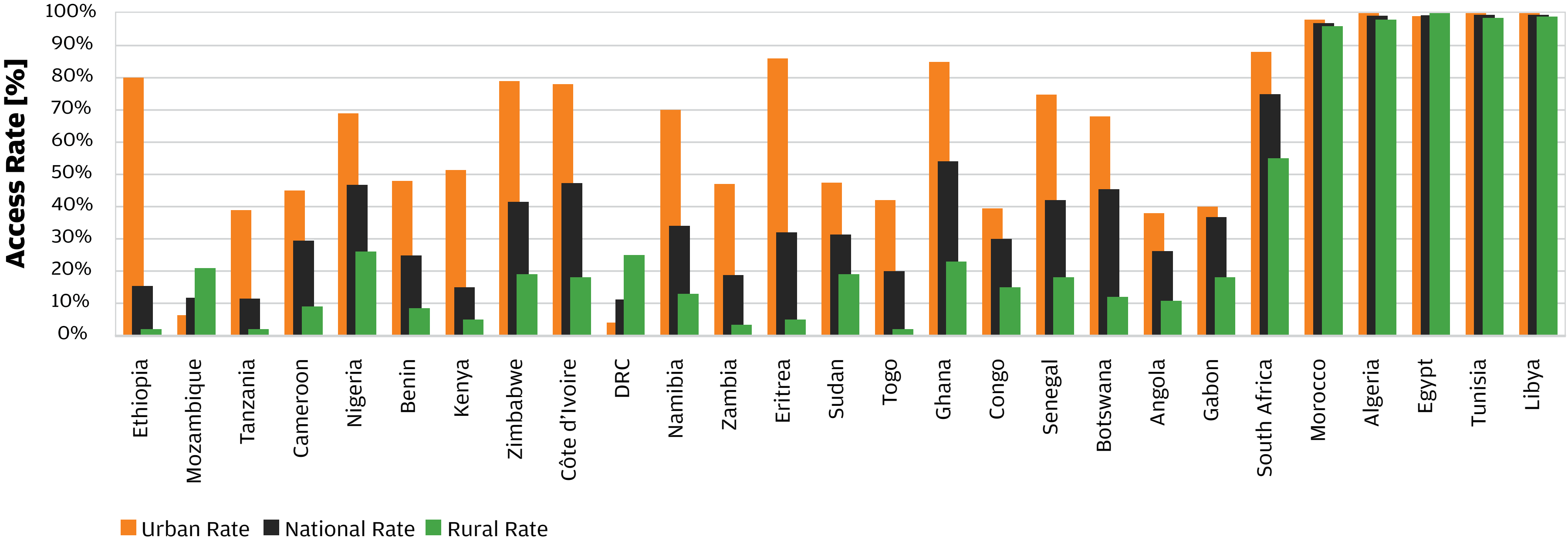
Source: Elaborated by FIESP using data from UNDP 2009.

A look at the African electricity sector shows considerable variation in electrification rates throughout the continent, seen in **graph 5**. Sub-Saharan Africa has the lowest rates of electricity access, especially in rural areas.

There is a significant disparity between rural and urban electrification, so that national electrification rates do not accurately reflect the situation in some countries.

An analysis of the total final consumption (TFC) by sector indicates that the residential sector is the main energy consumer in most countries, implying low industrial and economic development, as seen in **graph 6**.

Graph 5 - Comparison of national, urban and rural electricity access [%]



Source: Elaborated by FIESP using data from UNDP 2009.

The link between electrification rates and industrial energy consumption is clear: countries with higher industrial energy consumption usually have higher electricity access rates.

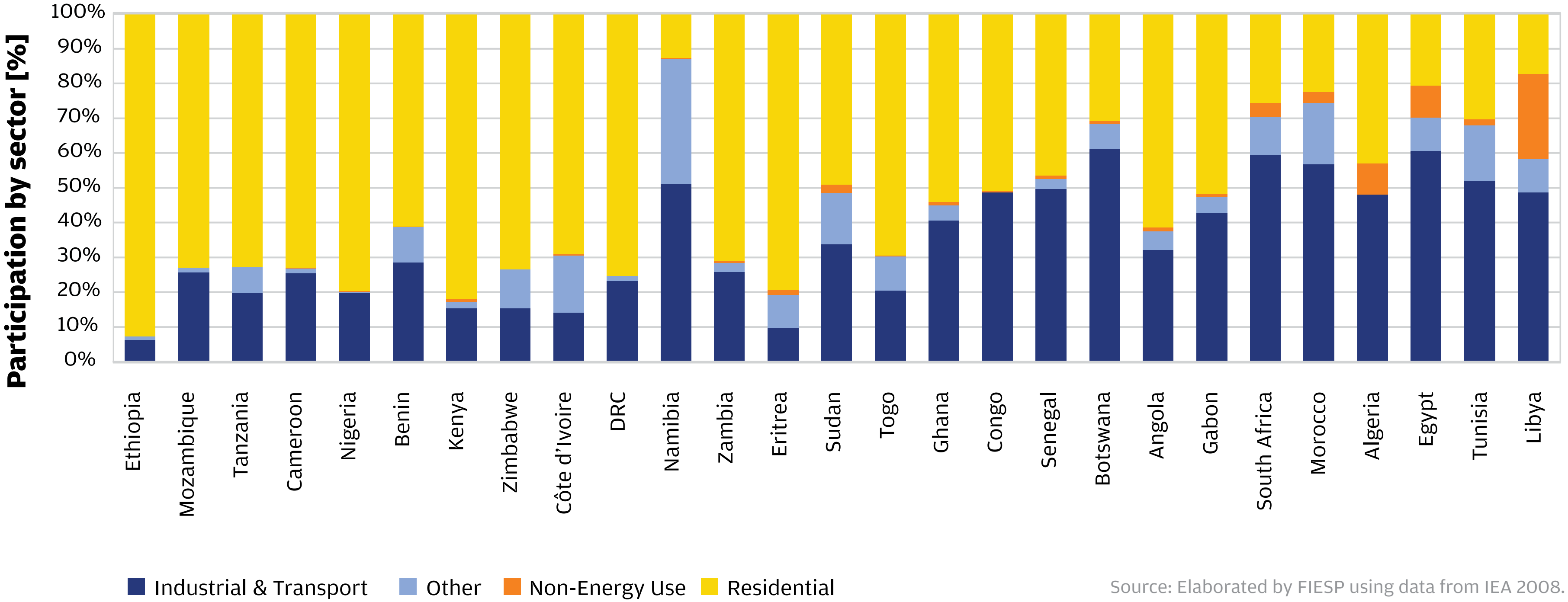
Thus electricity access correlates strongly with economic development. Namibia is an exception to this trend, with transportation and industry accounting for a significant share of energy use compared to the national electrification rate.

It is important to note the definitions of **other** and **non-energy use** included in computations of final energy consumption.

The International Energy Agency (IEA) defines other as “energy use in public services, agriculture, forestry, fishing, and other uses not specified elsewhere”.

Non-energy use covers fuel used as “raw materials by industry rather than to produce energy, such as natural gas and petroleum products used to produce plastic or rubber”.

Graph 6 - Total final consumption of energy - sector share [%]



Source: Elaborated by FIESP using data from IEA 2008.

Potential Paths

This study aims to analyse the potential paths to increase energy access in Africa, taking into account important elements such as energy security, efficient use of resources and sustainable development.

This concept of sustainable development was adopted almost 20 years ago at the United Nations Conference on Environment and Development, known as the Earth Summit and held at Rio de Janeiro.

During the Earth Summit, sustainable development was defined as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs".

Rio de Janeiro will again host the U.N. Conference on Sustainable Development, Rio+20, in 2012. This time, member states may adopt the new concept of **green economy**, where the U.N. Environment Program (UNEP) says that "where sustainable development is the destination, green economy offers a pathway".

The Conference aims to map out the path to poverty eradication and sustainable development, focusing on two themes: (a) the green economy in the context of sustainable development and poverty eradication (meeting the MDGs); and (b) the institutional framework for sustainable development.

As countries negotiate the principles to be included in this green economy, one thing is clear: energy is a major focus.

The African Development Bank (AfDB) is currently developing its own green growth strategy called "A New Green Deal for Africa". This green growth strategy will adopt a comprehensive growth model to bring about synergies between the public and private sectors in achieving the desired changes in the economy.

For example, by increasing loans and credit for investment in "green sectors", it will help set up the framework for a green economy in the long run.

Green growth for Africa is an important instrument to address urgent as well as long-term challenges, including (ii) the fight against climate change and environmental degradation, (ii) the enhancement of energy security, and (iii) the creation of new engines for economic growth.

The adoption of a green growth model at national, regional or international levels, countries will become more sustainable by increasing the share of renewable energy, clean transportation, green (energy-efficient) buildings, waste management, and sustainable management of natural resources in their GDP.

Green growth also reduces energy use per unit of production and carbon emissions per unit of GDP, while minimizing wasteful consumption in various sectors of the economy.

As pointed out by the AfDB, chronic underinvestment in domestic energy supply in the midst of rising prices of imported fuels has caused an energy shortage in African countries in recent years.

African countries are also increasingly aware of the threats posed by climate change, given the increasing frequency of extreme weather, above-average temperatures, drought, torrential rainfall, cyclones, floods, and sharp fluctuation in river flows and lake water levels.

Today, Africa has the opportunity to leap forward to a green economy if more investment is channelled into infrastructure and renewable energy.

Renewable energy can significantly contribute to national energy security, especially against the backdrop of rising and volatile fossil fuel prices.

This is an element of fundamental importance when opting for an energy model. Renewable energy sources should be utilised particularly within the context of rising fossil fuel prices.

This concern is most acute in oil-importing African countries, which spend 30% of their export revenues on imported oil on average (with some countries spending more than 50%).

At the local level, renewable energy can assure a more stable and reliable supply in remote areas, either through local mini-grids or through interconnected household systems such as photovoltaic or biogas.

Additional considerations on renewable energy potential and policy framework are analysed in the chapter **Renewable Energy**. Africa has a number of options for clean energy development with enormous potential.

African countries, especially in sub-Saharan Africa, need to make greater use of their huge, largely untapped renewable energy potential, especially in hydro, geothermal, wind and solar power.

Biomass can also make a fundamental contribution when used in a more efficient, sustainable manner, such as for producing advanced biofuels (ethanol from sugarcane) and bioelectricity.

Africa is not only rich in natural resources for power generation, but also has great potential for regional energy trade, especially in power and hydrocarbons.

With a more independent and diversified energy portfolio, Africa can reduce imported oil dependency and secure long-term energy needs by pooling regional resources and stimulating energy access at affordable prices.

Integration of energy resources is also an important path toward one of the elements mentioned: efficient use of resources. This is especially true where the most cost-effective resources are used in a rational way.

A further study of the potential for regional energy trade in Africa is developed in the chapter **Power Integration**.

African Energy Initiatives in the Maputo Declaration

The African Union Conference of Ministers stressed the importance of energy initiatives in Africa through the Maputo Declaration in November 2011, which highlighted:
(i) the absolute need for Africa to increase energy production in order to guarantee energy security for its economic and social development; (ii) the catalytic role played by energy in fast-tracking growth and development, especially in terms of Millennium Development Goals; (ii) the need for Africa to foster sub-regional, regional and continental cooperation with a view to achieving sustainable development and efficient use of energy resources for the benefit of our peoples; (iii) our will to pool our resources to promote energy production at affordable and competitive costs and for the benefit of all the stakeholders in the economy, as a means of reducing poverty and facilitating Africa's integration into the global economy; (iv) the urgent need to develop and strengthen national, regional and continental strategies for the development of sustainable energy supplies through the diversification of the various energy resources available on the continent; and (v) our will to promote renewable energy in a joint effort with others to reduce greenhouse gas effects and address all issues relating to climate change with technical and financial support from developed countries.

According to UNEP's report "Towards a Green Economy", renewable energy faces barriers that relate to technology transfer.

Before a technology can be transferred successfully, certain preconditions need to be satisfied, such as institutional and adaptive capacity, access to finance, and knowledge of the technology.

In developing countries, especially in remote rural areas, such conditions are often not present. Even when the renewable energy options are economically feasible in such areas, these barriers can hinder a successful project. Technology and knowledge flows are of vital importance for technology transfer to developing countries.

Brazilian engagement with Africa

As stated from the AfDB's economic brief on "Brazil's Economic Engagement with Africa", a timely opportunity is now in place for Brazil to expand its bilateral technical and technology cooperation in order to fast-track renewable energy production in Africa.

Brazil is aiming to become the world leader in the production and export of renewable energy technology.

The Brazilian Government has pledged to assist African countries in exploiting the production and export opportunities of agriculture and biofuels, through trade, cooperation and most importantly technology and skills transfer.

Brazil is assisting African countries to develop its agriculture and biofuels sector through trade, bilateral technology cooperation and technology transfer while also engaging in social wellbeing within the continent.

Brazil has been increasingly involved in the African scene, heavily influenced from forward thinking politics since the 1990s.

An agreement was signed on June 8, 2011, by the Brazilian Government and the AfDB to create a South-South Cooperation Trust Fund. The fund's aim is to provide technical assistance and training in areas such as: (i) clean energy; (ii) agribusiness; and (iii) private sector development.

Another example of Brazil's engagement with Africa via technology transfer is the opening of a Ghana office by Embrapa, Brazil's agricultural research agency, in 2008. The priority for this office is to help Ghana develop its ethanol industry through R&D and training.

The chapter **Biofuels** has been included in this study in light of the biofuel sector's potentially significant role in Africa's energy future and to highlight Brazil's ethanol experience in Africa.

In addition to its experience in ethanol production from sugarcane, Brazil has over a century of experience in hydropower development and has many lessons learned that it can share with Africa.

Brazil's know-how was built from overcoming and mitigating the social and environmental impacts of hydropower projects.

Its environmental awareness and modern hydropower technology can be used to identify opportunities in Africa while sharing its experience in avoiding, mitigating and fairly compensating possible negative impacts.

Brazilian companies have the expertise to identify sites, develop resource inventories, and analyse technical, economic, environmental and social feasibility. Among the top ten largest dam builders in the world, three are Brazilian, while the largest of these is the global leader in energy capacity.

This knowledge can be taken into new markets, as in the case of the African continent. In addition to technical expertise and experience, Brazil has also developed a regulatory framework and an institutional environment for hydropower that can serve as a model for other countries.

Brazil also has technical and regulatory expertise acquired from building an integrated power system with neighbouring countries such as Argentina, Paraguay, Uruguay, Venezuela and Bolivia.

Brazil's "modus operandi" differs from those of other countries that invest in Africa in its integrated vision of cooperation. The Brazilian approach not only focuses on leveraging commercial and geopolitical opportunities, but also embraces social and humanitarian goals.

This approach began during the term of President Luis Inacio Lula da Silva, who stated that "Brazil—not just me—has taken a political decision to re-encounter the African continent". Brazil is present in 37 of the 54 African countries by means of their embassies.

Celso Amorim, Brazil's former Minister of Foreign Affairs was the architect of this new strategy.

Amorim established the political principle that guides the relationship and can be summed up in his own words, "beyond incidental political and economic gains, the pursuit of closer relations with Africa is guided by historical, demographic and cultural ties."

Thus what distinguishes Brazil from other countries that are investing in Africa is the so-called comprehensive technical cooperation program, which is being expanded and strengthened by Ambassador by Antonio Patriota, Brazil's current Minister of Foreign Affairs, who said: "The program aims to share experiences that have proven successful in Brazil, from agriculture to public policies such as combating HIV/AIDS and sickle cell anaemia".

President Dilma Rousseff is also committed to developing the relations between Brazil and Africa by building on the solid tools established over the last decade as a result of innovative and creative diplomatic action. The main social and political initiatives are highlighted in **table 2**.

Tabela 2. - Main Brazilian Cooperation Initiatives in Africa

Project	Host Country	Year	Objective
School for All	Angola	2008	Increasing inclusion of students with special educational needs in the Angolan educational system
Anti-HIV/AIDS Drugs	Mozambique	2008	Construction of Africa's first public factory for anti-retroviral drugs
Social Development Cooperation Program	Ghana	2007	Design and implementation of social protection programs
Technical Capacity Building in Paediatric Cardiac Surgery	Algeria	2008	Training for Algerian specialists in paediatric cardiac surgery
Training Trainers in Construction	Morocco	2008	Assistance in strengthening the capabilities of trainers in the construction and public works sector

Source: Elaborated by FIESP using data from the World Bank 2011.

It is also important to note that the Brazilian private sector has already increased its status as a major investor in Africa. Trade between Brazil and Africa rose from US$ 5 billion in 2002 to US$ 20.6 billion in 2008.

The primary role of the Brazilian National Service of Industrial Learning (SENAI) in Africa is the transfer of theoretical and technical knowledge in the field of vocational training.

A noteworthy SENAI engagement in Africa is the creation of vocational training centres in Angola and Guinea-Bissau, projects that involve the important role of the SENAI from the state of São Paulo.

SENAI's main objective in Angola is contributing to the social reintegration and reconstruction of the country through training, which began in 2000 with the construction of a training centre at a cost of six million dollars.
The project was consolidated and transferred to the Angolan Government in July 2005.

Courses offered at the centre include: (i) civil construction, (ii) building and industrial electricity, (iii) industrial sewing, (iv) computers, (v) diesel mechanics, (vi) craftwork, (vii) baking (viii) refrigeration, and (ix) metalwork.

The main objective of the training centre in Guinea-Bissau is to contribute to the overall economic recovery of the country, through the development of professional education.

The project began its first classes in 2010 with the following courses: (i) construction, (ii) building electricity, (iii) non-industrial sewing, (iv) repair of household appliances, (v) bakery and confectionery, (vi) maintenance of computers (vii) refrigeration and (viii) metalwork.

Brazil, through its businesses and government, has a lot to offer toward advancing Africa's energy sector in an environmentally and socially advantageous manner. By building on its own experience in social and environmental programs, Brazil was able to raise income levels, increase access to "modern fuels", create one of the largest and cleanest power generating systems in the world, and achieve regional integration of its power system.

Energy poverty is the main obstacle faced by Africa in its efforts to achieve the MDGs, and strong South-South cooperation is essential to succeed.

In recognition of their contributions, joint efforts for the preparation of this study come from the African Development Bank (AfDB), the Brazilian Electric Power (Eletrobras) and the Federation of Industries of São Paulo (FIESP).

This study is one step towards Brazil and African countries in getting to know each other better, working together and fighting together, as in the inspired words from Mozambican poet Mia Couto:

I need to be another
to be myself

I exist where I am unaware
waiting for my past
standing in the hope for the future

In the world that I fight against, I die
in the world that I fight for, is where I am born

(Identidade, 1983)

2. OVERVIEW OF ENERGY SOURCES

Overview of Energy Sources

Chapter Notes:

It is important to note that this section discusses 27 out of the 54 African countries. The main reason is data availability: only countries for which comprehensive studies exist regarding energy production, consumption, imports and exports are covered, mainly using information from the International Energy Agency (IEA) for 2008.

Moreover, these 27 countries account for 97% of Africa's total power consumption and are therefore indispensable to this analysis.

Some of the other African countries which are not referred to in this chapter do have the potential to become significant players in the energy market in future decades, as initial assessments point to huge untapped resources.

The importance of these other countries is demonstrated in the chapters **Renewable Energy**, **Power Integration** and **Biofuels**.

The statistics used in this chapter are the most recent data available. Other data presented in this chapter include population in 2010, access to electricity in 2008, GDP in 2009, and Human Development Index (HDI) in 2010.

Combustible renewables and waste refers to vegetable and animal matter used directly as or converted into solid fuel, as well as biomass-derived gaseous and liquid fuels, and industrial and municipal waste converted to energy.

This is the definition used by the IEA in its statistics and studies on which this study is based.

The empirical evidence suggests, however, that the main biomass fuels used in Africa are fuelwood, charcoal, some agricultural residues, and dung.

It should also be noted that no export data have been found for Botswana, Eritrea, Ethiopia, Tanzania and Togo.

Algeria

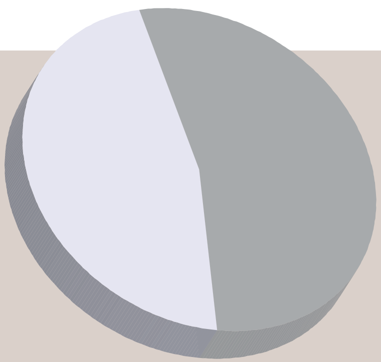
CAPITAL	Algiers
AREA (km²)	2,381,741
POPULATION	34.6 million
ELECTRICITY ACCESS	99.3%
GDP	US$ 139.8 billion
GDP per capita	US$ 7,100
HDI	0.677
CURRENCY	Algerian dinar

Algeria is a member of the Organization of the Petroleum Exporting Countries (OPEC) since 1969 and an important oil and natural gas exporter, mainly to Europe: the hydrocarbon sector accounts for 97% of export revenues. With a crude oil production of 1.8 million barrels per day, it is the third-largest crude oil producer in Africa after Nigeria and Angola.

In 2010 Algeria ranked tenth among the world's natural gas producers and first in Africa, producing 7.8 billion cubic feet of natural gas in that year.

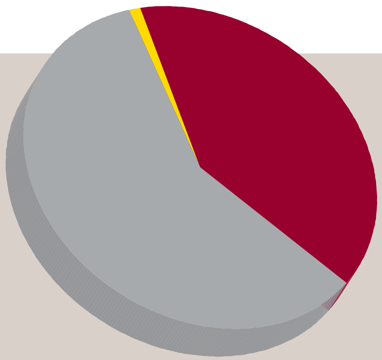
In 2008 Algeria's installed power generating capacity was 8,900 MW and it generated 35,000 GWh of electricity, almost entirely from gas-fired power plants.

Algeria is a net power exporter, ranking third on the continent in power generation after Egypt and South Africa.



Production - 162,044 kboe

- Oil - 54%
- Natural Gas - 46%



Imports 1,857 kboe

- Coal and Coal Products - 40%
- Oil and Oil Products - 59%
- Electricity - 1%

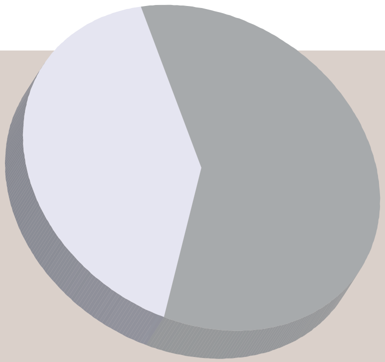
Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Forecasts show that Algeria's natural gas supply will not be sufficient to cover both domestic demand and contracted exports by 2030.

To mitigate this situation, plans exist to increase the share of renewables and nuclear power in power generation. Geothermal resources have been discovered and are estimated at 700 MW.

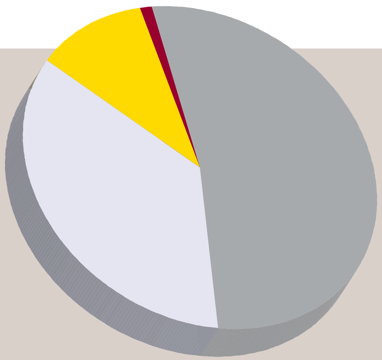
Algeria has untapped hydropower and solar potential, although further resource assessments are required in both cases.

The Middle East and North Africa (MENA) Region Clean Technology Fund Investment Plan has been approved for Algeria, Egypt, Jordan, Morocco and Tunisia. It aims to accelerate global deployment of concentrated solar power.



Exports 125,622 kboe

- Oil and Oil Products - 59%
- Natural Gas - 41%



Final Consumption 23,447 kboe

- Coal and Coal Products - 1%
- Oil Products - 53%
- Natural Gas - 35%
- Electricity - 11%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Luanda
AREA (km²)	1,246,700
POPULATION	13.1 million
ELECTRICITY ACCESS	26.2%
GDP	US$ 74.47 billion
GDP per capita	US$ 8,300
HDI	0.403
CURRENCY	Kwanza

Angola

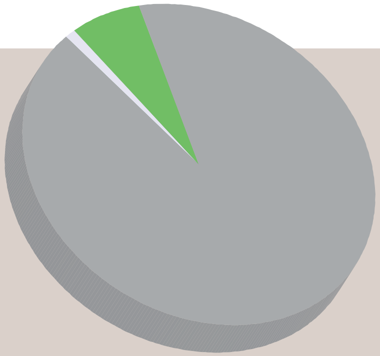
The oil sector plays an important role in Angola, accounting for over 90% of export revenues and over 80% of GDP.

Angola, which joined OPEC in 2007, is the continent's second largest oil producer after Nigeria.

In 2010 it had proven oil reserves of 13.5 billion barrels and crude oil production reached 1.85 million barrels per day. In the short term, Angola is expected to increase oil production as new offshore projects come online and foreign investment continues to flow into the sector.

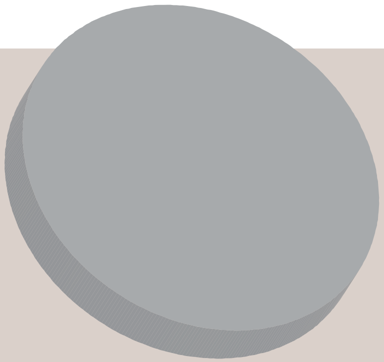
With proven natural gas reserves of 9.6 trillion cubic feet, Angola is not for the moment an important gas producer. All gas produced with oil is currently reinjected or flared, but a liquefied natural gas (LNG) plant is under construction, plans are under way to also use natural gas for domestic power generation.

Installed power capacity in 2008 was estimated at 1,000 MW, with generation reaching 3,700 GWh; 60% from hydropower and 40% from thermal power.



Production 105,837 kboe

- Oil - 93%
- Natural Gas - 1%
- Combustibles Renewables and Waste - 6%



Imports 2,020 kboe

- Oil and Oil Products - 100%

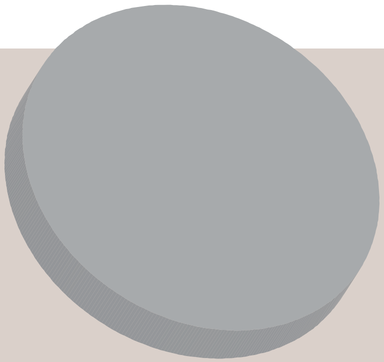
Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Angola still has huge untapped hydropower potential, estimated at 65,000 GWh/year, of which only 6% is currently being utilized.

It has plans to build five main dams and seven further hydropower plants, with an installed capacity of 16,500 MW.

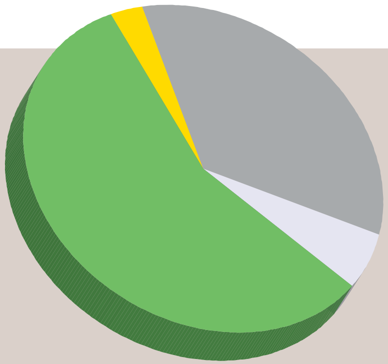
Electricity is currently supplied through three isolated power networks but the government plans to link the networks into a single national grid through the South African Power Pool (SAPP).

Biomass is the sole source of energy for heating and cooking for around 80% of Angolans.



Exports 95,724 kboe

- Oil and Oil Products - 100%



Final Consumption 8,989 kboe

- Oil Products - 34%
- Natural Gas - 6%
- Combustibles Renewables and Waste - 57%
- Electricity - 3%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Benin

CAPITAL	Porto-Novo
AREA (km²)	110,622
POPULATION (2010 est.)	9.1 million
ELECTRICITY ACCESS	24.8%
GDP (2009 est.)	US$ 6.65 billion
GDP per capita (2009 est.)	US$ 1,500
HDI (2010)	0.435
CURRENCY	West African CFA franc

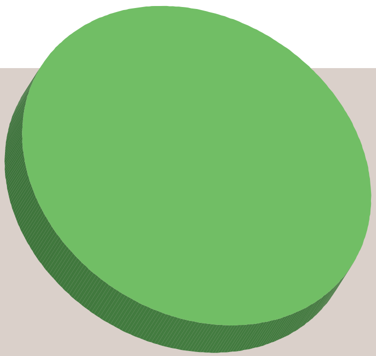
Crude oil reserves in 2010 are estimated at 8 billion barrels of oil and just over 35 trillion cubic feet of natural gas. Given that production of crude oil is limited and there are no oil refineries in the country, Benin imports all of its oil products, mostly from Nigeria.

Benin's installed power generating capacity in 2008 was only 60 MW and total domestic power production was 136 GWh, while consumption amounted to 650 GWh.

High demand growth is being met through power imports from Ghana, Côte d'Ivoire and Nigeria.

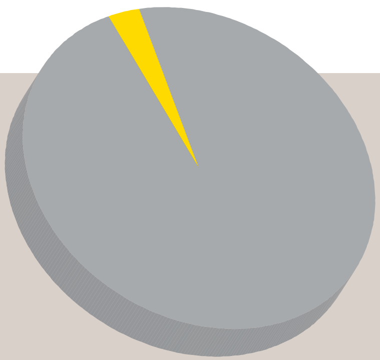
Shortages have forced some industries to install standby generators.

The rural electrification rate is especially low at only 9%. The population depends heavily on primary biomass, especially fuelwood, to meet its energy needs.



Production 1,833 kboe

- Combustibles Renewables and Waste - 100%



Imports 1,753 kboe

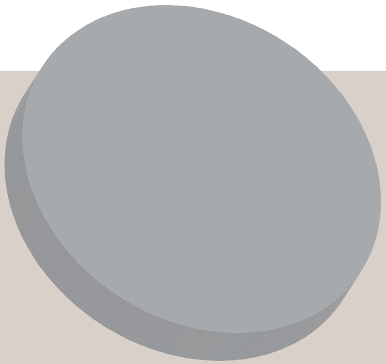
- Oil and Oil Products - 97%
- Electricity - 3%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

It is estimated that Benin has around 750 MW of exploitable hydropower potential, although it currently only has one mini hydropower plant in the north of the country. Biogas could also be used for power production, and pilot projects using animal residues are currently planned at former state-owned farms.

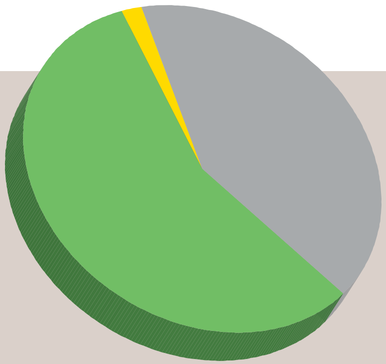
Several initiatives have been developed between Benin, Togo and Ghana to promote power integration.

Worth mentioning is the 1967 agreement under which Benin receives low-cost power from Ghana. Also, Togo and Benin are constructing the Adjarala dam on the Mono River to supply the southern regions of both countries. These three countries are members of the West African Power Pool (WAPP) and are planning new interconnection lines.



Exports 554 kboe

- Oil and Oil Products - 100%



Final Consumption 2,606 kboe

- Oil Products - 41%
- Combustibles Renewables and Waste - 57%
- Electricity - 2%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Gaborone
AREA (km²)	566,730
POPULATION	2.0 million
ELECTRICITY ACCESS	45.4%
GDP	US$ 11.68 billion
GDP per capita	US$ 12,700
HDI	0.431
CURRENCY	Pula

Botswana

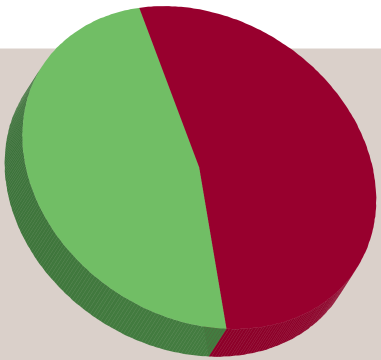
Botswana does not produce any oil or gas, but it has substantial coal reserves, estimated at 212.8 billion metric tons.

Although the coal reserves are located in various parts of the country, only the Morupule Colliery mine is currently being explored for electricity generation purposes.

The economic potential for coal bed methane (CBM) is still to be established, although it is being targeted for power generation with two companies performing exploration.

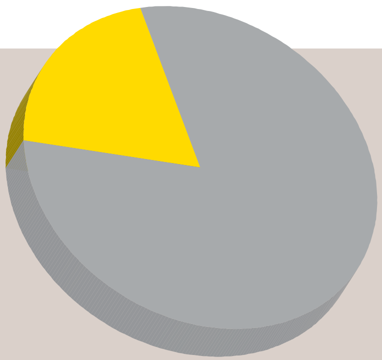
Botswana's refined oil needs are supplied by South Africa, with a small proportion coming from Namibia.

Total installed power capacity in 2009 was 120 MW from Botswana's only generation plant, Morupule A. Owing to low capacity and a lack of new facilities installed since 1990, 80% of Botswana's electricity supply was imported from the Southern African Power Pool (SAPP).



Production 1,002 kboe

- Coal - 53%
- Combustibles Renewables and Waste - 47%



Imports 1,132 kboe

- Oil and Oil Products - 80%
- Electricity - 20%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

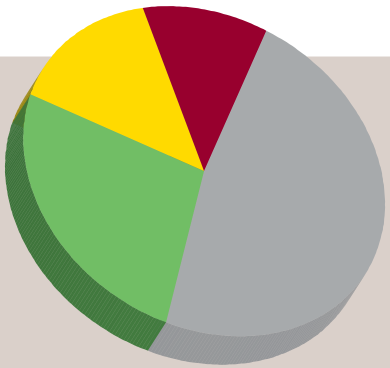
Access to modern forms of energy in Botswana is low and the majority of the population depends on non-commercial energy, mostly fuelwood.

The Botswana Energy Master Plan emphasizes rural electrification using solar energy.

This plan also promotes the use of indigenous energy resources such as coal to reduce dependency on imported energy.

The public utility plans to expand its one coal power plant, adding 400 MW capacity.

Policies for the primary biomass subsector aim to: (i) promote sustainable use of primary biomass energy, and (ii) collaborate with key stakeholders on policies



Final Consumption 1,839 kboe

- Coal and Coal Products - 11%
- Oil Products - 48%
- Combustibles Renewables and Waste - 26%
- Electricity - 15%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

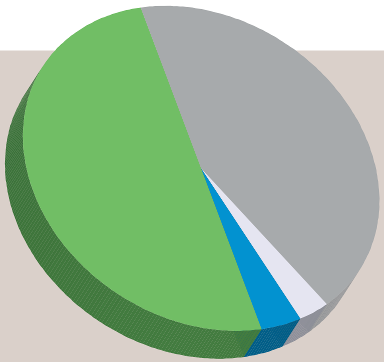
CAPITAL	Yaoundé
AREA (km²)	472,710
POPULATION	19.3 million
ELECTRICITY ACCESS	29.4
GDP	US$ 22.19 billion
GDP per capita	US$ 2,300
HDI	0.460
CURRENCY	Central African CFA franc

Cameroon

Cameroon had proven oil reserves of 200 million barrels in 2009, the majority located offshore in the Niger Delta.

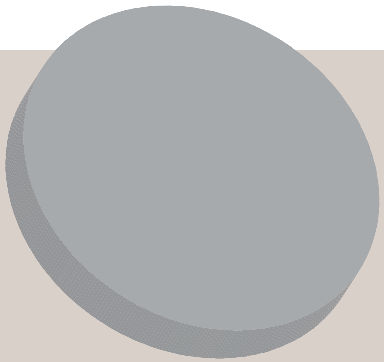
Oil production in 2008 was 92 million barrels per day, declining annually from 2000 owing to a lack of new fields over the past two decades. There is also some natural gas reserves yet to be exploited, estimated at 3.9 trillion cubic feet. In 2009 installed power capacity totalled 1,200 MW, 45% from hydropower and 55% from thermal power plants. Cameroon has the third-largest hydropower potential in Africa, estimated at 105,000 GWh/year, enough to meet demand from the Central African Power Pool (CAPP). The CAPP includes Angola, Burundi, Central African Republic, Congo (Brazzaville), the Democratic Republic of Congo, Gabon, Equatorial Guinea, Sao Tome & Principe, and Chad.

Most Cameroonians use biomass as their primary energy source, owing mainly to lack of household access to electricity.



Production 10,119 kboe

- Oil - 43%
- Natural Gas - 3%
- Hydro - 4%
- Combustibles Renewables and Waste - 50%



Imports 1,952 kboe

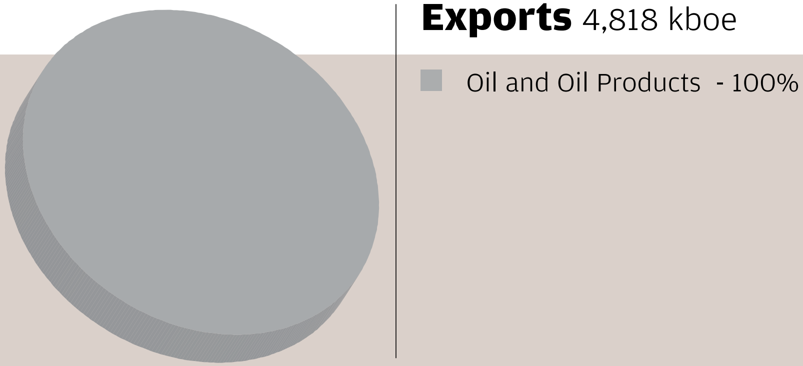
- Oil and Oil Products - 100%

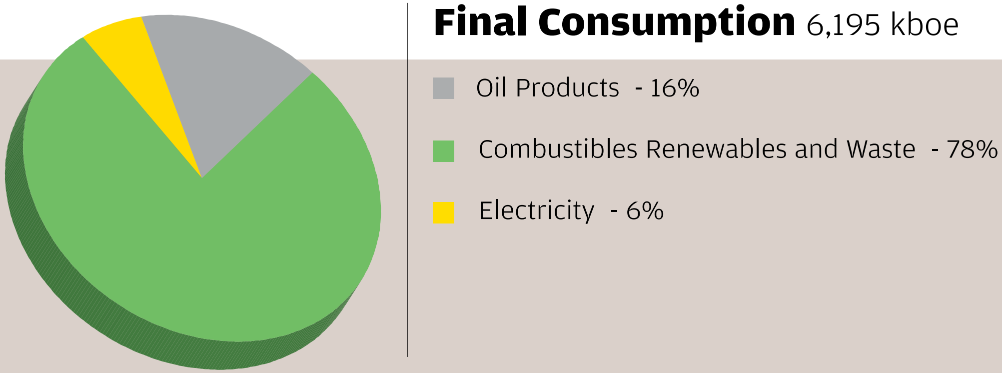
Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Consumption of primary biomass in the residential sector accounted for 70% of total final consumption in 2008, mainly for cooking and heating purposes.

To make up for the looming power deficit the government has launched a Power Sector Development Plan for 2009-2030.

Within the scope of this plan, a number of power plants are at an advanced stage of construction, such as the 30 MW Lom-Pangar hydropower plant, and the 82 MW Yassa and the 216 MW Kribi thermal plants. Also, an interconnection of 60 MW is planned between northern Cameroon and neighbouring Chad.





Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Brazzaville
AREA (km²)	341,400
POPULATION	4.1 million
ELECTRICITY ACCESS	30.0%
GDP	US$ 9.60 billion
GDP per capita	US$ 3,900
HDI	0.489
CURRENCY	Central African CFA franc

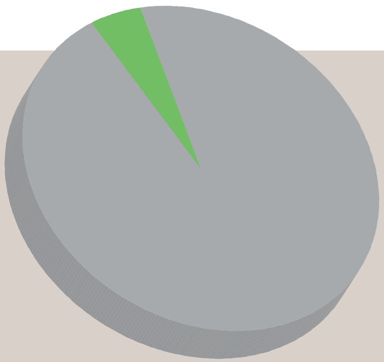
Congo (Brazzaville)

The hydrocarbon industry is Congo's primary source of economic growth. The oil sector accounts for roughly 65% of GDP, and for around 90% of total export revenues.

Oil production has grown during the past few years, reaching 292 million barrels per day in 2010, and industry analysts predict continued growth.

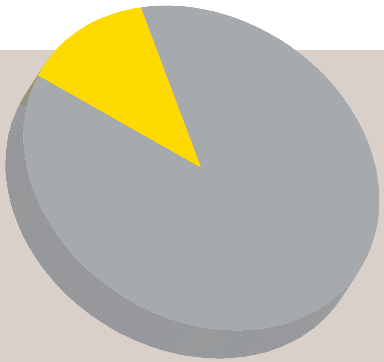
Owing to a lack of proper infrastructure, Congo does not produce or consume any natural gas, although proven reserves are estimated at five trillion cubic feet.

Natural gas associated with oil production is currently flared, but the government hopes to reduce flaring in the future and use gas for power generation.



Production 13,245 kboe

- Oil - 94%
- Combustibles Renewables and Waste - 6%



Imports 298 kboe

- Oil and Oil Products - 87%
- Electricity - 13%

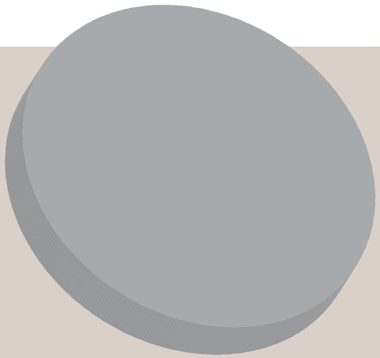
Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

In 2008 generating capacity totalled 120 MW, primarily from hydropower. Despite hydropower potential of over 2,500 MW, Congo is a net importer of electricity, mainly from the DRC. Supply comes primarily from the 74 MW Bouenza (Moukoukoulou) and 15 MW Djoué hydropower plants.

Electricity consumption is low due to a poor transmission and distribution system, coupled with the effects of the civil war.

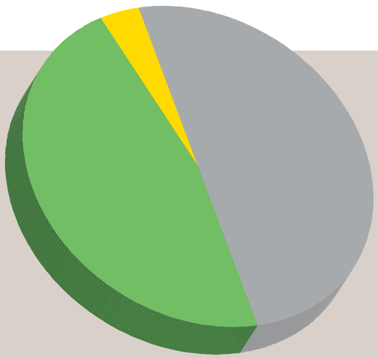
Electricity access in 2008 was 15% in rural areas and 40% in urban centres. Most Congolese in rural areas still rely on primary biomass as their main fuel source.

In recent years the government has worked with foreign investors and governments to rehabilitate the power system, especially the grid, while also building new power capacity throughout the country.



Exports 12,039 kboe

Oil and Oil Products - 100%



Final Consumption 962 kboe

Oil Products - 50%

Combustibles Renewables and Waste - 46%

Electricity - 4%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Côte d’Ivoire

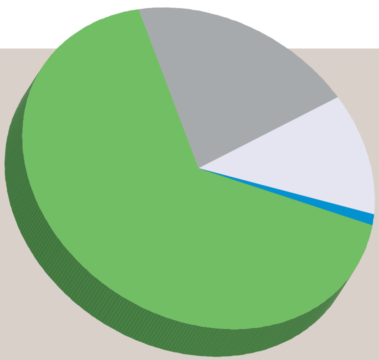
CAPITAL	Yamoussoukro
AREA (km²)	318,003
POPULATION	21.1 million
ELECTRICITY ACCESS	47.3%
GDP	US$ 22.5 billion
GDP per capita	US$ 1,700
HDI	0.397
CURRENCY	West African CFA franc

In recent years, Côte d’Ivoire has been an important supplier of power to the sub-Saharan region as a result of its excess generating capacity and recent offshore discoveries of oil and natural gas.

Proven oil and natural gas reserves in 2008 amounted to 100 million barrels and one trillion cubic feet respectively. Natural gas is used primarily for power generation.

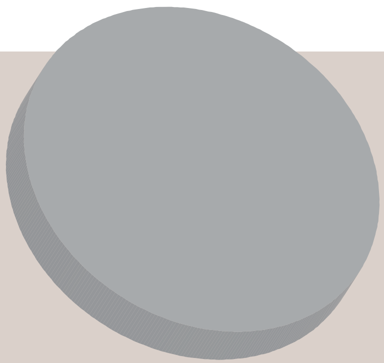
In 2008 installed power capacity totalled 1,200 MW from hydropower and thermal power plants and generation amounted to 5,800 GWh, of which 14% was exported via interconnections between the national grid and Benin, Burkina Faso, Ghana, Mali and Togo.

Two-thirds of the country’s power is gas-based and one-third is from hydropower. Future power projects include mainly gas-fired combined-cycle thermal plants.



Production 11,415 kboe

- Oil - 20%
- Natural Gas - 12%
- Hydro - 1%
- Combustibles Renewables and Waste - 67%



Imports 3,317 kboe

- Oil and Oil Products - 100%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Four large hydropower plants remain undeveloped, with capacities ranging from 5 to 290 MW, while other smaller sites have been identified with a potential between 0.5 and 5 MW. Estimated hydropower potential is 6,000 GWh/year, of which only 30% has been exploited.

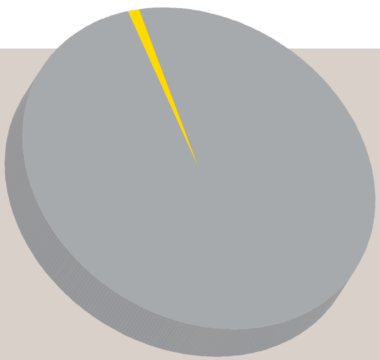
Primary biomass is the most common energy source, accounting for up to 70% of total consumption.

This includes fuelwood and charcoal in households, as well as forest residues used by agribusiness firms to produce steam and electricity.

Crop and plantation residues from the agro-industrial sector are another potential resource for power generation, estimated at over 4.3 million tons of oil equivalent (toe) per year.

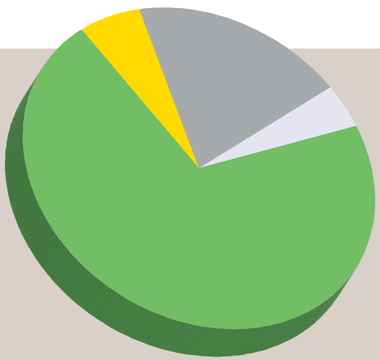
Finally, Côte d'Ivoire's sugar industry has the potential to start generating surplus power to sell locally, estimated at between 100 and 160 GWh/year.

This potential could be important in electrifying rural areas.



Exports 4,650 kboe

- Oil and Oil Products - 99%
- Electricity - 1%



Final Consumption 5,612 kboe

- Oil Products - 19%
- Natural Gas - 4%
- Combustibles Renewables and Waste - 71%
- Electricity - 6%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Kinshasa
AREA (km²)	2,267,048
POPULATION	70.9 million
ELECTRICITY ACCESS	11.1%
GDP	US$ 11.11 billion
GDP per capita	US$ 300
HDI	0.239
CURRENCY	Congolese franc

Democratic Republic of Congo (DRC)

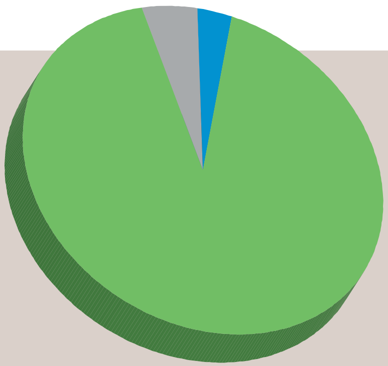
The DRC is rich in natural resources, particularly hydropower. Despite substantial energy resources, these have barely been harnessed, and dependency on imports of coal, oil and natural gas is high.

The DRC produces some crude oil but has no refineries and must import petroleum products. Its proven oil reserves were estimated at 187 million barrels in 2007.

The DRC has vast hydropower potential, estimated at 775,000 GWh/year, of which 145,000 GWh/year is economically viable. Despite having enough economic hydropower potential to generate double the aggregate power demands of Central, Eastern and Western Africa, only 5% of this is in currently in use.

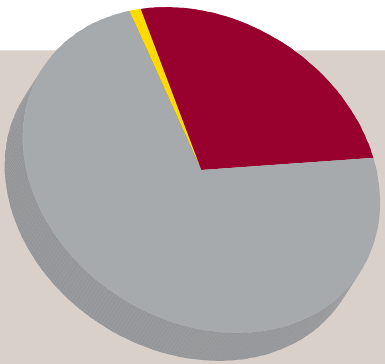
Hydropower accounts for 99% the current power production, with the rest coming from small thermal plants.

The two hydro plants at Inga account for more than half of installed capacity, which totals 2,445 MW.



Production 22,664 kboe

- Oil - 5%
- Hydro - 3%
- Combustibles Renewables and Waste - 92%



Imports 823 kboe

- Coal and Coal Products - 26%
- Oil and Oil Products - 73%
- Electricity - 1%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

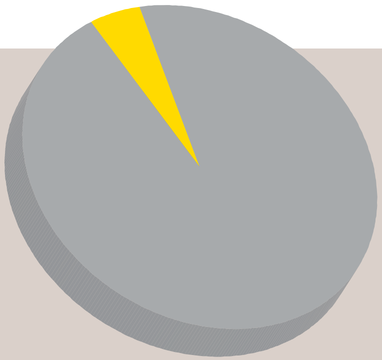
DRC currently exports power to neighbouring Congo (Brazzaville), as well as to South Africa through the Southern African Power Pool (SAPP).

Electrification rates are low, and the population depends on primary biomass to meet its energy needs.

Primary biomass used by households, mainly for cooking and heating, corresponds to 75% of all energy usage in the country.

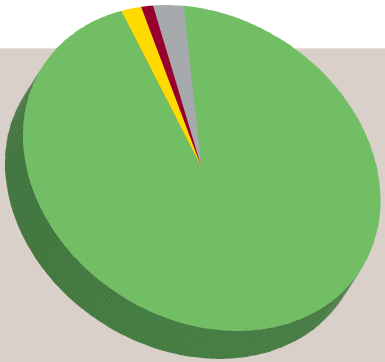
The government has long-term plans until 2030 for an electrification project using hydropower and other renewable sources.

In 2004, electricity companies from five southern African countries (Angola, Botswana, DRC, Namibia and South Africa) launched the Western Power Corridor Project (Westcor) to develop a third extension of the Inga dam, Inga III, which is designed to raise output by 2,000 MW.



Exports 1,205 kboe

- Oil and Oil Products - 95%
- Electricity - 5%



Final Consumption 21,664 kboe

- Coal and Coal Products - 1%
- Oil Products - 3%
- Combustibles Renewables and Waste - 94%
- Electricity - 2%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

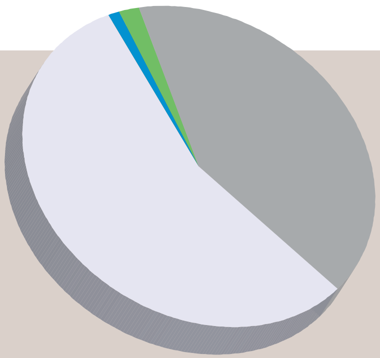
Egypt

CAPITAL	Cairo
AREA (km²)	995,450
POPULATION	80.5 million
ELECTRICITY ACCESS	99.4%
GDP	US$ 188.0 billion
GDP per capita	US$ 5,900
HDI	0.620
CURRENCY	Egyptian pound

The Suez Canal and Suez-Mediterranean (SuMed) Pipeline are strategic routes for Persian Gulf oil and gas, making Egypt an important transit corridor for world energy markets. Egypt is the fifth-largest oil producer in Africa and also has the largest oil refining sector in the continent: refining capacity now exceeds domestic demand, so that some non-Egyptian crude is being imported for processing and re-exportation.

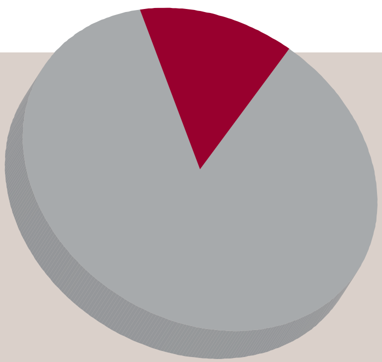
Proven natural gas reserves in 2010 amounted to 78 trillion cubic feet, being the largest reserves in Africa after Nigeria and Algeria. Natural gas production nearly tripled between 2000 and 2010, and 25% of production is exported both through pipelines and in the form of LNG. Egypt is also the third-largest exporter of natural gas in Africa. Domestic consumption also grew rapidly, more than doubling in the same period, thanks to aggressive government-run fuel switching programs since the early 1990s (in both industry and power stations).

Egypt has the second-largest installed power generating capacity in Africa, at 23,000 MW in 2008. In 2008 the electrification rate was among the highest on the continent, though around 500,000 people still lack access to electricity.



Production 87,487 kboe

- Oil - 41%
- Natural Gas - 56%
- Hydro - 1%
- Combustibles Renewables and Waste - 2%



Imports 8,375 kboe

- Coal and Coal Products - 14%
- Oil and Oil Products - 86%

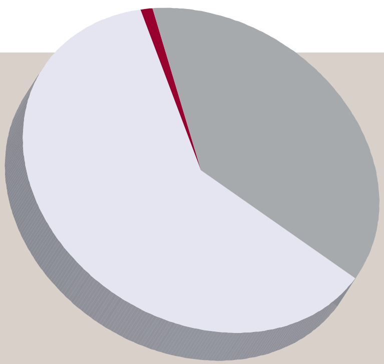
Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Like many African countries, Egypt is rich in renewable energy sources, but it is one of the few to invest significantly in assessment of this potential and in resource mapping. Solar photovoltaic potential is estimated to exceed 73,000 GWh/year, enough to supply over 60% of current power requirements. Untapped hydropower potential is still substantial, estimated at 50,000 GWh/year.

To harness wind energy potential, Egypt has established the largest grid-connected wind farms in the region, with 545 MW in the Gulf of Suez, generating over 900 GWh in 2009.

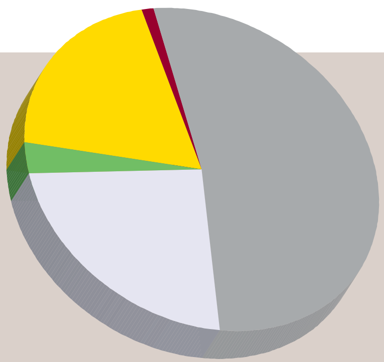
In February 2008, Egypt's Supreme Energy Council approved an ambitious plan to meet 20% of electricity needs from renewable energy sources by 2020.

Egypt is undergoing a political transition following the uprising against the government of President Hosni Mubarak in early 2011. Energy policies could therefore change in the near future.



Exports 23,900 kboe

- Coal and Coal Products - 1%
- Oil and Oil Products - 38%
- Natural Gas - 61%



Final Consumption 48,300 kboe

- Coal and Coal Products - 1%
- Oil Products - 53%
- Natural Gas - 23%
- Combustibles Renewables and Waste - 3%
- Electricity - 20%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

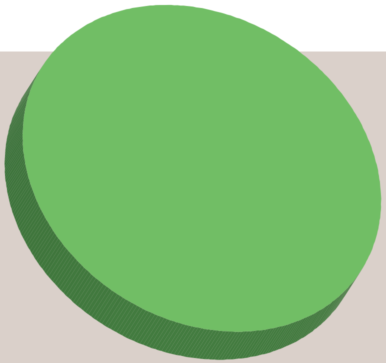
CAPITAL	Asmara
AREA (km²)	101,000
POPULATION	5.8 million
ELECTRICITY ACCESS	32.0%
GDP	US$ 1.87 billion
GDP per capita	US$ 700
HDI (2010)	-
CURRENCY	Nafka

Eritrea

One of the poorest countries in Africa, Eritrea's energy supply mainly comes from biomass, with a small proportion coming from oil imports. The only oil refinery, located at the Red Sea port of Assab, was shut down in 1997 due to high operating costs. As a result, all refined products, including jet fuel and gasoline, are imported.

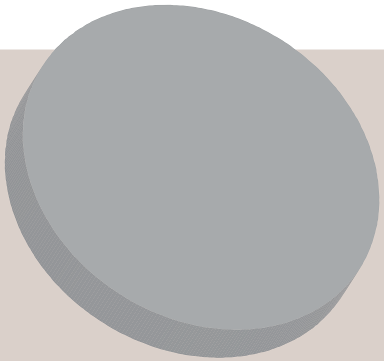
Electricity is available only in Eritrea's larger towns, leaving most of the population without access to electricity. In 2008, installed capacity totalled 170 MW, of which over 13% was lost due to aging and poor infrastructure maintenance.

There are no local sources of oil, natural gas, coal or hydropower in Eritrea, but there is potential for wind, solar and geothermal power.



Production 546 kboe

Combustibles Renewables and Waste - 100%



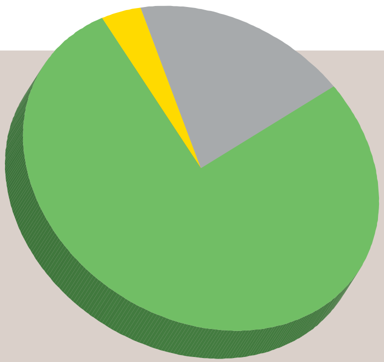
Imports 135 kboe

Oil and Oil Products - 100%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Geothermal potential is estimated at between 400 MW and 500 MW, located within the Great Rift Valley, the largest rift valley on the planet. With power capacity amounting to only 167 MW in 2008, developing geothermal power would have significant implications for the energy sector.

The World Bank has funded the Eritrea Power Distribution & Rural Electrification Project at a cost of US$ 57.2 million. This project includes (1) rehabilitation and expansion of the Asmara city distribution system, (2) rural electrification, and (3) power-sector reform to increase efficiency and attract private investment.



Final Consumption 486 kboe

- Oil Products - 19%
- Combustibles Renewables and Waste - 77%
- Electricity - 4%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Ethiopia

CAPITAL	Addis Abeba
AREA (km²)	1,000,000
POPULATION	88.0 million
ELECTRICITY ACCESS	15.3%
GDP	US$ 32.32 billion
GDP per capita	US$ 900
HDI	0.328
CURRENCY	Birr

Ethiopia has no oil and natural gas production and relies on imports to meet all its oil needs. Nevertheless, it has some untapped proven reserves of natural gas, estimated at one trillion cubic feet in 2008.

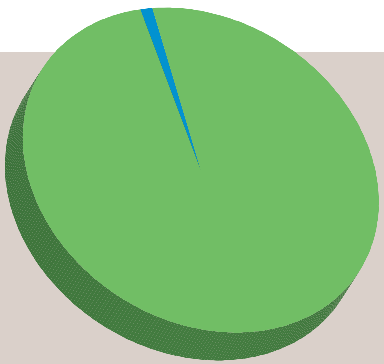
Installed capacity in Ethiopia is 750 MW, 98% from hydropower sources, with some thermal and geothermal power.

Ethiopia is one of the few countries in Africa that is rich in all types of renewables. Resources include geothermal, wind, hydropower and solar power which, if developed, will create a diverse and secure electricity supply for Ethiopia and the region.

There is enormous untapped hydropower potential along the rivers draining from the central highlands, amounting to an estimated 162,000 GWh/year, of which only 2% has been utilized.

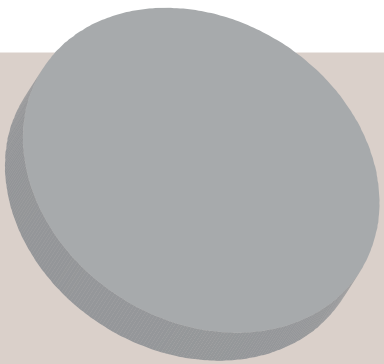
Located within the Great Rift Valley, Ethiopia is well endowed with geothermal power, estimated at 1,000 MW potential. Current capacity is only 9 MW but there are plans to install another 120 MW.

Wind power potential is especially high, estimated at 10,000 MW, with plans under way to start tapping into this source in the Tigray region.



Production 29,581 kboe

- Hydro - 1%
- Combustibles Renewables and Waste - 99%



Imports 2,122 kboe

- Oil and Oil Products - 100%

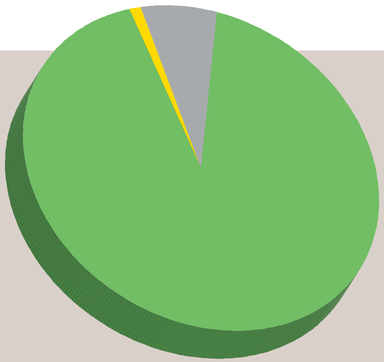
Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Access to electricity in rural areas is among the lowest on the continent, at about 2%.

Because of low access to commercial fuel and electricity, primary biomass accounts for a high proportion of energy consumption in Ethiopia, like many other sub-Saharan countries.

To reduce dependency on fuelwood, Ethiopia is experimenting with the use of ethanol cooking stoves.

With electricity demand increasing at a rate of 11% annually, the government plans to expand the electricity grid, increase the efficiency of the power system, and focus on renewables, especially hydro and geothermal power.



Final Consumption 30,020 kboe

- Oil Products - 7%
- Combustibles Renewables and Waste - 92%
- Electricity - 1%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Gabon

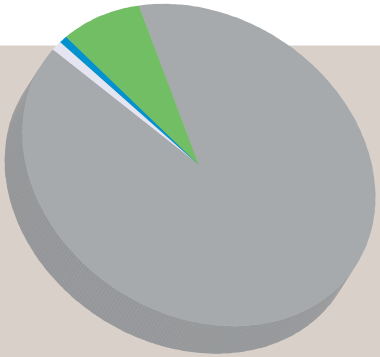
CAPITAL	Libreville
AREA (km²)	257,667
POPULATION	1.5 million
ELECTRICITY ACCESS	36.7%
GDP	US$ 11.02 billion
GDP per capita	US$ 13,900
HDI	0.648
CURRENCY	Central African CFA franc

Gabon is a net exporter of crude oil and petroleum products, exporting about 90% of its oil production. In 2010, Gabon's proven oil reserves totalled 3.7 billion barrels and it produced 245,000 barrels per day.

Gabon also has small natural gas reserves estimated at 1.2 trillion cubic feet. In 2008 Gabon produced three billion cubic feet per day of natural gas, entirely used to generate electricity and run the country's sole refinery.

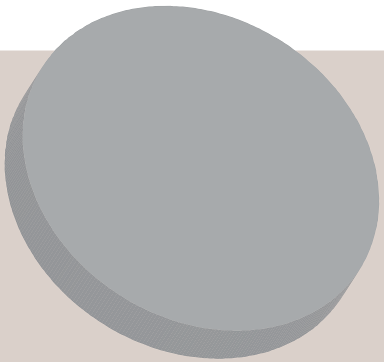
Installed power generating capacity totals 375 MW, 55% from conventional thermal plants and the remainder from hydropower. In 2008 the country's electricity generation reached 2,040 GWh, 45% of which was generated by gas-fired plants.

High rainfall and unique geography make for substantial hydropower potential. The economically exploitable hydro potential is around 76,000 GWh/year, while only 1% of this potential is presently being exploited.



Production 13,519 kboe

- Oil - 90%
- Natural Gas - 1%
- Hydro - 1%
- Combustibles Renewables and Waste - 8%



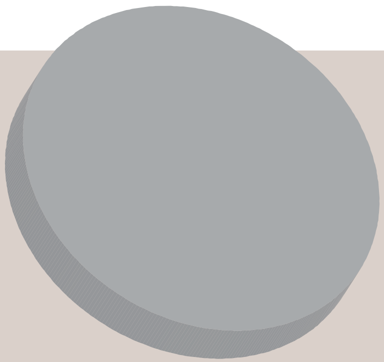
Imports 288 kboe

- Oil and Oil Products - 100%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

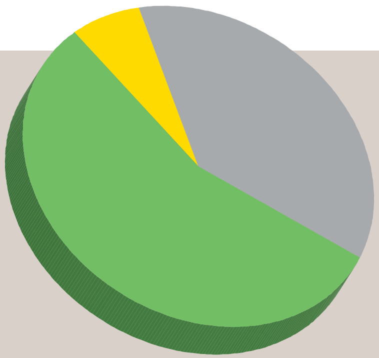
Around 40% of the urban population and only 18% of the rural population have access to electricity. Gabon has vast forests and primary biomass provides most of the total primary energy supply, at around 56%.

Mini hydropower projects are being planned to increase access rates in remote areas, and solar panels have been implemented in 100 villages in the countryside, including schools and shops.



Exports 11,588 kboe

- Oil and Oil Products - 100%



Final Consumption 1,923 kboe

- Oil Products - 37%
- Combustibles Renewables and Waste - 56%
- Electricity - 7%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Accra
AREA (km²)	227,533
POPULATION	24.3 million
ELECTRICITY ACCESS	54.0%
GDP	US$ 15.33 billion
GDP per capita	US$ 1,500
HDI	0.467
CURRENCY	Cedi

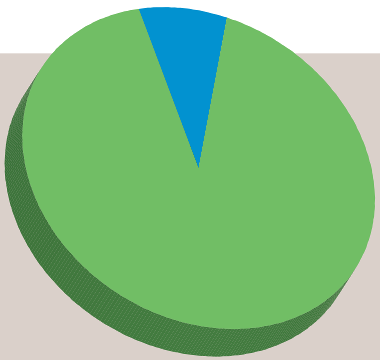
Ghana

Ghana has no hydrocarbon production and relies on imports from the Middle East and Nigeria to meet all of its oil needs. As the country has more refinery capacity than required, crude oil imports account for 34% of its total primary energy supply, and 27% of these imports are re-exported as refined oil products. Recent oil discoveries provide opportunities for future development.

Ghana is rich in a number of natural resources, with several lakes and rivers offering opportunities for hydropower to complement the large Lake Volta plant.

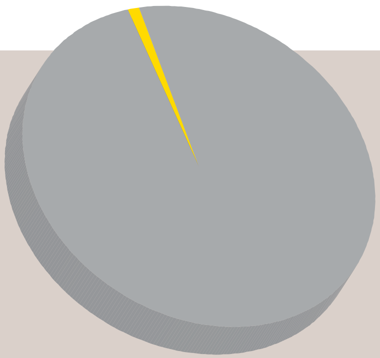
Total hydropower potential is around 1,200 MW and upcoming projects amount to 825 MW. There are also abundant wind power resources, estimated at 2,000 MW, which could be an important energy source for rural electrification.

The largest share of energy consumption comes from primary biomass, used mainly by the rural population, which corresponds to 60% of the total population.



Production 6,858 kboe

- Hydro - 8%
- Combustibles Renewables and Waste - 92%



Imports 3,198 kboe

- Oil and Oil Products - 99%
- Electricity - 1%

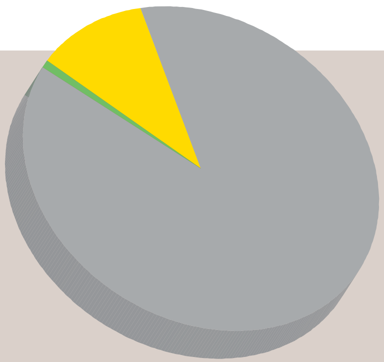
Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

In 2004 the rural electrification rate reached 54%, significantly higher than the average for sub-Saharan Africa, which is 20%. Since the late 1990s, Ghana has spearheaded numerous programs to extend reliable electricity access to rural areas.

The government instituted a National Electrification Scheme (NES) in 1989 for a 30-year period to extend electricity to all parts of the country. One of the phases comprises electrification of all district capitals and towns or villages en route.

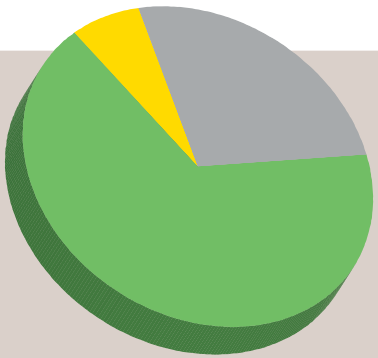
Within the NES, the Self-Help Electrification Program (SHEP) is an important example of a joint government and community initiative. Under SHEP, communities located up to 20 km from the national grid qualified for fast-track electrification if they acquired all the distribution poles.

Thanks to the success of these programs, more than 2,000 communities have been electrified, and access increased from 28% in 1989 to 54% in 2008.



Exports 407 kboe

- Oil and Oil Products - 88%
- Electricity - 11%
- Combustibles Renewables and Waste - 1%



Final Consumption 7,146 kboe

- Oil Products - 26%
- Combustibles Renewables and Waste - 67%
- Electricity - 7%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

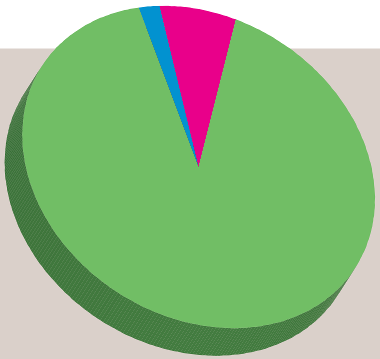
CAPITAL	Nairobi
AREA (km²)	569,140
POPULATION	40.0 million
ELECTRICITY ACCESS	15.0%
GDP	US$ 30.14 billion
GDP per capita	US$ 1,600
HDI	0.470
CURRENCY	Kenyan shilling

Kenya

Like other countries in Africa, Kenya does not produce any hydrocarbon products and relies entirely on imported oil. However, the Kenyan energy mix stands out among African countries for its diversity and for the large share of renewables, especially hydropower, geothermal and biomass. Nevertheless, Kenya still relies on imported oil to meet almost 40% of demand for power. In response to increasing oil prices and in order to reduce power production costs, Kenya has started importing cheaper hydropower electricity from Ethiopia.

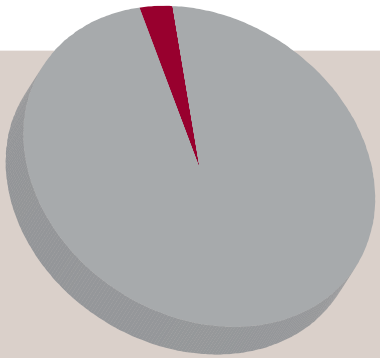
To reduce reliance on energy imports, the government has focused on increasing wind and geothermal power capacity. In 2008, 17% of the country's power came from geothermal energy.

Kenya has the largest geothermal resources on the continent, estimated at between 3,000 MW and 7,000 MW, enough to power all of Eastern Africa. Unleashing the development of Kenya's unique geothermal resources is a national priority, as laid out in its national energy strategy.



Production 15,108 kboe

- Hydro - 1%
- Others - 7%
- Combustibles Renewables and Waste - 92%



Imports Imports 3,554 kboe

- Coal and Coal Products - 3%
- Oil and Oil Products - 97%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

In 2009 the Kenyan government introduced incentives for private enterprises interested in geothermal power generation and exploration.

Geothermal installed capacity is 150 MW, located at the Olkaria field, and with an additional 1,200 MW planned for the future.

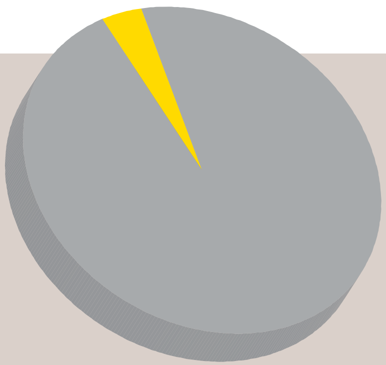
Kenya also has abundant wind resources, but detailed assessments of this source have yet to be carried out. The high initial cost and risk of resource exploration have slowed down the development of wind energy despite its cost competitiveness. Kenya has an active wind power investment program for both the public and private sectors.

The largest project in the pipeline is the 300 MW Lake Turkana wind project. Implementation requires construction of a 460 km transmission line to connect the project to the grid near Nairobi.

The transmission line would also facilitate the development of some geothermal fields that lie along the route, and would deliver base load power to towns and villages along the route.

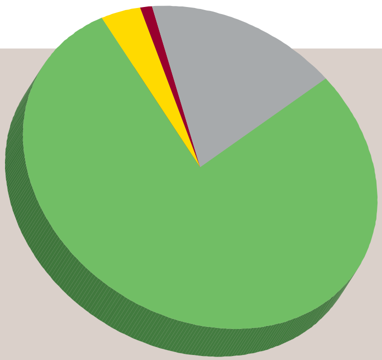
Also, more wind projects are planned totalling 300 MW in the same region as the Lake Turkana project. Total capacity would exceed 800 MW if most of these projects were realized.

Although Kenya currently relies on hydropower for about 40% of its power supply, there is still significant potential to increase hydropower capacity. Economic potential for hydropower is estimated at over 4,700 GWh/year, nearly doubling current hydropower generation, which totalled 2,850 GWh in 2008.



Exports 55 kboe

- Oil and Oil Products - 96%
- Electricity - 4%



Final Consumption 11,401 kboe

- Coal and Coal Products - 1%
- Oil Products - 17%
- Combustibles Renewables and Waste - 78%
- Electricity - 4%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Tripoli
AREA (km²)	1,759,540
POPULATION	6.5 million
ELECTRICITY ACCESS	99.8%
GDP	US$ 60.24 billion
GDP per capita	US$ 13,400
HDI	0.755
CURRENCY	Dinar

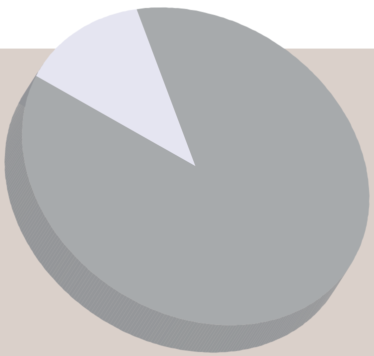
Libya

is a member of OPEC since 1962 and the Libyan economy is heavily dependent on the hydrocarbon industry, which accounted for over 95% of export earnings in 2010.

Libya holds around 46.4 billion barrels of oil reserves, the largest in Africa, and has the fourth-largest oil production after Nigeria, Angola and Algeria. Libya is also an important gas exporter mainly to Italy through the Greenstream pipeline. Libya has some 55 trillion cubic feet of natural gas reserves and produced 1.5 billion cubic feet per day in 2010.

Power generation is based on oil (60%) and natural gas (40%). With power demand on the rise, the government is planning to expand the use of natural gas to meet domestic electricity generation needs.

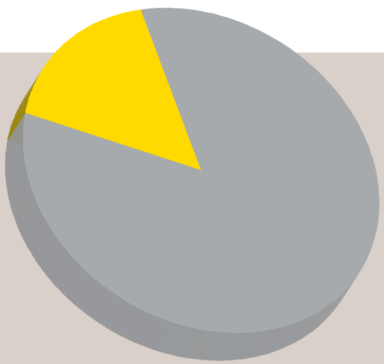
The Libyan grid is connected to Algeria, Egypt and Tunisia, which have further connections to other networks in Turkey and Morocco, with onward links to Europe.



Production 103,743 kboe

Oil - 87%

Natural Gas - 13%



Imports 36 kboe

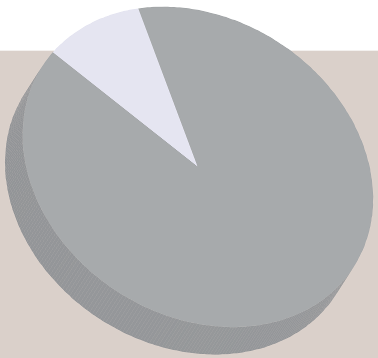
Oil and Oil Products - 84%

Electricity - 17%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

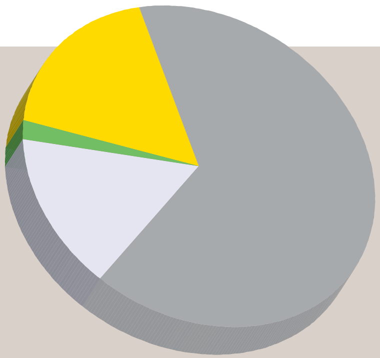
The Renewable Energy Authority of Libya, established in 2007, aims to raise the contribution of renewables to 10% by 2020. There is interest in developing solar PV, as well as concentrated solar power, thermal and wind in rural areas, although no advanced studies have been developed.

Libya is currently in a political transition following the uprising against the government of Muammar Al-Gaddafi in 2011. Changes in energy policy can therefore be expected.



Exports 85,273 kboe

- Oil and Oil Products - 90%
- Natural Gas - 10%



Final Consumption 8,951 kboe

- Oil Products - 65%
- Natural Gas - 15%
- Combustibles Renewables and Waste - 2%
- Electricity - 18%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Rabat
AREA (km²)	446,300
POPULATION	31.6 million
ELECTRICITY ACCESS	97.0%
GDP	US$ 91.37 billion
GDP per capita	US$ 4,600
HDI	0.567
CURRENCY	Dirham

Morocco

Morocco's energy mix is dominated by imported fossil fuels, which meet 95% of demand. Import dependency has steadily risen over the years as modest domestic resources are depleted and energy needs escalate.

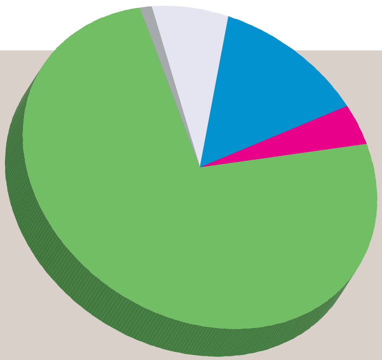
Like the overall energy mix, the power sector is also heavily dependent on fossil fuels, which accounted for 99% of total generation in 2008.

Coal-fired plants make the largest contribution to generation, with 55%, followed by oil- or natural gas-fired plants, hydro, and wind power.

Morocco also relies on electricity imports from Spain to meet demand.

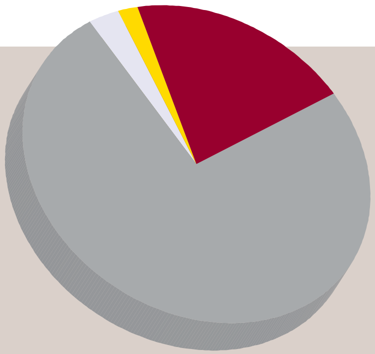
The government estimates renewable energy potential at 7,300 MW, mainly in solar and wind energy.

Current capacities are well below potential. Increased use of renewables and energy efficiency measures will help achieve many national energy objectives simultaneously and should be particularly effective in reducing emissions, given the high emission intensity of the power generation sector.



Production 637 kboe

- Oil - 1%
- Natural Gas - 7%
- Hydro - 13%
- Others - 4%
- Combustibles Renewables and Waste - 75%



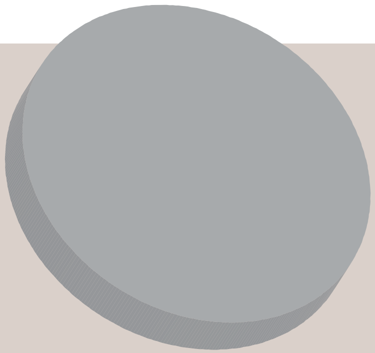
Imports 14,980 kboe

- Coal and Coal Products - 20%
- Oil and Oil Products - 75%
- Natural Gas - 3%
- Electricity - 2%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

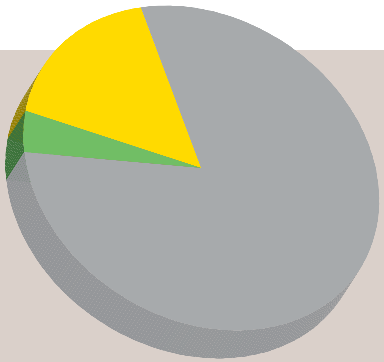
In 2008 Morocco launched a National Renewable Energy & Efficiency Plan with the aim of meeting 15% of domestic needs from renewable sources and increasing the use of energy-saving technologies.

The Clean Technology Fund (CTF) is financing 1,000 MW of wind power. The ultimate objective is to export renewable energy to European markets through the Morocco-Spain submarine interconnection.



Exports 742 kboe

- Oil and Oil Products - 100%



Final Consumption 11,313 kboe

- Oil Products - 79%
- Combustibles Renewables and Waste - 4%
- Electricity - 17%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Maputo
AREA (km²)	786,380
POPULATION	22.1 million
ELECTRICITY ACCESS	11.7%
GDP	US$ 9.83 billion
GDP per capita	US$ 900
HDI	0.284
CURRENCY	Metical

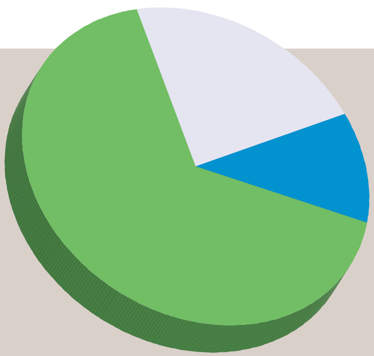
Mozambique

Mozambique has coal and natural gas resources, but nearly all natural gas production is exported to South Africa via a pipeline. On the other hand, the country relies entirely on oil imports to meet its domestic oil needs.

Mozambique is the largest producer of hydropower in Africa (with Egypt as a close second), thanks mainly to the Cahora Bassa hydropower plant, which accounts for 91% of the country's total hydropower capacity.

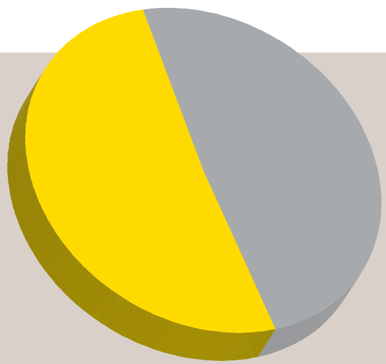
All of the country's power generation is based on hydro, but owing to limited transmission capacity and because the largest loads are located far from where generation occurs, Mozambique must rely on power exchanges with neighbouring countries (mainly South Africa) for its domestic supply.

Hydropower is an important commercial resource and offers significant scope for further development, with economic potential estimated at 32,000 GWh/year, about double current hydropower generation.



Production 11,460 kboe

- Natural Gas - 22%
- Hydro - 11%
- Combustibles Renewables and Waste - 67%



Imports 1,317 kboe

- Oil and Oil Products - 49%
- Electricity - 51%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

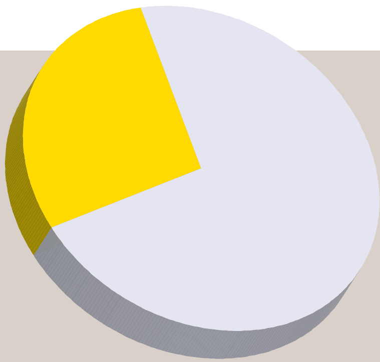
The government is focusing on expanding hydropower capacity and has identified roughly 100 locations for development.

In order to utilize its full resource potential, it has established a Transmission Backbone Project known as “CESUL”, which will facilitate access to renewables and improve rural power supply.

Major players in the biofuels industry are interested in Mozambique’s bioenergy potential.

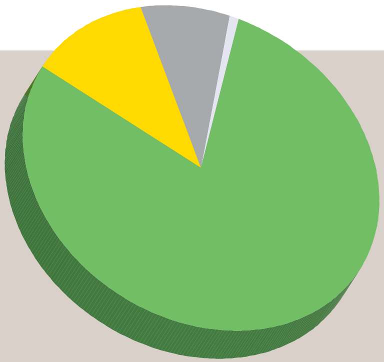
Several projects are in the design phase, but few are operational.

In 2011 the Ministries of Energy and Agriculture commissioned a report on biofuel sustainability.



Exports 3,389 kboe

- Natural Gas - 71%
- Electricity - 29%



Final Consumption 7,388 kboe

- Oil Products - 8%
- Natural Gas - 1%
- Combustibles Renewables and Waste - 80%
- Electricity - 11%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Windhoek
AREA (km²)	823,380
POPULATION	2.1 million
ELECTRICITY ACCESS	34.0%
GDP	US$ 9.39 billion
GDP per capita	US$ 6,600
HDI	0.606
CURRENCY	Namibian dollar

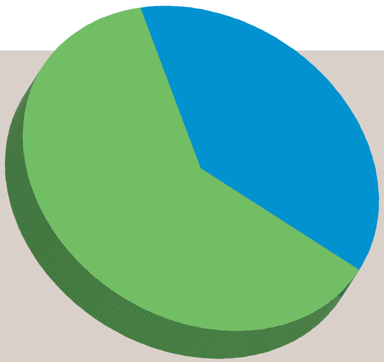
Namibia

Namibia has no oil, coal or natural gas, relying on imports to meet its energy needs. Electricity imports from South Africa account for around 50% of Namibia's power supply, but are under strain owing to South Africa's own energy shortages.

Namibia has modest renewable energy potential, mainly in wind, solar and hydropower, although few technical studies have been performed. Most of the hydropower resources have already been developed, but potential remains for another 6,000 GWh/year, or double the amount of electricity consumed in 2008. Planned wind power projects are estimated at 43 MW, and a 50 MW concentrated solar power project is currently under consideration by the government.

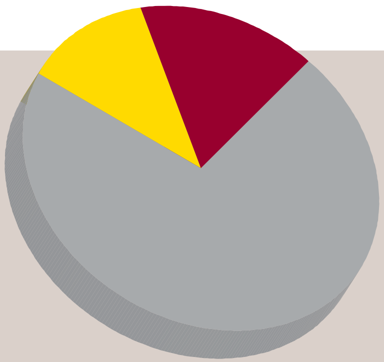
Approximately 12,000 tons of charcoal is produced annually, largely for export. The use of charcoal and charcoal briquettes is confined almost entirely to urban areas.

There is very little use of charcoal in farming areas either because households prefer to use free firewood or because charcoal is not available for sale in the areas concerned.



Production 317 kboe

- Hydro - 38%
- Combustibles Renewables and Waste - 62%



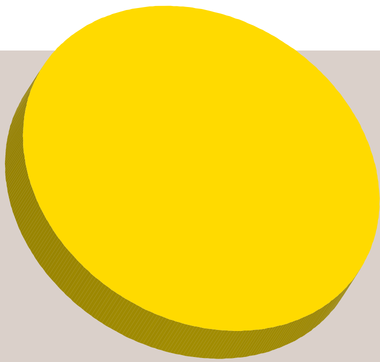
Imports 1,438 kboe

- Coal and Coal Products - 15%
- Oil and Oil Products - 72%
- Electricity - 13%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

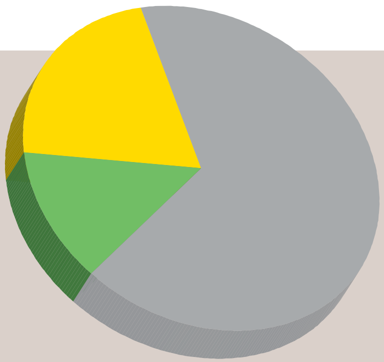
Considering the large fuelwood consumption, high-efficiency stoves could decrease consumption and minimize health risks from indoor pollution. Two high-efficiency cooking stove manufacturing centres that produce the Tso-tso fuel-efficient stove are located in Namibia. The Tso-tso stove generally requires 50% less wood than an open fire for an equivalent cooking task. About 2,500 stoves have been sold to date.

The Solar Cooker (box-type) which uses solar power for cooking is also manufactured in Namibia.



Exports 4 kboe

- Electricity - 100%



Final Consumption 1,548 kboe

- Oil Products - 66%
- Combustibles Renewables and Waste - 13%
- Electricity - 21%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Abuja
AREA (km²)	910,768
POPULATION	152.2 million
ELECTRICITY ACCESS	46.8%
GDP	US$ 168.8 billion
GDP per capita	US$ 2,300
HDI	0.423
CURRENCY	Naira

Nigeria

Nigeria is not only the most populated country in Africa, but also the largest oil producer and holder of the largest natural gas reserves on the continent. A member of OPEC since 1971, the Nigerian economy is heavily dependent on the oil sector, which accounts for over 95% of export earnings and about 65% of government revenues.

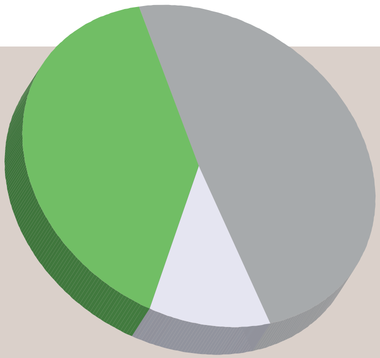
Natural gas accounts for nearly 60% of power generation, the rest being hydropower (25%) and oil-based (15%).

Nigeria has some potential for renewable energy development, especially in hydro and solar power.

Hydropower currently accounts for some 30% of the national power supply, although economic potential is estimated at five times that amount, or 30,000 GWh/year.

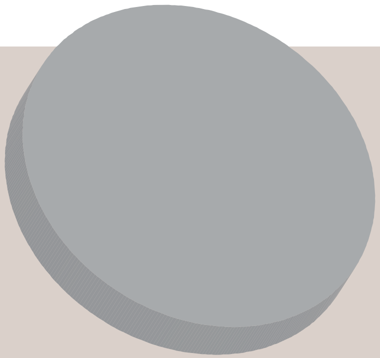
The government has issued a renewable energy master plan aiming to gradually move away from fossil fuel-based power. The upcoming projects include 20 MW from wind power and 120 MW from solar PV.

The Nigerian government plans to develop a sugarcane plantation with a bioethanol production unit for 70 million-80 million litres per year.



Production 226,793 kboe

- Oil - 49%
- Natural Gas - 11%
- Combustibles Renewables and Waste - 40%



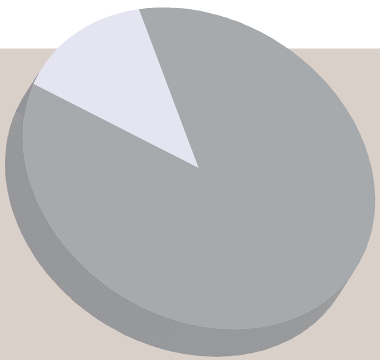
Imports 6,205 kboe

- Oil and Oil Products - 100%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

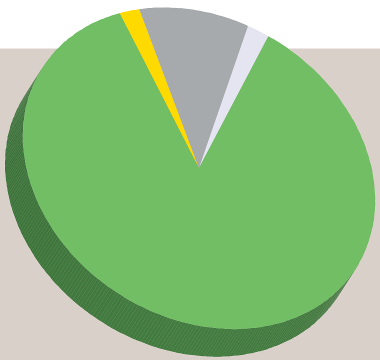
It also plans to establish a 5,000-10,000 hectares cassava plantation with a bioethanol production unit capable of producing 50 million-60 million litres each year.

The projects are to be implemented in Jigawa State. The Energy Commission of Nigeria, the National Centre for Energy Research & Development at Nsukka and the Sokoto Energy Research Centre are among the local institutions that have constructed bio-digesters in Nigeria.



Exports 121,645 kboe

- Oil and Oil Products - 86%
- Natural Gas - 14%



Final Consumption 101,313 kboe

- Oil Products - 10%
- Natural Gas - 1%
- Combustibles Renewables and Waste - 87%
- Electricity - 2%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Dakar
AREA (km²)	192,530
POPULATION	12.3 million
ELECTRICITY ACCESS	42.0%
GDP	US$ 12.79 billion
GDP per capita	US$ 1,900
HDI	0.411
CURRENCY	West African CFA franc

Senegal

Senegal has no oil, coal or natural gas production, relying heavily on oil imports to meet its energy needs. No comprehensive hydrocarbon assessments have been performed in Senegal to date, but some exploration is starting.

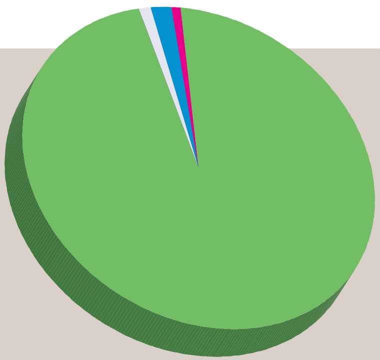
Heavy petroleum was discovered offshore, but oil production was considered not economical.

Small amounts of natural gas have been discovered and produced onshore near Dakar and are used to produce electricity.

Senegal's power sector is mostly oil-fired (85%), with hydropower and some biomass power plants meeting the rest of demand.

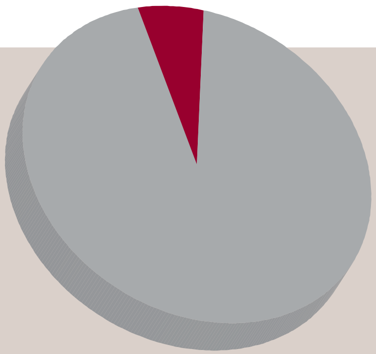
Power supply is an issue in Senegal owing to low energy diversity in power production, as well as high transmission and distribution losses, which accounted for 20% of electricity produced in 2008.

Senegal is exploiting some hydropower but currently uses only 10% of this resource potential.



Production 1,230 kboe

- Natural Gas - 1%
- Hydro - 1%
- Others - 1%
- Combustibles Renewables and Waste - 97%



Imports 2,158 kboe

- Coal and Coal Products - 6%
- Oil and Oil Products - 94%

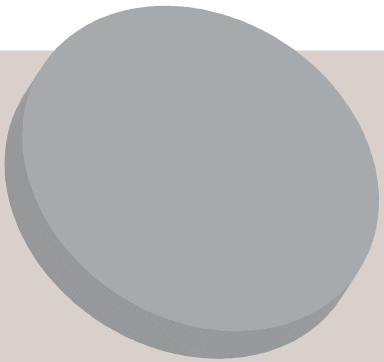
Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

A further 1,770 GWh/year could be exploited economically to reduce reliance on fossil fuel while meeting all power requirements.
Most Senegalese do not have access to modern energy sources, such as electricity and petroleum products. Around 75% of urban dwellers have access to electricity, compared with only 18% of their rural counterparts.

Access to electricity in rural areas is limited to the vicinity of urban centres, including social services (health centres, schools etc.).

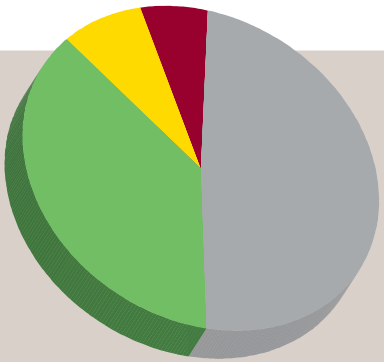
Over the last ten years, the electrification rate has increased very slowly and access to electricity is largely confined to the greater Dakar area and four urban centres: St. Louis, Kaolack, Ziguinchor and Tambacounda.

The government's strategy in rural areas, described in the Rural Electrification Development Letter of May 2004, is to implement a major program over a 15-20 year period with the aim of reaching a 62% access rate by 2022, compared with 18% in 2008.



Exports 3 kboe

- Oil and Oil Products - 100%



Final Consumption 2,141 kboe

- Coal and Coal Products - 6%
- Oil Products - 49%
- Combustibles Renewables and Waste - 37%
- Electricity - 8%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

South Africa

CAPITAL	**Cape Town (legislative) Pretoria (executive) Bloemfontein (judiciary)**
AREA (km²)	**1,214,470**
POPULATION	**49.1 million**
ELECTRICITY ACCESS	**75.0%**
GDP	**US$ 287.2 billion**
GDP per capita	**US$ 10,300**
HDI	**0.597**
CURRENCY	**Rand**

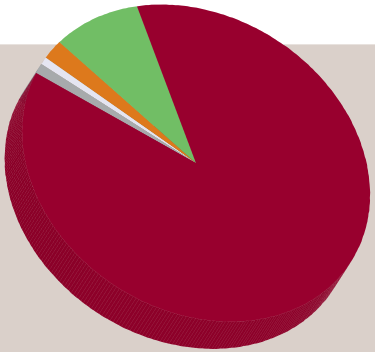
South Africa is the world's seventh-largest coal producer and one of the largest coal exporters. The coal mining industry is an important sector of the economy as well as a major energy consumer.

South Africa is currently responsible for 90% of the coal consumed on the continent. It has limited oil and gas reserves, and practically all crude oil, oil products and a large part of the gas supply are imported.

South Africa is the largest electricity producer and consumer in Africa and consumes more than double the amount of power used by all of sub-Saharan Africa.

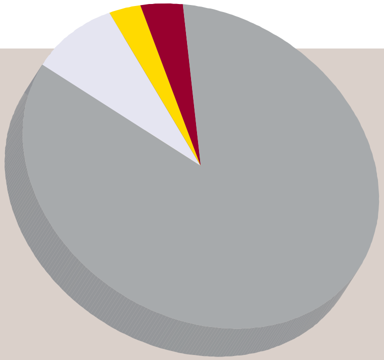
Power capacity is the highest on the continent at over 40,000 MW and is highly dependent on coal-fired plants. Since coal-fired power plants are the largest greenhouse gas emitters in the energy sector, South Africa is the largest emitter of greenhouse gas on the continent.

There are plans to double total generating capacity to 80,000 MW over the next 20 years, with nuclear power accounting for about half of the new capacity.



Production 162,951 kboe

- Coal - 87%
- Oil - 1%
- Natural Gas - 1%
- Nuclear - 2%
- Combustibles Renewables and Waste - 9%



Imports 27,287 kboe

- Coal and Coal Products - 4%
- Oil and Oil Products - 84%
- Natural Gas - 9%
- Electricity - 3%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

South Africa is the only African country that has nuclear power generating capacity, which supplied 5% of the total generated in 2008. After several years of sustained economic growth, South Africa's electricity system is now under considerable strain. The electricity sector, while generally efficient, has run into major capacity constraints during the last few years, especially in 2008.

Around 80% of economic hydropower potential has been developed, but some 4,700 MW remains untapped.

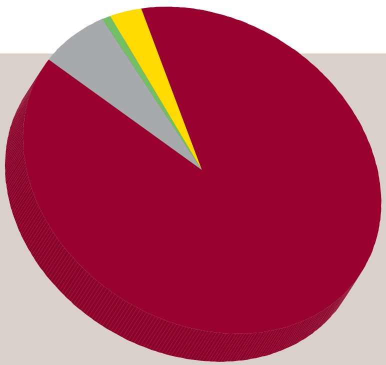
South Africa is considered one of the most economically feasible locations for solar power projects thanks to very high solar radiation levels.

Despite high per capita power consumption in relation to the rest of Africa, electricity access is highly uneven. Some 3.5 million homes have been electrified since 1990 under a mass electrification program.

The government aims to achieve universal access to electricity by 2012.

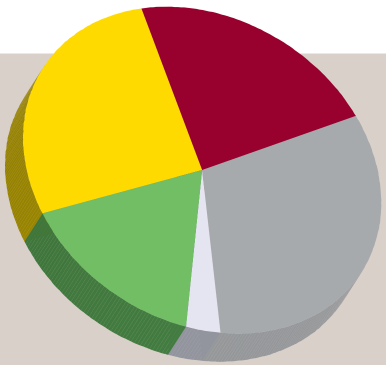
In 2009, the National Energy Regulator of South Africa approved the Renewable Energy Feed-In Tariff to achieve the government's target of producing 10,000 GWh of electricity per year from renewable sources by 2013.

Wind and solar tariffs are comparable with prices offered in Germany and Canada.



Exports 44,722 kboe

- Coal and Coal Products - 90%
- Oil and Oil Products - 7%
- Electricity - 2%
- Combustibles Renewables and Waste - 1%



Final Consumption 64,087 kboe

- Coal and Coal Products - 22%
- Oil Products - 32%
- Natural Gas - 3%
- Combustibles Renewables and Waste - 16%
- Electricity - 27%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Khartoum
AREA (km²)	2,376,000
POPULATION	43.9 million
ELECTRICITY ACCESS	31.4%
GDP	US$ 59.64 billion
GDP per capita	US$ 2,200
HDI	0.379
CURRENCY	Sudanese pound

Sudan

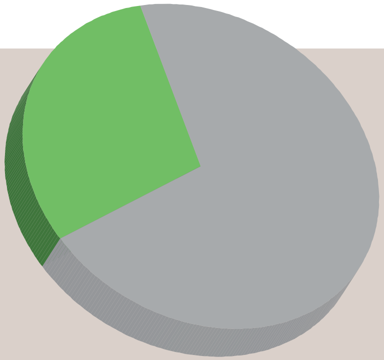
Oil plays a major role in the Sudanese economy, contributing over 90% of export earnings in 2009. Sudan has proven oil reserves of 6.7 billion barrels and produced 486 thousand barrels in 2010. In 2009, natural gas discoveries were announced in Sudan but their commercial viability has yet to be assessed.

The power sector depends mainly on oil-fired power plants (68% of power generation in 2008), with the remainder coming from hydropower. Approximately 27 million people in Sudan lack access to electricity; the electrification rate in urban areas is 48%, while in rural areas it is only 19%.

With a large population residing in rural areas, the share of primary biomass in final consumption is high. Many villages connect small diesel-powered generators for irrigation pumps, which are an inefficient and expensive way to generate electricity.

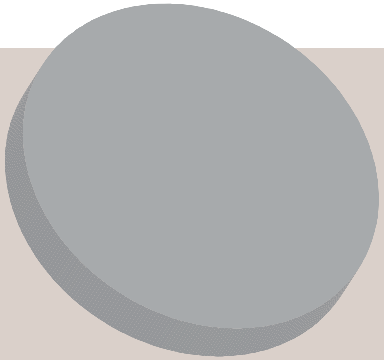
Despite the deficiencies of its power system, Sudan is rich in renewable energy sources. Hydropower potential is estimated at 19,000 GWh/year, of which only 8% is currently used.

Moreover, its location near the Great Rift Valley makes Sudan one of the few countries in Africa with significant geothermal resources.



Production 34,874 kboe

- Oil - 70%
- Combustibles Renewables and Waste - 30%



Imports 1,207 kboe

- Oil and Oil Products - 100%

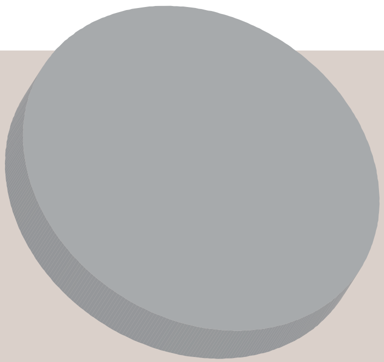
Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Geothermal potential is estimated at 400 MW. Sudan is also located within the world's Sun Belt, which offers the highest solar radiation levels on earth. Photovoltaic and concentrated solar power offer enormous potential.

Finally, power generation using bagasse (sugarcane refuse left after crushing to obtain sugar) for export to the local grid could potentially reach 500-700 GWh/year or around 20% of present consumption.

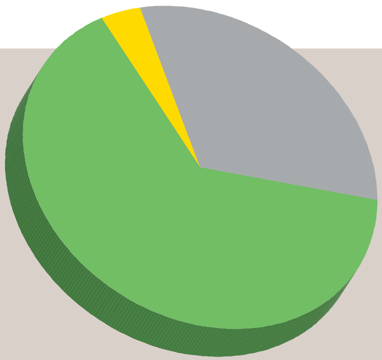
Co-generation with bagasse is currently used in the sugar industry, mainly for own consumption, and there are plans to develop this segment further using more energy-efficient equipment.

In 2011, when this chapter was being written, Sudan had just separated into the Republic of Sudan and the Republic of South Sudan. Due to restrictions in the data that is available within this new political framework, data for Sudan, pre-separation, is used.



Exports 20,265 kboe

- Oil and Oil Products - 100%



Final Consumption 9,656 kboe

- Oil Products - 31%
- Combustibles Renewables and Waste - 66%
- Electricity - 3%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Tanzania

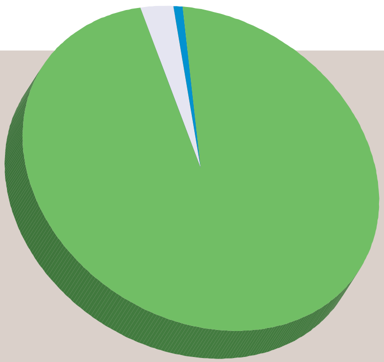
CAPITAL	Dodoma
AREA (km²)	885,800
POPULATION	41.9 million
ELECTRICITY ACCESS	11.5%
GDP	US$ 21.31 billion
GDP per capita	US$ 1,400
HDI	0.398
CURRENCY	Tanzanian shilling

Although Tanzania has coal and gas resources, and prospects for oil discovery are promising, it relies on primary biomass to meet 90% of its energy needs. The country's proven coal and gas reserves are estimated at 304 million tons and 1.6 trillion cubic feet respectively.

Installed power capacity in 2008 was 950 MW, with hydropower as the main source of power generation (60% in 2008) and gas fired thermal power supplying the rest. Electricity accounts for only 2% of total final energy consumption because the vast majority of Tanzanians do not have access to electricity.

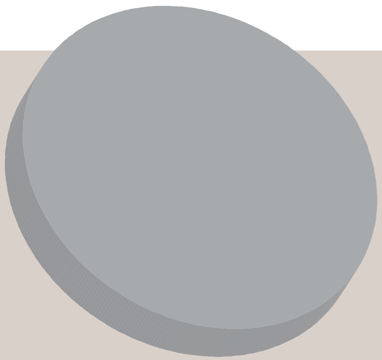
The rural population is particularly hard hit: only 2% have access to electricity. Tanzania suffered an acute power shortage in 2006 due to severe droughts that affected economic growth.

The problem of low power diversity in Tanzania can be solved by developing its vast renewable energy resources. Geothermal sources from the Great Rift Valley are estimated at 450 MW and a 10 MW project is planned to start developing these sources, which have low carbon emissions.



Production 17,470 kboe

- Natural Gas - 3%
- Hydro - 1%
- Combustibles Renewables and Waste - 96%



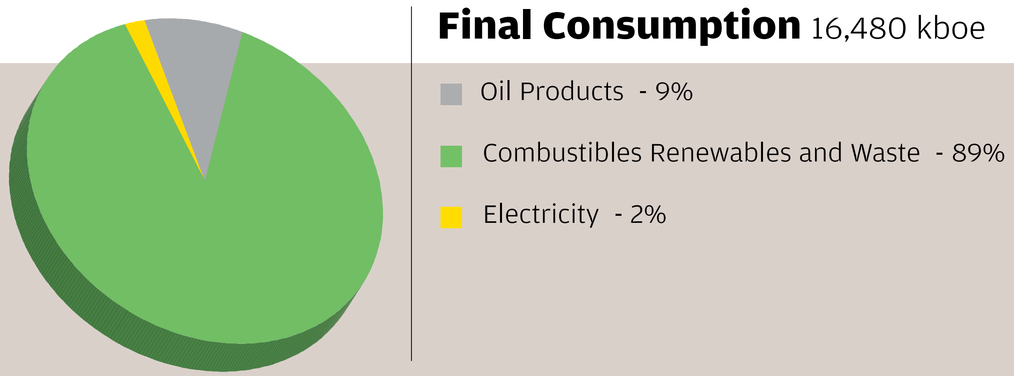
Imports 1,617 kboe

- Oil and Oil Products - 100%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Potential generation from sugarcane bagasse for export to the local grid is 100-200 GWh/year, or around 6% of total power consumption. Only some 10% of the country's hydropower potential has been tapped and development could increase capacity by another 3,500 MW.

The government's short to medium-term plan consists of a 750 MW increase in capacity from diesel and gas-fired plants plus a wind farm. Interconnection with Mozambique, Kenya, Ethiopia, Rwanda, Burundi and Zambia is also planned under the aegis of the East African Power Pool (EAPP).



Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Lomé
AREA (km²)	54,385
POPULATION	6.6 million
ELECTRICITY ACCESS	20.0%
GDP	US$ 3.15 billion
GDP per capita	US$ 900
HDI	0.428
CURRENCY	CFA franc

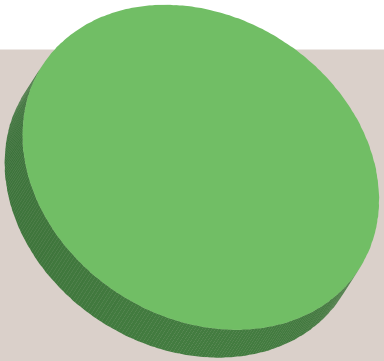
Togo

Togo does not produce oil, natural gas or coal and therefore depends heavily on imports of both oil and electricity. In 2008, these imports accounted for 16% of the total primary energy consumption mix, biomass providing the remaining 84%.

Togo imports 84% of its power supply from Ghana, Côte d'Ivoire and Nigeria. Domestic supply comes from hydropower and oil-fired power plants from imported sources. With a large proportion of electricity imports coming from hydropower, Togo experiences energy shortages during dry seasons and at times of drought.

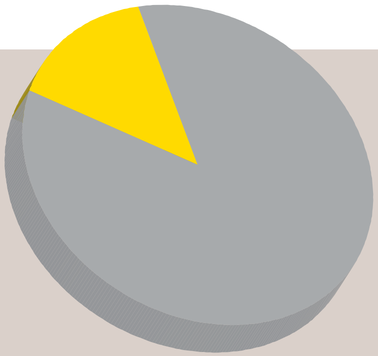
Electricity access rates are 42% in urban centres and only 4% in rural areas, lagging behind the average for sub-Saharan Africa (25%). These low percentages reflect limited investment in transmission and distribution.

Primary biomass is the most prominent source of energy for cooking and heating.



Production 2,138 kboe

Combustibles Renewables and Waste - 100%



Imports 385 kboe

Oil and Oil Products - 85%

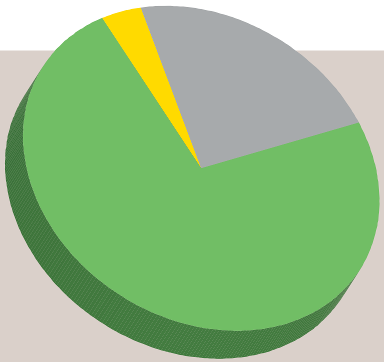
Electricity - 15%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

With significant biomass resources available, mainly from agricultural waste (cotton and maize stalks etc.) and livestock, the biogas industry has potential, but has not yet been developed for lack of technology and expertise.

There is also potential for mini and micro hydropower plants, especially on the Mono and Oti rivers, with at least 40 sites offering up to 225 MW. Only a few hydropower plants have been brought on stream to date, however.

The electricity distribution system is being rehabilitated through the Emergency Infrastructure Rehabilitation & Energy Project (2009-2013) approved by the World Bank in 2009. Co-financed by the International Development Organization and the Global Environment Facility (GEF), the project includes refurbishment of the Lomé distribution network and enhancement of energy efficiency within the system.



Final Consumption 1,587 kboe

- Oil Products - 23%
- Combustibles Renewables and Waste - 74%
- Electricity - 3%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Tunis
AREA (km²)	155,360
POPULATION	10.6 million
ELECTRICITY ACCESS	99.5%
GDP	US$ 43.52 billion
GDP per capita	US$ 9,100
HDI	0.683
CURRENCY	Tunisian dinar

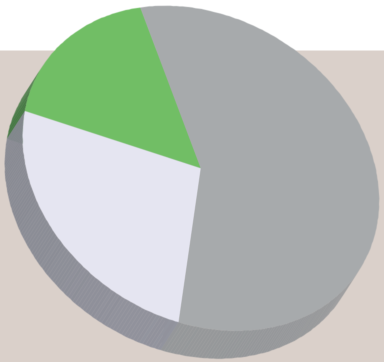
Tunisia

Tunisia produces enough oil to meet domestic demand. The vast majority of electricity is generated by fossil fuel plants, fired mainly by natural gas, 50% of which is imported.

Economic growth and rising living standards have led to a significant increase in electricity consumption, resulting in saturation of the grid. In addition, some power plants and facilities are no longer appropriate to the current load.

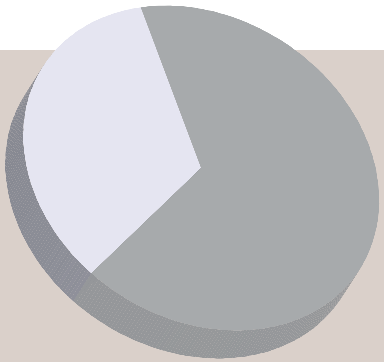
Tunisia has already begun tapping into its large wind resources from the coastline, with installed capacity of 115 MW plus plans for an additional 1,000 MW. Being located in the Sahara Desert, it also has large solar power potential.

Tunisia is a participant in a trans-Maghreb project to link the power grids of all the Maghreb countries to those of Spain and the rest of the European Union with the aim of exporting renewable energy. However, Tunisia's own grid must first be upgraded to meet domestic demand and ensure greater reliability.



Production 7,534 kboe

- Oil - 58%
- Natural Gas - 26%
- Combustibles Renewables and Waste - 16%



Imports 6,203 kboe

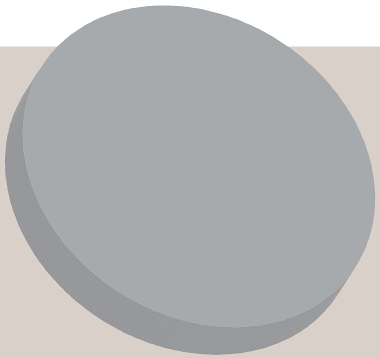
- Oil and Oil Products - 66%
- Natural Gas - 34%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Tunisia is already linked to Algeria's grid and efforts to connect it to Libya's grid have begun. When the two networks are connected, an integrated North African power grid will stretch from Morocco to Egypt.

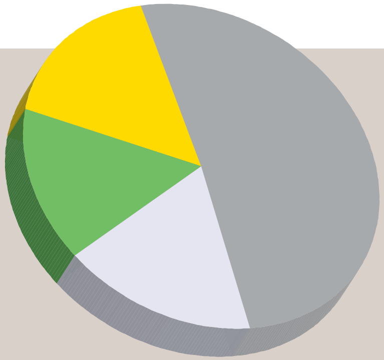
There are plans to install 2,000 MW of concentrated solar power in the south using resources from the Clean Technology Fund (CTF), and a 50 MW test plant is being installed by the government.

Tunisia is currently undergoing a political transition following the uprising against the government of former president Ben Ali in early 2011. Energy policies may therefore change in future.



Exports 4,420 kboe

- Oil and Oil Products - 100%



Final Consumption 6,576 kboe

- Oil Products - 51%
- Natural Gas - 34%
- Combustibles Renewables and Waste - 15%
- Electricity - 17%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Lusaka
AREA (km²)	743,398
POPULATION	13.5 million
ELECTRICITY ACCESS	18.8%
GDP	US$ 12.81 billion
GDP per capita	US$ 1,400
HDI	0.395
CURRENCY	Zambian kwacha

Zambia

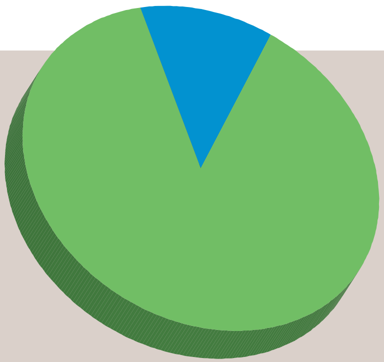
With no coal, oil or gas production, Zambia relies on oil imports to meet its commercial energy needs. Biomass accounts for 80% of total primary energy supply.

However, proven coal reserves exceed 30 million tons and the government plans to revamp the Maamba coal mines and develop a coal-fired power plant.

The copper mines consume about 70% of the electricity generated, while the rest of the population consumes the remainder.

The electricity access rate remains low at 3% for rural areas and 48% for urban areas. No major power plants have been developed since the 1980s and demand has rapidly outstripped generating capacity. Since 2002, electricity demand has risen rapidly owing to new coal mines, factories and growing household consumption. Demand is rising about 100 MW per annum and is expected to continue doing so.

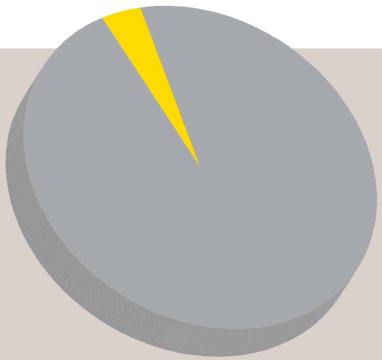
Hydropower plants account for 99% of the electricity produced in Zambia. There are abundant hydro resources, representing around 40% of the total for Southern Africa.



Production 6,790 kboe

Hydro - 12%

Combustibles Renewables and Waste - 88%



Imports 621 kboe

Oil and Oil Products - 96%

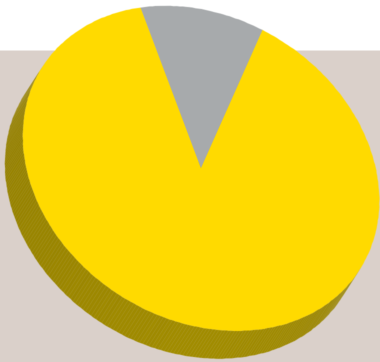
Electricity - 4%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

Hydropower potential is estimated at some 20,000 GWh/year, enough to meet more than double the current level of electricity demand. Several plants are planned, with an installed capacity totalling over 1,500 MW.

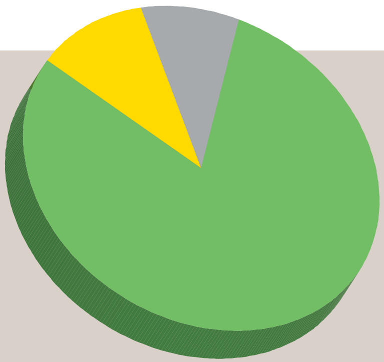
The government recognizes that limited access to electricity services has been a major economic growth bottleneck and has made improved access a major priority for development of the power sector. Integration with the grids of neighbouring countries is part of a plan to increase access from 20% to 90% by 2030.

The Zambia-Tanzania-Kenya Interconnector Project calls for the construction of 1,600 km of 330 kV transmission lines, 697 km on the Zambian side and about 740 km on the Tanzanian side. Growth centres will be electrified through a five-year electricity access expansion program using three principal methods of electrification: grid extension, implementation of standalone electricity systems from renewable sources including mini hydropower plants and biomass, and installing solar power systems.



Exports 9 kboe

- Oil and Oil Products - 11%
- Electricity - 89%



Final Consumption 5,676 kboe

- Oil Products - 9%
- Combustibles Renewables and Waste - 80%
- Electricity - 11%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

CAPITAL	Harare
AREA (km²)	386,847
POPULATION	11.7 million
ELECTRICITY ACCESS	41.5%
GDP	US$ 4.62 billion
GDP per capita	Less than US$ 100
HDI	0.140
CURRENCY	None

* Zimbabwe's currency, the Zimbabwean dollar, was indefinitely suspended on April 12, 2009.

Zimbabwe

Zimbabwe lacks oil and natural gas resources, and coal accounts for 23% of the energy mix. About 45% of power generation is based on coal and 55% on hydropower. There are large coal deposits, but the government lacks the financial resources to boost output significantly.

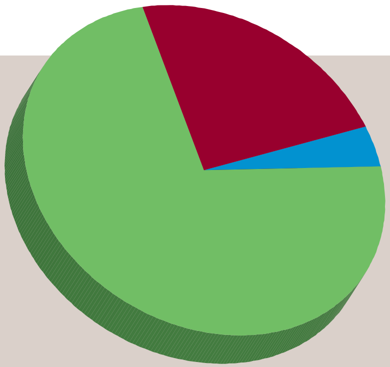
Total installed power capacity in 2008 was 1,990 MW. This is not enough to meet demand and power therefore has to be imported from neighbouring countries, such as Mozambique and the DRC.

Almost all rural households and 40% of urban households use fuelwood for cooking.

Power generation could be increased by means of hydropower projects, since Zimbabwe's water resources are largely untapped.

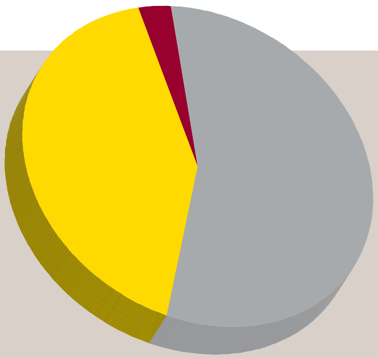
The country currently uses 25% of its technical hydro resources and further investigation is required to determine how much additional potential is firm. The Zambezi River, for instance, has significant potential that can be shared with Zambia.

The large sugar industry provides opportunities for co-generation using sugarcane bagasse, which offers an estimated potential of 350-630 GWh/year.



Production 8,533 kboe

- Coal - 23%
- Hydro - 4%
- Combustibles Renewables and Waste - 73%

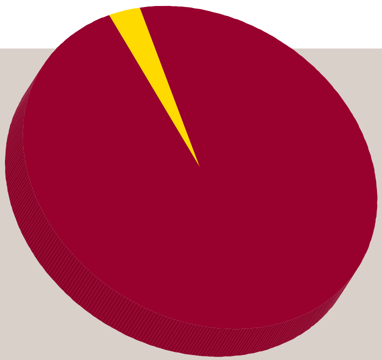


Imports 1,104 kboe

- Coal and Coal Products - 2%
- Oil and Oil Products - 56%
- Electricity - 42%

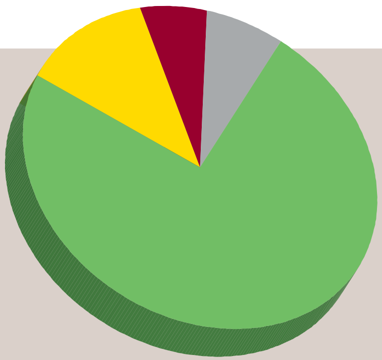
Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

There is also potential for using wood waste to generate power. More than 200 biogas plants have been installed, mainly by the Department of Energy. The vast livestock population offers great potential for using biogas from animal waste for electricity generation.



Exports 139 kboe

- Coal and Coal Products - 97%
- Electricity - 3%



Final Consumption 8,345 kboe

- Coal and Coal Products - 6%
- Oil Products - 7%
- Combustibles Renewables and Waste - 74%
- Electricity - 13%

Source: Elaborated by FIESP using data from IEA, 2010 (year 2008).

3. RENEWABLE ENERGY

Renewable Energy

Introduction

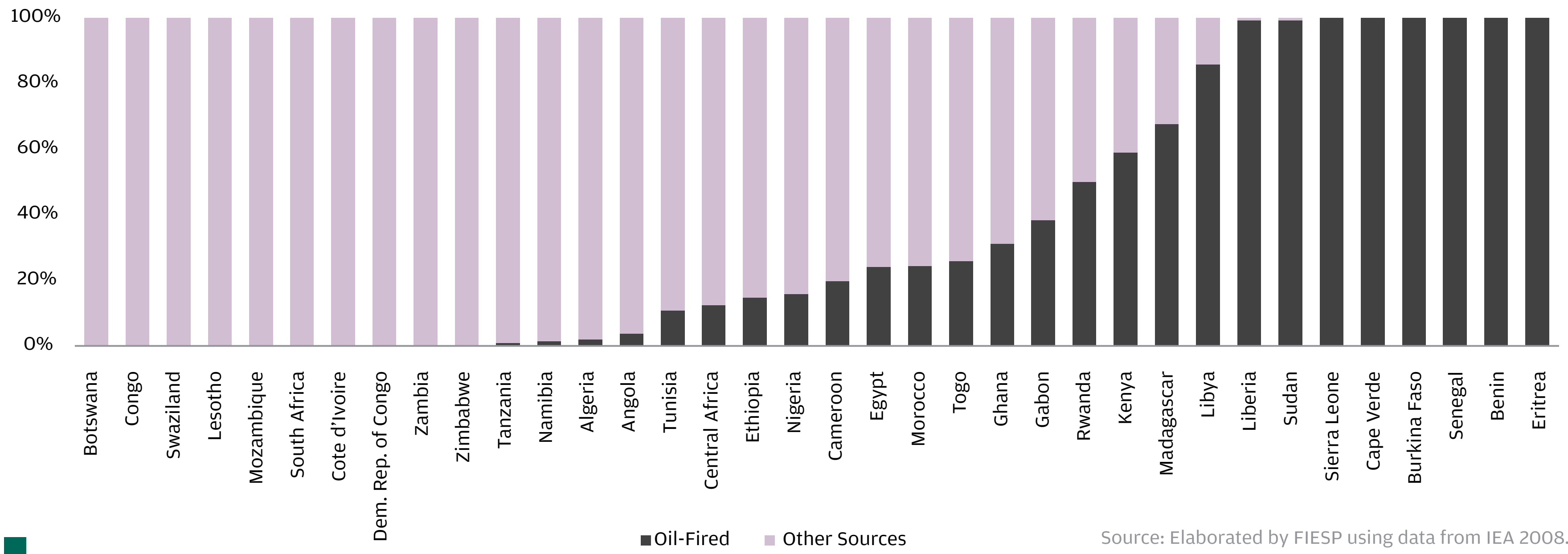
African countries are already pursuing renewable energy development. As illustrated in this chapter, however, there is still enormous untapped potential.

Renewable energy, as mentioned throughout this study, is key to energy security, wider electricity access and sustainable development. A significant number of public, private and civil-sectors in Africa are ever more aware of the risks associated with relying on fossil fuels and see an urgent need for a fundamental transformation of energy systems towards more sustainable ones.

Energy security requires a reduction in dependency on imported fossil fuels with a backdrop of increasingly volatile oil prices. Prices have been rising steeply since 2005 and peaked in 2008 at almost US$ 140 per barrel. They dropped when the economic crisis broke out but have been rising again since 2010. The implications for African economies are particularly severe, since 38 out of 54 countries are net oil importers. **Graph 7** shows the percentage of electricity generated from oil-based power plants in Africa.

The repercussions of rising oil prices on power structures in Africa, where many countries depend on oil for power generation, are high.

Graph 7 - Percentage of power produced from oil-fired power plants in selected African countries [%]



Source: Elaborated by FIESP using data from IEA 2008.

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Renewable energy can help African countries diversify their power mixes while reducing operating costs.

In any discussion on energy security, special attention must be paid to the environmental sustainability and cost of power projects. Renewable energy may not only help achieve sustainability but is sometimes the cheapest option available.

In **graph 8**, average "levelised costs of energy" (LCOE) are compared for different power generation technologies (using both renewables and fossil fuels) while also comparing their lifecycle emissions.

The graph reads left to right for carbon emitters, whereas the width of the bar represents LCOE. The taller the bar, the more carbon emitted per unit of electricity and the wider the bar, the higher the levelised cost.

It is important to note that the LCOE values shown here are averages, and that power plant economics are highly dependent on local conditions, especially for renewable energy projects.

Because the technologies for fossil fuel power generation are mature and fossil fuel markets tend to be globalized or regionalized, their LCOE values tend to vary within a narrow range from one market to another.

The cost of renewable energy technologies on the other hand, varies widely from one site to another, owing to differences in the availability of local resources, such as agricultural waste for a biomass-fired power plant, or wind availability for a wind farm. Detailed feasibility studies are therefore required to ascertain the costs of individual projects for all types of power plants.

It is clear from Graph 8 that renewable energy technologies have the lowest lifecycle emissions, while fossil fuel power technologies have the highest. Hydropower has the lowest carbon emissions, originating mainly from the construction phase.

Coal-fired power plants are the largest Carbon emitters, even when using high-efficient technologies.

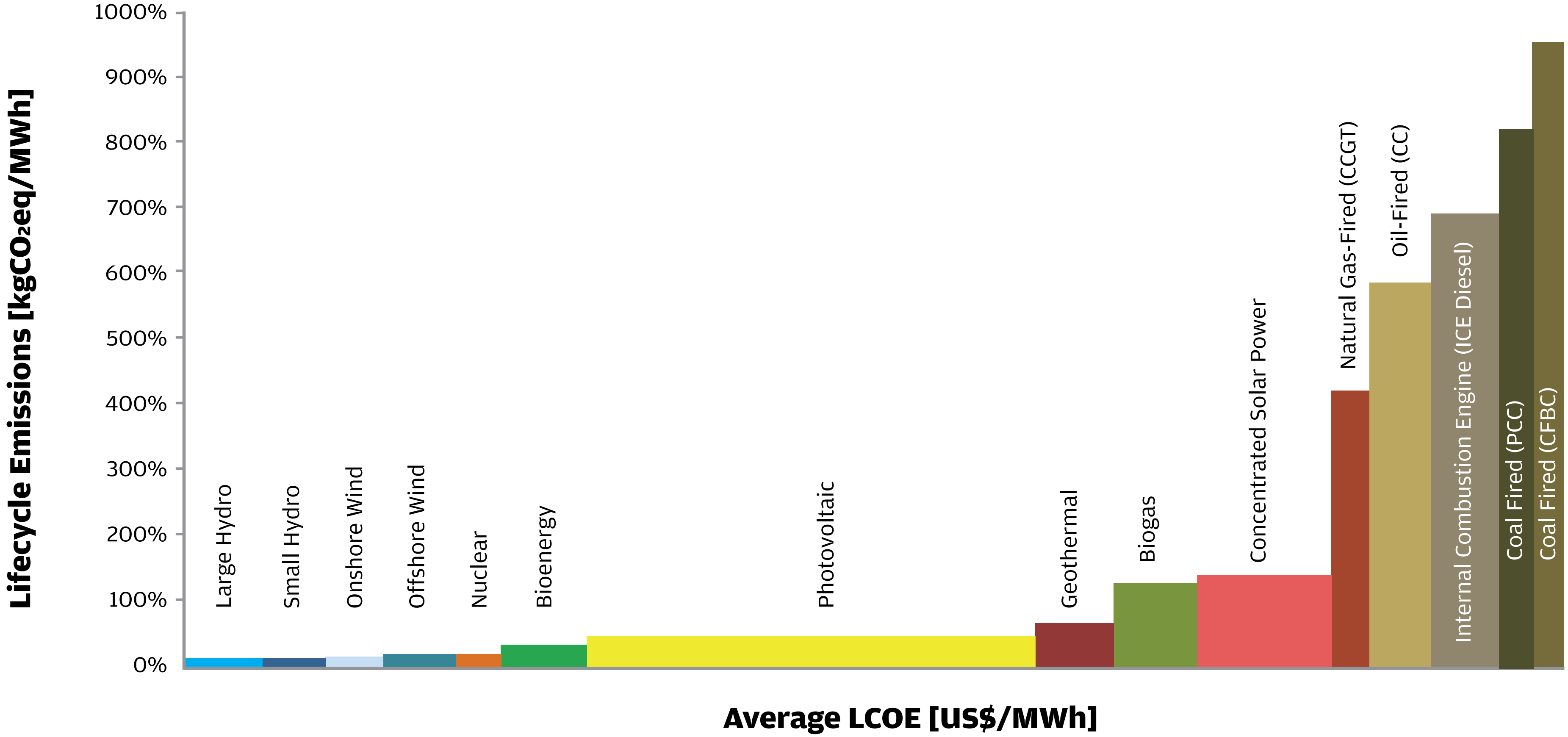
Biogas, CSP and biomass-fired power plants emit some Carbon owing to the use of fossil fuels (usually natural gas) for backup, and in some cases to transport biomass to the plant site.

The Carbon emissions associated with photovoltaic (PV), wind and hydropower come mostly from the manufacturing of the materials used in the plants rather than from fuel use.

Although **graph 8** suggests that fossil fuel power generation technologies are generally less expensive than renewable energy (based on average LCOE), fossil fuel projects are often less attractive when abundant renewable energy is available. Renewable energy also plays an important role in reaching rural populations located far from the grid.

Rural electrification is one of the major challenges facing African countries, and in many cases, decentralised generation based on different types of renewable energy is the most cost-effective solution rather than large centralized power plants coupled with expensive transmission lines.

Graph 8 - Average power plants costs & lifecycle emissions



Power generation costs are usually expressed in terms of LCOE, defined as the present value of the total cost of building and operating a power plant throughout its lifecycle, including fuel and maintenance costs as well as the initial capital investment and return on investment.

Lifecycle emission is a term used to compare carbon emissions, measured in kg of CO_2 equivalent per MWh of electricity generated. It is calculated as the sum of the carbon dioxide emissions that a power plant will emit during all phases of its lifetime (the cradle-to-grave concept), i.e. from raw material and energy extraction through materials processing, manufacture, construction, operation and maintenance, distribution and decommissioning.

Source: Elaborated by FIESP using data from Commission of the European Communities 2008.

Renewable Energy Potential in Africa

There is an enormous range of climates, environments and therefore energy resources throughout the African continent. One important point to note in analysing energy resource data is that there is a general lack of investment in pre-feasibility studies, which could provide the figures on economic potential required to research renewable energy potential properly.

Since many countries covered here lack the pre-feasibility studies required to establish firm potential, countries investing more in pre-feasibility studies and resource mapping tend to show the largest potential whereas those with few or no studies have unknown capacity.

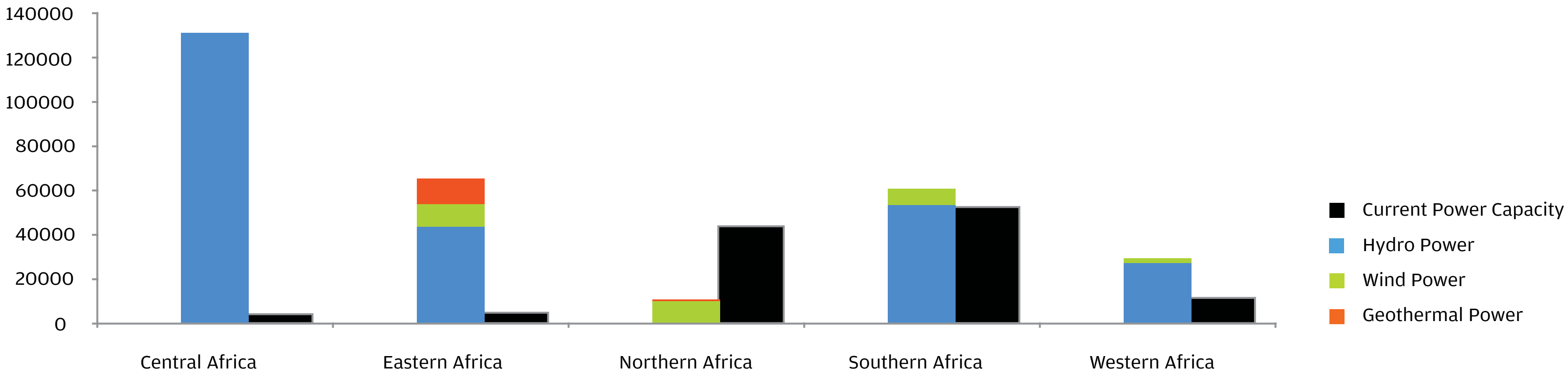
Resource potential values are therefore not exclusive in this study, especially in the case of wind and solar power.

For the purposes of this study the continent is divided into five regions, in line with the AfDB's regional divisions: Northern, Eastern, Western, Central and Southern Africa.

This chapter investigates the potential for hydro, solar, wind, geothermal and cogeneration using bagasse for power generation, using data that is available from various sources. These potentials are first overviewed regionally, then in more detail by energy source.

Graph 9 summaries the current power capacity from all sources (thermal and renewable) with the potential capacity from renewable sources.

Graph 9 - Comparing power capacity with total renewable energy potential [MW]



Source: Elaborated by FIESP using data from AfDB 2011, WEC 2010, GWEC 2010, IEA 2008.

Only hydro, wind and geothermal power are assessed in this graph. Since from a technical standpoint, solar power is virtually limitless and its economic potential is therefore hard to estimate. Installed power capacity for the entire continent (including all thermal and renewable energy power plants) currently totals 117,000 MW.

Total potential from hydro, wind and geothermal power is estimated at more than 345,000 MW, enough to almost triple total installed power capacity across the continent.

More than 85% of this renewable energy potential, or 304,000 MW, comes from hydropower.

Hydro resources are abundant in all regions except Northern Africa. Geothermal resources are concentrated in Eastern Africa. Wind resources are abundant along coastlines and in mountain ranges in most regions.

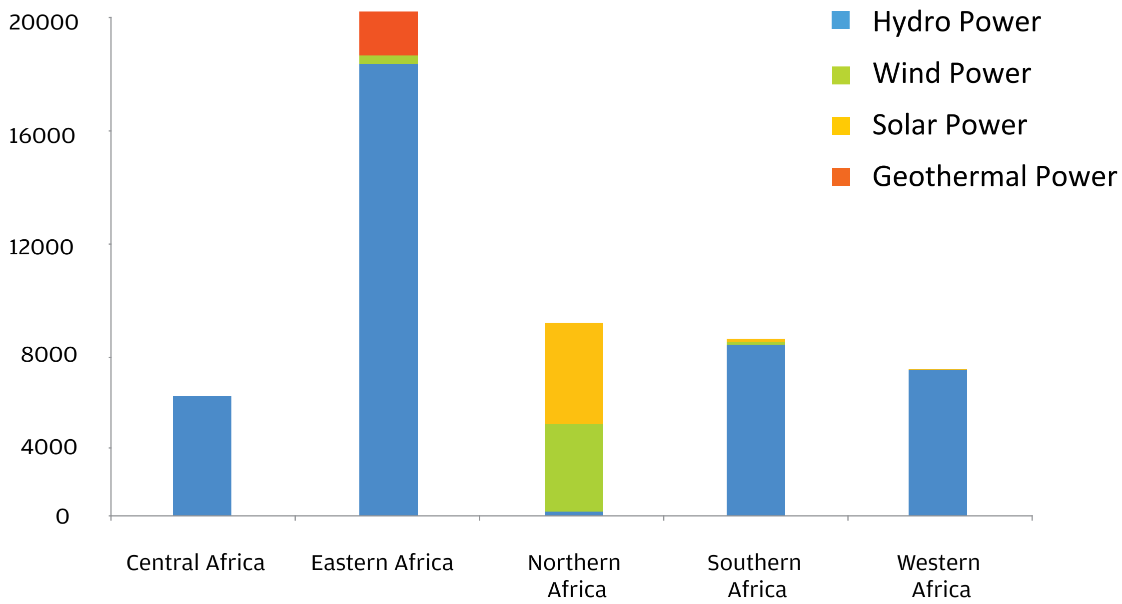
From this graph, the opportunities for regional integration are vast.

Central, Eastern and Western Africa have the largest share of renewable energy potential while also having the lowest demand for power. These opportunities for power integration are further analysed in a chapter dedicated to this subject.

An analysis of the hydro, geothermal, wind and solar power projects that are under-construction or planned highlights regional differences in current investment in the power sector, as shown in **graph 10**. Investment is strongest in hydropower, especially in Eastern Africa, while many wind power projects are being developed in Northern and Eastern Africa.

Northern Africa has the most of investment in CSP.

Graph 10 - Planned renewable energy projects [MW]



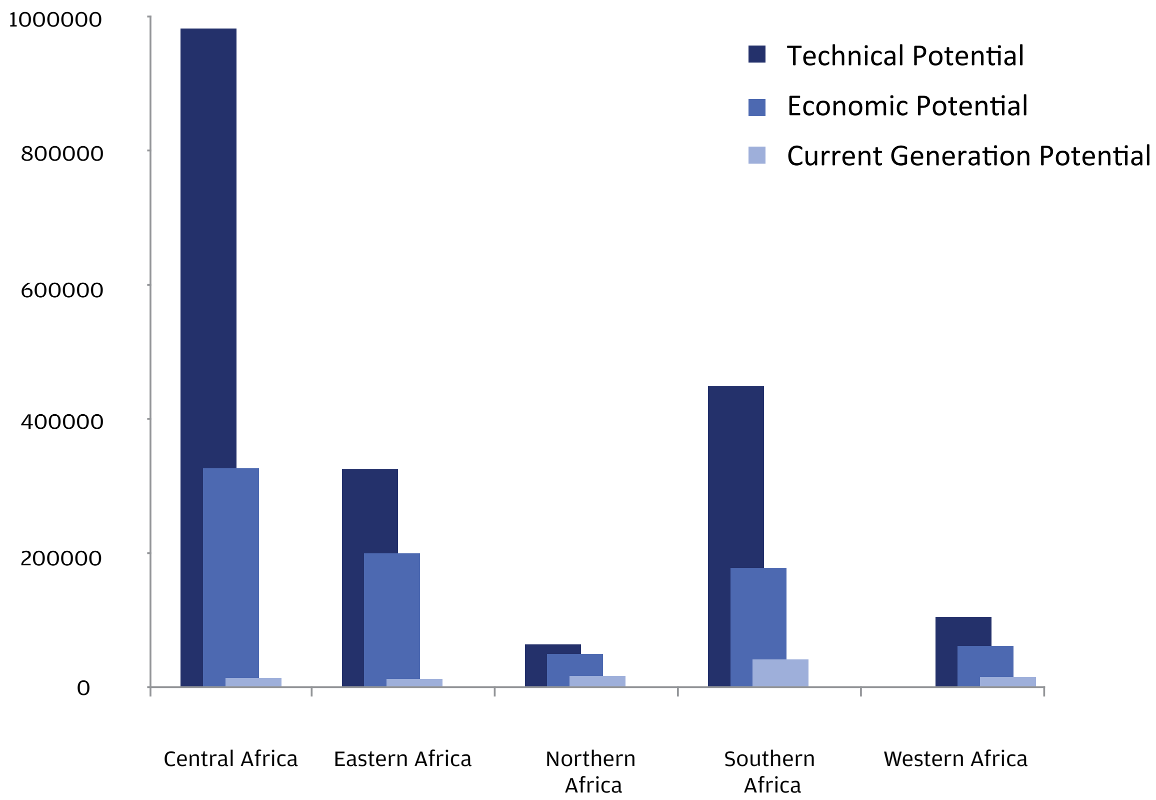
Fonte: Elaborado por FIESP a partir de WEC Report 2010, GWEC 2010 e GTZ 2009.

Hydropower

Hydropower potential in Africa is vast enough to meet the entire continent's current power demand. The total economic potential for hydropower generation in Africa is estimated at over 800,000 GWh/year. This study analyses both technical and economic potential in order to demonstrate the general lack of resource assessment in these countries and stress that pre-feasibility studies should be an investment priority.

Graph 11 shows the huge hydropower resources available in Africa at the regional level.

Graph 11 - Regional hydropower generation potential [GWh/year]



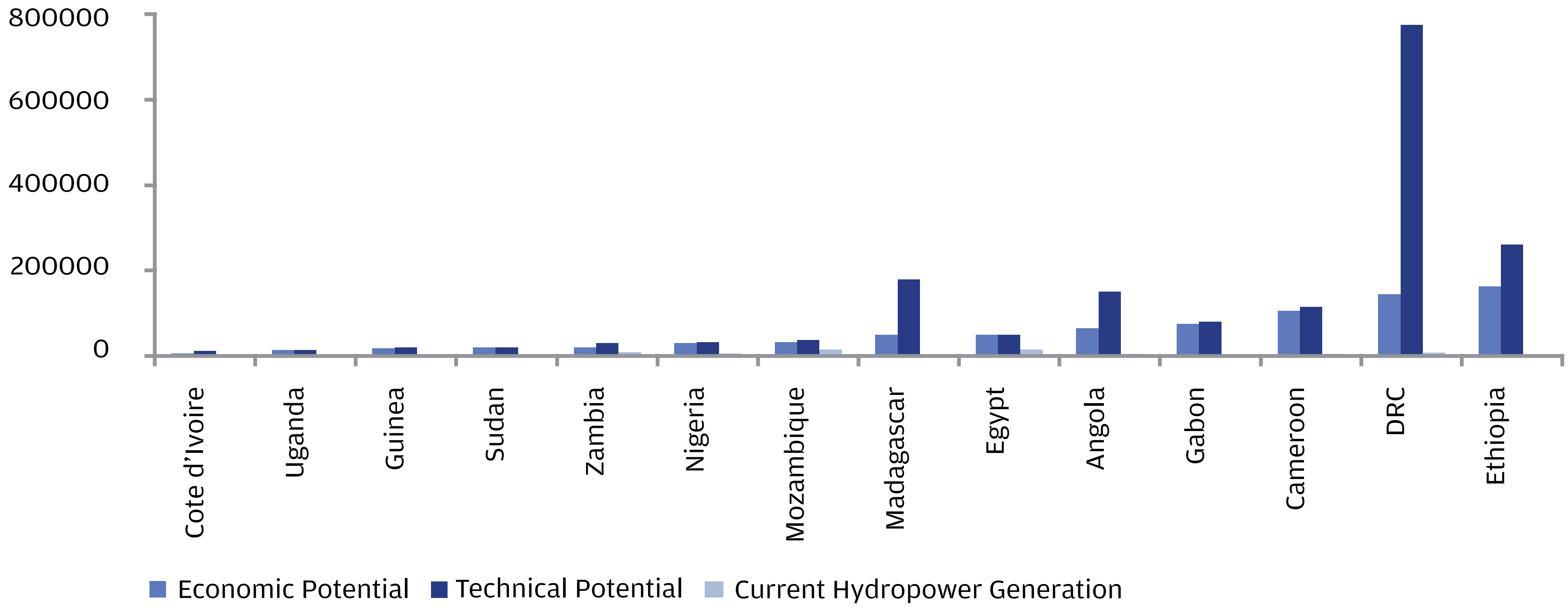
Source: Elaborated by FIESP using data from WEC 2010, IEA 2008.

While all five African regions have significant hydropower potential, Central Africa has the largest, with an economic potential of 325,000 GWh/year, followed by Eastern Africa with 200,000 GWh/year.

The potential in these two regions alone is enough to meet the entire continent's current power demand. The technical potential in Central Africa is enormous, estimated at 775,000 GWh/year.

Graph 12 shows the countries with the most hydropower potential, both technical and economic. Current hydropower generation is also shown, demonstrating the huge volume of untapped resources.

Graph 12 - Hydropower potential by country [GWh/year]



Source: Elaborated by FIESP using data from WEC 2010, AfDB 2011.

The countries with the most hydropower potential are Ethiopia (162,000 GWh/year), DRC (145,000 GWh/year) and Cameroon (105,000 GWh/year), all of which correspond to 60% of the total potential. A vast proportion of the technical potential has yet to be evaluated as economic, notably in Madagascar and Angola.

Country Notes on Hydropower

Ethiopia holds the largest economic potential for hydropower on the continent, at 162,000 GWh/year, with 10% representing the potential for small hydro plants.

Hydropower projects under construction at the end of 2008 amounted to 3,150 MW capacity, with expected generation of around 11,000 GWh/year, and another 7,000 MW capacity is planned in the medium to long-term.

There are two important projects currently at the pre-feasibility phase: Karadobi at 1,600 MW and Boarder at 1,200 MW.
There are also plans to construct the Mandaya plant, with a capacity of 2,000 MW and average generation of between 16,000 GWh/year and 18,000 GWh/year. The project is currently undergoing pre-feasibility. The energy generated in the above mentioned project will have export potential.

The **Democratic Republic of Congo (DRC)** has the second-largest economic potential in Africa, at 145,000 GWh/year, with 160 MW capacity currently under construction and another 3,850 MW capacity planned for the medium to long-term. In addition to its own market, the DRC is targeting export markets. The Inga development is aimed at exporting power to neighbouring countries.

There are unconfirmed plans to expand the potential of the Inga site called Inga III, with a capacity of 4,500 MW, and to interconnect the DRC grid with those of Namibia, Angola, Botswana and South Africa.

There is another proposal to construct the Grand Inga, estimated at over 40,000 MW capacity, and to connect the power grids to other parts of Africa. The AfDB is currently financing the pre-feasibility study and assisting the DRC to take an informed decision.

Cameroon's economic potential in hydropower is the third-largest in Africa, estimated at 105,000 GWh/year, with 1,820 MW capacity planned for the medium to long-term. Cameroon currently uses only 4% of its hydropower resources. Projects under development include Nachtigal (230 MW), Menveele (120 MW), Lompangar (25 MW) and Birni à Warak (80 MW). The potential for small hydro (up to 1 MW) is estimated at 1,100 GWh/year, mainly in the eastern and western regions. In spite of the considerable potential, small hydro is almost non-existent. Around 30% of projected investment will be for small hydro to guarantee electricity supply to seven isolated areas.

Angola has some important projects, mainly on the Kwanza River. There are plans to build two hydropower plants in the north of the river with combined capacity of 2,000 MW. In the central portion, a 2006 study indicated the possibility of building a hydropower complex with a capacity of 6,000 MW.

The largest hydropower plants planned for the region are the Lauca site, at 2,070 MW, and the Caculo-Cabaça site, at 2,050 MW.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The Ingula plant in **South Africa** is currently under construction, scheduled for completion in 2012. It is located on the Wilga and Klip Rivers, on the border between the provinces of Free State and KwaZulu-Natal, with a capacity of 1,350 MW. South Africa is a major power consumer at the sub-regional, regional and national level.

At 1,000 MW, the planned Monontsa hydropower plant in **Lesotho** will be located between the Malibamatso, Matsoku, Senqunyane Senqu Rivers, using the largest water transfer system in Africa, called the Lesotho Highlands Water Project. It is currently undergoing pre-feasibility studies.

In **Mozambique**, The planned Mphanda Nkuwa hydropower project will have total capacity of 2,400 MW, producing on average 9,000 GWh/year. It is expected to start its construction in 2012, and will be implemented in two phases. It is currently undergoing environmental and social impact studies.

The **Sudanese** Merowe Dam hydropower plant on the Nile, with a capacity of 1,250 MW, has already been partially commissioned with two turbines of 125 MW.

Uganda currently has projects to build a series of hydropower plants that together will power more than 2,000 MW. These plants will be located on the Nile. The Murchison Falls plant will have 750 MW capacity and average generation of 3,680 GWh/year. The Karuma plant will have 700 MW capacity and average generation of 1,745 GWh/year.

The project is currently at the feasibility and environmental impact study phase. The hydropower plant Ayago has a capacity of 550 MW and average generation of 4,600 GWh/year. The plant already has completed its pre-feasibility study.

The Akosombo Dam in **Ghana** is undergoing feasibility studies and waiting on funding to start construction. Located on the Volta River, the hydropower plant will have 1,060 MW capacity.

Geothermal

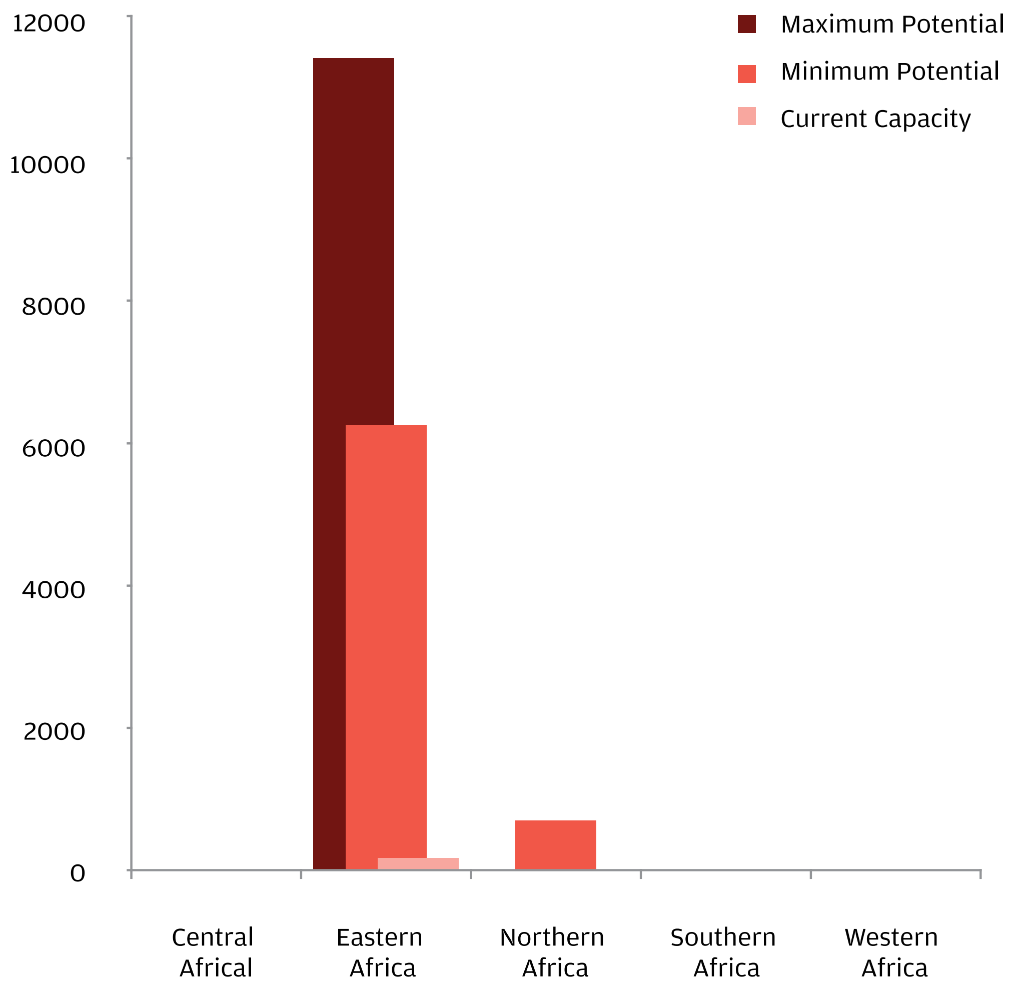
Geothermal potential in Eastern Africa is very large at around 12,000 MW, or about two and a half times current total power capacity in the region.

Graph 13 shows that the economic potential for geothermal power is estimated at between 7,000 MW and 12,000 MW, found in the Great Rift Valley. Potential depends on drilling depth, fluid quantity and quality, and temperature.

Northern Africa has some potential for geothermal generation, but is currently using geothermal heat only for direct use in industrial processes.

Although geothermal is an economically viable energy option in Eastern Africa, the high cost and risk of exploratory drilling, compounded by institutional and regulatory barriers, have prevented the development of this indigenous and environmentally friendly energy source in the region.

Graph 13 - Regional Geothermal potential [MW]

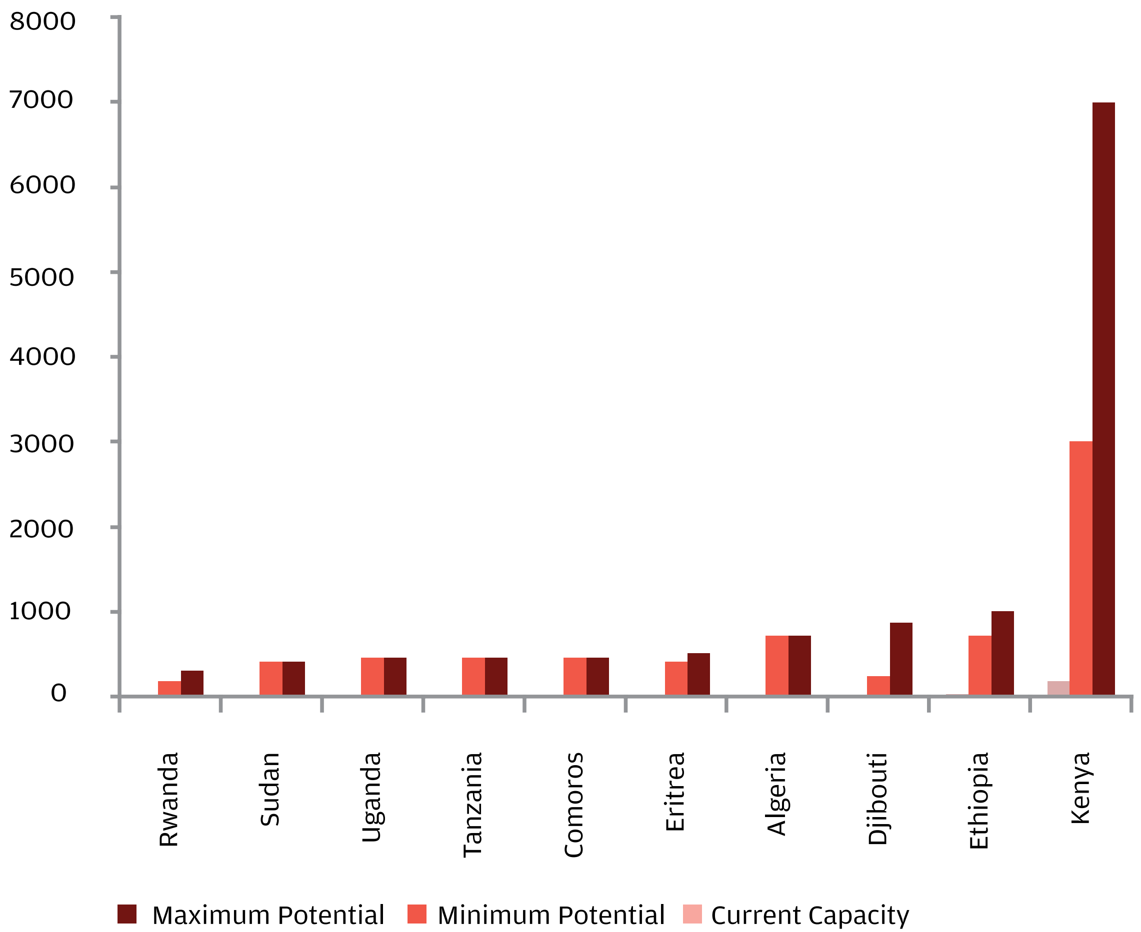


Source: Elaborated by FIESP using data from AfDB 2011, GTZ 2009, ArGEO 2008.

The African Rift Geothermal Facility (ARGeo) was established in 2004 to overcome the barriers to geothermal energy development in the African Great Rift Valley. The ARGeo project was initiated by six countries: Ethiopia, Eritrea, Djibouti, Kenya, Uganda, and Tanzania. It is funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Program (UNEP) and the World Bank. According to ARGeo, technical geothermal power potential in Africa's Rift Valley is estimated to exceed 15,000 MW.

As shown in **graph 14**, Kenya and Ethiopia have the largest potential for geothermal power generation, estimated at 3,000 MW-7,000 MW in Kenya and 700 MW-1,000 MW in Ethiopia, or 70% of the continent's total geothermal potential. Other Eastern African countries with geothermal potential are Eritrea, Rwanda, Djibouti, Tanzania, Burundi, Uganda, Sudan and Comoros, while in Northern Africa Algeria's potential is estimated at 700 MW.

Graph 14 - Geothermal potential by country [MW]



Source: Elaborated by FIESP using data from AfDB 2011, WEC 2010.

Country Notes on Geothermal

Kenya is one of only two African countries that are using geothermal power for electricity generation and has the largest potential on the continent. Kenya's current installed geothermal power capacity is 163 MW and it plans an additional 1,200 MW. Kenya's National Strategy Paper includes geothermal development as a high priority and in 2009 the government created a company to develop this resource as a significant contributor to the national power supply. One objective is to add at least 2,000 MW of capacity within 10 years and at least 4,000 MW by 2030 through a fast-tracked geothermal development program.

Past drilling explorations in **Ethiopia** have revealed geothermal power potential of between 700 MW and 1,000 MW, with some estimates as high as 5,000 MW. Of the 120 identified geothermal sites, two have been found appropriate for electricity generation. A much larger number of sites could generate direct heat for use in horticulture, animal breeding, aquaculture, agroindustry, health and recreation, heating, etc. A number of sites, amounting to 390 MW, have been selected for further exploration and study. The necessary investigations and studies prior to construction will take an estimated four to seven years to carry out.

Geothermal potential in **Djibouti** is especially interesting, since the country relies entirely on imported oil to generate electricity and the cost of electricity is among the highest in sub-Saharan Africa. Under the ARGeo project, the Assal site in Djibouti was selected as the most feasible project for consideration by GEF and the World Bank in 2009.

The government of Djibouti is currently looking for a developer.

Wind Power

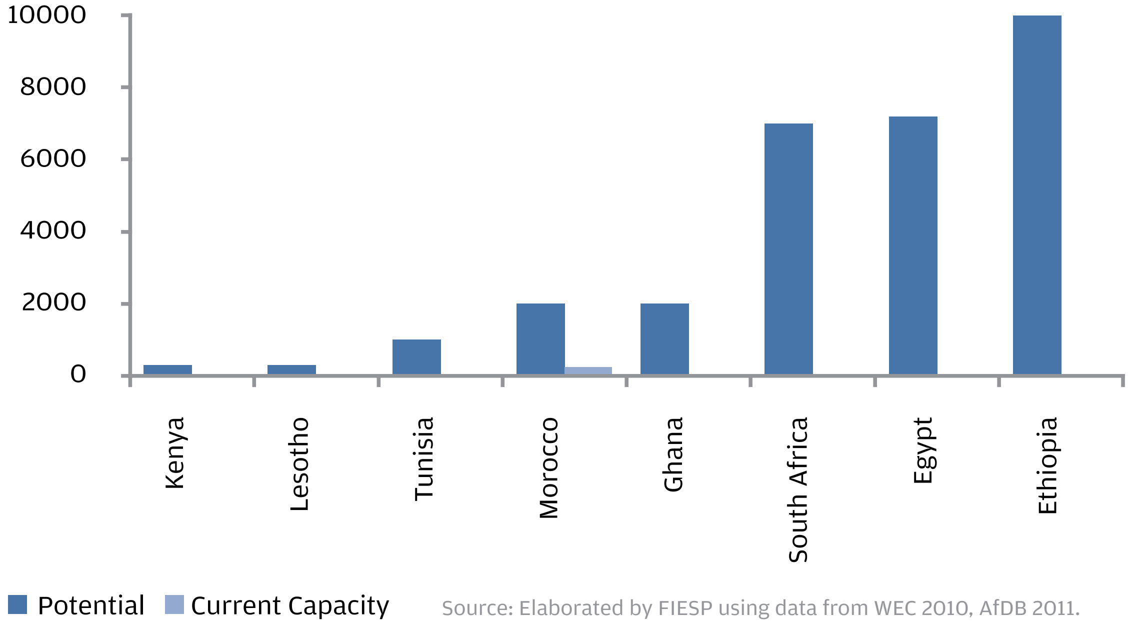
Wind power potential in Africa is estimated at almost 30,000 MW, although this figure is non-exhaustive since few countries have looked into this resource and published data on it. Wind energy is an attractive resource in developing countries as it can be installed quickly and cost-effectively in areas where electricity is urgently needed. It may also be the most cost-effective solution if hydropower or fossil fuel sources are not readily available. In addition, there are many applications for wind energy in remote regions, either to supplement expensive diesel power or to supply farms, homes and other installations on an individual basis. Even in countries with wind speeds that are insufficient for electric power generation, there is often sufficient power for less demanding applications such as pumping water for irrigation.

The best sites for wind power development are located mainly along the northern coast and Mediterranean, in elevated regions of sub-Saharan Africa, in the southern coastal regions, and in Eastern Africa off the Arabian Sea. Eastern Africa along the Arabian Sea and the Gulf of Aden, especially on the Somali plains, has some of the best sites for wind power development in Africa, although the resource has so far not been tapped into.

Southern Africa has substantial regional wind resources and could benefit considerably from integration of wind power across the region.

There is a lack of reliable data on wind power potential in most of Africa. The wind potential for selected countries is shown in **Graph 15**, although it should be noted that this list is by no means complete, including only the countries for which data is available. Ethiopia has the largest share of wind potential, with a capacity of 10,000 MW, followed by Egypt with 7,000 MW and South Africa with 6,900 MW.

Graph 15 - Wind power potential [MW]



Source: Elaborated by FIESP using data from WEC 2010, AfDB 2011.

Country Notes on Wind Power

In 2008 the **Egyptian** government approved an ambitious plan to produce 20% of total electricity from renewable energy sources by 2020, including a 12% contribution from wind energy. In order to achieve this target, the government has earmarked 7,600 km^2 of desert land for implementing new wind energy projects.

The Government of **Morocco** has set a target of raising the contribution of renewable energy to 20% of national electricity consumption by 2020. Wind power is set to play a key role, with a target of 2,000 MW, up from 286 MW at the end of 2010.

Half of this will be installed by the government-owned utility, with the other half coming from industrial players producing their own wind power. With 38% of electricity generation in Morocco coming from oil- and gas-fired power plants, the government began promoting renewable energy in the 1980s in a bid to alleviate the country's expensive dependency on fossil fuels and to improve energy security.

Solar Power

According to the IEA, the best solar resources in the world are in the deserts of South Africa and Chile, where direct sunlight provides almost 3,000 kWh/m^2/year, a huge potential for development.

There are two types of solar power technology: photovoltaic (PV) and concentrated solar power (CSP).

Quantifying solar power potential is especially difficult, since power from the sun is almost endless and implementation of these technologies is not limited by the resource but by cost.

Photovoltaic (PV)

PV converts sunlight directly into electricity. It can be installed on land or buildings, on a small or large scale, and is ideal for off-grid electrification since it can be located very close to demand centres.

Because PV applications are often implemented at the household level, and often off-grid, it is very difficult to establish a comprehensive assessment of current installed power capacity, let alone ultimate economic potential.

Although PV systems are still too expensive for many applications, they have played an important role in rural electrification in Africa, since PV technology is cheaper than extending national grids to remote regions.

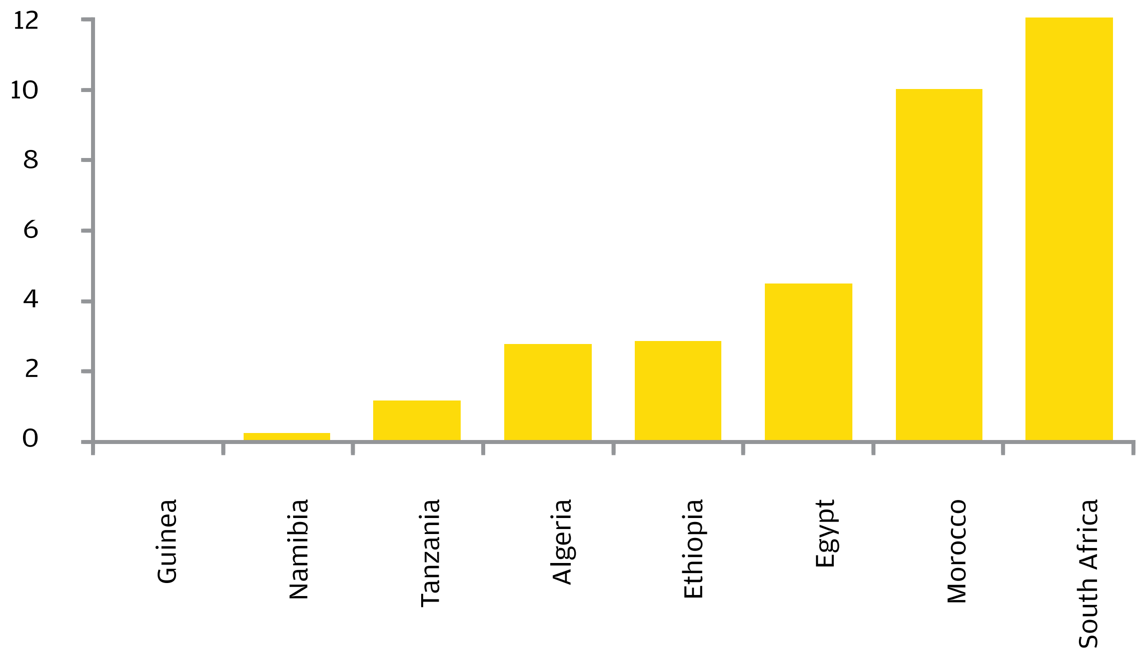
The potential for PV expansion, especially in rural electrification programs, is very large but site-specific studies are required to evaluate their economic viability in a given location.

In 1995, 25% of photovoltaic capacity worldwide was installed in Africa, but while it increased substantially in many parts of the world in recent years, it stagnated in Africa. Africa is still considered to be the continent with the highest potential for development of off-grid PV.

Some encouraging initiatives to extend access to lower-income households and public institutions (schools, clinics, health centres etc.) and for community development (water pumping, street lighting, telecommunications, refrigeration etc.) are under way in a number of countries, notably Morocco, Tunisia, Mauritius, Seychelles, and South Africa.

South Africa currently has the largest installed capacity in PV, with 12 MW_p, followed by Morocco with 10 MW_p. The rest of the continent is lagging behind, as can be seen in **graph 16**.

Graph 16 - PV installed capacity in 2008 [MW_p]



Source: PV Installed Capacity in 2008 [MWp].

Country Notes on PV

The River Estate in **Zimbabwe** boasts one of the best solar-village models in Africa. 52 commercial farming families share PV systems. There is one PV system for every two houses, with each family having two lamps and a connection for a radio or small television set. The new lighting systems have improved the quality of life for the community by extending study hours for schoolchildren, reducing rural-to-urban migration in the area, and upgrading health standards through the electrification of a local health centre.

The **Moroccan** Government, with AfDB support, launched a rural electrification program in January 1996. By end-2008 some 3,600 villages, or about 51,500 households, were supplied with photovoltaic kits.

Namibian incentives have successfully encouraged the deployment of solar devices. As early as 1991 the Namibian power utility, in partnership with Namibia's Ministry of Mines and Energy, began working on a rural electrification program. This program, alongside other initiatives, achieved an eightfold increase in stand-alone PV capacity between 2004 and 2008. Solar water pumping capacity for isolated systems has risen nearly fivefold. Stand-alone solar thermal capacity has increased twelvefold.

Concentrated Solar Power (CSP)

CSP systems use the same electricity generating technology as thermal power plants except instead of burning fossil fuel to generate steam, CSP uses the sun.

By using mirrors to concentrate direct sunlight towards a fluid, enough heat is generated to generate steam within a heat exchanging system.

CSP technology can be used for applications that require high-temperature steam, including generating electricity and several industrial applications.

The most innovative and expensive equipment from CSP is the set of mirrors and piping system, which is called the solar field, whereas the rest of the equipment is similar to conventional thermal power plants. An advantage of CSP is that it can easily use fossil fuels (natural gas) as backup fuel, or store heat to overcome intermittent sunlight. However, unlike PV, CSP requires direct sunlight, limiting this technology to areas with very high direct solar radiation, mostly arid areas and deserts, thereby limiting where this technology can be used.

For this reason, African CSP potential is concentrated in Northern and Southern Africa.

The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) created a model to quantify this large potential from CSP in Africa. Using technical criteria to narrow down areas most suitable for CSP application, it found that only 17 African countries had the potential to generate electricity using CSP.

The potential ranged from 7,000 GWh/year in Eritrea to 40,500,000 GWh/year in Libya.

CSP potential is not as widespread as PV potential across Africa, but where CSP potential does exist, the generation potential is massive because of the nature of the technology.

The land area identified in the model represents an electricity generating potential in Africa of 215,000,000 GWh/year, more than total world electricity consumption in 2009. Although the potential is very high, CSP is a new technology and hence comparatively expensive. There are currently only three CSP power plants on the African continent, all of them still under construction.

Graph 17 summarizes the capacity of CSP projects under construction or planned in the medium term.

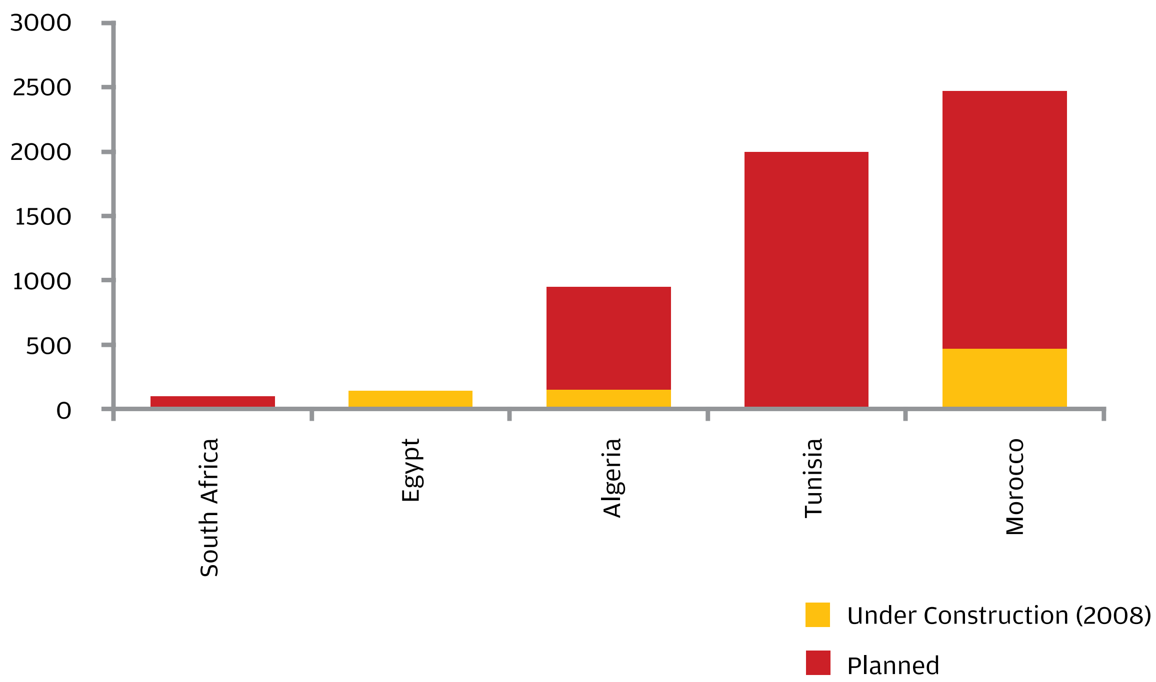
Projects under construction all use the same integrated solar combined cycle (ISCC) technology, in which natural gas is a backup fuel for solar power. Morocco's Ain Bni Mathar CSP power plant is the largest on the continent at 470 MW, followed by Algeria's Hassi R'mel plant with 150 MW and Egypt's El-Kureimat Egyptian plant with 140 MW. Once these plants are commissioned, CSP installed capacity in Africa will total 760 MW.

The technical criteria include areas with annual average direct normal irradiance (DNI) of 6.75 kWh/m2 per day or greater and terrain slope less than or equal to 1%, excluding all urban areas, water bodies and protected areas. Remaining land is assumed to have installed capacity of 50 MW/km2 operating at a 30% capacity factor.

The European Union (E.U.) is keen to develop CSP in the North African deserts, mainly in Morocco, Algeria, Tunisia and Egypt, for electricity exports to Europe. The IEA projects that Africa will produce a large amount of CSP electricity to meet marginal electricity demand, while exporting the rest to the E.U. and Turkey.

If fully developed, the potential for CSP applications in the Middle East and North Africa would amount to about 100 times the current consumption of the Middle East, North Africa and the E.U. combined.

Graph 17 - CSP project overview [MW]



Source: Elaborated by FIESP using data from NREL 2010, Greenpeace 2009, WEC 2010.

Country Notes on CSP

Algeria has a domestic commitment to increase the proportion of solar energy in its energy mix to 5% by 2015. Beyond this domestic target, Algeria is also considering a partnership with the E.U. to deliver green power to Europe. A company called New Energy Algeria (NEAL) has been set up to enhance participation of local and international private companies.

The Algerian government has introduced a subsidy for CSP, setting a premium price for electricity produced using this technology.

South Africa plans the world's largest central receiver type CSP plant. Once built, this will have a power capacity of 100 MW. The government has set a feed-in tariff to increase renewable energy development and encourage additional CSP projects.

It is also supporting research on CSP through the Department of Science and Technology, which is providing funding to universities in the field.

There is a national solar and CSP research program and a possibility that South Africa will establish a national solar/CSP centre in the future.

The Ain Bni Mathar ISSC project is part of a major combined photovoltaic and CSP project in **Morocco**, launched in 2009. The Kingdom of Morocco is preparing the project at five sites: Laayoune (Sahara), Boujdour (Western Sahara), Tarfaya (south of Agadir), Ain Beni Mathar (centre) and Ouarzazate, with state-of-the-art solar facilities comprising photovoltaic and solar thermal energy.

The sites will cover 10,000 hectares and should produce up to 2,000 MW of electricity. Included in this project is the Ouarzazate CSP plant with a power capacity of 500 MW.

Bagasse Cogeneration

Another renewable resource with strong potential is cogeneration in the sugar industry. Bagasse is sugarcane residue that could be used as fuel for power generation.

Although potential seems much lower than for other renewables at a regional level, this source has great potential for small-scale projects in rural areas. Using the conversion factors from the successful bagasse program in Mauritius, the estimated potential for this resource is between 6,000 and 10,000 GWh/year, depending on the efficiency of the equipment used.

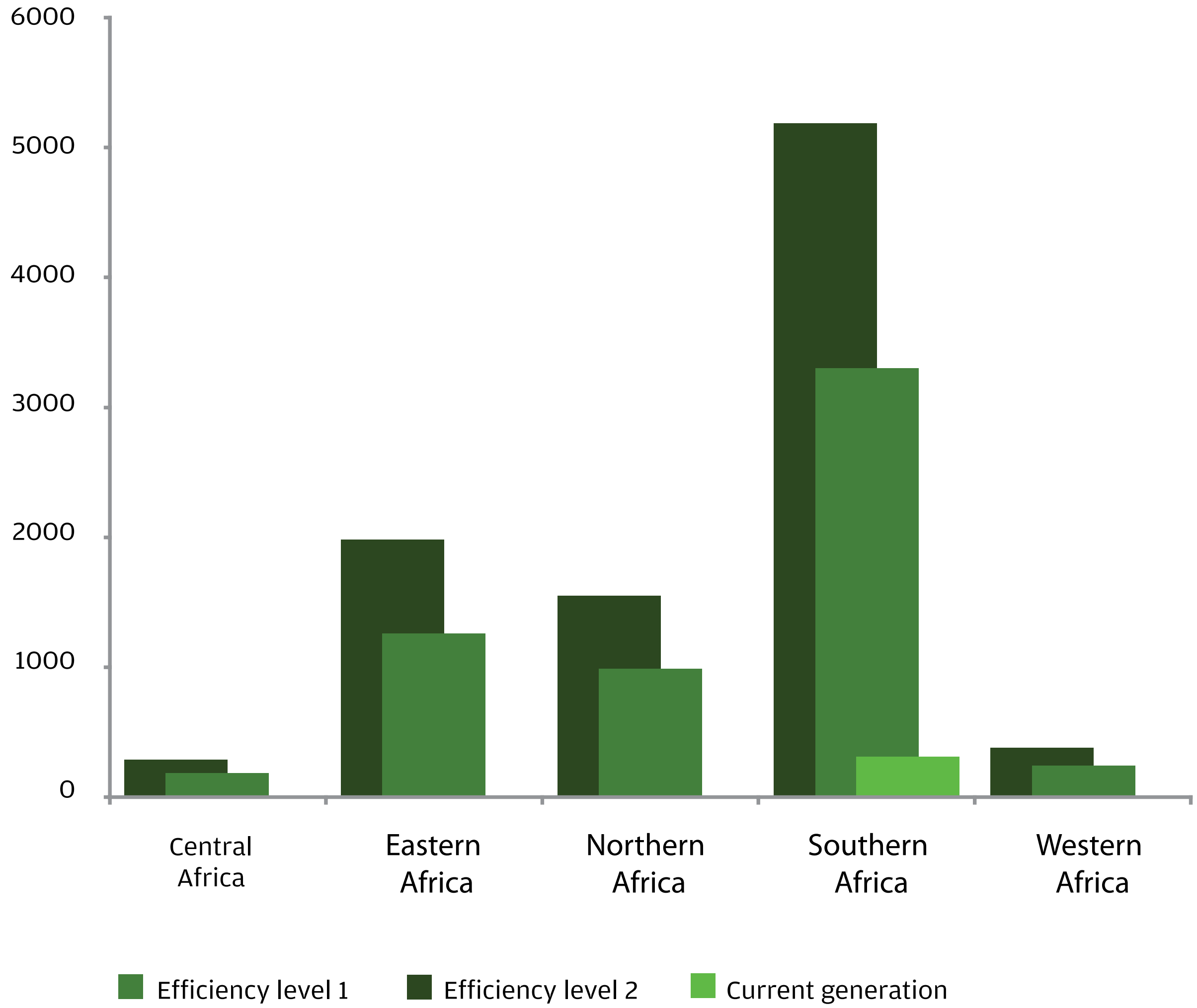
Cogeneration produces both electricity and heat. It is a well-known process in the sugar industry and is already standard practice in most modern sugar mills, although older mills use bagasse only to produce the power and heat needed for their own operations, and do not generate surplus power for export to the grid. High-efficiency boilers not only provide cheaper heat for sugar processing but also achieve far higher power output.

Bagasse is used in Africa today only to meet the steam and power requirements of sugar mills, besides a few countries, but investing in more efficient boilers would allow surplus electricity to be exported to the grid or consumed locally in off-grid systems. Because electricity from bagasse is linked directly to sugar production, regions with higher sugar production have greater potential for bagasse use in power generation.

As shown in **graph 18**, Southern Africa has the highest potential for bagasse-based electricity generation, while Western and Central Africa have the lowest. There are several ways to use this surplus electricity: it can be exported to the local grid if there is one, or a mini-grid could be built for local distribution.

Alternatively, the surplus electricity can be sold directly to local industry or communities within the area.

Graph 18 - Bagasse power generation potential [GWh/year]



Source: Elaborated by FIESP using data from Mauritius Sugar Authority 2005.

Graph 19 shows the potential to expand on a country-by-country basis.

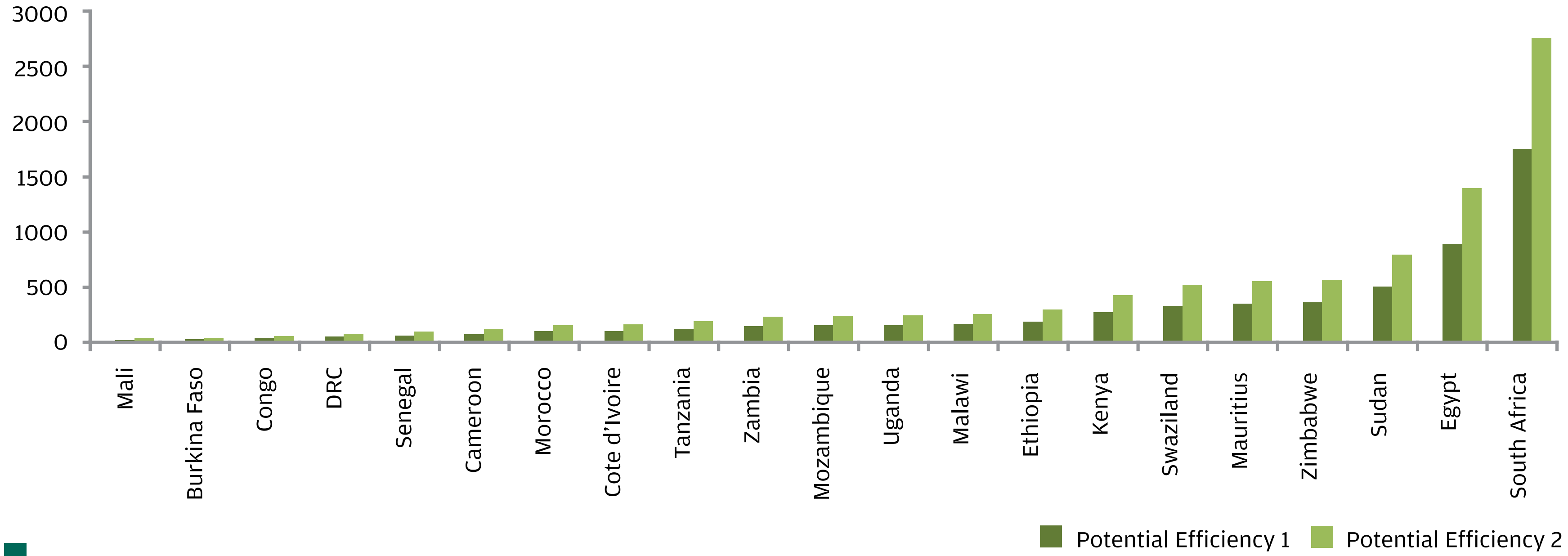
In 2008 Mauritius was the only country generating surplus electricity from the sugar industry. Tanzania, Sudan, Swaziland and Zimbabwe have started generating surplus electricity recently.

The graph shows that South Africa, Egypt and Sudan have the highest potential for electricity generation using this technology, accounting for 50% of the potential on the continent.

These countries have the largest potential since they are also the largest producers of sugar from sugarcane.

To achieve this potential, the sugar industry would need to rehabilitate and modernize production practices, not only using more efficient boiler technologies, as mentioned, but also increasing cane crushing capacity to supply enough bagasse for power generation. However, the cane industry in a number of African countries is being modernized, making implementation of more efficient technologies in these facilities a real possibility.

Graph 19 - Bagasse power generation potential [GWh/year]



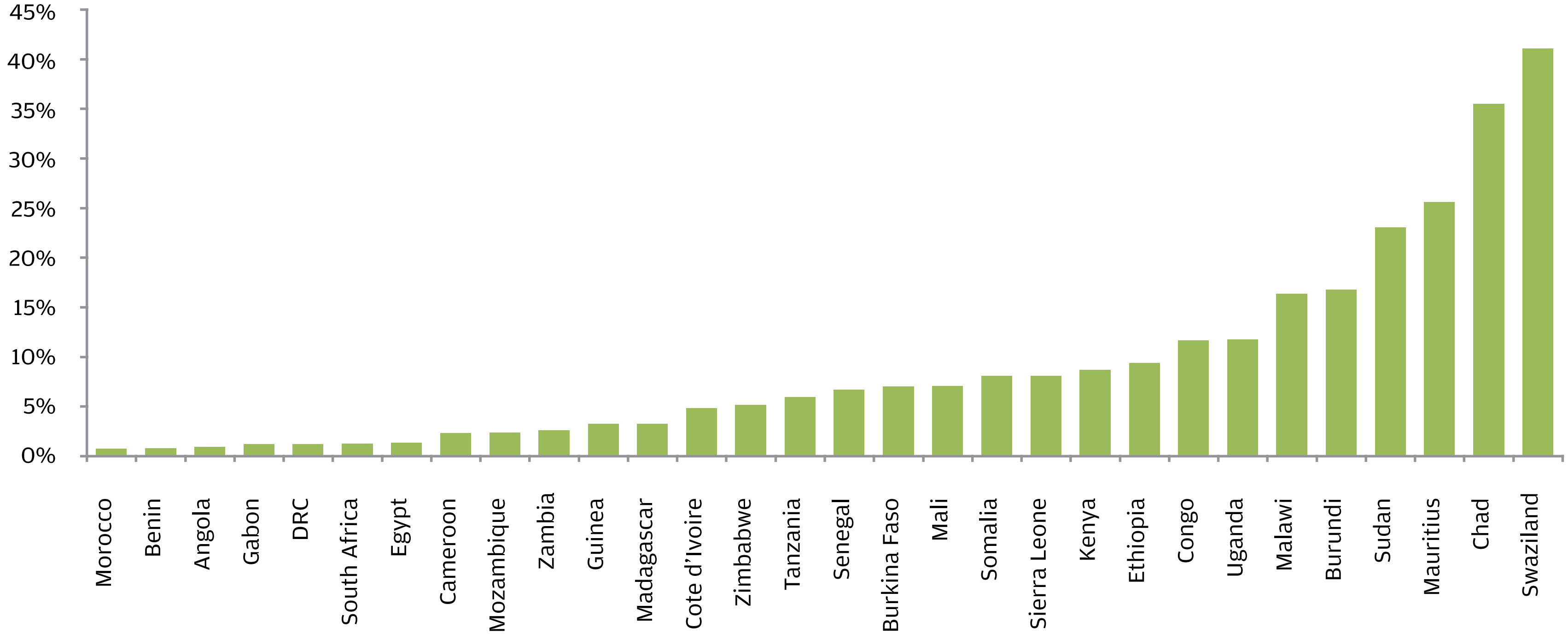
Source: Elaborated by FIESP using data from Mauritius Sugar Authority 2005.

Exports of electricity can make cogeneration from sugar processing attractive and cost-effective by cutting production costs, reducing pollution, generating additional revenue and providing local power generation.

Supply of power to the local grid has a particularly strong impact on countries with lower demand for power. **Graph 20** shows the percentage of total power demand that could be met from bagasse.

These figures clearly demonstrate the potential for this technology, not only to supply power locally, but also to diversify power supply and generate low-carbon electricity. Swaziland is starting to tap into this technology, but still has considerable potential to generate electricity from bagasse, which could supply up to 40% of current demand. In Chad and Burundi, where electricity access is extremely low, bagasse use is an attractive and viable option for both local communities and promoting small industry. Power generation from bagasse could meet up to 35% of current demand in Chad and over 15% of demand in Burundi. Chad and Burundi have the lowest electricity access rates in Africa, with 3.5% and 2.8% respectively. Mauritius, Sudan and Malawi could also benefit from bagasse cogeneration.

Graph 20 - Percentage of total power demand that could be met from bagasse [%]

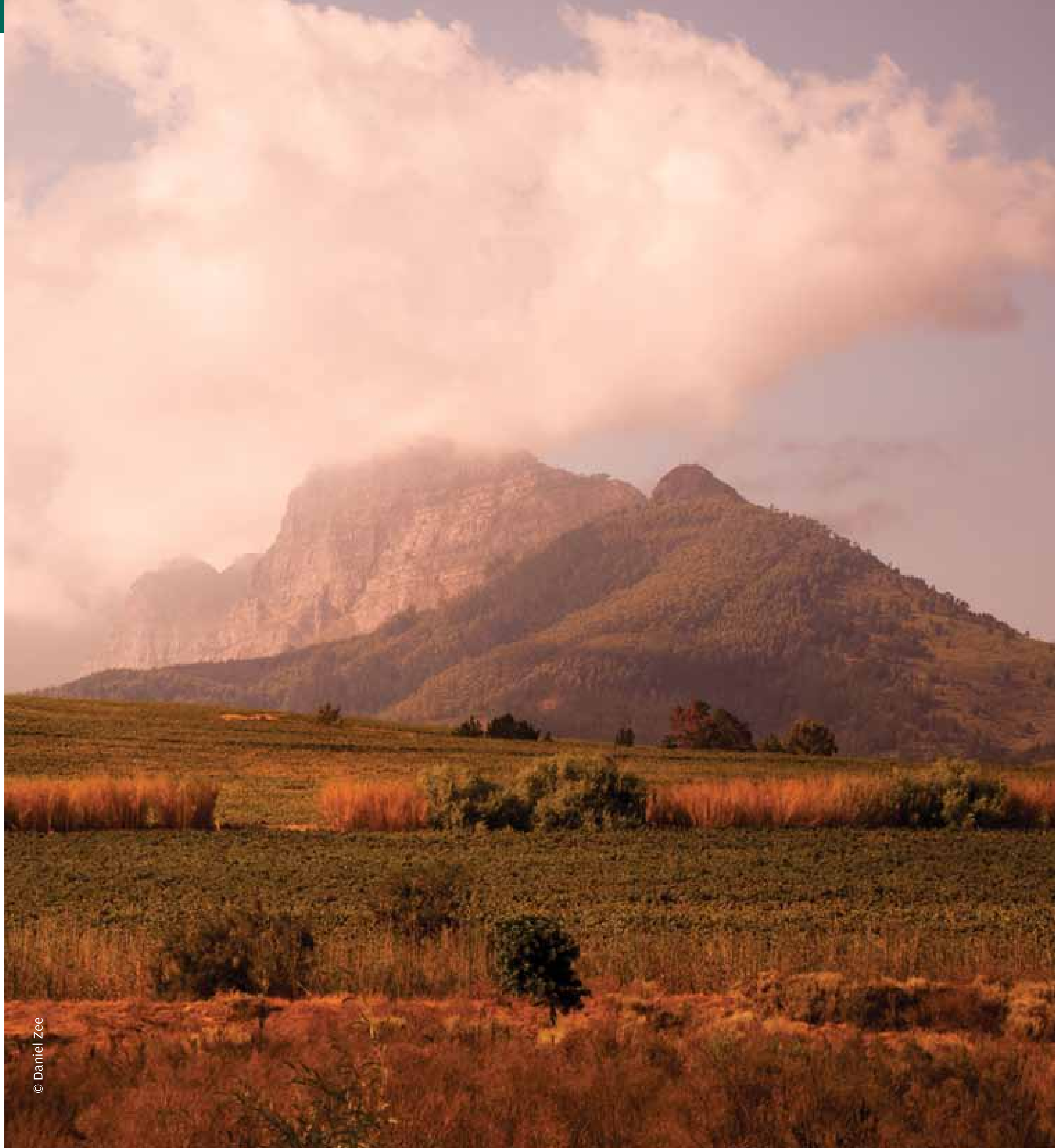


Source: Elaborated by FIESP using data from IEA 2008, Mauritius Sugar Authority 2005.

Country Notes on Bagasse Cogeneration

Ten out of 11 factories in **Mauritius** are currently exporting electricity to the grid during the crop season. This development has been possible thanks to participation by all stakeholders (corporations and small planters), with the government providing appropriate policy guidelines, a legal framework and incentives.

Mauritius was highly dependent on local hydropower and imported oil, making this program important in terms of energy diversity and security. Electricity from bagasse cogeneration has significantly increased local capacity and reduced dependency on imported energy. The Sugar Industry Efficiency Act was passed by Mauritius in 1988 to enhance the sugar industry's viability while also promoting diversification in both agriculture and the sugar industry.



Renewable Energy Policy Framework

Appropriate institutional measures are required to accelerate investment in the energy sector for sustained growth.

African countries will need to develop and implement medium and long-term national energy plans integrated with collective regional energy development strategies.

According to the AfDB, the following elements are key to a successful clean energy investment framework for a typical African country aiming to attain “access to all” and reliable energy supplies by 2030:

• Extension and upgrading of national power transmission grids, and interconnection to create sub-regional power pools or markets;

• Extension and upgrading of local distribution networks;

• Accelerating the connection of new residential and business customers to the national power supply in cities and peripheral area;s

• Accelerating the development of stand-alone energy supplies and mini-grid distribution systems in rural areas remote from the national power grid;

• Promoting capital investment in petrol refineries, fuel transportation infrastructure (pipelines, rail tankers, storage reservoirs etc.), and commercial distribution by private operators, PPP, or autonomous parasternal energy corporations;

• Disseminating information on energy saving to residential consumers and small business (e.g. on energy-saving light bulbs);

• Galvanizing collective efforts to reverse deforestation by strengthening and rewarding community efforts in sustainable management of forests and other local natural resources;

• Assisting households and small businesses to switch to higher efficient stoves.

In summary, planning in the energy sector requires strong resource mapping and pre-feasibility studies, in conjunction with a policy framework to set the path for sustained growth within the sector. By analysing renewable energy potential at the country level, governments can see which energy is the most viable within their borders and boost efforts to develop those resources.

Finally, integration of grids across country boundaries make energy systems increasingly secure and cost-effective, especially at times of rising fuel prices or climate fluctuations that affect energy availability.

Several countries have made large leaps to renewable energy in recent years, paving the way for others to implement national renewable energy master plans.

Country Notes on Policy Framework

In 2008 **Kenya** introduced a feed-in tariff for wind, small hydro and biomass energy. In 2010 this was extended to include geothermal, biogas and solar resources. The intent is to use solar power to replace thermally generated electricity in isolated and off-grid locations.

In 2009 the National Energy Regulator of **South Africa** (NERSA) approved renewable energy feed-in tariffs called REFITs. These are based on the levelised cost of electricity for CSP, wind, small hydro and landfill gas. The term of the power purchase agreement is 20 years.

The REFITs will be reviewed every year for the first five-year period of implementation and every three years thereafter.

The resulting tariffs will apply only to new projects.

Egypt's success in the renewable energy sector is due to government commitment and policy, as well as successful international cooperation since the 1980s against a backdrop of increasing energy imports.

The New & Renewable Energy Authority was set up in 1986 to assess Egypt's renewable energy resources and investigate technology options through studies and demonstration projects. In recent years the government has invested in a detailed wind atlas, outlining the best sites for development.

In 2008 the Egyptian government approved an ambitious plan to produce 20% of total electricity from renewable energy sources by 2020.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4. BIOFUELS

Biofuels

Introduction

Bioenergy is an important tool in achieving all three spheres of sustainable development. It produces environmental benefits by replacing fossil fuels while reducing atmospheric pollution and greenhouse gas emissions.

They contribute to income generation and job creation, especially in rural areas, where poverty tends to be the hardest hit and job opportunities most scarce. Bioenergy is also a source of clean and sustainable energy for domestic use.

As well as bolstering sustainable development, bioenergy also enhances energy security by contributing to the diversification of the local energy mix and by reducing fosseil fuel dependency.

Bioenergy can also be used to supply power to areas not connected to the national electricity grid, as discussed in the chapter **Renewable Energy**.

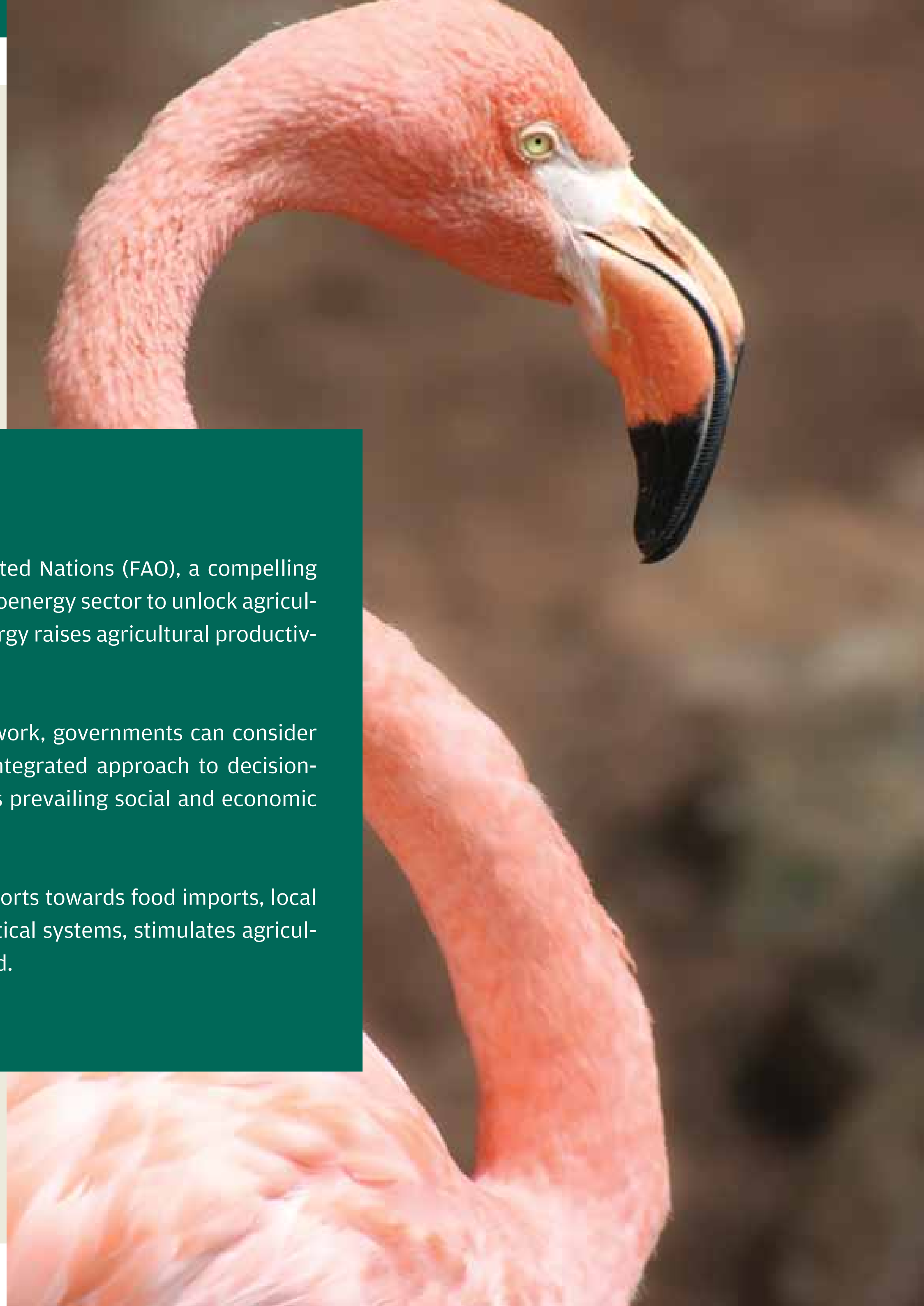
Biomass can be converted into power in remote areas, wich is one of the cheapest ways of supplying power to isolated communities.

Bioenergy and Food Prices

According to the Food and Agriculture Organization of the United Nations (FAO), a compelling argument for bioenergy development lies in the ability for the bioenergy sector to unlock agricultural potential. By bringing in much needed investments, bioenergy raises agricultural productivity which spurs food security and reduces poverty.

Under the FAO Bioenergy and Food Security Analytical Framework, governments can consider viable pro-poor strategies for bioenergy development in an integrated approach to decision-making that combines the technical viability with the country`s prevailing social and economic development objectives.

In addition to freeing up financial resources from fossil fuel imports towards food imports, local production of energy inputs drives improvements to local logistical systems, stimulates agricultural research, and encourages crops rotation to grow more food.



Brazil's experience in the use of biofuels dates from the 1970s, and currently accounts for over 50% of the energy consumed by the national fleet of light vehicles. Since then, the use of bioethanol instead of gasoline has saved more than one billion barrels of oil equivalent, avoiding the release of some 800 million metric tons of carbon into the atmosphere.

Brazilian ethanol from sugarcane reduces greenhouse gas emissions up to 80% when compared to gasoline.

Every ton of cane is estimated to avoid the release of 126 kilograms of carbon from the atmosphere thanks to the use of ethanol instead of gasoline and electricity generated by burning bagasse instead of other power sources.

The sugarcane industry currently employs about half a million people, whose average salary is higher than for any other agro-industrial segment in Brazil.

The many benefits arising from the production of bioenergy have led Brazil to use its experience to develop initiatives to stimulate the production and use of bioenergy in other countries. This experience was acquired over several decades, from regulation and standardization to technical processes at agricultural and industrial stages.

Africa is one of the regions that could benefit most from the economic, social and environmental benefits of bioenergy.

Africa is also one of the world's most suitable areas for bioenergy production. In addition to an extensive inter-tropical zone with abundant sunshine, it has large amounts of arable land, a growing consumer market and favourable export tariffs.

A few of Brazil's cooperation projects with African countries in the area of bioenergy are outlined here.

Structured Program for Support to Other Developing Countries in the Area of Renewable Energy (Pro-Renova)

The main objectives of Pro-Renova are disseminating the benefits of biofuel production and use, and providing technical assistance to African countries interested in projects. The program aims to expand to other continents in the near future. Program activities to date included hosting:

• A series of technical seminars on "Agro-ecological zoning as a public policy instrument for the agricultural stage of sustainable biofuel production", held in Botswana, South Africa, Angola, Zambia, Tanzania, Zimbabwe and Mozambique in October-November 2009;

• Technical courses on "Public policy for biofuel" held in April 2010 in the West African Economic & Monetary Union countries (Burkina Faso, Benin, Côte d'Ivoire, Guinea Bissau, Mali, Senegal and Togo);

• A series of presentations on "Development and innovation in the biofuel industry", delivered in Kenya, Uganda, Tanzania, Ethiopia, Sudan and Mozambique in July-August 2010.

Memorandum of Understanding between Brazil and the U.S. to Advance Cooperation on Biofuels

The governments of Brazil and the U.S. are financing and promoting feasibility studies in Senegal and Guinea Bissau in collaboration with the United Nations Environment Program (UNEP).

The studies include a comprehensive survey of geographical conditions such as topography, climate and soil, social and economic conditions, especially markets and infrastructure, and other factors that affect the sustainability and viability of bioenergy production.

The end-result is the identification of areas best suited for sustainable production of the main crops used in biofuel production.

The studies also recommend business models for regions considered suitable for production while also identifying specific projects that are economically viable.

Feasibility studies on biofuel production in Africa are an important means of advancing the Brazilian strategy to promote sustainable bioenergy abroad.

Bioenergy production and use should be environmentally, economically and socially sustainable. The best way to achieve this goal is to first understand the specific characteristics of each country or region, and only then create public policy and promote investment in the sector.

This approach ensures that local decision makers and investors do not overlook any aspect of sustainability.

West African Economic and Monetary Union (WAEMU)

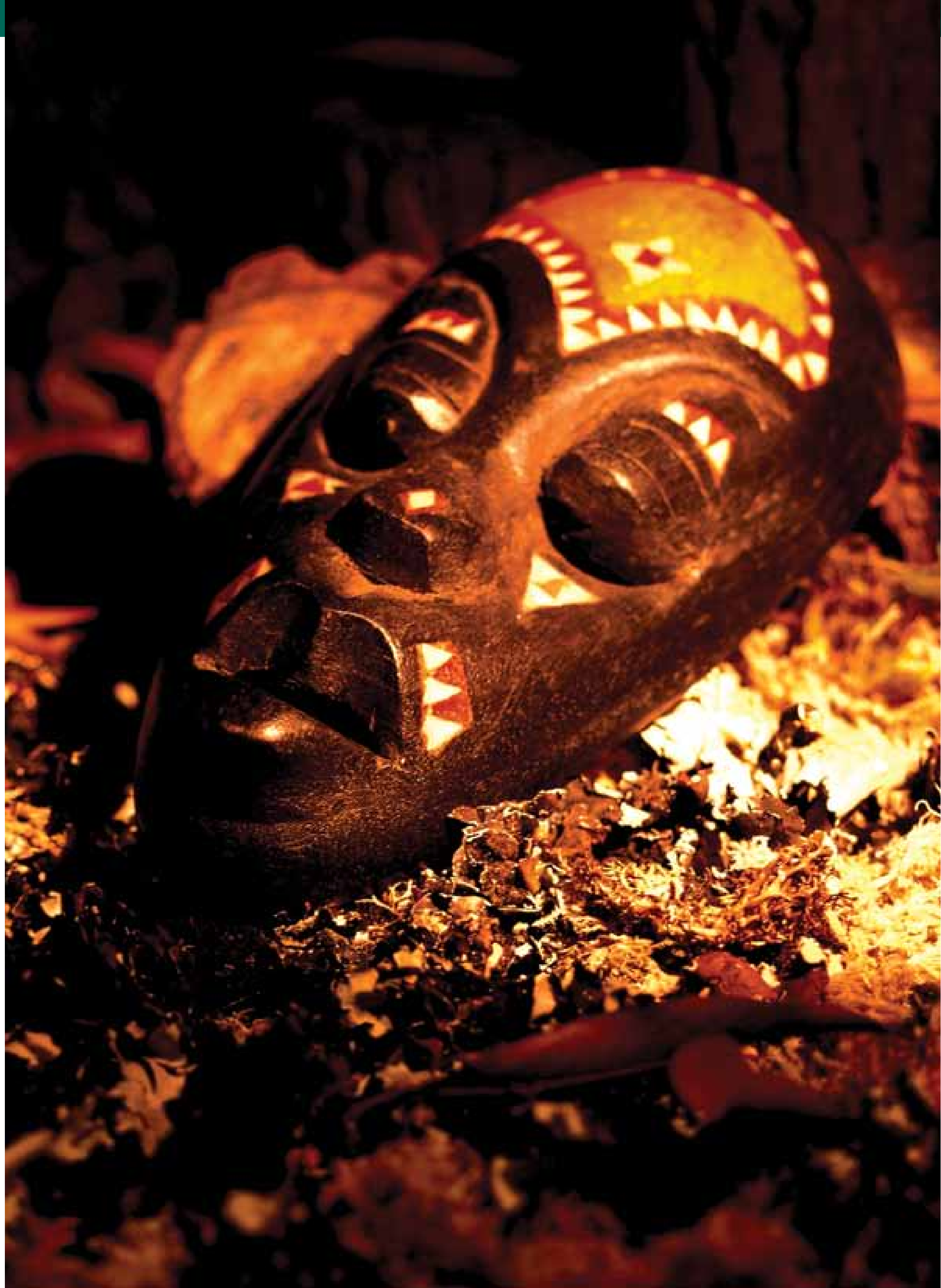
In 2007 Brazil signed a memorandum of understanding for cooperation on biofuels, this time with WAEMU, whose members are Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo.

In West Africa, as in other parts of Africa, a regional approach to biofuel development can help create synergies that enable biofuels to be included in the energy balances at the country level. Regional scale economies assure the viability of projects which would not otherwise be feasible or economically if confined within country borders, as seen in the chapter **Power Integration**.

In February 2011 the Brazilian Foreign Ministry signed a technical cooperation agreement with the Brazilian National Development Bank (BNDES) to stimulate research on the economics of biofuels by investing or extending low-cost credit. A Work Plan for 2011-12 annexed to the agreement calls for cooperation with WAEMU as a first step. This is expected to take the form of a feasibility study on the production of biofuels in the region.

The Brazil - European Commission Initiative for Cooperation in Bioenergy in Africa

In December 2008 Brazil and the European Commission launched a partnership to promote bioenergy in Africa. The initiative encompasses two main lines of action: the development of feasibility studies for sustainable bioenergy production in African countries; and the implementation of projects based on the studies' conclusions in those countries. Work began on the Mozambique feasibility study in February 2011. In the case of Kenya, a funding mechanism has to be defined before work can begin.



Status of Bioenergy in Africa

Although sustainable production and consumption of bioenergy in Africa are incipient, they are clearly set on a course for growth. A reliable database on the subject is not yet available for the entire region, but several countries are developing national policies and stimulating the creation of projects capable of leveraging the continent's competitive advantages in the production of biomass in general and biofuels in particular. However, bioenergy use is rising more in some countries than in others. This section overviews the initial steps made by African countries toward higher levels of sustainable bioenergy production and consumption.

Table 3 summarises the main initiatives concerning bioenergy development in those countries.

Important to mention here is that some countries, like Ethiopia, Gabon, Guinea, Guinea-Bissau, Mali, Congo (Brazzaville), Swaziland and Zambia, despite having environmental conditions suitable for the production of bioenergy have no legislation or completed feasibility studies to date.

Table 3: Current situation of bioenergy in Africa

	Regulation Framework	Mandatory Blending	Production	Power Generation	Exports
South Africa	YES	NO	YES	YES	YES
Angola	YES	NO	NO	NO	NO
Botswana	YES	NO	NO	NO	NO
Cape Verde	YES	NO	NO	NO	NO
Mauritius	YES	NO	NO	YES	NO
Mozambique	YES	NO	NO	NO	NO
Nigeria	YES	NO	NO	YES	NO
Senegal	YES	NO	NO	NO	NO
Sudan	YES	NO	YES	YES	YES
Tanzania	YES	NO	YES	YES	NO
Zimbabwe	YES	NO	YES	YES	YES

Source: Elaborated by FIESP 2011.

Angola

Fossil fuels derived from petroleum predominates Angola's energy mix. Since 2008, however, the government has advocated the production of biofuels to diversify energy sources and create jobs in the countryside. In agricultural terms, Angola is considered potentially one of the wealthiest countries in sub-Saharan Africa.

Before the civil war, it was self-sufficient in most crops and was a major producer of palm oil and sugarcane, among others, that can be used as biofuel feedstock.

The climate in Angola's farmlands resembles that of some parts of tropical Brazil, with distinct dry and wet seasons. Some 500,000 hectares could be allocated to biofuel feedstock production.

Angola's 2010 biofuel law calls for bioethanol and biodiesel to be blended with fossil fuels but does not specify how much or set deadlines, both of which are to be determined by executive decree. The law is designed to foster the growing of sugarcane and other crops that can be used as biofuel feedstock.
A working group coordinated by the Angolan Ministry of Agriculture has been charged with establishing the terms of reference for a national biofuel production program to implement the law and the national biofuel strategy.

The working group's goals include mapping the areas to be allocated to the production of biofuel feedstock and studying the yields of various crops. Because the law is recent there are as of yet no studies geared to the classification, zoning, mapping and demarcation of land for exclusive production of biofuels.

At present there is no local production of biofuel in Angola. It is expected to start producing ethanol in Malanje Province (Project Biocom) in 2012.

Production of anhydrous ethanol is expected to reach 30 million litres per year, with electricity generation of 30 MW.

It aims to produce sufficient sugar for the domestic market to reduce imports by 65%. More than 20 other projects are reportedly being analysed and awaiting approval by the authorities, showing Angola's considerable potential in the sector.

Botswana

The government has set a target of raising renewable energy use to 25% of demand for electricity by 2030 and included in the 10th National Development Plan the goal of reaching 15% by 2016.

The Ministry of Minerals, Energy & Water Resources plans to add 10% biodiesel to fossil diesel by 2020.

Botswana has favourable natural conditions for local production of biofuels, especially biodiesel. The Ministry of Agriculture has said that 500,000 hectares of land in each district could be set aside for the production of bioenergy feedstock without affecting food production. Only 29% of the country's arable land is used for cropping.

Bioenergy is not yet commercially produced but the Ministry of Minerals, Energy & Water Resources treats it as a priority. In January 2010 it set up a task force to plan and facilitate the development of competitive and sustainable biofuel production. Before kick-starting bioenergy production and consumption in this way, in April 2007 the ministry had commissioned a feasibility study, which concluded the potential for local production and use of bioenergy, especially ethanol and biodiesel, with biodiesel having the greater potential.

Sweet sorghum and sugarcane were identified as the most promising feedstock for ethanol, with jatropha and animal fat being recommended for biodiesel.

Based on the study, the ministry has issued a plan calling for the production of 15 million litres of biodiesel per year by 2016 and 50 million litres per year by 2020.
This requires at least 70,000 hectares of land on which to grow the feedstock.

To help achieve the targets the ministry plans to acquire a biodiesel processing unit with the capacity to produce 10,000 litres per day, initially from animal fat and vegetable oils, switching to jatropha at a later stage. Start-up has been scheduled for December 2012.

Cape Verde

In 2008, the Government of Cape Verde issued an energy policy document (Política Energética de Cabo Verde) outlining the energy situation in the country and setting as its main objective the reduction of fossil fuel dependency. The key strategy to achieve this objective is diversification of the energy mix.

The document emphasizes initiatives to increase the penetration of renewable energy sources, such as biofuels. The aim of the government's energy policy includes meeting 50% of the country's power requirement via renewables by 2020, with 100% on at least one island.

The media recently reported a pre-agreement to implement an ethanol processing and dehydration plant on the Island of São Vicente.

Hydrated ethanol will be supplied by Brazil and the anhydrous end-product will be re-exported to Europe.

Mauritius

Mauritius does not produce ethanol or biodiesel on a commercial basis, however, feasibility studies and pilot production projects are under way.

Cogeneration of electricity using sugarcane bagasse produced 350 GWh in 2009 and the government plans to increase this to 600 GWh per year by 2015.

In 2009, 19% of the electricity produced in the country came from renewable sources, cogeneration (bagasse) and hydropower. Only sugarcane bagasse is used in cogeneration. The bioenergy production pilot projects are using cane molasses, coconut oil, jatropha and vegetable oil.

The Government of Mauritius's Long-Term Energy Strategy calls for a 10% ethanol blend in gasoline in 2012 and a 20% blend in future.

Ethanol production required for the first target is estimated at 25 million litres per year.

Mozambique

Mozambique has a strong agricultural vocation, especially in regards to production of biofuels. It has a suitable climate and an abundance of arable land (some 30 million hectares).

It is strategically located to export biofuels to Asia and Europe, with three suitable ports along the coast, and it is close to South Africa, the largest potential market in the region.

Although the government is clearly interested in developing agriculturally based renewable energy sources, as of yet there is no commercial production of biofuels.

Mozambique is, however producing bioenergy on an experimental basis, mainly growing sugarcane for bioethanol and Jatropha curcas for biodiesel.
A document entitled “Mozambique Biofuels Policy & Strategy” (Política e Estratégia de Biocombustíveis de Moçambique) approved in May 2009 constitutes the country’s main effort to create a regulatory framework for biofuel production and use.

The aim is combating poverty and promoting energy and food security. The strategy centres on bioethanol and biodiesel produced from feedstock suited to each region’s agricultural conditions and climate, above all for use in the transportation sector.

It also includes a section that sets environmental and social parameters for biofuel production and use. In June 2011 the executive issued a decree regulating nationwide biofuel blends. This stipulates a 10% bioethanol blend in gasoline and a 3% biodiesel blend in conventional diesel by 2015.

The government has entered into international partnerships with the aim of developing Mozambique’s bioenergy sector.

In May 2009 it signed a memorandum of understanding on biofuels with Brazil to promote cooperation and technical exchanges in this field.

In February 2011, work began on a feasibility study for sustainable production and use of bioenergy.

The study aims to identify suitable areas for sustainable farming of the main crops used to produce biofuel.

Nigeria

Nigeria is a major exporter of hydrocarbons, with oil revenues accounting for 80% of the national budget. Without losing sight of this sector’s importance, the government has advocated diversification of the nation’s energy mix, including the development of biofuels.

Nigeria has the right climate, soil and amount of land for sugarcane growth, and has sought foreign technical cooperation to develop appropriate varieties and technologies.

Bioenergy is commercially produced but because sugar and cassava output habitually falls short of demand there are no surpluses for use in production of biofuels. There are tax incentives currently in place for biofuel imports.

The government's interest in developing domestic bioenergy production and consumption is reinforced by legislation for the sector.

The Nigerian Biofuels Policy dates from June 2007 and its revision is currently being discussed. The aim is to make the biofuel sector more attractive to investors and markets. The review will be conducted by a technical committee under the aegis of the Department of Petroleum Resources.

In the context of the National Biofuels Policy the government introduced an Automotive Biomass Program with the aim of achieving a 10% ethanol blend in gasoline (E-10) and gradually extending the use of E-10 until it becomes the national standard.

The program and legislation remain in force but have not been implemented. In addition, the National Sugar Development Council (NSDC), under the aegis of the Federal Ministry of Commerce & Industry, has adopted a plan for the development of sugar and ethanol production from sugarcane to reduce imports and foster growth of the sugar and ethanol industry.

In August 2005 the Nigerian National Petroleum Corporation (NNPC) established a Renewable Energy Division to develop a biofuel program and enable Nigeria to participate in Clean Development Mechanism projects.

The NNPC has a memorandum of understanding with Petrobras (Brazilian oil company) to transfer ethanol production and market expertise, with ambitious goals for the short term (importing ethanol and implementing pilot projects for domestic production), medium term (growing sugarcane and cassava in a total area of 60,000 hectares and producing enough ethanol to supply 20% of the domestic market) and long term (producing surplus ethanol for export).

The program is still in place but has not been implemented.

Senegal

Biodiesel is not yet produced in sufficient volume to go to market and ethanol production is awaiting completion of the requisite legal framework.

Some electricity is generated from biomass but for internal consumption only. The feedstock is sugarcane bagasse and peanut shells (peanuts are Senegal's main cash crop).

A local company is developing a project to produce electricity from jatropha oil which is currently in the trial phase.

There are no records of biofuel imports by Senegal, but the government has targets for blending biofuel with fossil fuel in accordance with production levels, at 3%-5% biodiesel/diesel and 8%-10% ethanol/gasoline.

The effort to achieve these targets are being assisted by the national program to produce jatropha oil for biodiesel, begun in 2007. This program calls for the cultivation of 321,000 hectares to produce 1.134 billion litres of biodiesel. Based on the current level of production, however, it is likely to be extended to 2015. As for ethanol, a local distillery is already in operation with a capacity of 60,000 litres per day and scope for rapid expansion if warranted by demand.

The Senegalese government has two laws to regulate the bioenergy sector, enacted in December 2010. The decrees concerning these laws are still in development. It is intended to strengthen gradually, the legal framework for the sector.

South Africa

South Africa produces liquid biofuels (ethanol and biodiesel), albeit on a small scale, and exports any surpluses to the member countries of the Southern African Development Community (SADC).

South Africa produced ethanol from sugarcane between the 1920s and 1960s, but this production fell owing to low oil prices at the time. Today some producers of ethanol from sugarcane use bagasse to generate electricity which is consumed internally.

The Ethanol Producers Association of South Africa has five member companies that in aggregate produce 388 million litres of ethanol per year. It is important to note that they currently produce ethanol for mainly other applications.

The main policy document, “Biofuels Industrial Strategy for South Africa”, produced in 2007, defines priority feedstock as sugarcane and sugar beet (ethanol), sunflower, canola and soybeans (biodiesel), while recommending investment in R&D to develop second-generation biofuel technologies.

Besides the feedstock already mentioned, some small-scale producers are using spent vegetable oils to produce biodiesel.

Jatropha and corn are excluded as feedstock in the document owing to food security concerns, although the document stresses the need for further research on the feasibility of growing jatropha.

The government proposes a blending ratio with fossil fuels at 8% for ethanol and 2% for biodiesel. However, blending is not yet mandatory since the Biofuels Industrial Strategy is not binding.

Government support for biofuel production and marketing comprises guaranteed minimum prices, tax exemption, training for growers, financial and production support by state entities, and R&D.

The policy now being implemented calls for a gradual phasing-out of government support.

South Africa has substantial sugarcane growth potential, especially in the eastern part of the country, in the province of KwaZulu-Natal.

According to the policy document, about 14% of its arable land is underutilized, and estimates that 2% biofuel penetration in the national liquid fuel supply could be achieved using only 1.4% of arable land in South Africa.

The document states that the proposed feedstock for bioethanol and biodiesel production in South Africa are not water-intensive but calls for joint surveillance of their impact on water availability from the Department of Water Affairs & Forestry and the Department of Minerals & Energy.

It is worth stressing that according to the policy document, achieving 2% penetration by biofuels in the national liquid fuel supply will create 25,000 jobs and reduce unemployment by 0.6%.

Sudan

Development of the biofuel industry has made significant progress in Sudan in recent years. Using Brazilian technology, Sudan produces biofuel in the form of ethanol from sugarcane.

Ethanol production currently amounts to some 60 million litres per year and is expected to reach 65 million litres in 2011. Natural conditions for biofuel production are highly favourable. Sudan has some 100 million hectares of arable land and currently uses only 20%.

Sudan is an exporter of ethanol. Of the 60 million litres produced in 2009, five million were exported to Europe. In 2010, exports to Europe rose to 15 million litres. Sudan's 2008 Agriculture Development Plan calls for action in focal areas such as food security and poverty reduction, as well as incentives for commodity exports. In this context the government plans additional production of 140,000 tons of sugar and 30 million litres of ethanol by 2014.
There are plans to build 13 new sugar mills as part of Sudan's strategy to achieve self-sufficiency in the sector and produce exportable surpluses.

To date there are no plans to blend biofuels with fossil fuels.

The transportation sector currently accounts for 22% of demand for energy and is expected to grow significantly in the coming years. As oil revenues dwindle, the government aims to replace at least 10% of the fossil fuel consumed by the transport sector with biofuels by 2020.

Tanzania

Tanzania's natural conditions may be the most favourable for the development of large-scale biofuel production on the African continent. The country has plenty of available arable land, the climate is tropical; similar to the Brazilian savannah (cerrado). Private sources estimate that roughly one million hectares could be rapidly deployed for biofuel production. A 2010 study by FAO ("Bioenergy and Food Security Analysis for Tanzania") concluded that sugarcane (in the case of large-scale commercial farming), sweet sorghum and cassava are the most sustainable ethanol feedstock, and recommended sunflower and jatropha for biodiesel.

Bioenergy is commercially produced in Tanzania. Official statistics point to the production of nine tons of oil equivalent per day in 2009, mainly by a biogas plant burning sisal waste in Tanga.

As for electricity generation, the country's top four sugar mills are estimated to produce some 40 MW, burning bagasse. These mills produce ethanol in their distilleries, but practically all the ethanol produced is shipped to the beverage industry.

Tanzania does not import or export bioenergy where its current output is entirely consumed domestically, but several projects are being implemented to export biofuels to Europe.

Since January 2011 the "Guidelines for Sustainable Liquid Biofuels Development in Tanzania" have been in force, which calls for safeguards to assure adequate land use in order to avoid negative effects on food production.

This document will serve as a basis for a “National Plan” to be sent by the executive to parliament in 2011.

Development of a legal framework for the sector is being funded by the governments of Sweden and Norway and is nearing completion.

In June 2011 the Tanzanian Petroleum Development Corporation (TPDC) announced that by the end of the year Tanzania will begin importing ethanol from Brazil as one of several ways to cut the cost of gasoline and reduce petroleum consumption.

Zimbabwe

Bioethanol production currently amounts to about 25 million litres per year, but there is sufficient capacity to produce 40 million litres per year. Zimbabwe also has the capacity to produce 36 million litres per year of biodiesel, but has not been able to do so to date for lack of raw material.

Bagasse is used to produce about 70 MW of electricity and a sawmill generates 0.5 MW from wood waste. The ethanol is produced from sugarcane molasses after sugar production. In the case of biodiesel, the main feedstock is cottonseed oil.

Zimbabwe exports ethanol, mostly to Europe. Ethanol output is expected to reach about 100 million litres per year in 2012, 190 million litres per year within three years, and 260 million litres per year within five years. Ethanol blending with gasoline at 10% should begin by the end of this year, rising gradually to 20%.

Flex-fuel vehicles are expected to be introduced, leading to a rise in ethanol demand.

5. POWER INTEGRATION

Power Integration

Introduction

The African continent is vast and home to a multidude of political, economic and geographic particularities.

In power generation and transmission, these particularities make for major opportunities for regional interconnections to integrate countries with similar objectives, such as economic development and growth in electricity access rates.

This chapter outlines the main interconnected systems in Africa, their current status, and the expansion projects being implemented or in the pipeline.

As major exporters of electricity, countries like the DRC, Ethiopia and Guinea are key players in the development of regional power trade.

In addition to power integration across the continent, this chapter looks at the Desertec Industrial Initiative (Dii), a large-scale project to export power from the MENA region to Europe.

Regional Power Interconnections

The interconnected systems in Africa are the Central Africa Power Pool (CAPP), the Eastern Africa Power Pool (EAPP), the Western Africa Power Pool (WAPP), the Southern Africa Power Pool (SAPP), and the Maghreb Power Committee (COMELEC). In addition to these, there is also the Union of African Producers, Transporters & Distributors of Electricity (UPDEA), which aims to integrate the entire continent.

The experience in the development of regional power systems in Europe, North America, and more recently Central America, has highlighted the importance of adequate regional integration policies, whose key elements are listed in **table 4**.

Table 4: Regulatory and operational framework for power integration

Legal & Regulatory Framework	Planning & Operating Systems	Trade	Capacity Building
Memorandum of understanding between governments & utilities	Clear political mandate for regional planning	Fair market rules	Capacity building plan to develop & oversee projects
Regional electricity laws	Organizational structure	Conflict resolution mechanism	Qualified system operator
Regional regulator	Energy integration planning framework		Authority to impose financial discipline

Source: Elaborated by FIESP using data from AfDB 2011.

Eastern Africa Power Pool

EAPP (Eastern Africa Power Pool)	
Countries: Burundi, DRC, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Libya	
Population (million inhabitants)	380
GDP (US$ billion)	460
Current access to electricity	41%
Future access to electricity (2040)	65%
Required investment in access to electricity (US$ billion)	29.0
Projected rise in demand	7.7%
Total additional capacity required (GW)	273

North-eastern Africa has an abundance of natural resources but they are not evenly distributed throughout the region.

Power generation potential from these natural resources is immense, but access to electricity is low, ranging from 3% to 20%, except in Egypt, where it is 99%.

Power supply reliability and quality are also an issue in several countries in the region. There are relatively few interconnections between national grids and those that do exist are weak and unstable.

Considering this, the EAPP was established in 2005 by an intergovernmental memorandum of understanding signed by Burundi, Democratic Republic of Congo (DRC), Egypt, Ethiopia, Kenya, Rwanda and Sudan.

The region's power utilities also signed a memorandum of understanding on the same day.

The pool is open to any other countries in the region that wish to join, but only Tanzania and Libya have done so to date, although Djibouti and Uganda are also expected to join in the near future.

EAPP is governed by these two memorandums of understanding, as well as an operating agreement among its members and a Regional Grid Code establishing rules and standards for technical planning and operation of the interconnected grid.

EAPP's main objectives are to: (I) provide a secure power supply; (ii) optimize the use of available energy resources in socially, economically and environmentally acceptable ways; (iii) increase power supply and raise the regional rate of access to electricity; and (iv) reduce regional electricity costs.

Table 5 lists EAPP's long-term interconnection planning schedule from a commissioned study in 2011, which includes existing installed capacity, scheduled projects coming on stream by 2012, and potential projects by 2030.

Table 5: Current situation and planned projects in EAPP

Country	Installed by 2012 (MW)	Future 2013-2030 (MW)	Total 2030 (MW)	Demand 2030 (MW)	Surplus 2030 (MW)
Burundi	49	422	470	385	86
Djibouti	123	187	310	198	112
DRC (East)	74	1,117	1,191	179	1,012
Egypt	25,879	46,570	72,449	69,909	2,540
Ethiopia	2,179	13,617	15,796	8,464	7,332
Kenya	2,051	6,288	8,339	7,795	544
Rwanda	103	411	514	484	30
Sudan	3,951	11,310	15,261	11,054	4,207
Tanzania	1,205	4,881	6,086	3,770	2,316
Uganda	822	2,531	3,353	1,898	1,455
Total	36,436	87,334	123,769	104,136	19,633

Source: Elaborated by FIESP using data from EAPP 2011.

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Based on the national surpluses shown above, the study commissioned by EAPP presents two scenarios. One of these scenarios, shown in **Figure 1**, indicates the current interconnections and the need for future interconnections to meet growth targets and power demand in the region.

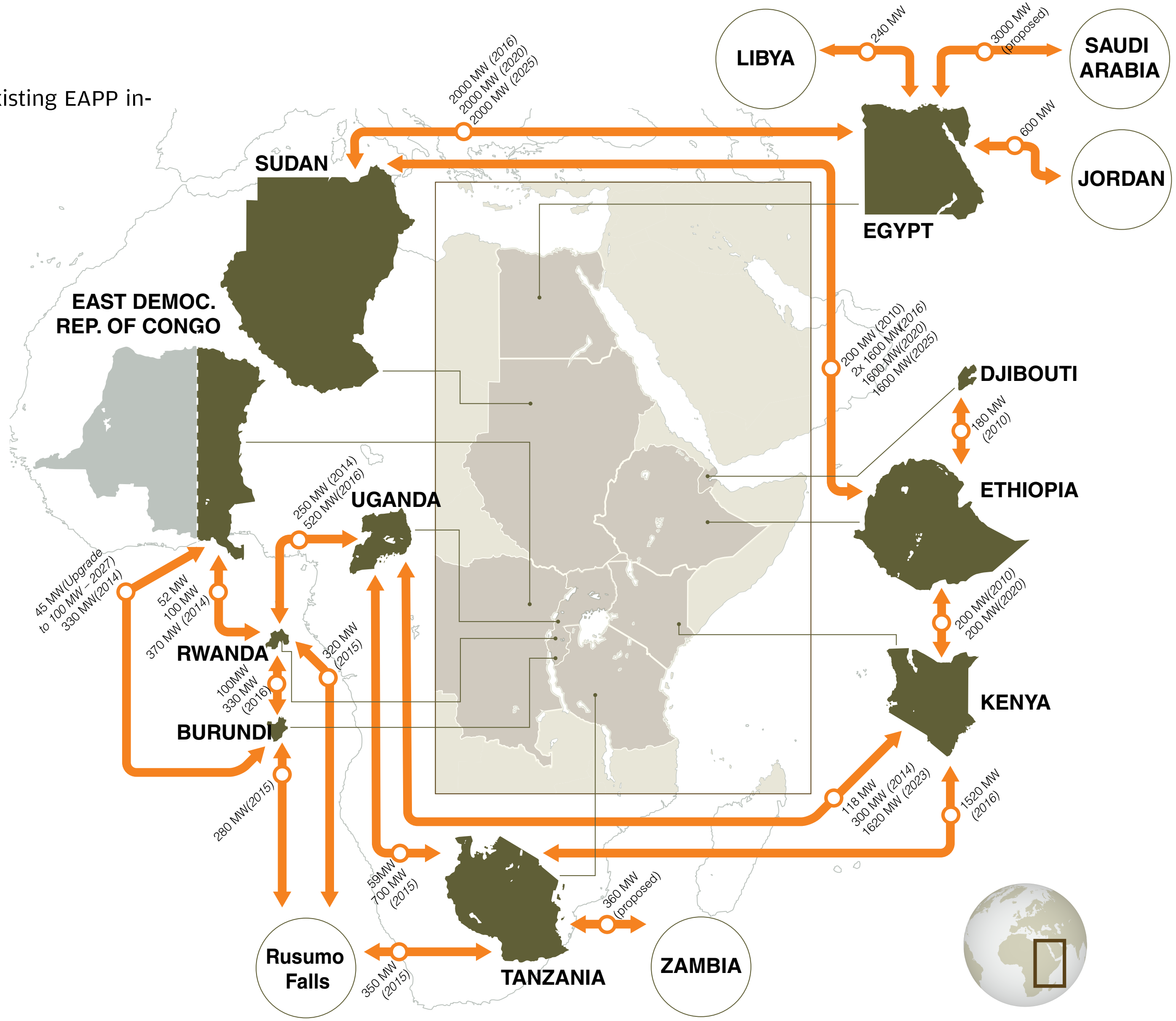
With regard to the interconnections to be constructed under the above scenario, scheduled investment by project is as follows in **table 6**.

Tabela 6:
EAPP - Planned investments in interconnections

Interconnections		Investment (US$ million)
Tanzania	Uganda	30.4
	Rwanda	37.6
	Burundi	47.9
	Kenya	117.0
Ethiopia	Sudan	510.8
	Kenya	845.3
Egypt	Sudan	3101.7
Uganda	Rwanda	51.3
	Kenya	71.0
Ethiopia	Kenya	845.3
	Sudan	510.8

Source: Elaborated by FIESP using data from EAPP 2011.

Figure 1 – Scheduled and existing EAPP interconnection projects.



Source: Elaborated by FIESP using data from EAPP 2011.

West African Power Pool

WAPP (West African Power Pool)	
Countries: Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo	
Population (million inhabitants)	300
GDP (US$ billion)	320
Current access to electricity	35%
Future access to electricity (2040)	62%
Required investment in access to electricity (US$ billion)	16,9
Projected rise in demand	8.9%
Total additional capacity required (GW)	141

The chapter **Renewable Energy** shows the abundance of available energy sources in Western Africa that have not yet been tapped. Despite the considerable power generation potential, the rate of access to electricity in WAPP averages only 23%.

WAPP is a specialized agency of the Economic Community of West African States (ECOWAS). Set up in 1999, it includes 19 power utilities and is responsible for managing cooperation in power projects among the member countries.

The cooperation framework put in place by WAPP regulates grid interconnections and determines the participation of each utility.

WAPP's main objective is to integrate the national grids of its members into a single regional market. This mechanism is expected in the medium to long-term to assure a stable and reliable power supply that is affordable to the region's population.

Any public or private entity in any of the member countries can join WAPP, provided it generates more than 20 MW.

In 2003 the ECOWAS Energy Protocol established the legal framework within which cross-border grid interconnections are made within WAPP. Its overarching aim is to facilitate long-term cooperation, boost investment and assure growth in energy trade.

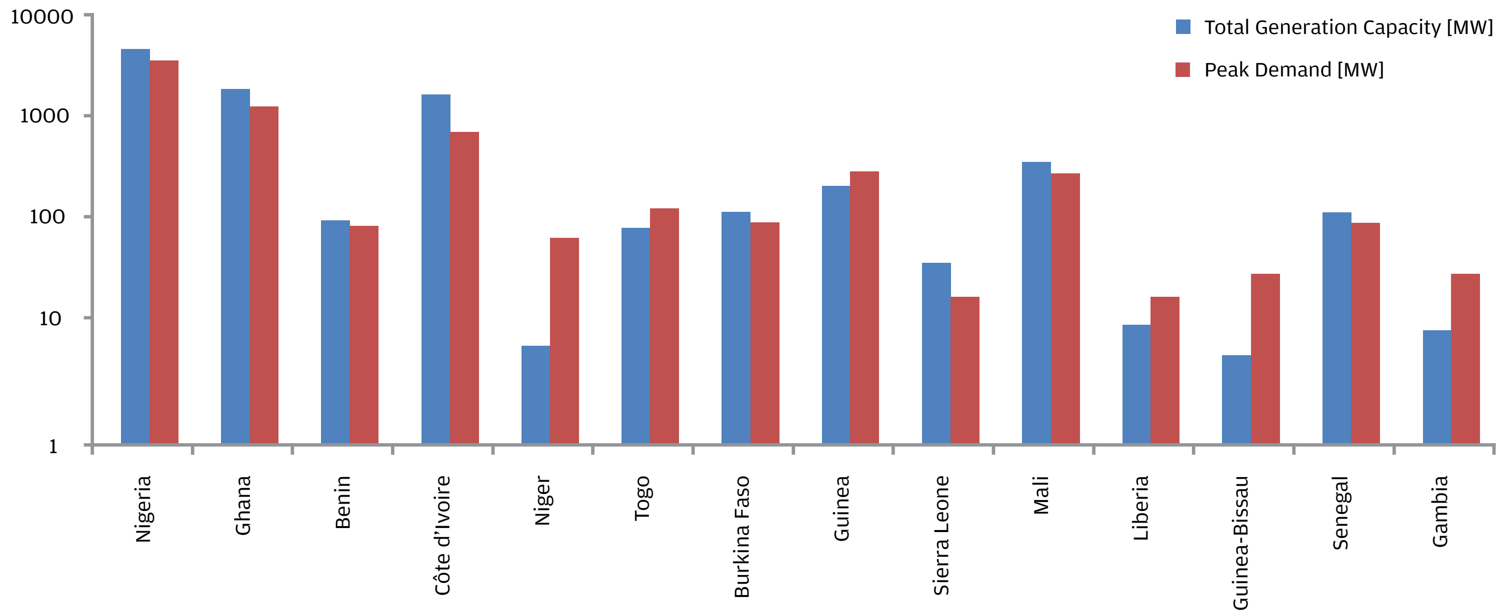
The provisions of this legislation include: (i) protection for foreign investment; (ii) non-discriminatory terms and conditions for trading in energy; and (iii) dispute settlement.

The ECOWAS Regional Electricity Regulatory Authority (ERERA) was established in Ghana in 2008 primarily for the purpose of regulating the regional and cross-border electricity market, supporting national regulators, and overseeing the development and monitoring of uniform regional and national standards.

Expansion of the grid and upgrading of existing interconnections will assure access to electricity to countries with low production capacity such as Niger and Togo.

Graph 21 shows power capacity in WAPP by country. It is important to note that while some countries are self-sufficient, capacity lags behind demand in many countries.

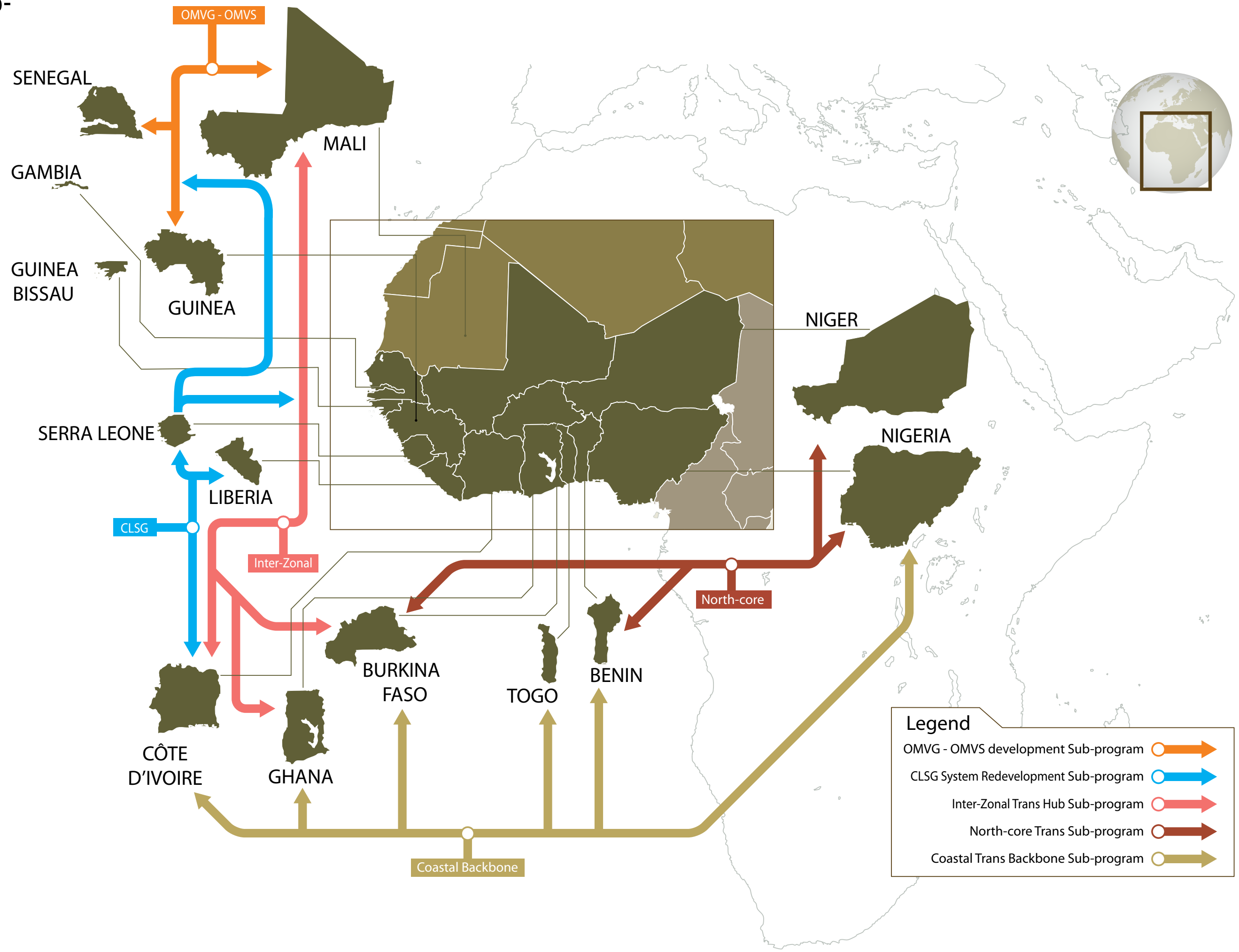
Graph 21 - Power capacity in WAPP [MW]



Source: Elaborated by FIESP using data from ECOWAS 2008.

Figure 2 shows the main WAPP transmission projects. The arrows indicate priority sub-programs, with the location and destination of each interconnection.

Figure 2 – WAPP priority Sub-programmes.



Source: Elaborated by FIESP using data from ECOWAS 2011.

WAPP Priority Sub-Programmes

Coastal Transmission Backbone Sub-program to establish a robust interconnection link between the national power systems of Côte d'Ivoire, Ghana, Benin, Togo and Nigeria.

Power System Development Sub-programs to interconnect national power systems from Gambia, Guinea, Guinea-Bissau, Liberia, Mali, Senegal and Sierra Leone, as well as securing access to sources of low-cost hydropower from facilities to be built primarily on (i) the Senegal River Basin (Guinea, Mali) and (ii) the Konkoure River Basin (Guinea).

Inter-Zonal Transmission Hub Sub-program to establish more secure, reliable transmission corridors for the transfer of low-cost power supply (produced by large-capacity hydro and gas-fired power plants in Côte d'Ivoire, Ghana, Togo, Benin and Nigeria).

North-Core Transmission Sub-program to upgrade and extend existing capacity to transfer low-cost power supply (produced by large-capacity hydropower plants on the Niger River Basin and gas-fired power plants) from Nigeria into Niger and other Niger Basin riparian countries, including Benin, Burkina Faso and Mali.

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Central African Power Pool

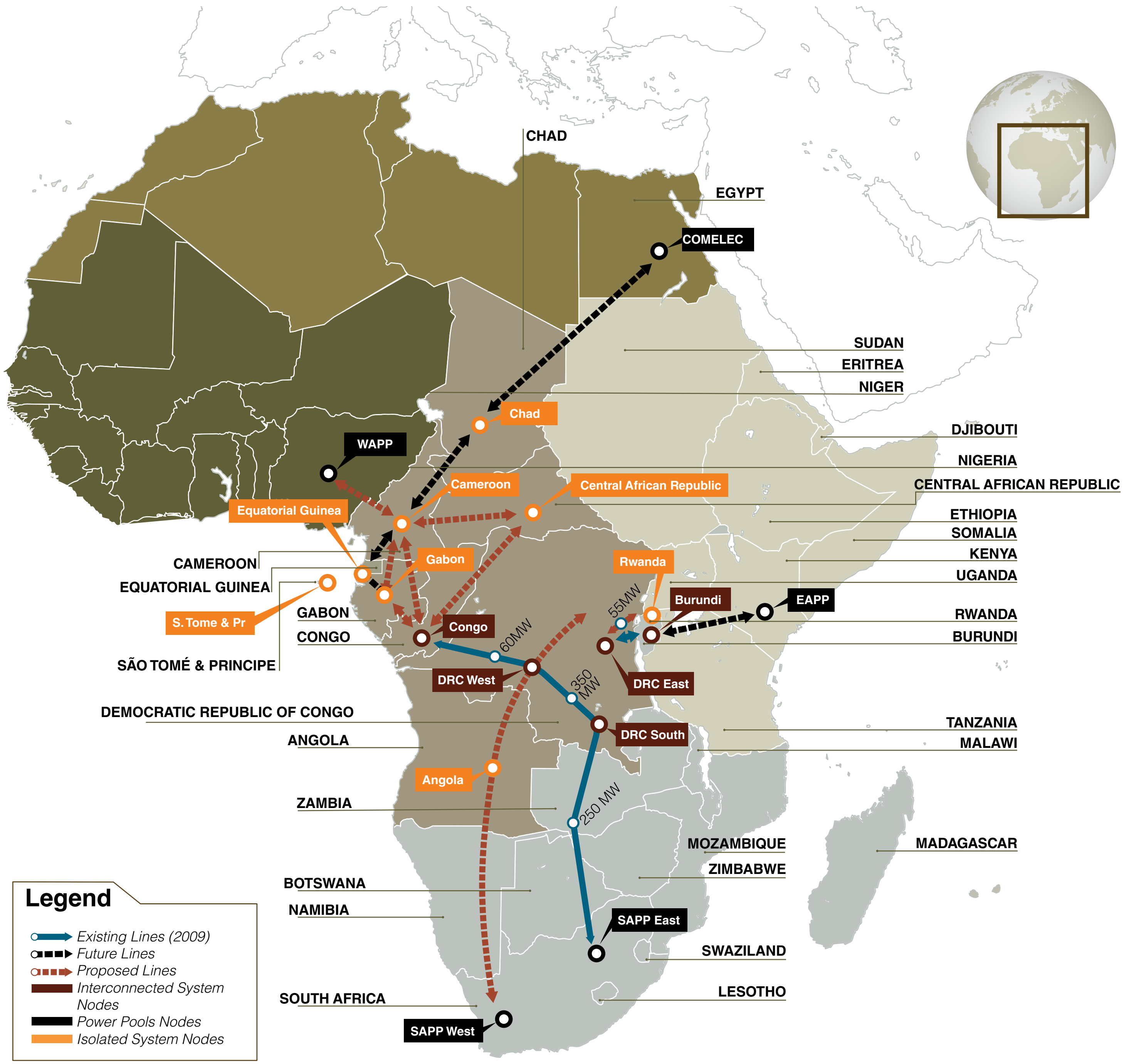
CAPP (Central African Power Pool)	
Countries: Angola, Burundi, Cameroon, Central African Republic, Congo (Brazzaville), DRC, Gabon, Equatorial Guinea, Rwanda, São Tomé & Príncipe, and Chad	
Population (million inhabitants)	150
GDP (US$ billion)	170
Current access to electricity	15%
Future access to electricity (2040)	54%
Required investment in access to electricity (US$ billion)	7.0
Projected rise in demand	7.8%
Total additional capacity required (GW)	29

CAPP is a specialized agency of the Economic Community of Central African States (ECCAS) set up in 2003.
CAPP's mission is to develop energy policy for Central African region, conduct monitoring, build group infrastructure, and manage cross-border trade in electricity and related services.

Its main priorities are to (i) secure electricity supply to member states, (ii) increase electricity access rates to populations within the region and reduce energy poverty, and (iii) improve the reliability of the region's power systems and the quality of its power supply.

Figure 3 shows the transmission lines in existence in 2009, new lines scheduled to come on stream, and proposed lines for implementation by 2025.

Figure 3 –
Preliminary CAPP Scheme



Source: Elaborated by FIESP using data from CAPP 2009.

Southern African Power Pool

SAPP (Southern African Power Pool)	
Countries: Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe and Tanzania	
Population (million inhabitants)	226
GDP (US$ billion)	330
Current access to electricity	26.9%
Future access to electricity (2040)	56.4%
Required investment in access to electricity (US$ billion)	15.7
Projected rise in demand	6.3%
Total additional capacity required (GW)	346

SAPP was established in 1995 under the aegis of the Southern African Development Community (SADC).

The pool comprises significant hydropower potential in the northern portion of the region, which contains the basins of the rivers Zambezi (Zambia, Zimbabwe, Mozambique and Malawi), Congo and Cunene (Angola and Namibia). The southern portion of the region (South Africa, Botswana and Zimbabwe) has large reserves of coal and a well-developed mining industry.

Figure 4 illustrates geographic distribution of resources in the region, which includes the **Super Grid**, a SADC project designed to increase electricity supply in step with the rise in demand projected for the coming years.

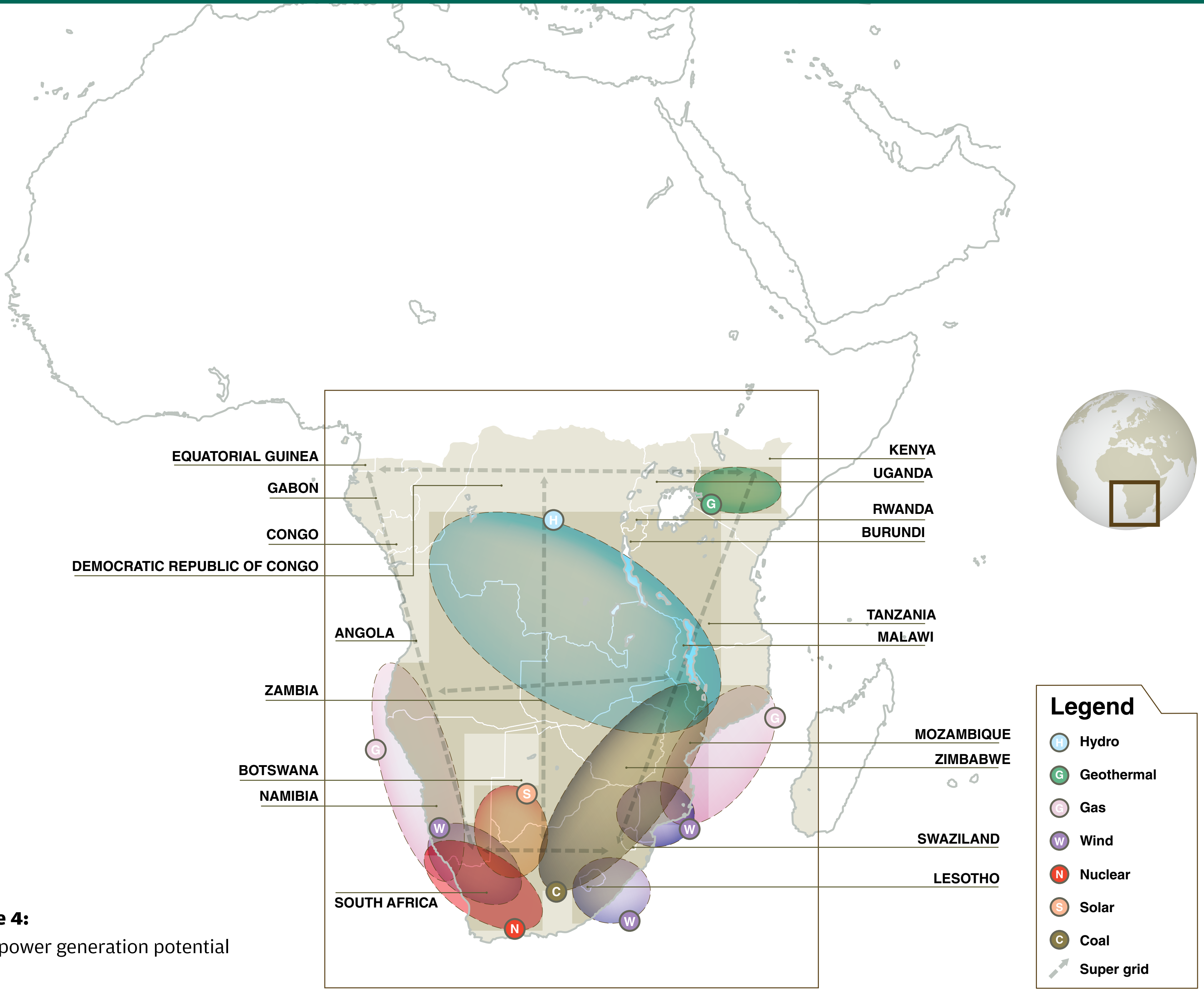


Figure 4:

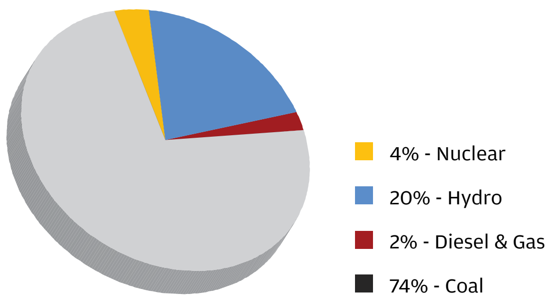
SAPP power generation potential

Source: Elaborated by FIESP using data from Eskom 2009.

The mining industry accounts for a large proportion of electricity demand in the region. Throughout the last century its demand shaped the local power system, basing it mainly on coal, and directly influenced the construction of specific interconnections to tap the hydropower potential of the northern region.

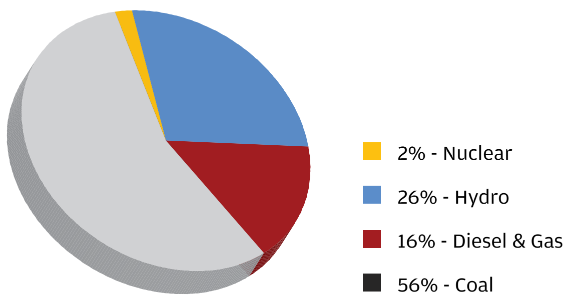
Graph 22 shows the region's current energy mix in 2008 and **graph 23** shows the projected mix for 2025. It is important to note the decrease in fossil fuel use, estimated at 4%.

Graph 22 - SAPP energy mix 2008



Source: Elaborated by FIESP using data from ECA 2009.

Graph 23 - SAPP energy mix 2025



Source: Elaborated by FIESP using data from ECA 2009.

In support of this, a regional regulatory framework was established to bring together all interconnections and an energy trade agreement under the umbrella of an intergovernmental memorandum of understanding. An inter-utility memorandum of understanding was also signed for the region.

The main objectives of SAPP are to: (i) improve the reliability and security of the existing regional power system, (ii) facilitate grid expansion and integration with non-member countries, (iii) increase electricity access in rural areas, (iv) develop a competitive energy market, and (v) foster a short-term energy market by facilitating trade in surplus power not contracted for under existing agreements.

Grid interconnections have also facilitated development of energy potential in the region, minimizing the need for new power plants and hence reducing environmental impact. **Figure 5** shows the location of power plants and the existing grid interconnections.

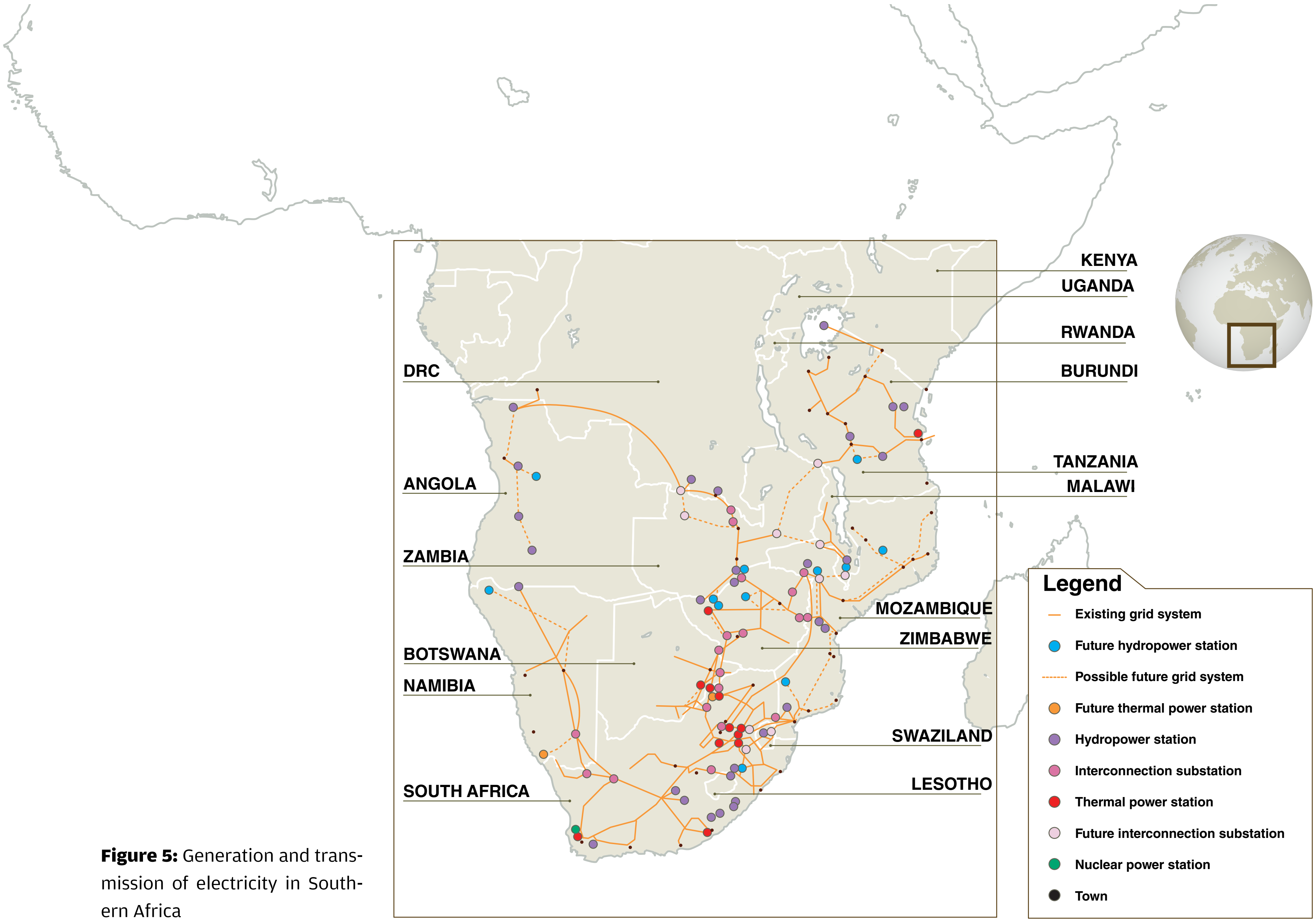


Figure 5: Generation and transmission of electricity in Southern Africa

Source: Elaborated by FIESP using data from Eskom 2009.

Figure 6 shows existing SAPP interconnections, highlighting transmission capacities and future interconnection projects.

Planning priorities include: (i) expanding generation, transmission and distribution capacities to increase energy security and keep pace with the growth of demand; (ii) making small cross-border connections to increase rates of electricity access; and (iii) promoting the harmonization of rules, regulations and codes to develop competitive energy markets.

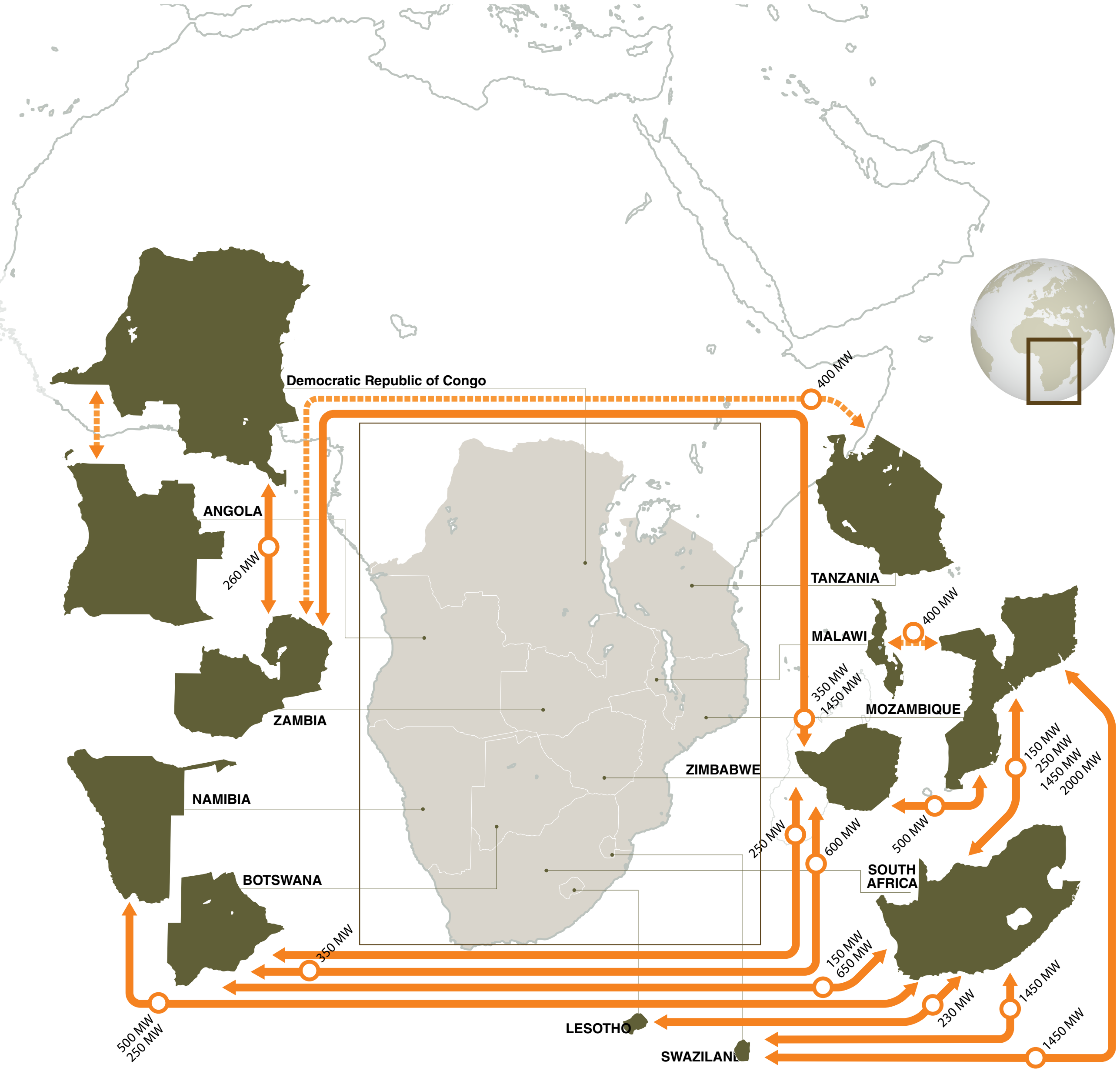


Figure 6 – Capacities of existing and future SAPP interconnections

Source: Elaborated by FIESP using data from SAPP 2011.

Maghreb Power Committee

COMELEC (Comité Maghrébin de l'Electricité)	
Countries: Morocco, Algeria, Tunisia, Libya and Mauritania	
Population (million inhabitants)	88
GDP (US$ billion)	380
Current access to electricity	95%
Future access to electricity (2040)	95%
Required investment in access to electricity (US$ billion)	----------
Projected rise in demand	7.1%
Total additional capacity required (GW)	551

The Maghreb Power Committee, known as Comelec, was established in 1992. Comelec's electricity integration initiatives mostly take the form of cooperation agreements between member countries to allow the use of each other's utility infrastructure.

Its members therefore also include the respective national utilities (Morocco's Office National d'Electricité, Societé Tunisienne de l'Electricité e du Gaz, Société Algérienne de l'Electricité et du Gaz, Société Mauritanienne de l'Electricité, and Société Générale de l'Electricité de Libye).

With the mission of integrating power supply to industries in Maghreb countries, Comelec performs the following functions: (i) overseeing the growth of grid interconnections; (ii) promoting a regular exchange of information; and (iii) coordinating human resources and professional training.

Cooperation in North Africa's electricity sector dates from construction of the Algeria-Tunisia interconnection between 1975 and 1980. By 1988 another interconnection was brought on stream between Algeria and Morocco.

Since 1996 the whole of Northern Africa has been connected to the European Union via Spain through two submarine lines with a total capacity of 1,400 MW. There are further plans to connect the Maghreb region with Europe via the Tunisia -Italy interconnection.

Figure 7 shows the existing and planned interconnections within the region, the years they came on stream, and the interconnections with Europe by voltage level.

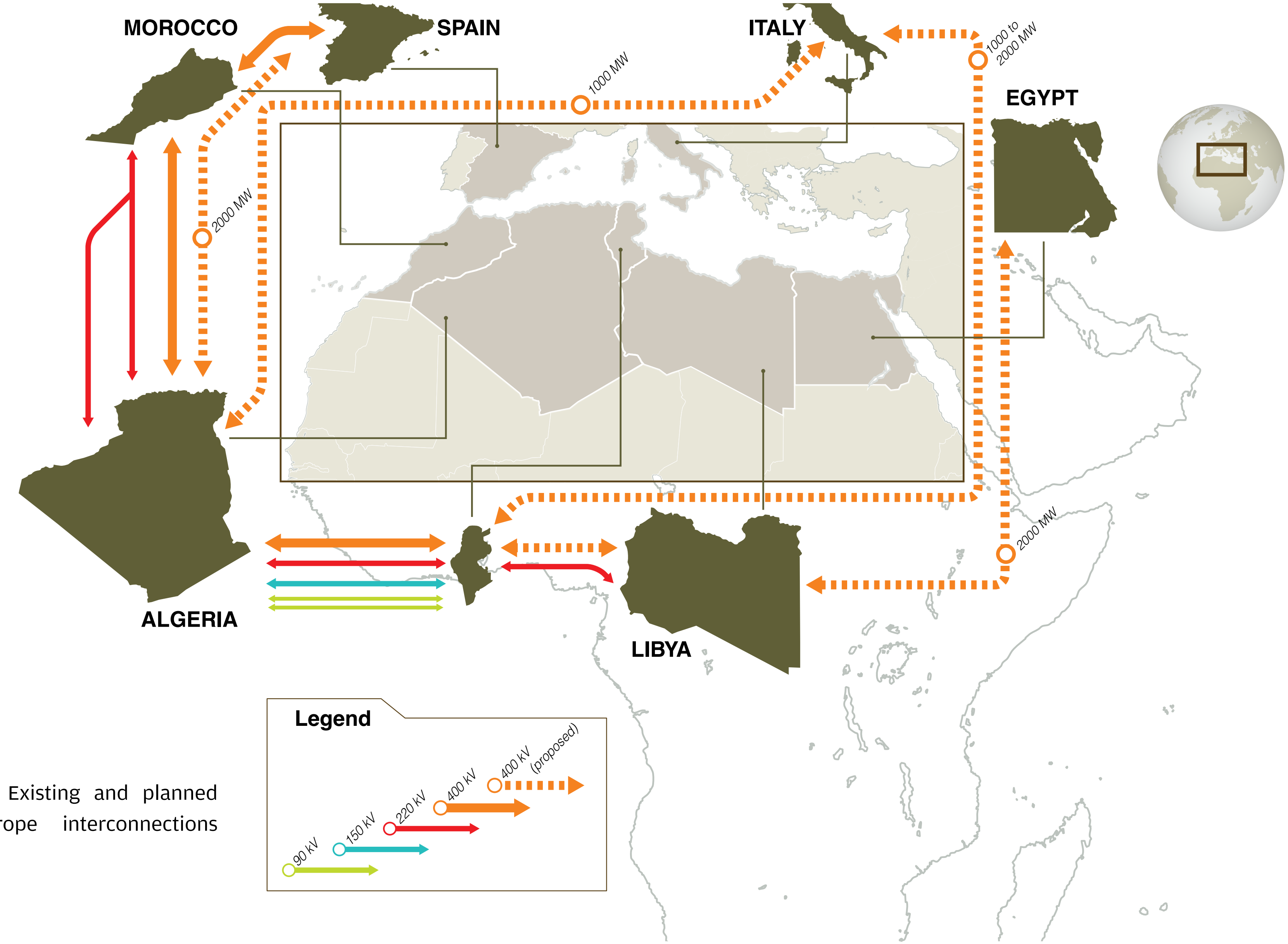


Figure 7 – Existing and planned Maghreb-Europe interconnections (2008 level)

Source: Elaborated by FIESP using data from Auptde 2011.

Project to Export Electricity to Europe

The existing transmission lines that link Northern Africa with Europe will also be used to transmit power from the Desertec Industrial Initiative (Dii), which is a consortium of European companies and the Desertec Foundation.

The Dii, proposed by the Desertec Foundation, is a large-scale project to generate electricity from solar and wind energy in Middle East and Northern Africa (MENA) and export it to Europe.

The proposal is to build solar and wind power plants in the Sahara Desert and transport the power to Europe through a super grid of high-voltage direct current cables.

It is estimated that the project will provide a considerable part of the electricity demand of the MENA countries as well as supplying 15% of the power required by continental Europe.

The Dii is researching the most suitable and viable technologies for solar generation, wind energy, and long-distance power transmission.

This includes, for example, concentrated solar power systems, photovoltaic technologies, direct and alternating current transmission, and different technologies for harnessing wind power. It also aims to facilitate and encourage investment, including the transfer of knowledge to the MENA region and the establishment of local industry.

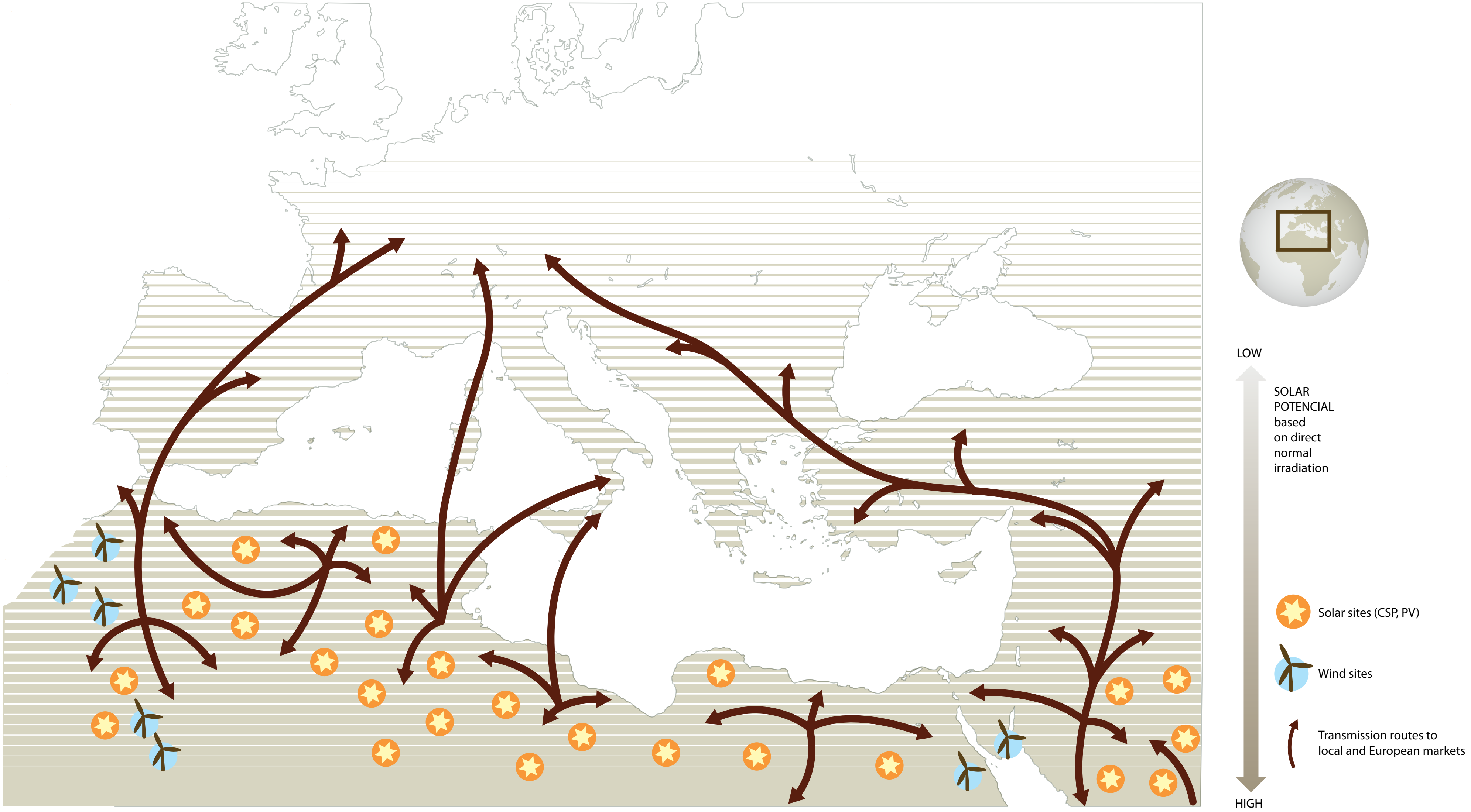
Project locations

Morocco is the first country to implement this project. Its grid is connected to Spain's and in 2010 the government set up the Morocco Solar Energy Agency (Masen) to develop a 2,000 MW solar energy program by 2020.

The Dii has also begun feasibility studies in **Tunisia**. Other reference projects will be defined by end-2012.

Figure 8 shows the solar irradiance in the MENA region, indicating the probable sites for the installation of solar and wind power plants as well as the transmission lines proposed by the Dii consortium.

Figure 8 – Proposed solar and wind power projects in the MENA region



Source: Elaborated by FIESP using data from Dii 2011.

Integration of Power Systems in Africa (UPDEA)

The Union of African Electricity Generators, Transporters & Distributors (UPDEA) was set up in 1970 to promote the development and integration of power systems throughout the continent via grid interconnections and exchanges of experience and know-how. UPDEA has 52 member companies representing 42 of the 54 countries in Africa. Since each sub-region of Africa has its own interconnected grid, UPDEA's role is limited to harmonizing master plans and exchange data and experience. The ultimate goal is continental integration to enable loads to flow freely between all regions.

According to UPDEA, the main strategy for developing the power sector in Africa is to tap into its immense hydropower potential and organize wheeling circuits within and between regions. **Figure 9** shows the main centres of power integration which will be based on major hydropower development, involving all the regional power systems.

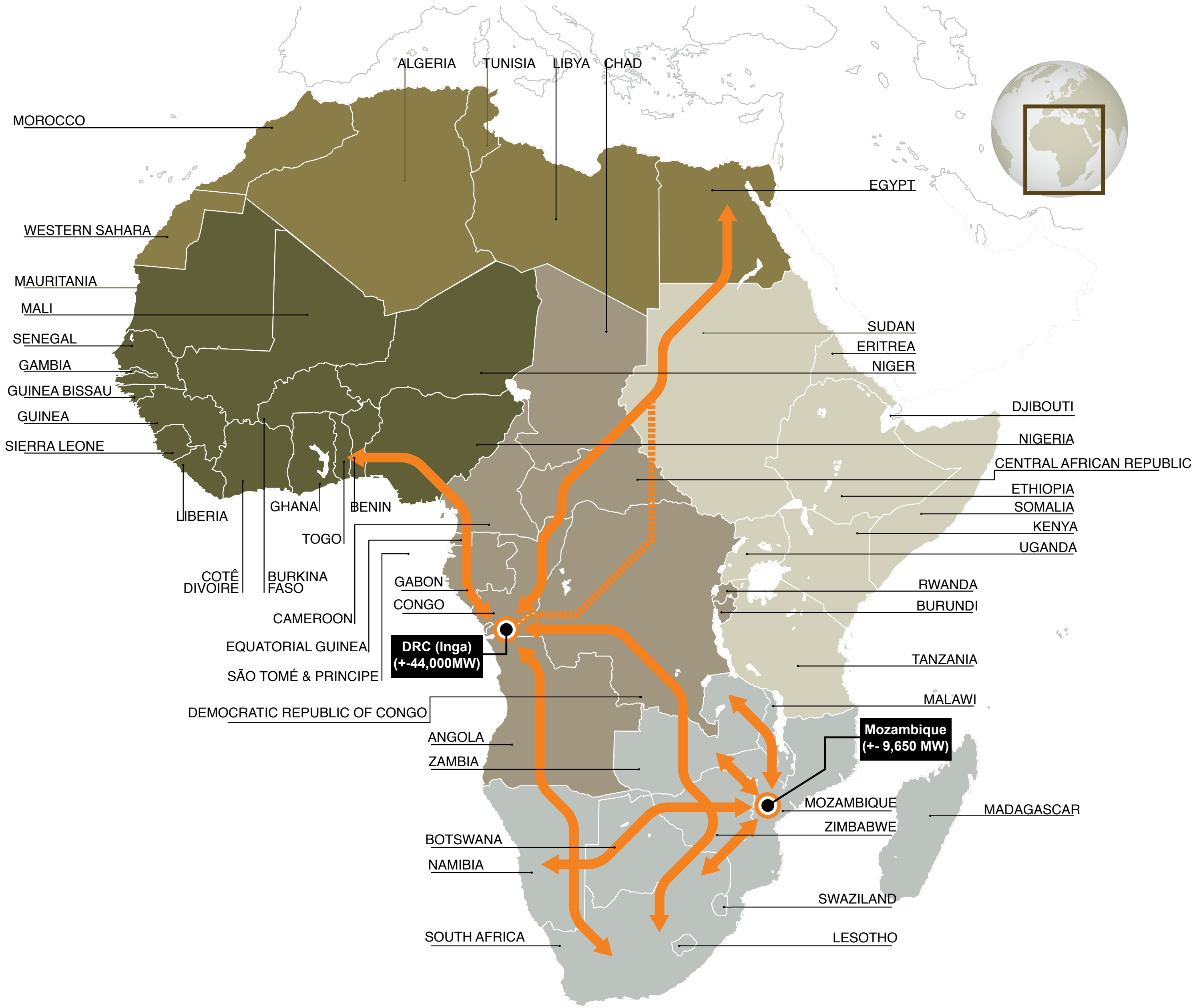


Figure 9 – UPDEA Map

Source: Elaborated by FIESP using data from UPDEA 2008.

Bibliography

Prologue

1. African Development Bank – AfDB Website (2011): Data Portal - http://dataportal.afdb.org/Default.aspx
2. The World Health Organization - WHO and United Nation Environment Programme – UNEP (2009): The Energy Access Situation in Developing Countries. a review focusing on the least developed countries and Sub-Saharan Africa.
3. The United Nations Department of Economic and Social Affairs - UN-DESA, United Nation Environment Programme – UNEP and UN Conference on Trade and Development (2011): The Transition to a Green Economy: Benefits, Challenges and Risks from a Sustainable Development Perspective. http://www.uncsd2012.org/rio20/content/documents/Transition%20to%20a%20Green%20Economy_summary.pdf
4. ENERGIA - International Network on Gender and Sustainable Energy (2005): Energy as a Key Variable in Eradicating Extreme Poverty and Hunger: a gender and energy perspective on empirical evidence on MDG #1.
5. Balmer, M (2007): Energy Poverty and Cooking Energy Requirements: the forgotten issue in South African energy policy? Journal of Energy in Southern Africa, August 2007. http://www.erc.uct.ac.za/jesa/volume18/18-3jesa-balmer.pdf
6. United Nations Development Programme – UNDP Website (2011): International Human Development Indicators (2011). http://hdr.undp.org/en/statistics/
7. Francisco L. S. Gomide (2004): Hydropower Development in Brazil: experiences and perspectives. Presented at the United Nations Symposium on Hydropower and Sustainable Development, October 2004. http://www.un.org/esa/sustdev/sdissues/energy/op/hydro_gomide_brazil.pdf
8. United Nations Human Settlements Programme (2011): Infrastructure for Economic Development and Poverty Reduction in Africa.
9. United Nations Conference on Sustainable Development - UNCSD Secretariat and United Nations Conference on Trade and Development - UNCTAD (2011): RIO+20 Issues Briefs - Trade and Green Economy.
10. UN Secretary-General's Advisory Group on Energy and Climate Change – AGECC (2010): Energy for a Sustainable Future.
11. O Programa das Nações Unidas para o Meio Ambiente - PNUMA (2011): Rumo a uma Economia Verde: Caminhos para o Desenvolvimento Sustentável e a Erradicação da Pobreza
12. African Union (2010): Maputo Declaration. African Union Conference of Ministries in Charge of Energy.
13. Ministério das Relações Exteriores (2011): Discurso proferido pelo Ministro Antônio de Aguiar Patriota Durante Solenidade em Comemoração do Dia da África.
14. Deutsche Gesellschaft für Technische Zusammenarbeit – GTZ and African Development Bank – AfDB (2011): Fueling our Strategy Right – report on bio-energy consultative meeting.
15. Standard Bank (2011): Economic Strategy - BRIC dominant in Angola's economic awakening.
16. Standard Bank (2010): Economics – placing the BRIC and Africa commercial partnership in a global perspective.
17. African Development Bank – AfDB (2010): Financing of Sustainable Energy Solutions – Committee of Ten Policy Brief.

18. United Nations Environment Programme – UNEP (2011): Towards a Green Economy – pathways to sustainable development and poverty eradications.
19. Celso Amorim (2010): Brazilian Foreign Policy under President Lula (2003-2010): an overview
20. Organization for Economic Co-Operation and Development – OECD and International Energy Agency – IEA (2010): Low-Emissions Development Strategies (LEDS): technical, institutional and policy lessons.
21. The African Development Bank Group Chief Economist Complex (2011): Africa Economic Brief - Brazil's economic engagement with Africa.
22. The World Bank (2009): Africa Energy Poverty – G8 Energy Ministers Meeting 2009.
23. African Development Bank – AfDB (2008): Proposals for a Clean Energy Investment Framework for Africa – role of the African Development Bank Group.
24. The New Partnership for Africa's Development (NEPAD), African Union and the African Development Bank – AfDB (2010): Study on Programme for Infrastructure Development in Africa (PIDA) – Phase I report energy sector.

Overview of Energy Sources

25. AECOM International Development (2009): Technical Report - National Energy Policy For Botswana.
26. U.S. Energy Information Administration – EIA Website (2011): International Country Energy Profiles - http://www.eia.gov/countries/
27. The Programme for Basic Energy and Conservation – ProBEC (2011): Basic energy facts Botswana - http://www.probec.org/displaysection.php?czacc=&zSelectedSectionID=sec1193009236
28. Cameroonenergy.com (2011): www.cameroonenergy.com
29. Encyclopaedia of Earth (2011): Country Energy Profiles of Congo-Brazzaville - http://www.eoearth.org/article/Energy_profile_of_Congo-Brazzaville
30. Encyclopaedia of Earth (2011): Energy profile of Congo-Brazzaville -http://www.eoearth.org/article/Energy_profile_of_Cote_d'Ivoire
31. Encyclopaedia of Earth (2011): Energy profile of Eritrea - http://www.eoearth.org/article/Energy_profile_of_Eritrea
32. Encyclopaedia of Earth (2011): Energy profile of Gabon - http://www.eoearth.org/article/Energy_profile_of_Gabon
33. The Programme for Basic Energy and Conservation – ProBEC (2011): Mozambique "Progress 2009" - http://www.probec.org/displaysection.php?czacc=&zSelectedSectionID=sec1193009236
34. Encyclopaedia of Earth (2011): Energy profile of Tunisia - http://www.eoearth.org/article/Energy_profile_of_Tunisia
35. Lazarus Gatawa and Paul Mushamba (2000): Report on Baseline Survey of Villages 28, 41 & 68, of Hurungwe District. Social Forestry Program - SFP in Co-operation with the Programme for Biomass Energy Conservation in Southern Africa - ProBEC.
36. Climate Investment Fund -CIF (2011): Country Sheets - Program on Scaling-Up Renewable Energy in Low Income Countries – SREP.
37. 37. Felix Njini (2010): SADC in Bid to Revive Westcor. The Southern Times - http://www.southerntimesafrica.com/article.php?title=SADC_in_bid_to_revive_

Westcor&id=5018
38. Alexander Richter (2009): Kenya to Offer Geothermal Drilling Incentive to Drive Development. Think Geoenergy - http://thinkgeoenergy.com/archives/3117
39. Zambia Rural Electrification Authority – REA (2011): http://www.rea.org.zm/
40. CTF Trust Fund Committee (2009): Clean Technology Fund Investment Plan for Morocco - http://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/morocco_ctf_investment_plan_kd_101309.pdf

Renewable Energy

41. African Development Bank – AfDB Website (2011): Data Portal - http://dataportal.afdb.org/Default.aspx
42. Anthony M Makwiramiti (2011): Oil Price Volatility and Economic Development in Africa. Consultancy Africa Intelligence, 2011.
43. African Development Bank – African Development Fund (2008). Clean Energy Investment Framework for Africa – role of the African Development Bank Group.
44. Central Intelligence Agency – CIA Website (2011): The World Factbook. Electricity Consumption Data - https://www.cia.gov/library/publications/the-world-factbook/index.html
45. Commission of the European Communities (2008): Energy Sources, Production Costs and Performance of Technologies for Power Generation, Heating and Transport.
46. Deutsche Gesellschaft für Technische Zusammenarbeit – GTZ (2009): Regional Reports on Renewable Energies - 30 Country Analyses on Potentials and Markets in West Africa, East Africa and Central Asia.
47. Deutsche Gesellschaft für Technische Zusammenarbeit – GTZ (2010): Policy and Regulatory Framework Conditions for Small Hydropower in Sub-Saharan Africa.
48. Eritrea Ministry of Energy and Mines - Department of Mines (2005): Geothermal Exploration Opportunities in Eritrea. Proceedings World Geothermal Congress 2005, April 24-29, 2005.
49. Franz Trieb, Hans Müller-Steinhagen, Jürgen Kern (2010). Financing Concentrating Solar Power in the Middle East and North Africa – subsidy or investment? Energy Policy 2010.
50. GeoSteam Services Ltd. (2010): The African Rift Geothermal Facility (Argeo) Status
51. Global Wind Energy Council – GWEC (2011): Global Wind Report - Annual Market Update 2010.
52. Greenpeace International, IEA Solar PACES and ESTELA (2009): Concentrating Solar Power - Outlook 2009.
53. International Energy Agency – IEA (2010): Technology Roadmap - Solar Photovoltaic Energy.
54. International Energy Agency – IEA Website (2011): By Country Analysis - http://www.iea.org/country/index_nmc.asp
55. International Energy Agency – IEA (2010): Renewable Energy Essentials - Hydropower.
56. International Energy Agency – IEA (2010): Technology Roadmap - Concentrated Solar Power.
57. International Sugar Organization (2009): Cogeneration - Opportunities in the World

Sugar Industries.
58. Intpow (2009): World Hydro Potential and Development.
59. Kenya Electricity Generating Company Ltd. (2005): The Geology and Geothermal Activity of the East African Rift System. Paper presented at the Workshop for Decision Makers on Geothermal Projects and Management, organized by UNU-GTP and KengGen, November 14-18, 2005.
60. Mauritius Sugar Authority (2005): Sugar Cane Bagasse Energy Cogeneration – Lessons from Mauritius. Paper Presented to the Parliamentarian Forum on Energy Legislation and Sustainable Development, October 5-7, 2005.
61. REEGLE Website (2011): Clean Energy Portal, Country Profiles - http://www.reegle.info/countries
62. The Infrastructure Consortium for Africa – ICA (2008): Power Supply Situation in Africa. Background paper prepared for the ICA Annual Meeting, March 13-14, 2008.
63. The World Bank Global Environment Facility Program – GEF (2006): Assessment of the World Bank/GEF Strategy for the Market Development of Concentrating Solar Thermal Power.
64. U.S. Energy Information Administration – EIA Website (2011): International Country Energy Profiles - http://www.eia.gov/countries/
65. United Nations Statistics Division Website (2011): UN data Explorer. Energy Statistic Database (UNSD) - http://data.un.org/Explorer.aspx?d=EDATA
66. U.S. Department of Energy's National Renewable Energy Laboratory – NREL (2008): Technical Potential of Solar Energy to Address Energy Poverty and Avoid GHG Emissions in Africa. Presented at the International Congress on Renewable Energy (ICORE), October 16–17, 2008.
67. U.S. Department of Energy, Energy Efficiency and Renewable Energy (2010): Life-Cycle Analysis of Geothermal Technologies.
68. The World Energy Council – WEC (2010): 2010 Survey of Energy Resources.
69. The World Health Organization - WHO and United Nation Environment Programme – UNEP (2009): The Energy Access Situation in Developing Countries. A Review Focusing on the Least Developed Countries and Sub-Saharan Africa.
70. Zambian Rural Electrification Authority – REA (2011): Rural Electrification Master Plan (REMP) - http://www.rea.org.zm/index.php?option=com_content&view=article&id=57&Itemid=50

Biofuels

71. Food and Agriculture Organization of the United Nations (2010): Bioenergy and Food Security - the Bioenergy and Food Security Project (BEFS) Analytical Framework.
72. Ministério das Relações Exteriores do Brasil (2011).
73. Brazilian Ministry of Foreign Affairs (2007): Biofuels in Brazil, realities and prospects.

Power Integration

74. AfDB (2011): Programme for Infrastructure Development in Africa http://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/programme-for-infrastructure-development-in-africa-pida/
75. African Energy (2011): http://www.africa-energy.com/
76. Arab Union of Electricity (2011): AUPTDE Publication data - www.auptde.org
77. Desertec Foundation (2011): www.desertec.org
78. Desertec Industrial Initiative – DII (2011): www.dii-eumena.com
79. Economic Consulting Associates - ECA (2009): South African Power Pool (SAPP) Transmission & Trading Case Study.
80. Eskom (2009): Annual Report 2009.
81. Government of Mozambique (2011): Information on Mphanda Kawanda (2010) - http://www.portaldogoverno.gov.mz/
82. Hydroworld.com (2011): http://www.hydroworld.com/
83. Kwame Nkrumah University of Science and Technology: www.knust.edu.gh/
84. Power Pool Development Group and Purdue University (2005): The Future of SAPP, WAPP, CAPP, and EAPP - With Inga.
85. Southern African Power Pool – SAPP (2011): www.sapp.co.zw
86. The Corporate Council on Africa (2011): http://www.africacncl.org/
87. The Eastern Africa Power Pool – EAPP (2011): Presentation to Hydropower for Sustainable Development Conference Addis Ababa, Ethiopia.
88. The Eastern Africa Power Pool – EAPP (2011): www.eappool.org
89. The Infrastructure Consortium for Africa – ICA (2011): www.icafrica.org
90. UN Economic Commission for Africa (2005): The Challenges of Operationalizing Power Pools in Africa.
91. Union of Producers, Transporters and Distributors of Electric Power in Africa (2011): www.updea-africa.org
92. West African Power Pool – WAPP (201): www.ecowapp.org
93. Desertec Website (2011): http://www.desertec.org/en/global-mission/milestones/
94. Desertec Industrial Initiative – Dii Website (2011): www.dii-eumena.com
95. The West Africa Power Pool (WAPP) Organization (2006): Business Plan for the WAPP Organization.
96. The Western Africa Power Pool Project - ECOWAS: the Nigeria – Benin – Togo-Ghana Interconnection Project
97. Economic Consulting Associates (2009): The Potential of Regional Power Sector Integration – South African Power Pool (SAPP) Transmission and Trading Case Study.
98. UN Economic Commission for Africa (2005): The Challenge of Operationalizing Power Pools in Africa.
99. SNC-Lavalin (2011): EAPP/EAC Regional PSMP and Grid Code Study.

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