Groupe
Génie des Matériaux pour l'Energie, l'Electronique et la Construction
(**GMEEC**)
Responsable: Pr Diouma Kobor

African Energy Access and Development: Situation and Research State of the Art

Summary

Context

- ➢ Statistics in African Energy Sector
- ➢ African Research and Innovation Contribution in Energy Area
- ➢ Conclusion and Recommendations

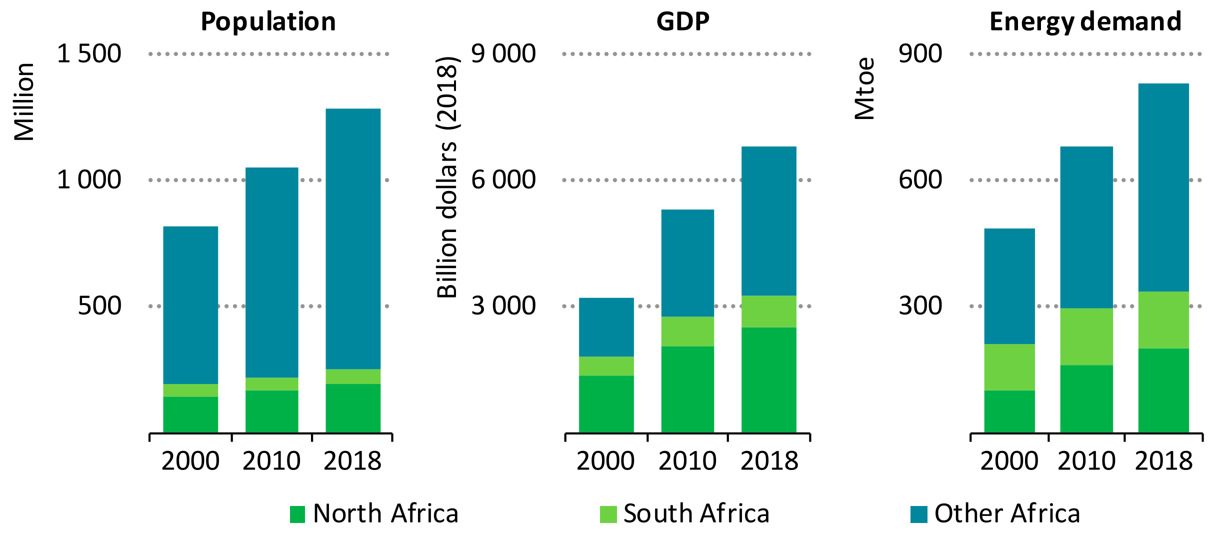
Context

Cooking System Evolution vs Time in African rural area

- How to moderate and increase energy efficiency in cooking
- Need Energy for cooling buildings due to non appropriate materials selection

Context

Figure 1.1 ▹ Selected indicators for Africa, 2000, 2010, 2018



Africa's urban population is expanding fast while energy services and GDP struggle to keep pace

Note: GDP = Gross domestic product in PPP terms, $2018.

Table I.2 ▹ Population assumptions

	Total population (million)		**2018-2040**	
	2018	**2040**	**Delta** (million)	**CAAGR***
North Africa	196	263	67	1.3%
South Africa	57	71	14	1.0%
Other sub-Saharan Africa	1 034	1 761	728	2.5%
Nigeria	196	329	133	2.4%
Ethiopia	108	173	65	2.2%
DR Congo	84	156	72	2.8%
Tanzania	59	108	49	2.8%
Kenya	51	79	28	2.0%
Angola	31	60	29	3.1%
Mozambique	31	55	24	2.7%
Ghana	29	44	15	1.9%
Côte d'Ivoire	25	42	17	2.4%
Senegal	16	28	12	2.5%
Africa	**1 287**	**2 095**	**808**	**2.2%**

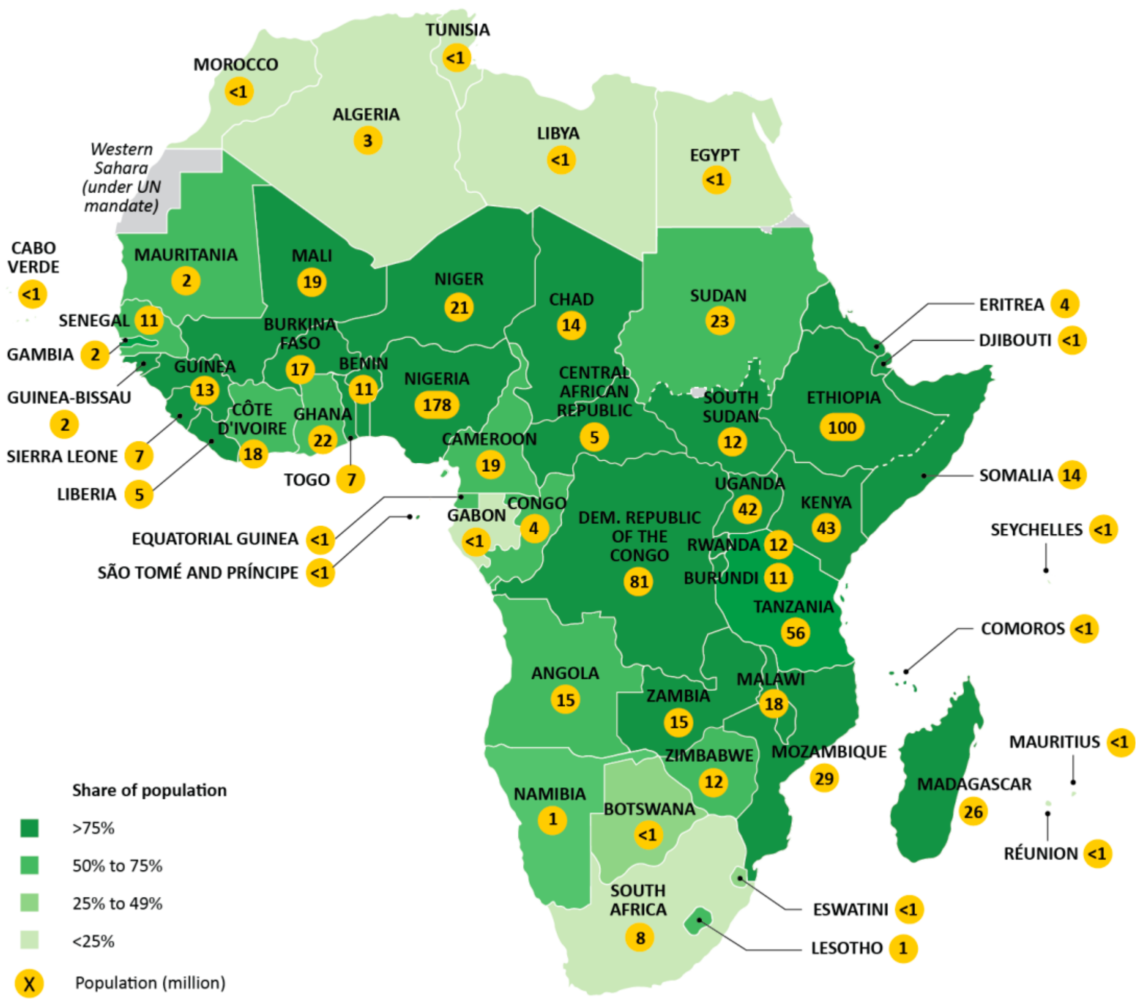
* CAAGR = compound average annual growth rate.

Source: IEA, Africa energy outlook, Report 2019

Statistics in African Energy Sector: Energy Access

Statistics in African Energy Sector: Energy Access

Figure 1.7 ▹ **Population without access to clean cooking in Africa, 2018**

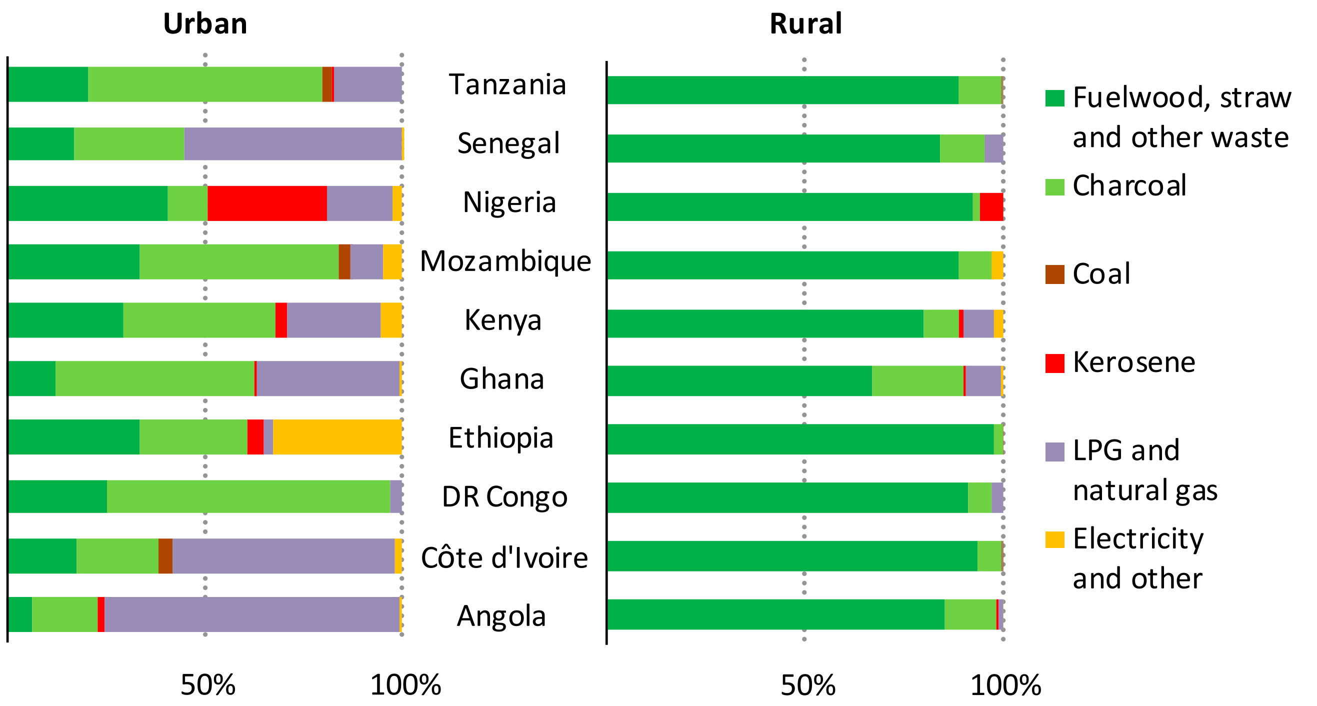


Around 900 million people are without access to clean cooking in Africa; in 32 countries more than 75% of the population is without access to clean cooking

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Sources: IEA analysis; World Health Organization (WHO) Household Energy Database.

Figure 1.8 ▹ **Main fuels used by households for cooking, 2018**

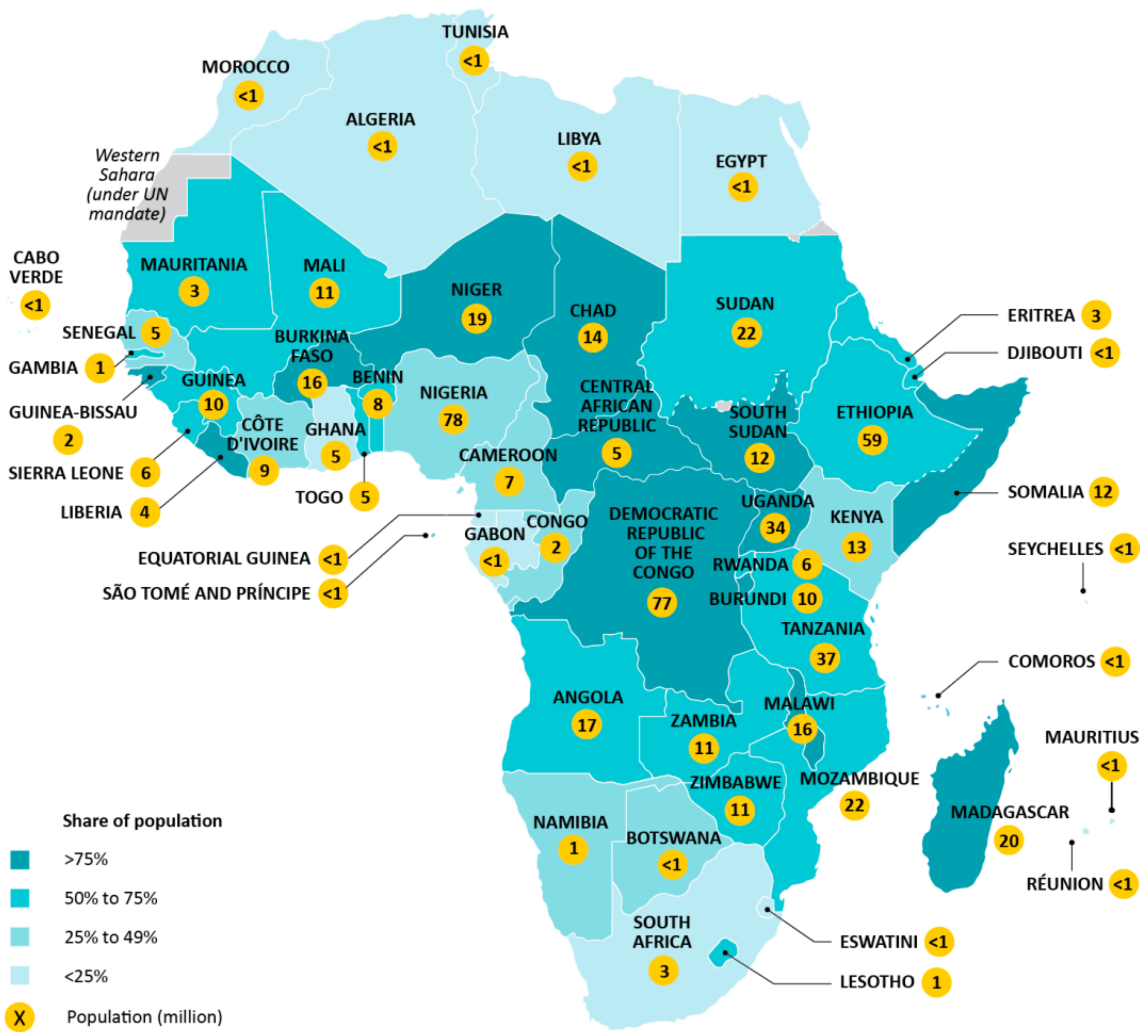


Use of clean cooking fuels such as LPG continues to increase in urban areas, but reliance on traditional use of biomass still dominates in rural areas

Sources: IEA analysis; WHO Household Energy Database.

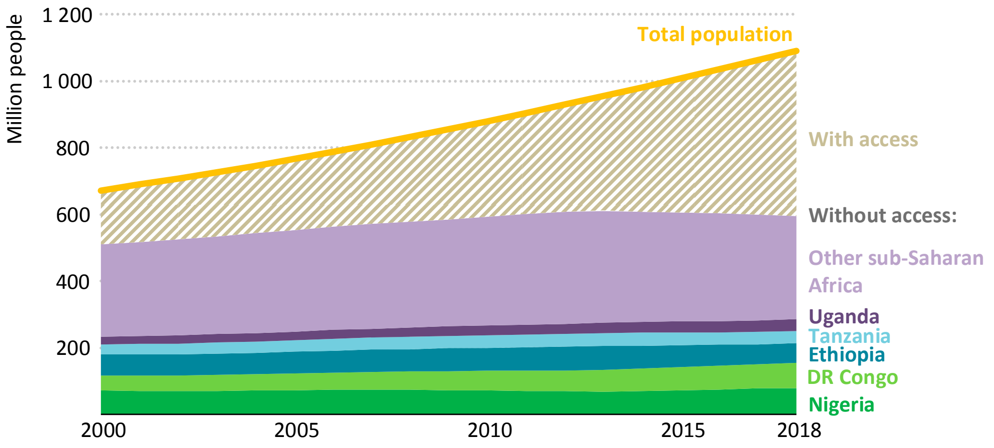
Statistics in African Energy Sector: Energy Access

Figure 1.10 ▷ Population without access to electricity by country in Africa, 2018



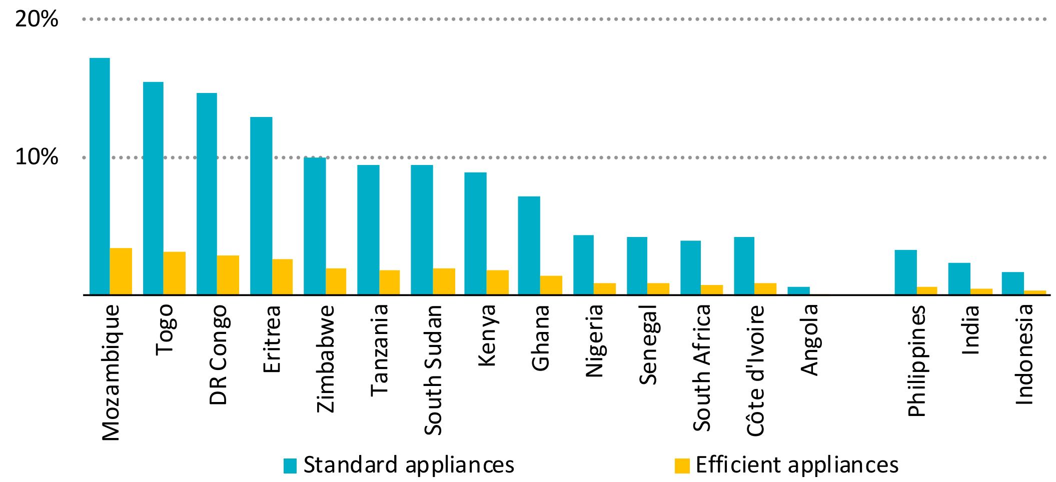
In sub-Saharan Africa 55% of people lack access to electricity; in thirteen countries, more than three-quarters of the population do not have access to electricity

Figure 1.9 ▷ Electricity access by country in sub-Saharan Africa, 2000-2018



Population without electricity access has plateaued since 2013 thanks to the acceleration of connections; almost 50% of those without access live in five countries

Figure 1.12 ▷ Electricity expenses required to power basic appliances as a percentage of household revenues for the poorest 40%

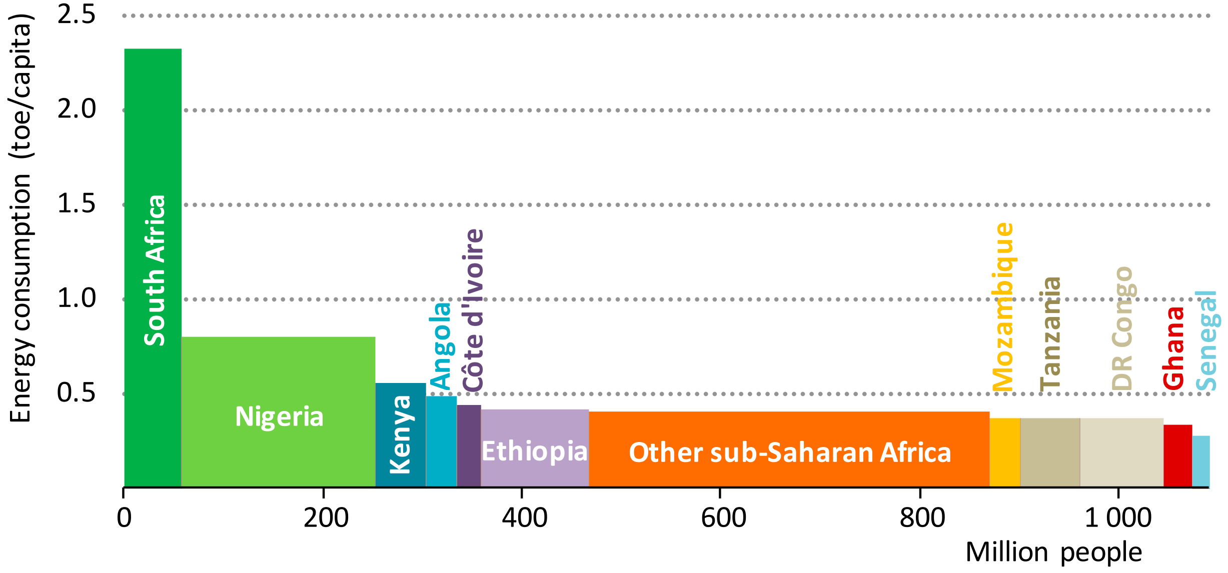


Affordability of electricity remains an issue for many people in African countries. Efficient appliances can help keep costs down

Source: IEA, Africa energy outlook, Report 2019

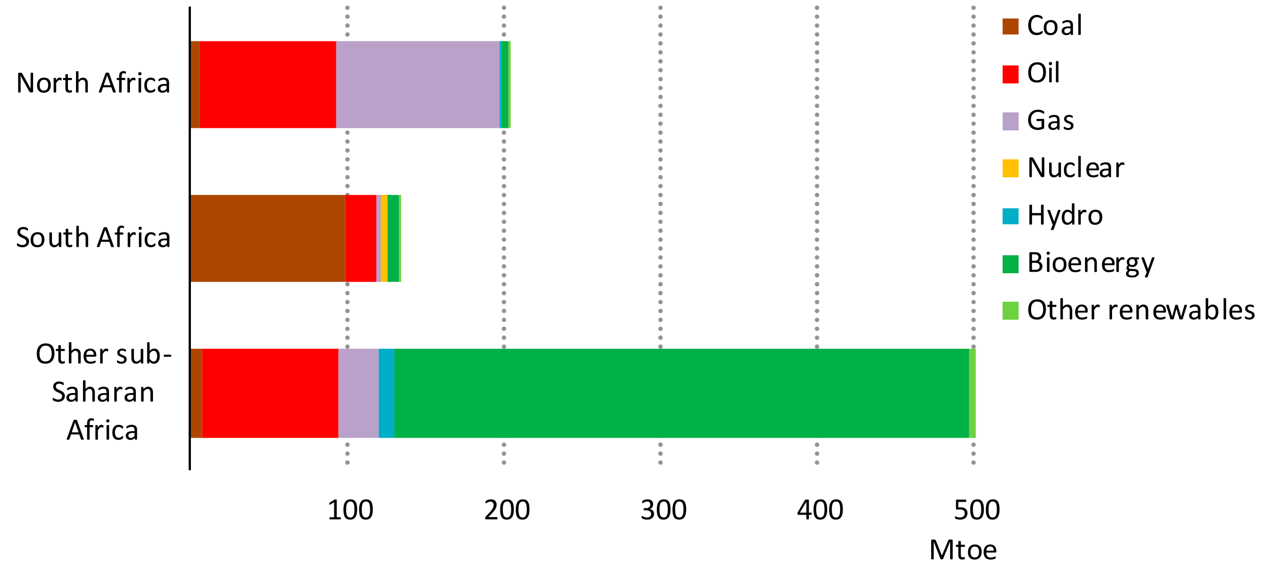
Statistics in African Energy Sector: Energy Consumption

Figure 1.14 ▹ Energy consumption per capita and population in selected sub-Saharan African countries, 2018



Excluding South Africa, per capita consumption in sub-Saharan Africa is 65% below the average for developing economies

Figure 1.16 ▹ Total primary energy demand by fuel for selected African regions, 2018

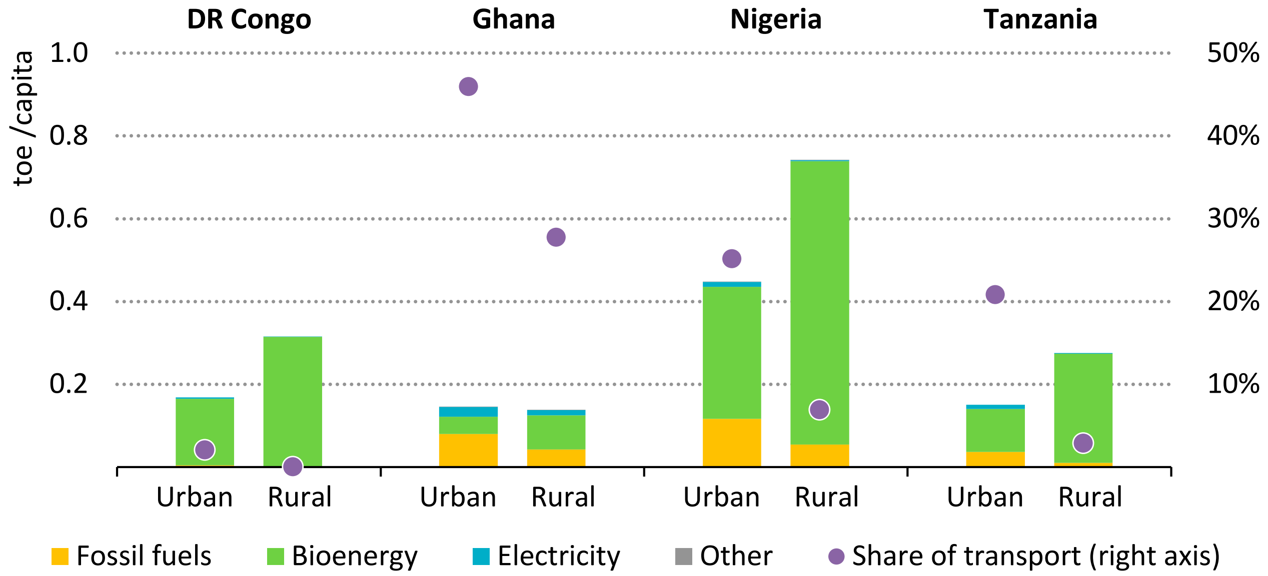


With the exception of South Africa, the sub-Saharan Africa energy mix is dominated by solid biomass and oil

Source: IEA, Africa energy outlook, Report 2019

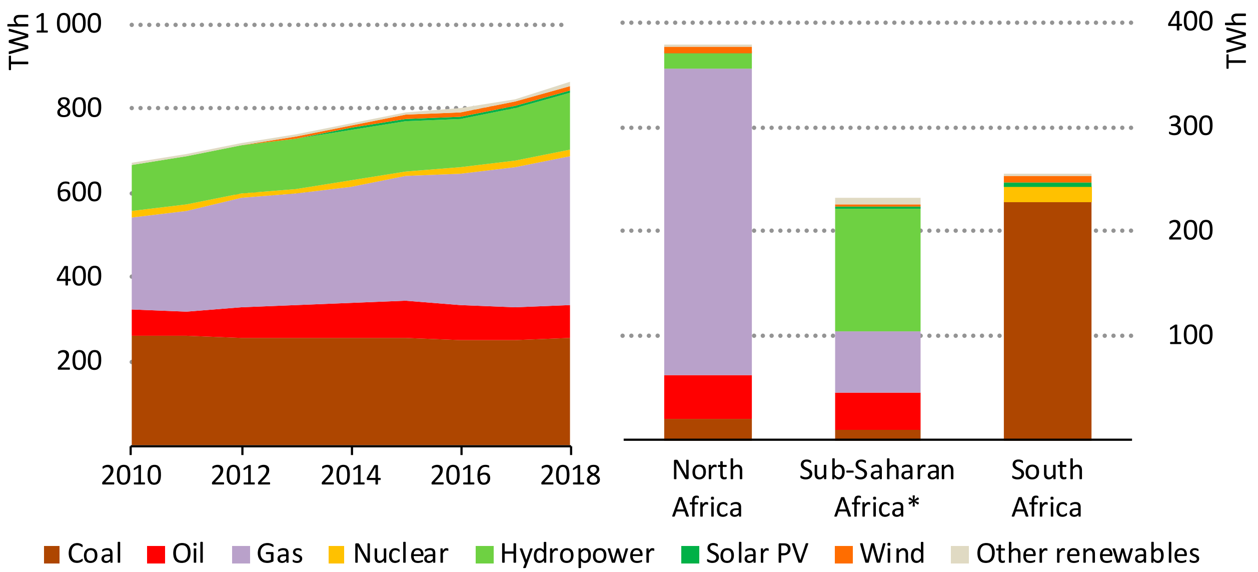
Statistics in African Energy Sector: Energy Consumption

Figure 1.17 ▷ Urban and rural household energy consumption per capita and by fuel for selected African countries, 2018



Average household energy consumption varies between urban and rural and across countries, as does the fuel mix, though generally with a high share of bioenergy

Figure 1.19 ▷ Electricity generation by fuel in Africa, 2010-2018 (left) **and in key regions in 2018** (right)

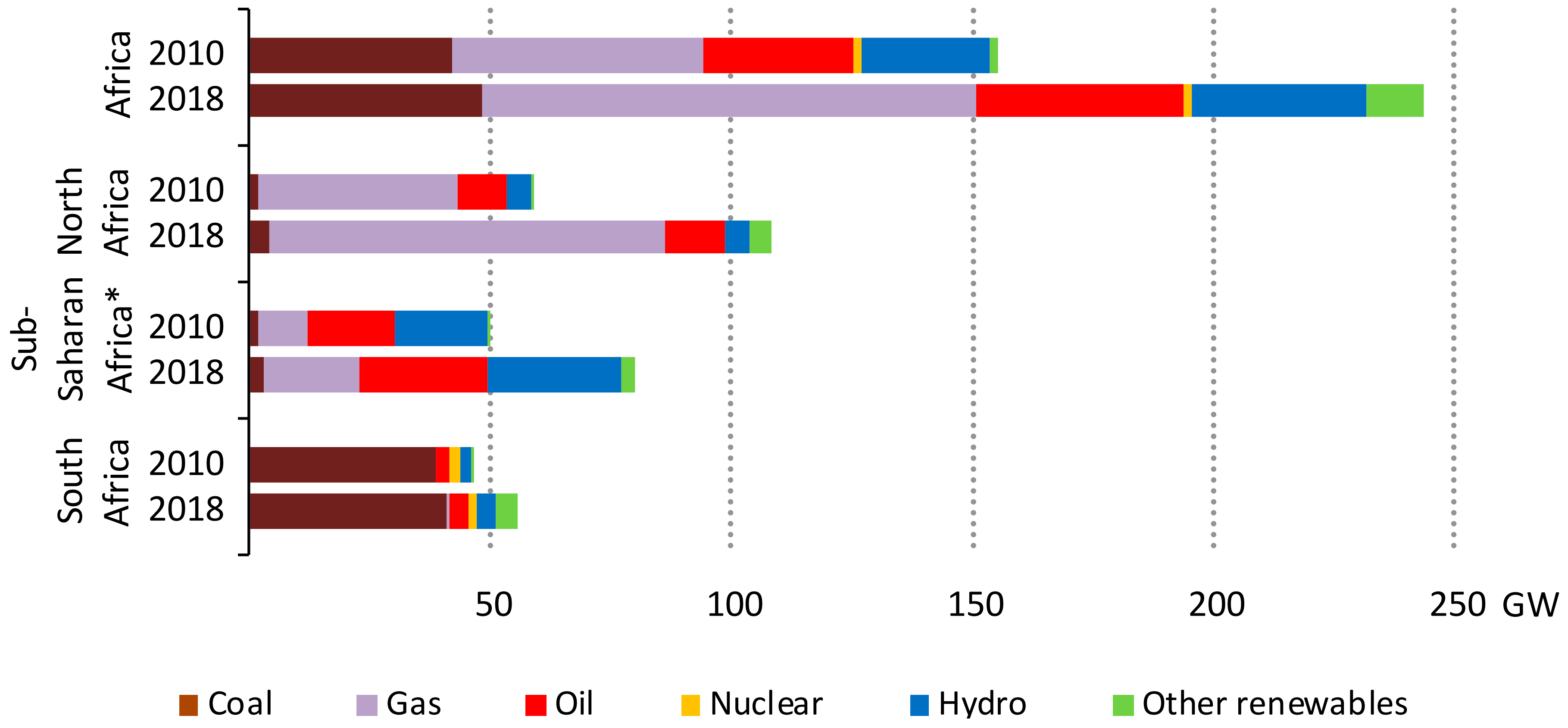


Natural gas fuelled most of the increase in electricity supply for the continent on the whole, but fuel shares varied by region and coal dominated in South Africa

Source: IEA, Africa energy outlook, Report 2019

Statistics in African Energy Sector: Installed Capacity and trade

Figure 1.20 ▷ Installed power capacity by fuel in selected regions/countries

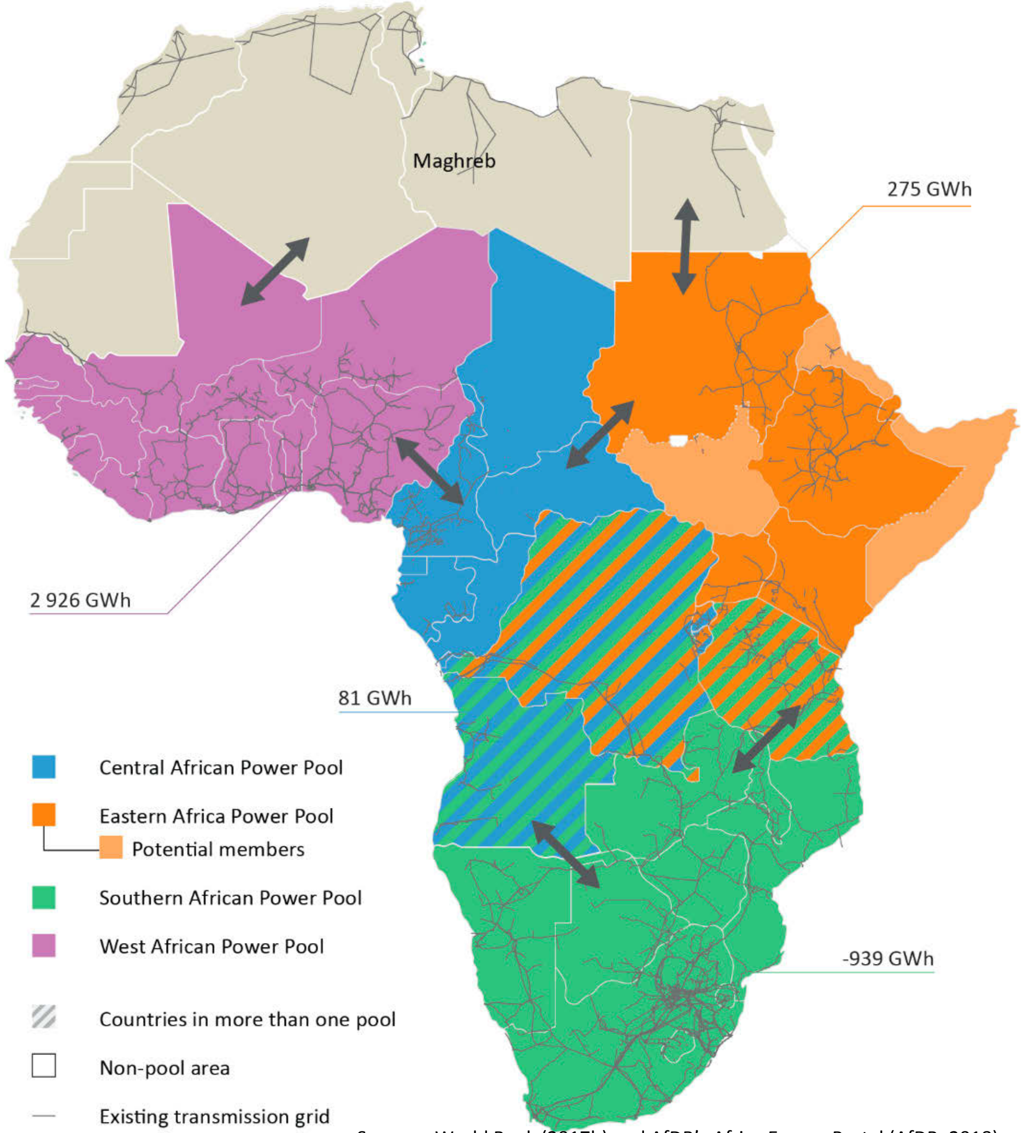


Fossil fuels dominate the power mix but the role of non-hydro renewables is increasing

Source: IEA, Africa energy outlook, Report 2019

Statistics in African Energy Sector: Installed Capacity and trade

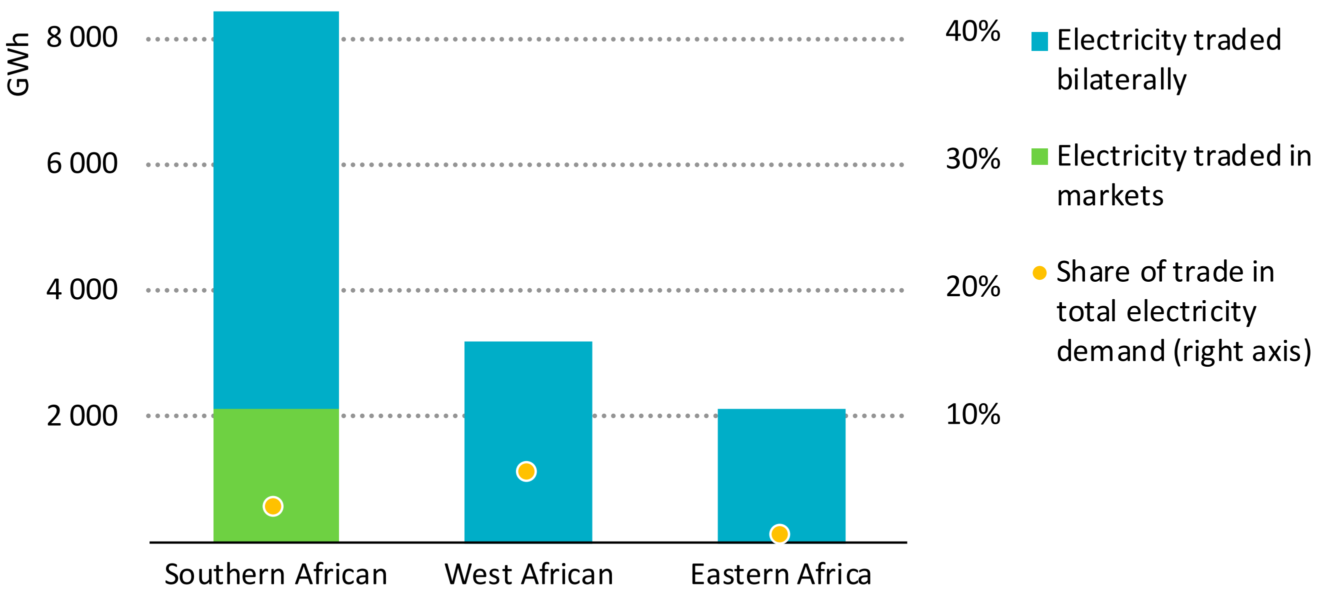
Figure 1.21 ▹ **Electricity trade between power pools in sub-Saharan Africa, 2018**



Sources: World Bank (2017b) and AfDB's Africa Energy Portal (AfDB, 2018).

Regional power pools help to connect power generation sources across Africa

Figure 1.22 ▹ **Power traded bilaterally and through competitive markets in the Southern African, West African and Eastern Africa power pools**



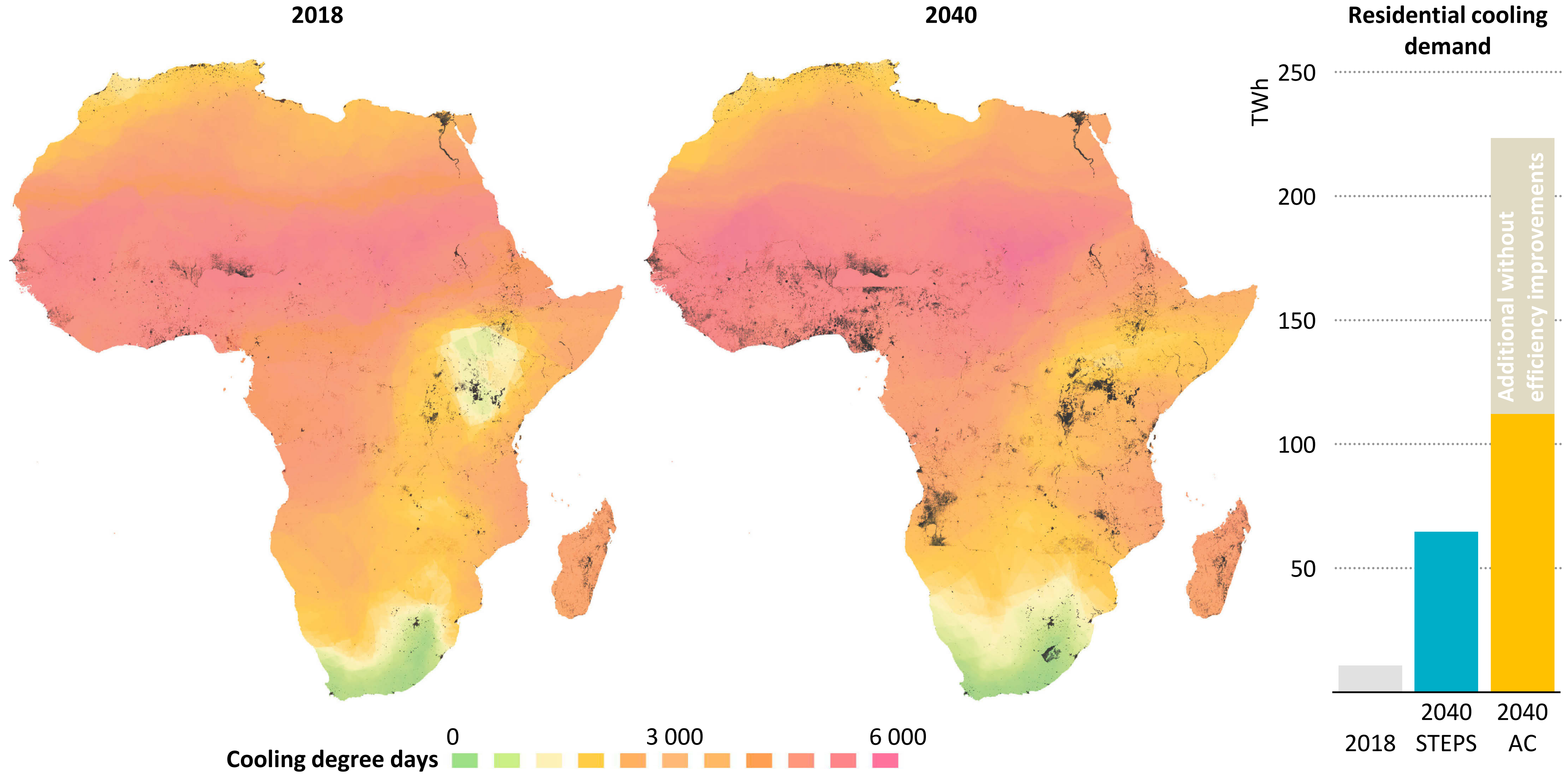
Power trade is low across the power pools and, except for the Southern African Power Pool, only bilateral trade

Trade across the region remains low and is mostly realised through bilateral contracts. At present, in sub-Saharan Africa only SAPP has a functioning market. Some countries remain isolated from regional grids. Even where transmission interconnections exist, these are sometimes congested and need to be upgraded to facilitate trading.

Around 1.8 TWh of electricity were matched in the competitive markets in SAPP in 2016/17, but were not traded because of transmission constraints

Statistics in African Energy Sector: Energy Demand for Cooling

Figure 2.7 ▷ Cooling degree days in the Stated Policies Scenario and cooling electricity demand, 2018 and 2040



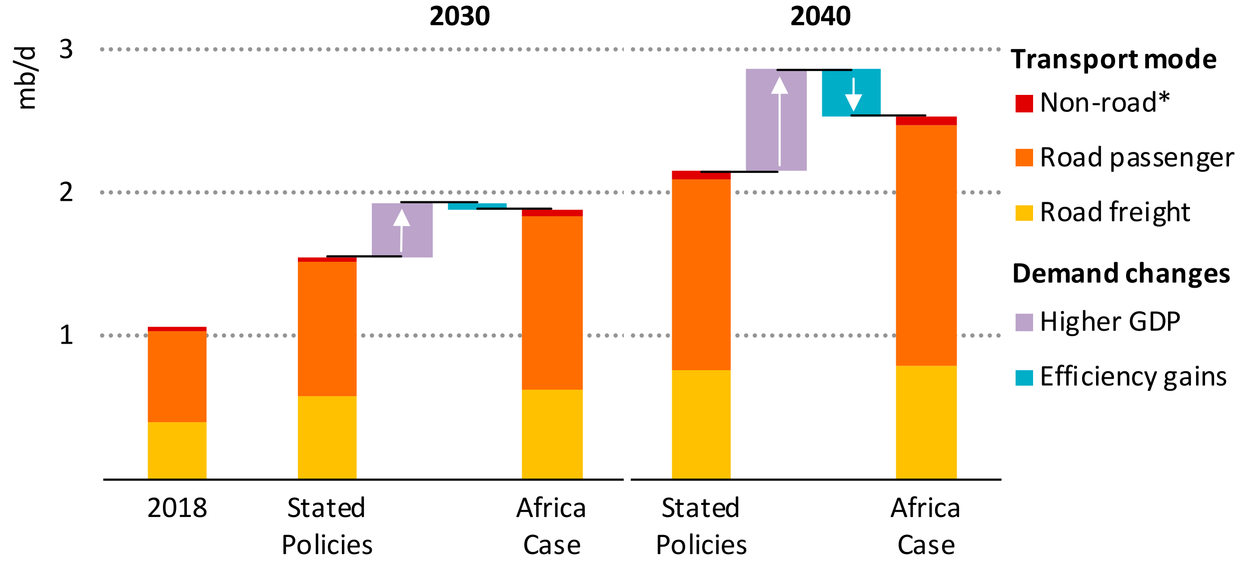
Urban migration alongside a big increase in the number of hot days in Africa's cities will drive major growth in demand for cooling needs

Source: IEA, Africa energy outlook, Report 2019

Roughly 680 million people in Africa (more than half of the population) currently live in areas that may need cooling systems

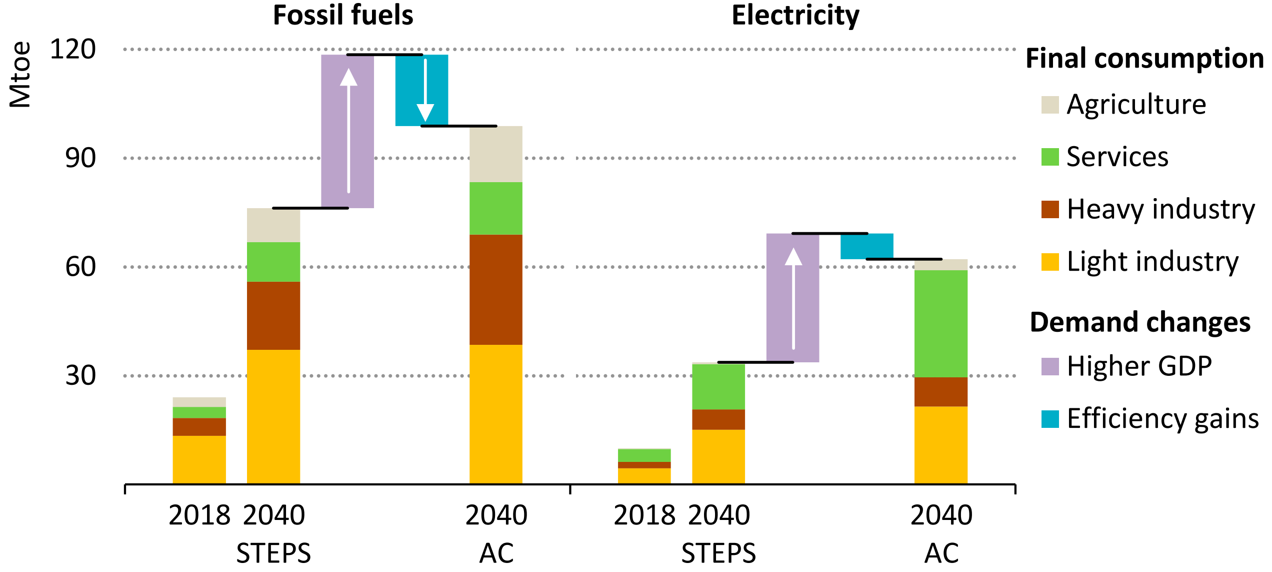
Statistics in African Energy Sector: Energy Demand for Transport

Figure 2.10 ▹ Oil demand for transport in sub-Saharan Africa (excluding South Africa) **in the Stated Policies Scenario and Africa Case**



Introduction of fuel economy standards could avoid 0.32 mb/d of oil demand growth driven by the fleet expansion

Figure 2.12 ▹ Final consumption in productive uses in sub-Saharan Africa (excluding South Africa) **by scenario**

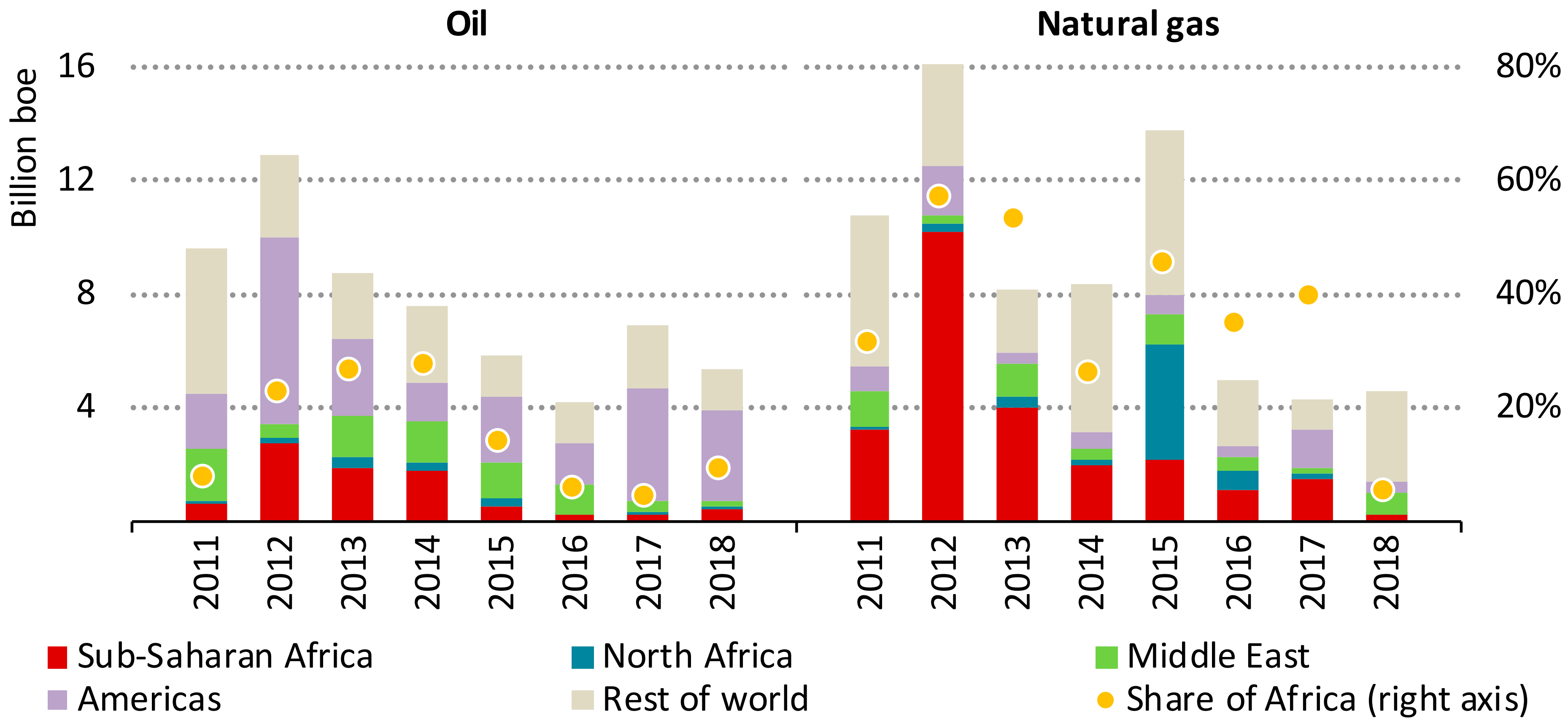


Energy efficiency standards and material efficiency temper oil and gas demand growth by around 25% and electricity by 15% for productive uses

Source: IEA, Africa energy outlook, Report 2019

Statistics in African Energy Sector: Energy Potential in Oil

Figure 1.27 ▹ Global discoveries of oil and natural gas by region



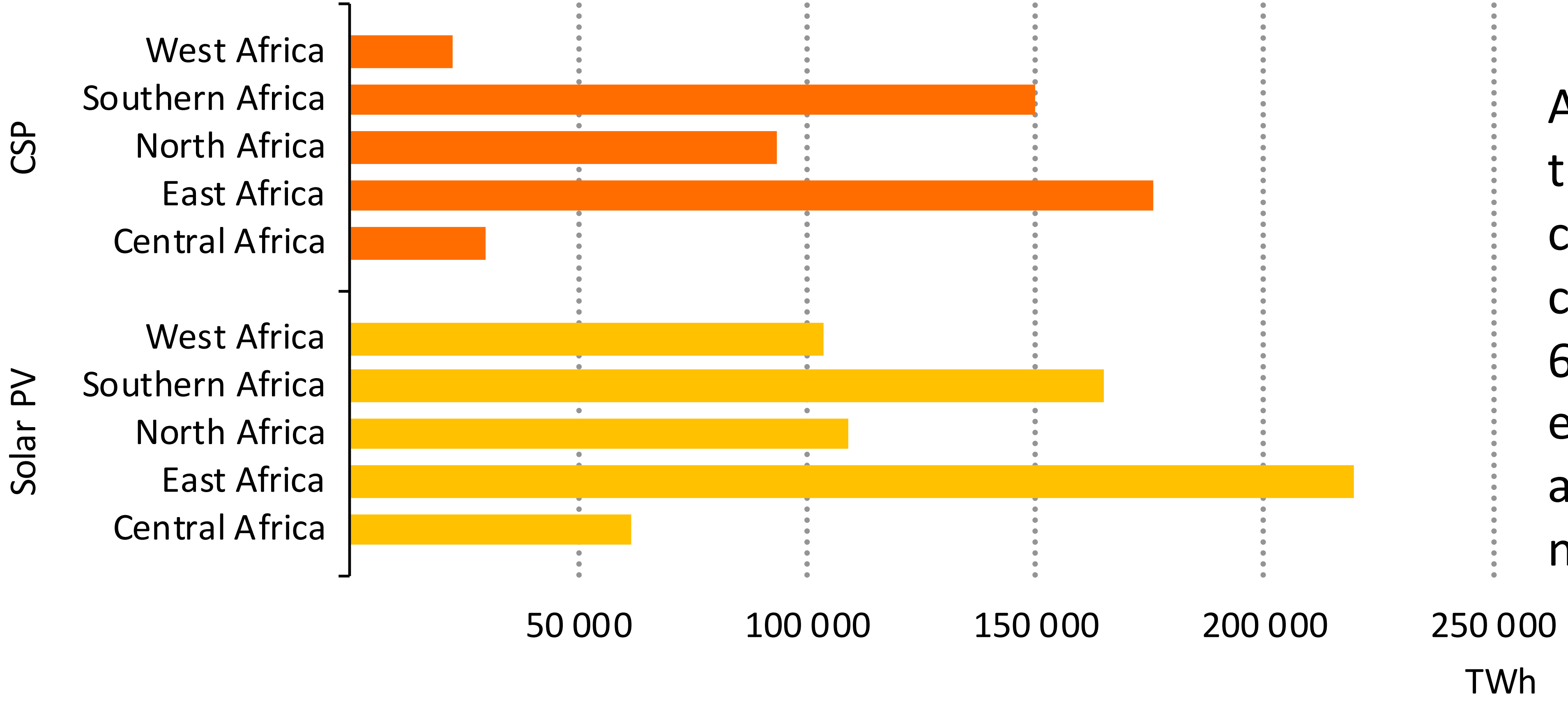
Africa's share in global oil discoveries has fallen markedly since the oil price fall, but the region has seen significant gas discoveries

Note: boe = barrels of oil equivalent.

Source: IEA, Africa energy outlook, Report 2019

Statistics in African Energy Sector: Energy Potential in Solar Energy

Figure 1.32 ▻ Solar energy resource potential per year in Africa



Africa’s solar PV theoretical potential could provide the continent more than 660 000 TWh of electricity a year, far above its projected needs.

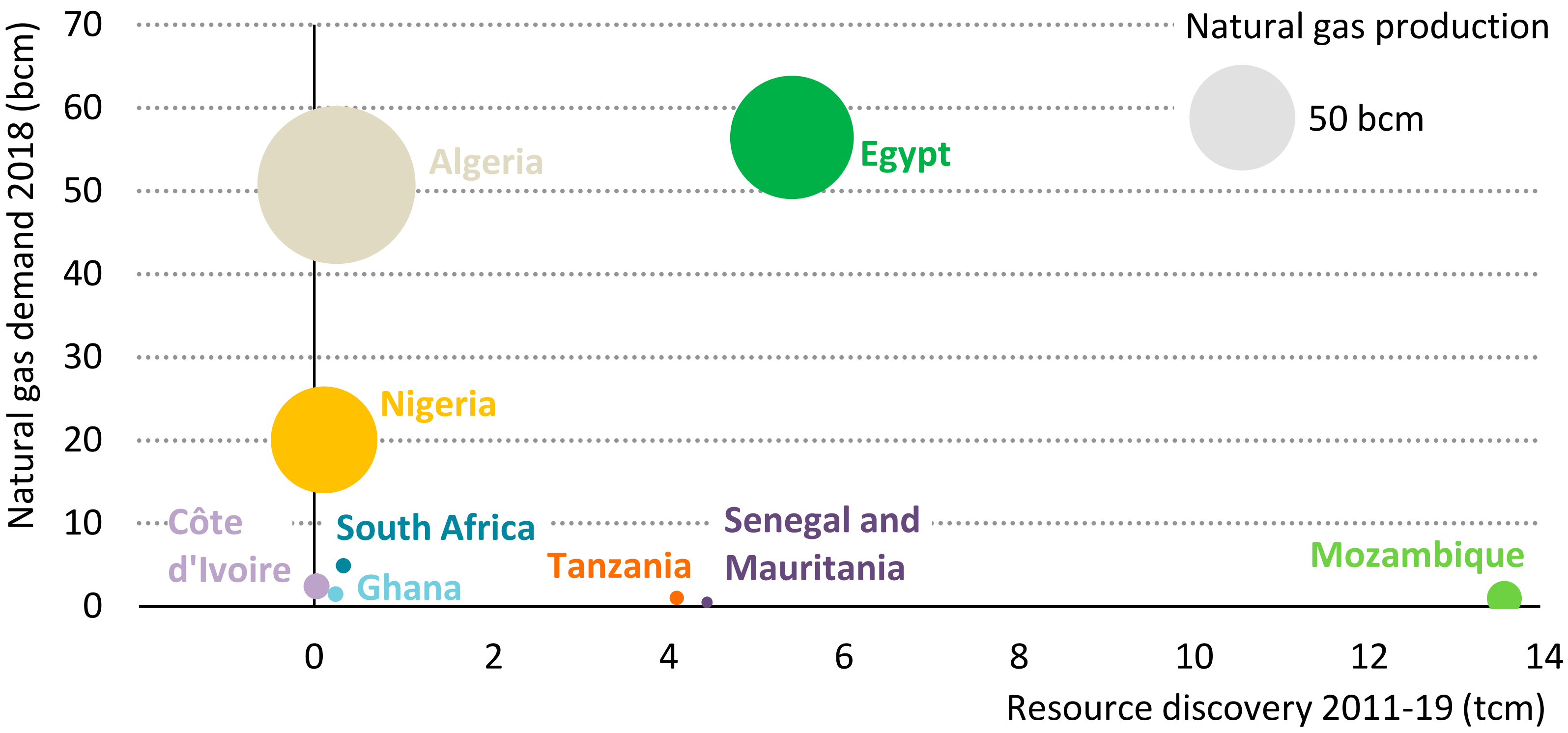
East Africa and Southern Africa contain the highest solar resource potential

Note: CSP = concentrating solar power.

Source: IRENA (2014).

Statistics in African Energy Sector: Energy Potential in Natural Gas

Figure 4.2 ▷ Natural gas resource discoveries, demand and production in selected countries in Africa



With the exception of Egypt, recent gas discoveries in Africa have been in countries with very small gas markets

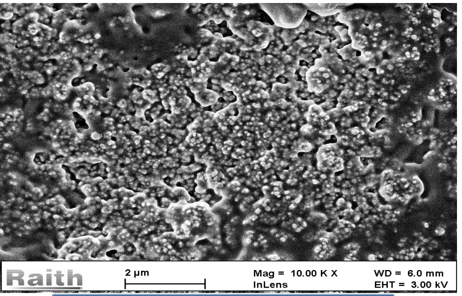
Notes: bcm = billion cubic metres; tcm = trillion cubic metres. Bubble size represents production volume in 2018.

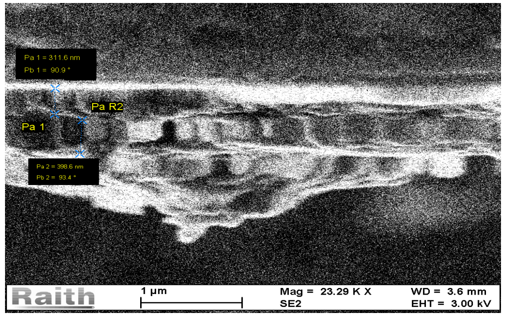
Source: IEA, Africa energy outlook, Report 2019

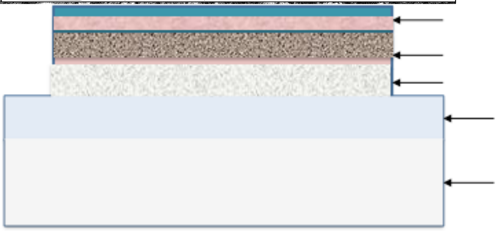
African Research and Innovation Contribution in Energy Area

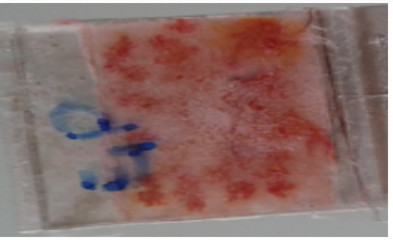
African Research and Innovation Contribution in Energy Area: Solar Energy

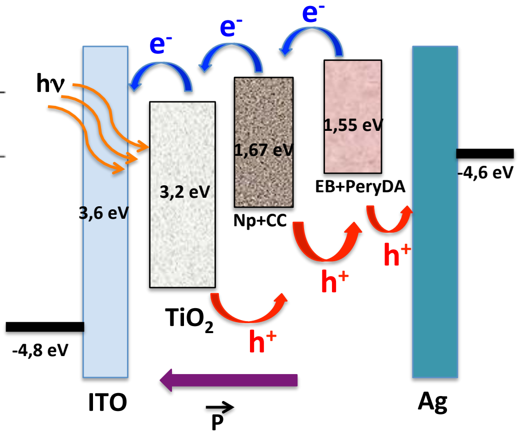
Innovative and new materials for photovoltaic solar cells

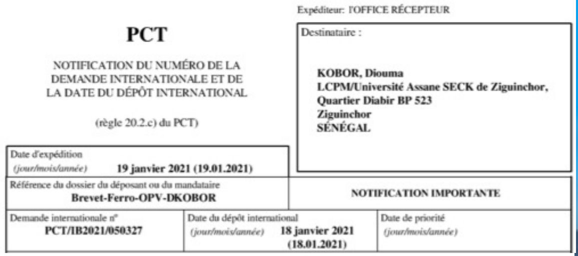












Expéditeur: l'OFFICE RÉCEPTEUR

PCT

NOTIFICATION DU NUMÉRO DE LA DEMANDE INTERNATIONALE ET DE LA DATE DU DÉPÔT INTERNATIONAL

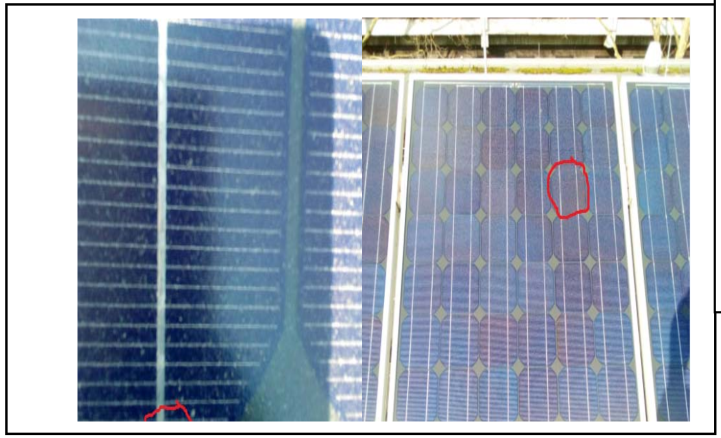
(règle 20.2.c) du PCT)

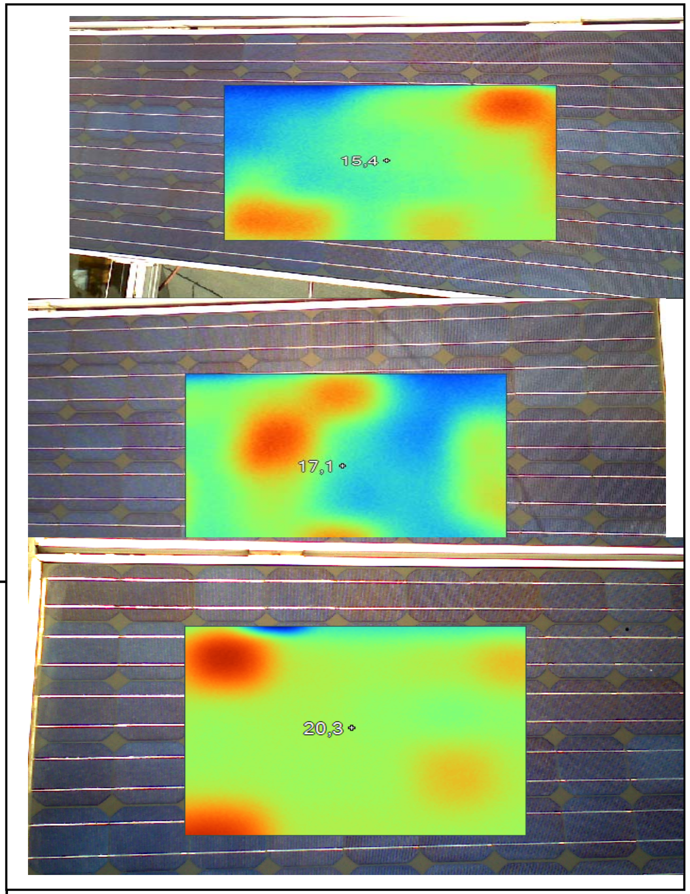
Destinataire :

KOBOR, Diouma
LCPM/Université Assane SECK de Ziguinchor,
Quartier Diabir BP 523
Ziguinchor
SÉNÉGAL

Date d'expédition (jour/mois/année) 19 janvier 2021 (19.01.2021)		
Référence du dossier du déposant ou du mandataire Brevet-Ferro-OPV-DKOBOR	NOTIFICATION IMPORTANTE	
Demande internationale n° PCT/IB2021/050327	Date du dépôt international (jour/mois/année) 18 janvier 2021 (18.01.2021)	Date de priorité (jour/mois/année)

Degradation and comparative experimental study of crystalline photovoltaic module after a few years outdoor exposure in casamance and cologne climate





Dr. I. Faye, IEEE, 2018

African Research and Innovation Contribution in Energy Area: Biomass and Bioenergy



Biomass technologies

Solid biofuel

Some pictures showing the first phase of production of fuel briquettes at the Assane Seck University of Ziguinchor.

1. Weighing the raw material

2. The filling

3. Advanced charring

4. Material’s withdrawal

5. Mixing and grinding

6. Briquetting

7. Recovery of briquettes

Digest
(Non degradated residue)

3

Lighting


Fertilizer

P. Himbane et al

Characterization and Valorization of Biomass for energy efficiency in cooking and agriculture

African Research and Innovation Contribution in Energy Area: Nuclear Energy

Eleven research reactors currently exist across the African continent, covering a wide power range, from 0.1 kW to 22 MW. Common designs include General Atomics TRIGA model and the miniature neutron source reactor (MNSR). Other, unique, designs exist, as shown in the table below.

IRT-1 reactor hall (Lybia): AIEA

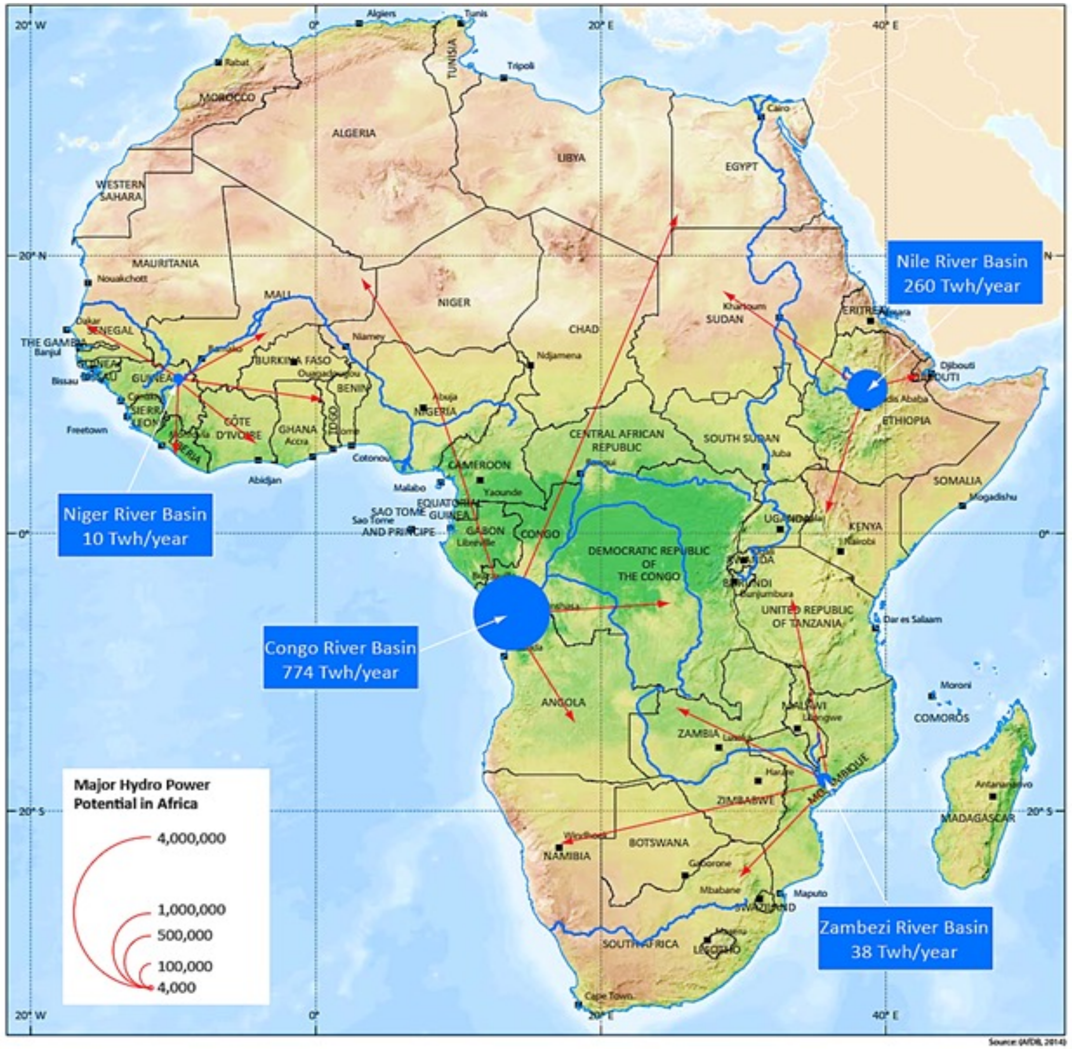
Country	Facility name	Type	Thermal power (kW)	Neutron flux (cm^{-2} s^{-1})
Algeria	NUR	Pool	1000	5.0×10^{13}
	Es-Salam	Heavy water	15 000	2.0×10^{14}
Democratic Republic of the Congo	TRICO II[1]	TRIGA Mark II	1000	3.0×10^{13}
Egypt	ETRR-1[1]	Tank WWR	2000	3.6×10^{13}
	ETRR-2	Pool	22 000	2.7×10^{14}
Ghana	GHARR-1	MNSR	30	1.0×10^{12}
Libya	IRT-1[2]	Pool, IRT	10 000	2.0×10^{14}
	TNRC	Critical assembly	0.1	1×10^{7}
Morocco	MA-R1	TRIGA Mark II	2000	7.1×10^{13}
Nigeria	NIRR-1	MNSR	34	1.2×10^{12}
South Africa	SAFARI-1	Tank-in-pool	20 000	4.0×10^{14}

New Research Reactor Projects

- Kenya: 2025 and 2028
- Nigeria: Expansion of the safely operated a 30 kW (MNSR)
- Senegal: 2018, a technical cooperation project with the IAEA entitled “Developing a National Nuclear Infrastructure for Establishing a Research Reactor”
- United Republic of Tanzania: Thermal Power of 1 MW
- Tunisia: An extraneous neutron source of plutonium–beryllium
- Zambia: 10 MW research reactor

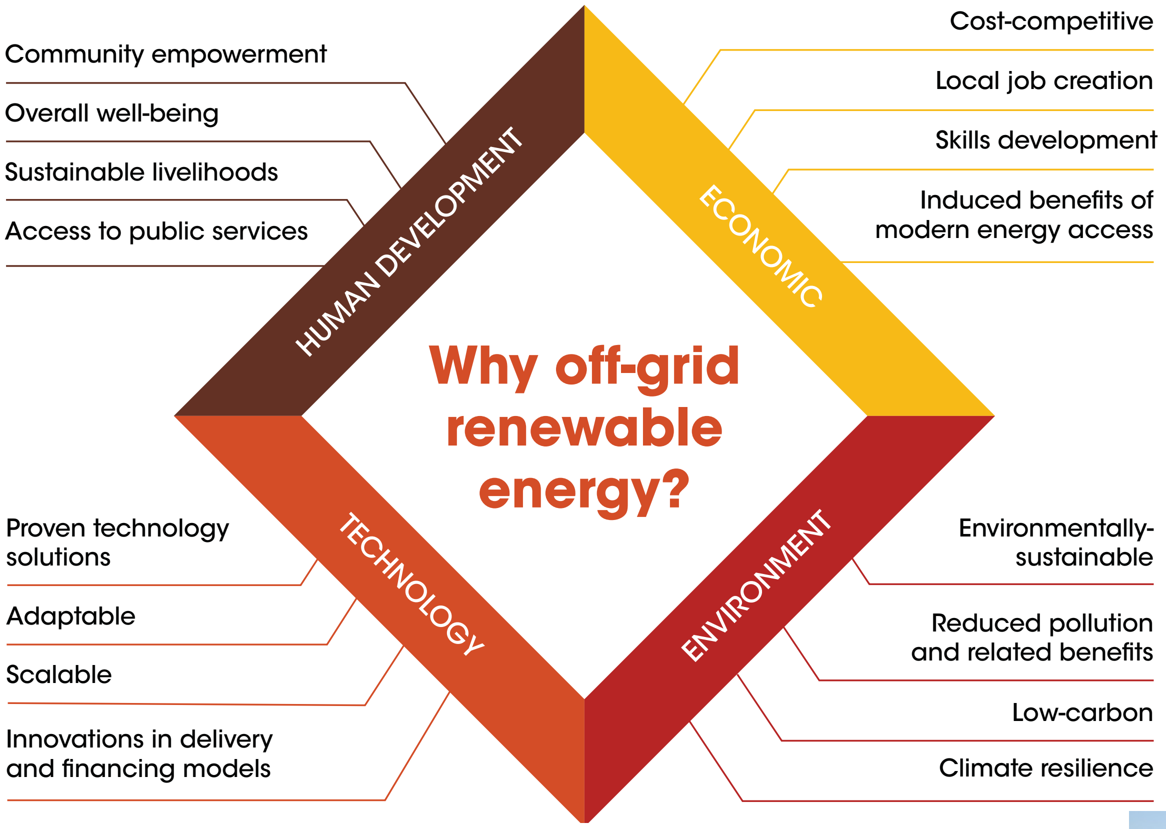
African Research and Innovation Contribution in Energy Area: Hydro and Wind Energy

Hydropower potential of Africa



Region	Technically feasible hydro generation potential (GWh)	Total installed hydro capacity (MW)	Hydro capacity under construction (MW)
North Africa	91,252	6,759	358
Central Africa	492,758	4,014	698
East Africa	549,218	7,065	7,411
West Africa	109,371	4,964	2,602
Southern Africa	303,715	10,051	3,921

African Research and Innovation Contribution in Energy Area: Off-Grid Energy Applications



Source: IRENA

African Research and Innovation Contribution in Energy Area: Energy Efficiency

Exergy = is the maximum useful work possible during any process.

Exergy = is the potential of a system to cause a change as it achieves equilibrium with its environment.

Exergy is the real energy that is available to be used

New approach more relevant and effective in the optimization of industrial processes

A good metric to value energy flows.

Energy quality =The ratio of exergy to energy $F_Q = \frac{Ex}{En}$

Exergy destruction is a measure of resource degradation

$Ex_d = (1 - \Psi)\, Ex_{in}$

- **Irreversibility** is related to exergy destroyed and/or wasted work potential, called dissipated energy,

$I = T_0 S_{gen}$

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Exergy approach: allows to go further in energy optimization of industrial processes.

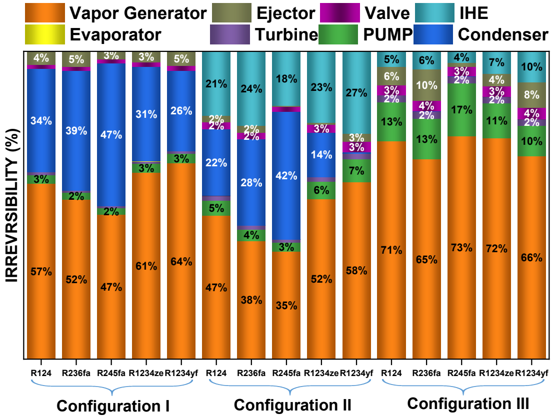

Fig 2: Rate of irreversibility of the different components

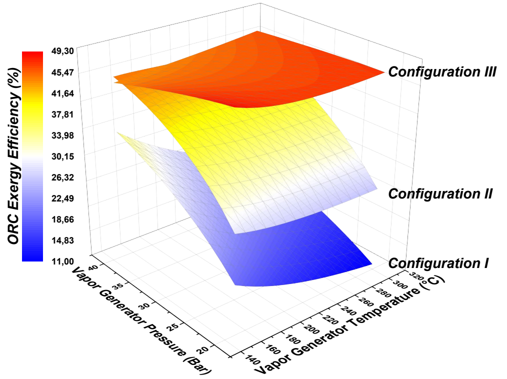

Fig 3: ORC exergy efficiency versus the vapor generator temperature and pressure

Exergy leads to a better understanding and quantification of the causes of inefficiency.

Deductions not possible with only energy investigation.

Exergy quantifies not only the loss of exergy, but also the degradation of the quality of energy (i.e. the destruction of exergy) in each of the components of the system.

Exergy Efficiency, will be adopted as a Common National Energy-efficiency Metric.

African decision makers (Policymakers) implement exergy sustainability indicators in addressing the sustainability of energetic projects & Industrial projects & technological research & Renewable and non renewable resources

Exergy is necessary for Energy Policy Recommendations

The work could be implemented in the whole African continent for efficient use of energy.

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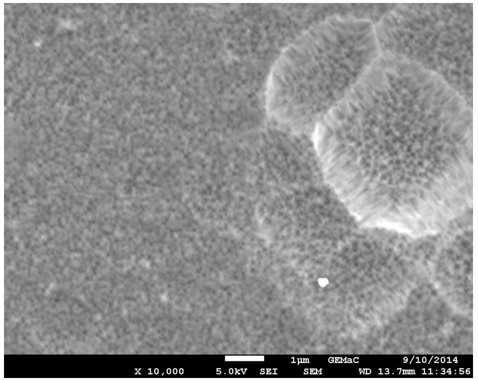
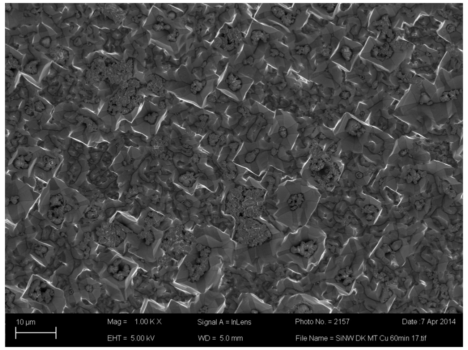
ASP 2022

Prof. N. Bouaziz

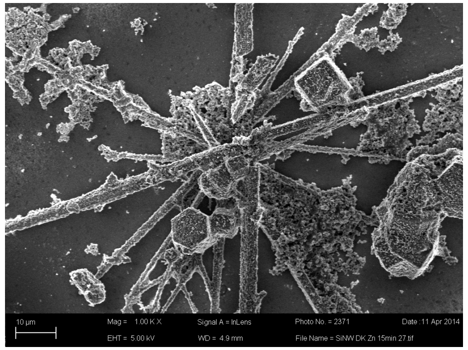
African Research and Innovation Contribution in Energy Area: Advanced Materials for Energy and EE



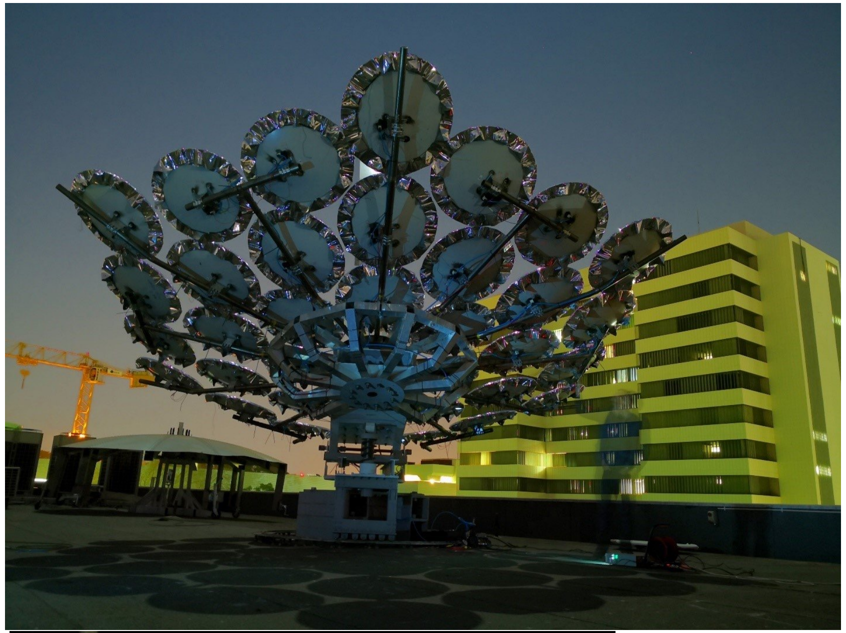
Si nanowires/New Procedure

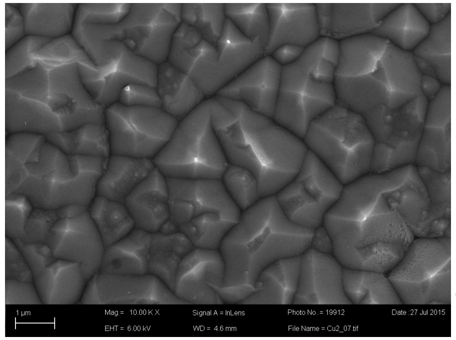


Si Inverted pyramids/MACE

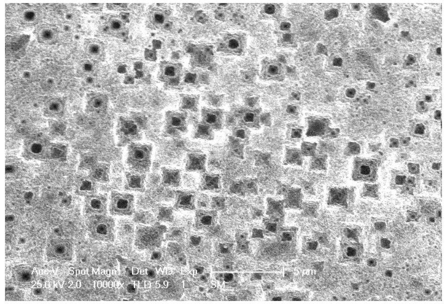


ZnO thin film/MACE

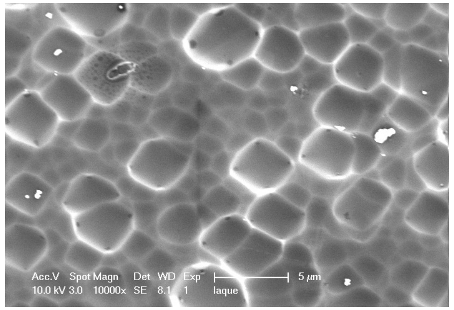




Si Pyramids/MACE

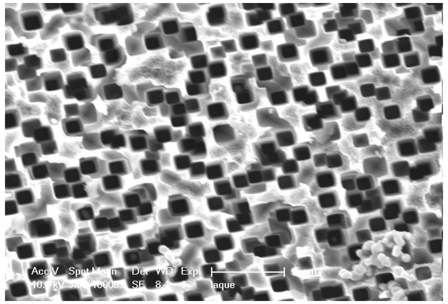


Si dispersed inverted pyramids/New Procedure

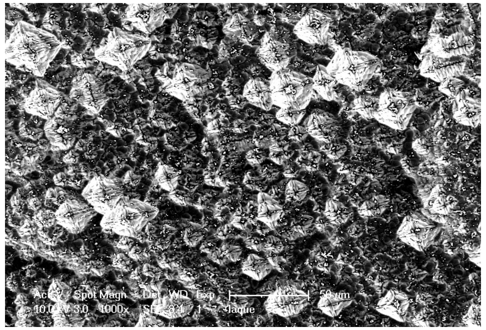


Si Inverted pyramids/New Procedure

Si nanotexturation patentent deposited new Procedure (patent deposited: PCT/IB2019/060499 and OAPI)



Si cubic nanoholes/New Procedure



Si nanobukets/New Procedure

(12) DEMANDE INTERNATIONALE PUBLIÉE EN VERTU DU TRAITÉ DE COOPÉRATION EN MATIÈRE DE BREVETS (PCT)

(19) Organisation Mondiale de la Propriété Intellectuelle
Bureau international

(43) Date de la publication internationale
10 juin 2021 (10.06.2021)

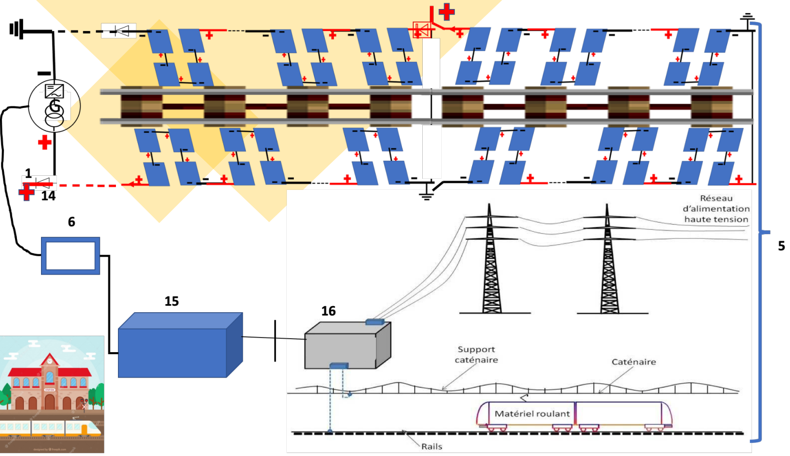
WIPO | PCT

(10) Numéro de publication internationale
WO 2021/111177 A1

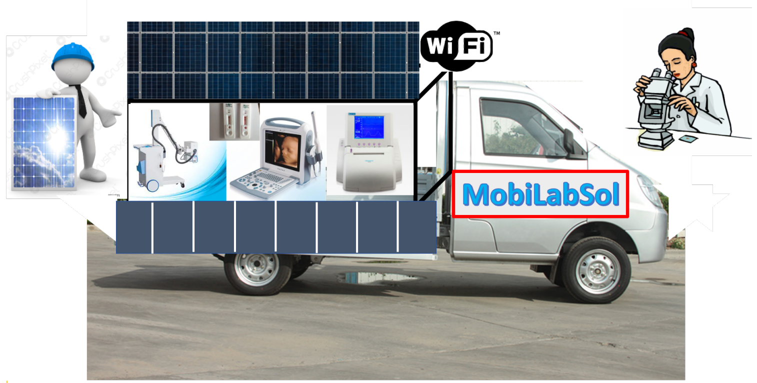
A solar concentrating system being tested at night, comprising of multiple dishes concentrating the moon's rays onto a collector.

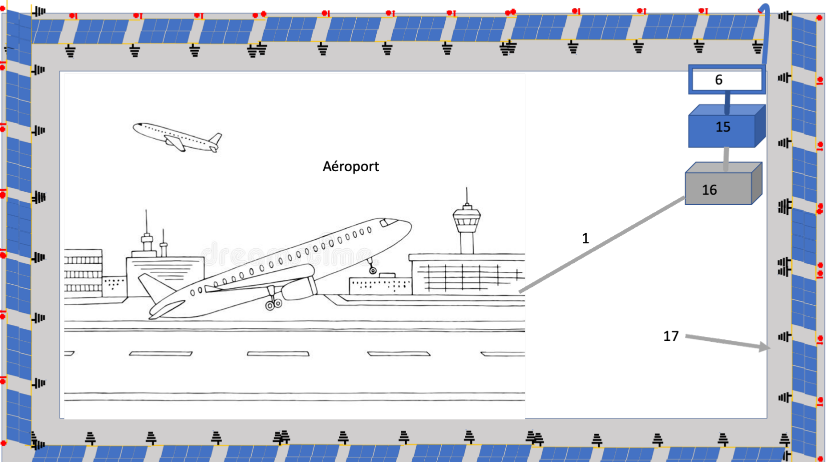
Hlengiwe Mnguni,
Department of Mechanical and Aeronautical Engineering, University of Pretoria, SA

Conclusion and Recommandations



Patent AOIP, 2022





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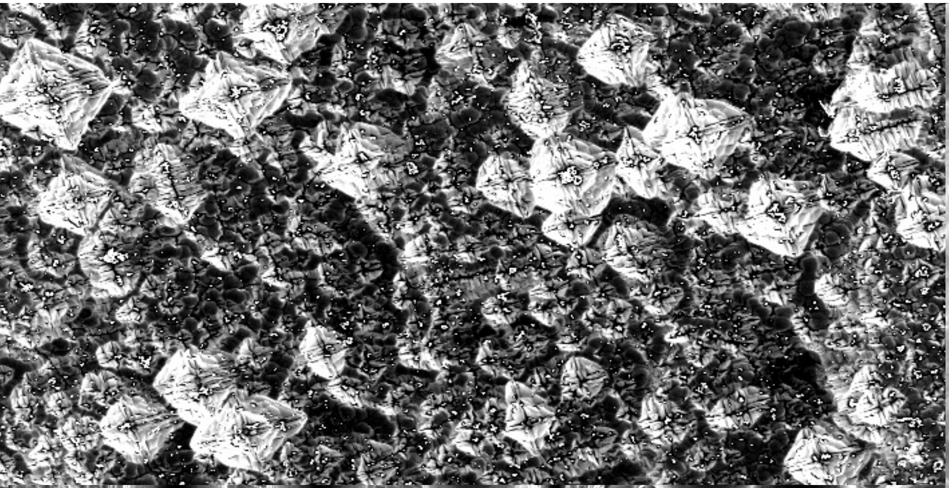
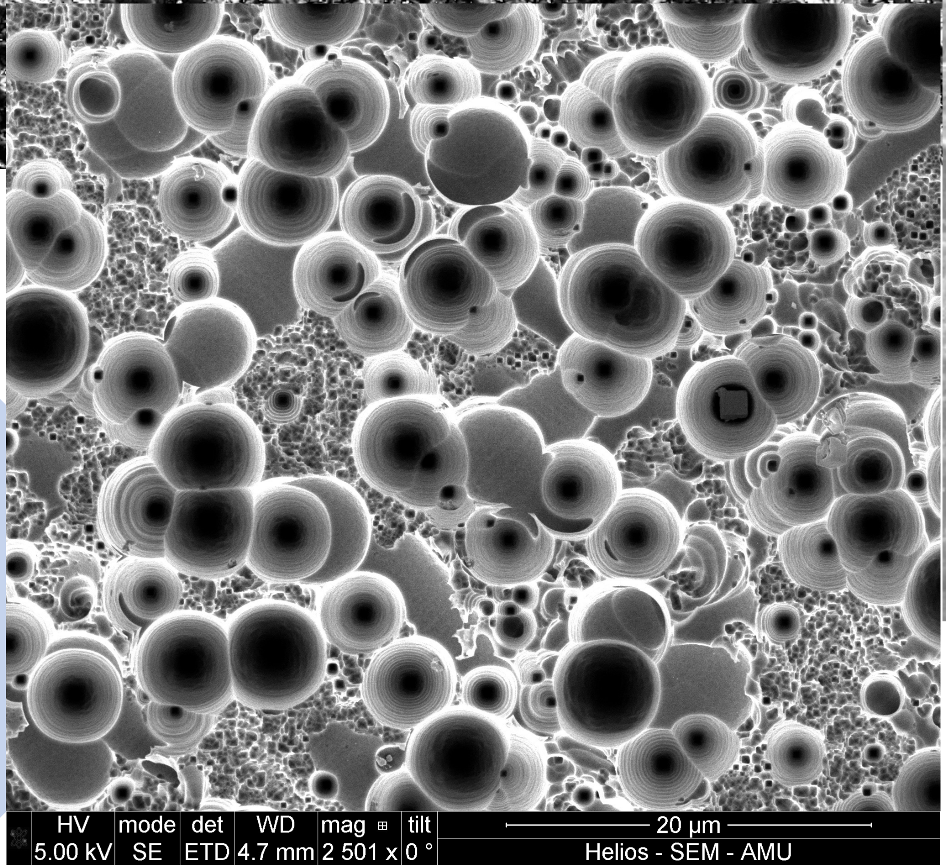
What can we do for African Energy

- ❑ Develop and set-up PanAfrican Research Excellent Centers in Energy area
- ❑ Develop Efficient and Sustainable Energy Use for the construction of interconnected projects in Africa
- ❑ African Energy Resources mapping and survey
- ❑ Develop new energy for Indoor applications and IoT.
- ❑ Develop the HEWE (Health – Education – Water – Energy) Nexus Projects around Africa
- ❑ Facilitate support for women and girls in Energy area
- ❑ Investigate Solutions using the Most Efficient and Low Coast Energy for Each African country and industry sector depending on local resources

Let’s come together for a better Africa!





THANK YOU FOR YOUR ATTENTION!

NOW LETS ENJOY SILICON NANOTEXTURES

Interested in joining us or do you have any remark or suggestion, please do contact us on:

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