General Situation of Energy Production and Consumption in Africa

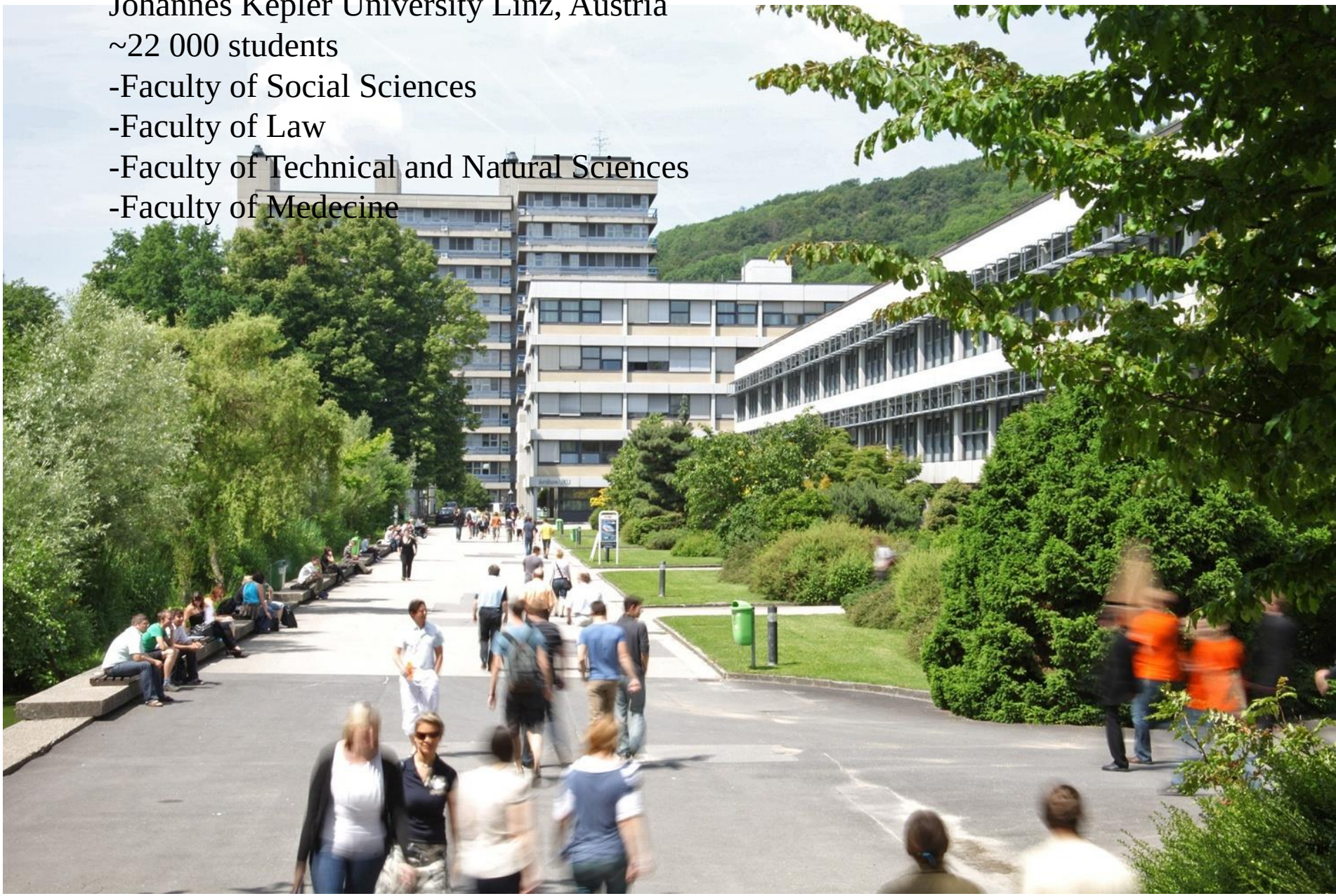
Daniel Ayuk Mbi EGBE

ANSOLE e.V Wagnergasse 25. 07743 Jena, Germany, daniel.egbe@ansole.org

Institute for Polymeric Materials and Testing, JKU Linz,
Altenbergerstr. 69, 4040 Linz, Austria, daniel_ayuk_mbi.egbe@jku.at

First Biennial African Conference on Fundamental Physics and Applications
28.06-04.07.2018, NUST, Windhoek, Namibia

Johannes Kepler University Linz, Austria
~22 000 students
-Faculty of Social Sciences
-Faculty of Law
-Faculty of Technical and Natural Sciences
-Faculty of Medecine



Development Plan of JKU Linz, Austria: 2019-2024

- SUSTAINABLE DEVELOPMENT: SCIENCE, TECHNOLOGIES & MANAGEMENT
- DIGITAL TRANSFORMATION

https://www.un.org/sustainabledevelopment/sustainable-development-goals/

RNCT

RWANDA NETWORK FOR CLEAN TECHNOLOGIES

Official Signing for Statutes of Rwanda Network for Clean Technologies by Founder Members

#Rwandanct 27 June 2018 / Kigali, Rwanda

OUTLINE

- My Research
- Energy Situation in Africa
- Research Networks

Organic Semiconductors

- Large area & flexible substrates possible
- Large variety of materials
- Low cost

Organic materials

Organic light emitting diodes

Photovoltaic cells

Transistors and memory

Images source: Karl Leo, TU-Dresden

Renewable Energies

- ♦ Hydropower
- ♦ Geothermal Energy
- ♦ Solar Energy
  - *Solarthermics*
  - *Photovoltaics*
- ♦ Ocean tides
- ♦ Wind energy
- ♦ Bioenergy (biomasses)

Photovoltaics

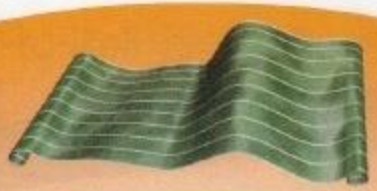
First Generation:
- Monocrystralline Si: η >16%
- Polycrystalline Si: η >12%

Second Generation
- Amorphous Si: η >8%
- CdTe: η > 8 %
- GaAs: η > 20%
- CIGS: η >12 %

Third Generation
- Grätzel-Cells: η > 11 %
- Organic Solar Cells: η >12 %
- Perovskite Solar Cells: η >20 %

Expectation of Organic-PV

gioa



Auto

Building/
Housing

Flexible

Low-Cost

Light

Suggesting the best multi solutions for healthier,comfortable life in the environmental friendly society

Ubiquitous・
Mobile

Colorful

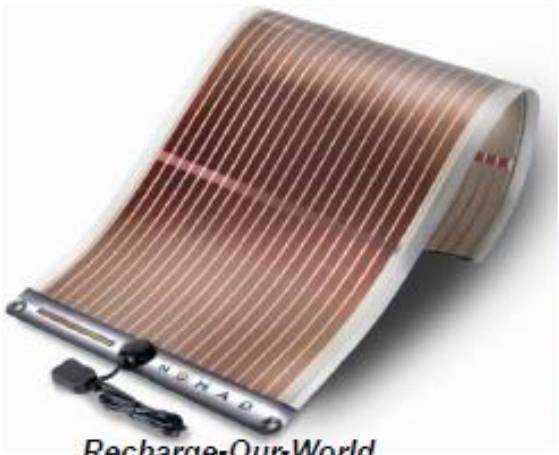
See-through

Agriculture

Interior

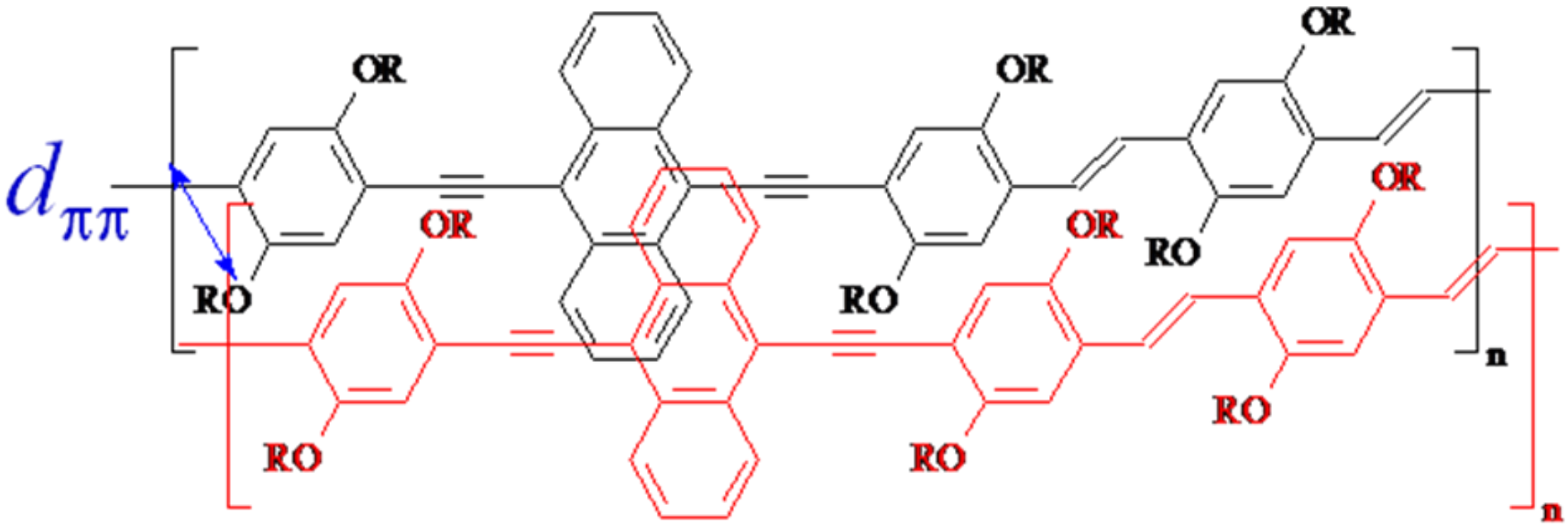
RFID Tag

San Francisco Municipal Transportation Agency + Konarka +3 others



Recharge-Our-World,
Nomad® Outdoor Charger

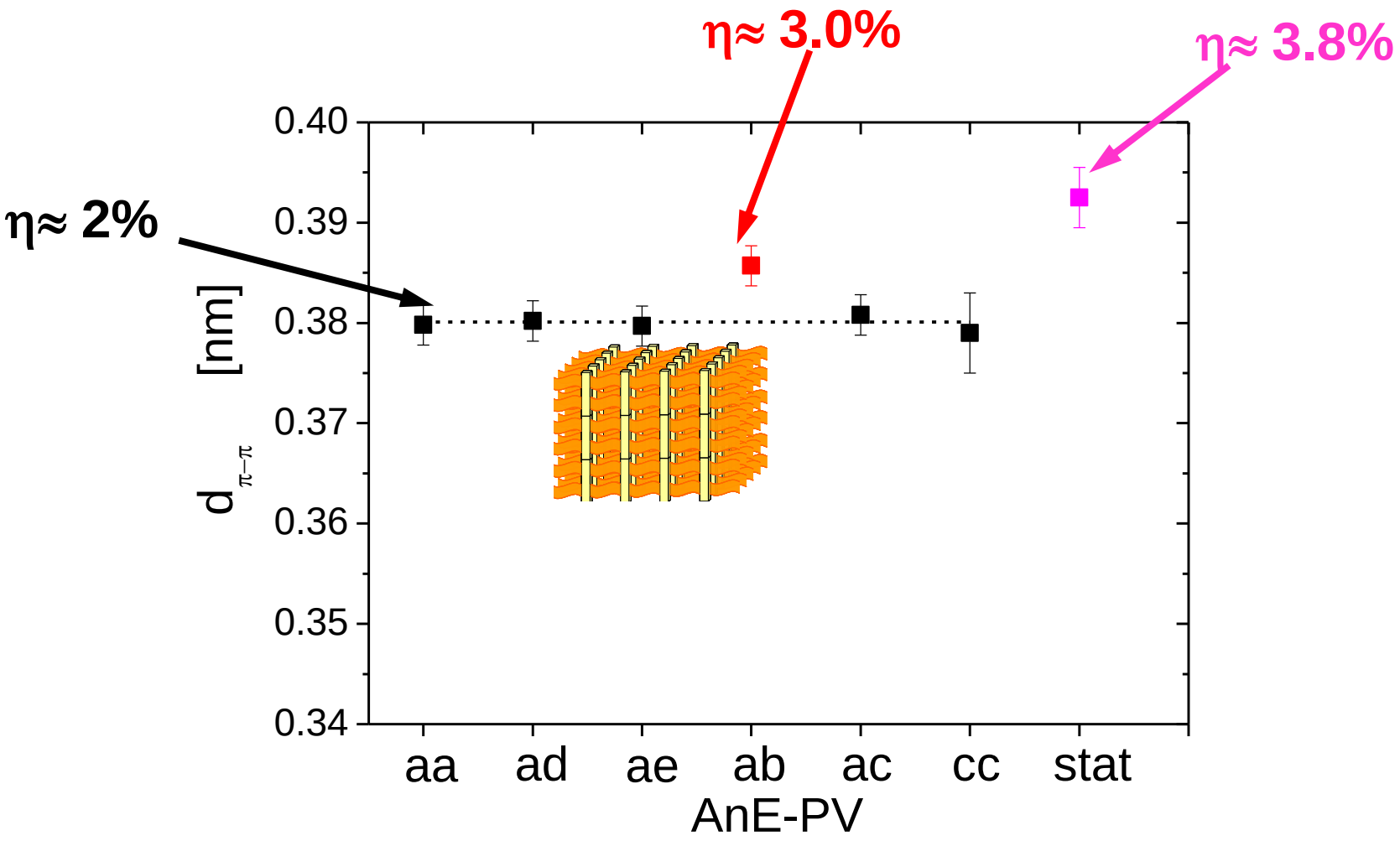
Effect of ππ-Stacking Distance



ππ-stacking distance, $d_{\pi\pi}$, tuned by
R = linear and/or branched side chains

Phys. Status Solidi A. **2009,** *12*, 2695; *Macromolecules* **2010**, *43*, 1261; *Macromolecules* **2010**, *43*, 306, *J. Mater. Chem.* **2010**, *20*, 9726

Correlation between pi-pi-Stacking Distance and Photovoltaic Performance



nature photonics

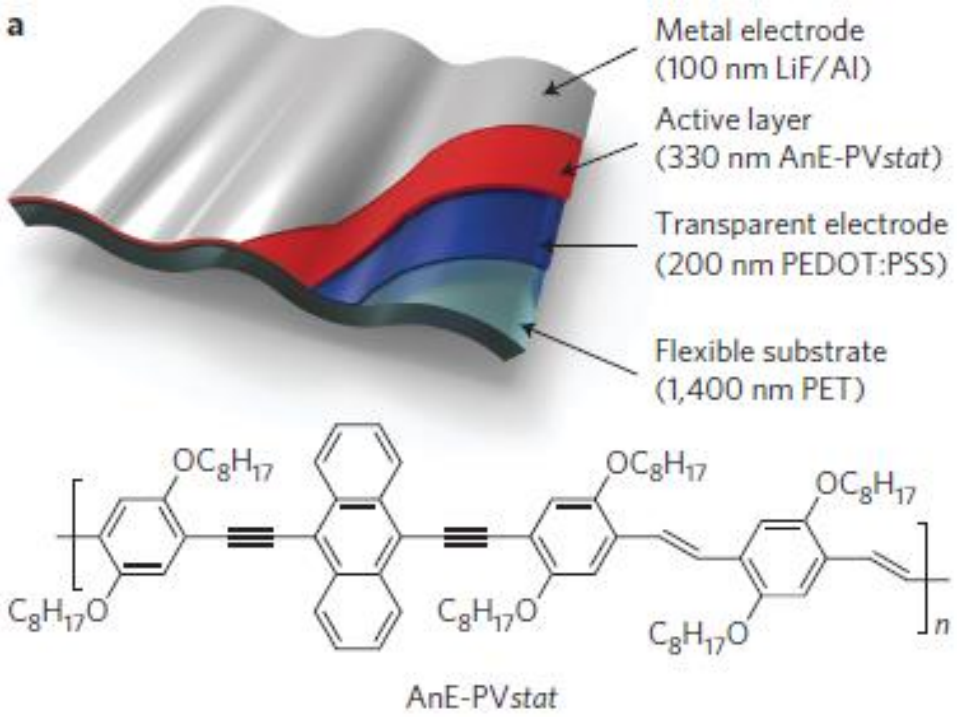
ARTICLES

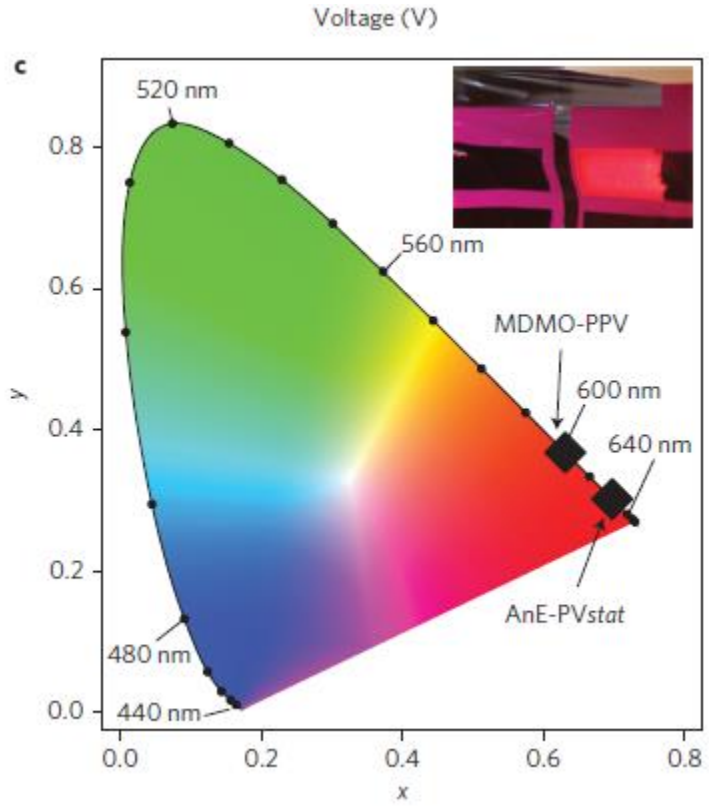
PUBLISHED ONLINE: 28 JULY 2013 | DOI: 10.1038/NPHOTON.2013.188

Ultrathin, highly flexible and stretchable PLEDs

Matthew S. White[1]*, Martin Kaltenbrunner[2,3,4], Eric D. Głowacki[1], Kateryna Gutnichenko[1], Gerald Kettlgruber[4], Ingrid Graz[4], Safae Aazou[5,6], Christoph Ulbricht[7], Daniel A. M. Egbe[1], Matei C. Miron[8], Zoltan Major[8], Markus C. Scharber[1], Tsuyoshi Sekitani[2,3], Takao Someya[2,3], Siegfried Bauer[4] and Niyazi Serdar Sariciftci[1]

We demonstrate ultrathin (2 μm thick) red and orange polymer light-emitting diodes with unprecedented mechanical properties in terms of their flexibility and ability to be stretched. The devices have a luminance greater than 100 cd m^{-2}, sufficient for a variety of optoelectronic applications including indoor displays. They can be operated as free-standing ultrathin films, allowing for crumpling during device operation. Furthermore, they may be applied to almost any surface whether rigid or elastomeric, and can withstand the associated mechanical deformation. They are shown to be extremely flexible, with radii of curvature under 10 μm, and stretch-compatible to 100% tensile strain. Such ultrathin light-emitting foils constitute an important step towards integration with malleable materials like textiles and artificial skin.





S. AAZOU (ANEX, Morocco-Austria)

Nature Photonics **2013**, *7*, 811-816

Africa's energy sector is still best understood as 3 distinct regions:

- **North Africa**, dependent on **oil and gas**
- **South Africa**, dependent on **coal**
- **Rest Sub-Saharan Africa**, largely dependent on **biomass**

➢ Even oil-rich sub-Saharan African countries still continue to rely on biomass to meet the bulk of their household energy requirements (> 85 % in Nigeria)

Stephen Karekezi & Waeni Kithyoma, 2003

Energy Situation in Africa

- Extremely low levels of modern energy supply and access

Electricity

- Low Generation Capacity
  - Total capacity about 140 GW , South Africa accounts for 36%, North Africa (39%), other Sub-Saharan Africa (25%)
- Low Access to Electricity
  - Only about 31% of the Sub-Saharan African population has access to electricity, Contrast with N. Africa – 99% access
  - Electrification rates as low as 9 – 20% in many Sub-Saharan African countries
- Inefficient Transmission and Distribution System
  - Distribution losses as high as 20% in Ghana and Senegal to 55% in Botswana
- Highly unstable and unreliable electricity supply from the grid

Commission

Energy Situation Africa

High Generation costs

- Over 80% of electricity generation in Africa is from fossil fuels
  Highly vulnerable to price shocks
- Average tariffs are US$0.14 per kWh compared to US$0.04 and US$0.07 per in South and East Asia, respectively

Low Electricity Consumption

- Per capita electricity consumption of 571 kWh in Africa is 5 times less than world average

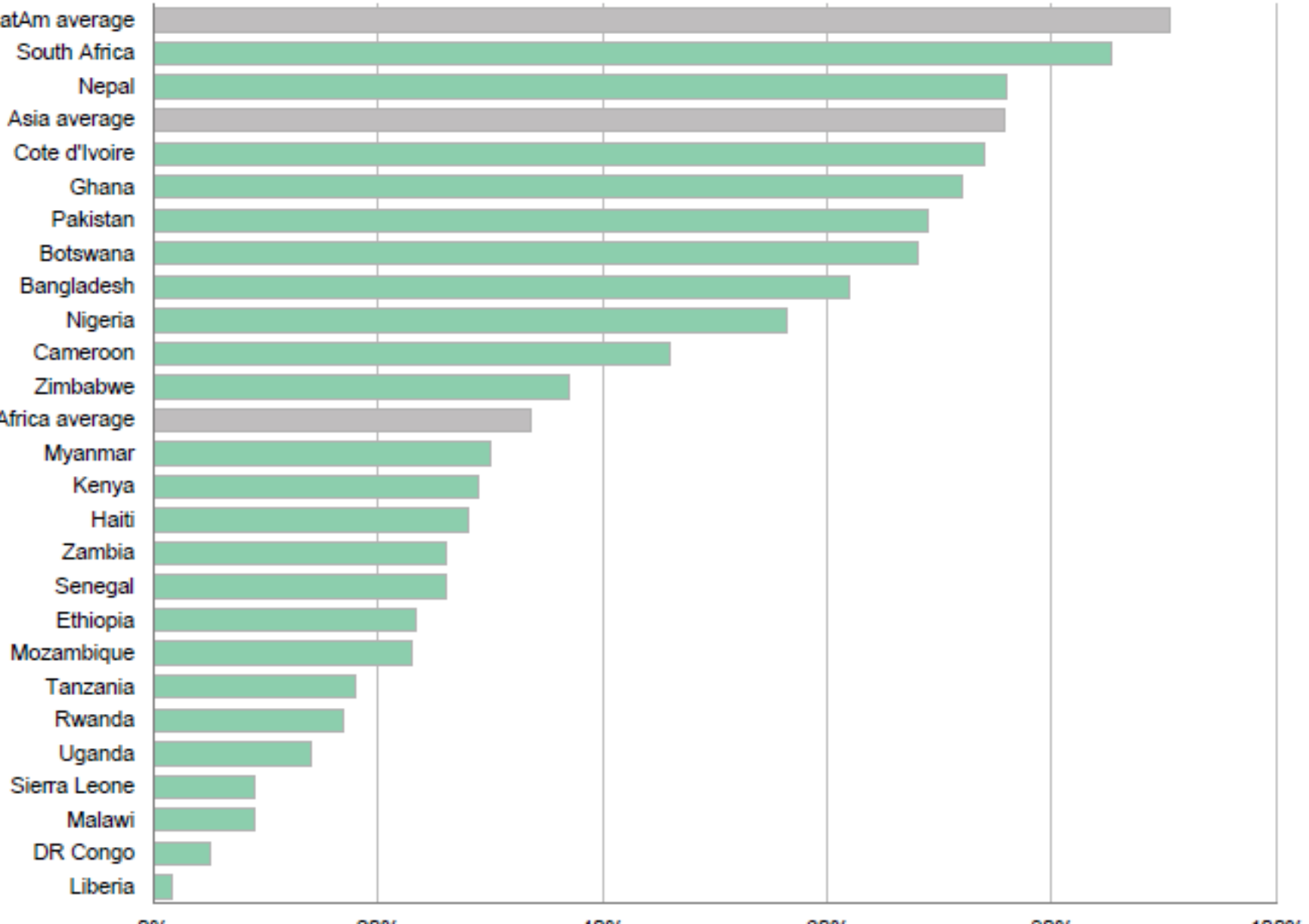
er forms of energy

About 80% of SSA population depends on biomass for cooking with very
efficiency in heat conversion of traditional stoves (10 – 15% efficiency)

- Serious impacts on health and mortality (mostly affecting women and childr

Huge dependence on animal and human labor for productive activities
especially in rural areas

ECTRIFICATION RATE 2013 (%)



nergy Type	Reserves	Regional Distribution
Non-renewable		
rude oil	132.1 billion barrels	Northern Africa: 53.2% Western Africa: 28.2% Central Africa: 16.9% Other Africa: 1.7%
atural gas	14.7 trillion m^3	Northern Africa: 55.8% Western Africa: 36.1% Other Africa: 8.2%
oal	31.696 billion tones	Southern Africa: 95.2% Other Africa: 4.8%
uclear	Reasonably assured resources: 663,400 tonnes Inferred resources: 286,300 tonnes	Northern Africa: 2.9% Western Africa: 36.7% Central Africa: 2.7% Eastern Africa: 4.2% Southern Africa: 53.5%
Renewable		
ydro	1,834 TWh/yr	Central Africa: 57% Eastern Africa: 32% Other Africa:11%
iomass	Woody biomass: 70 billion tonnes	All regions
olar	[1]Solar insolation: 1800 – 2850 $kWh/m^2.a$	Most of Africa
Vind	[1]Wind speeds: Southern Africa (6 – 8 m/s)	Most attractive sites in the Northern an Southern coasts

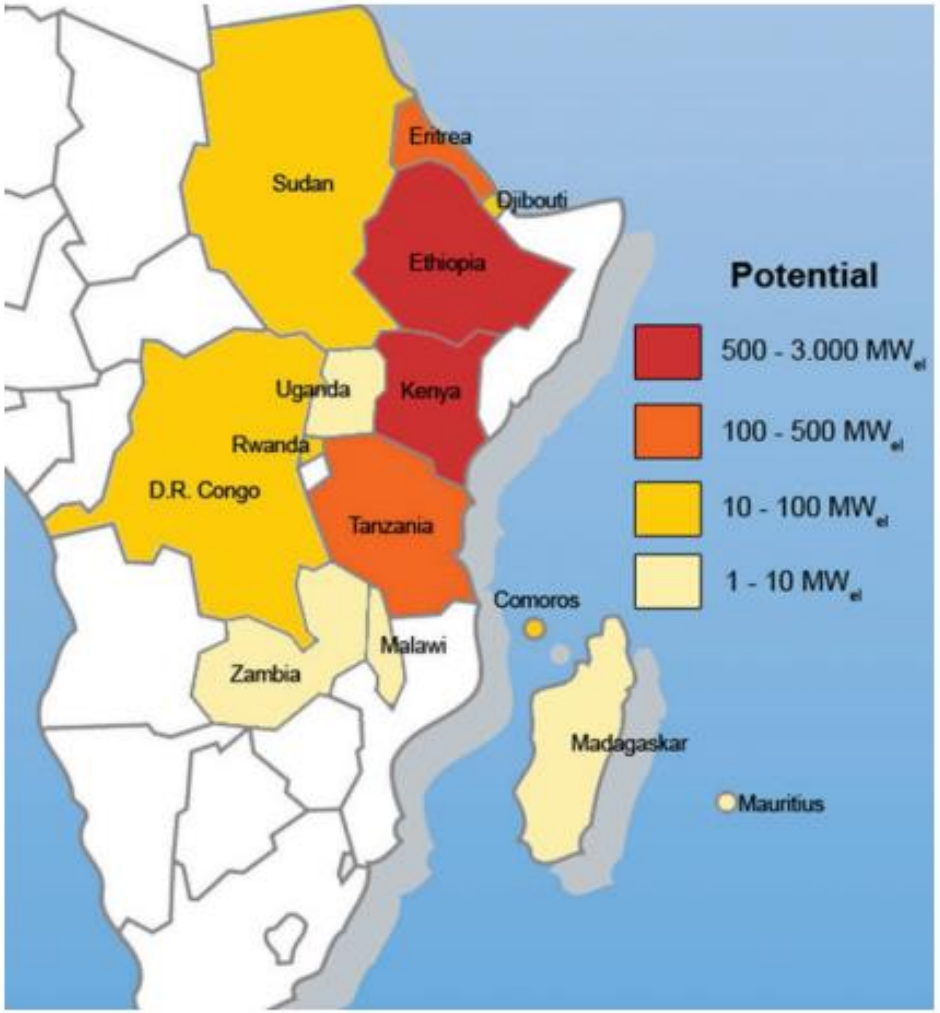
Pan African University
Institute of Water
and Energy Sciences

Energy resources in Africa

Energy potentials : renewable energy resources (geothermal)

Geothermal energy

More concentrated in Eastern Africa

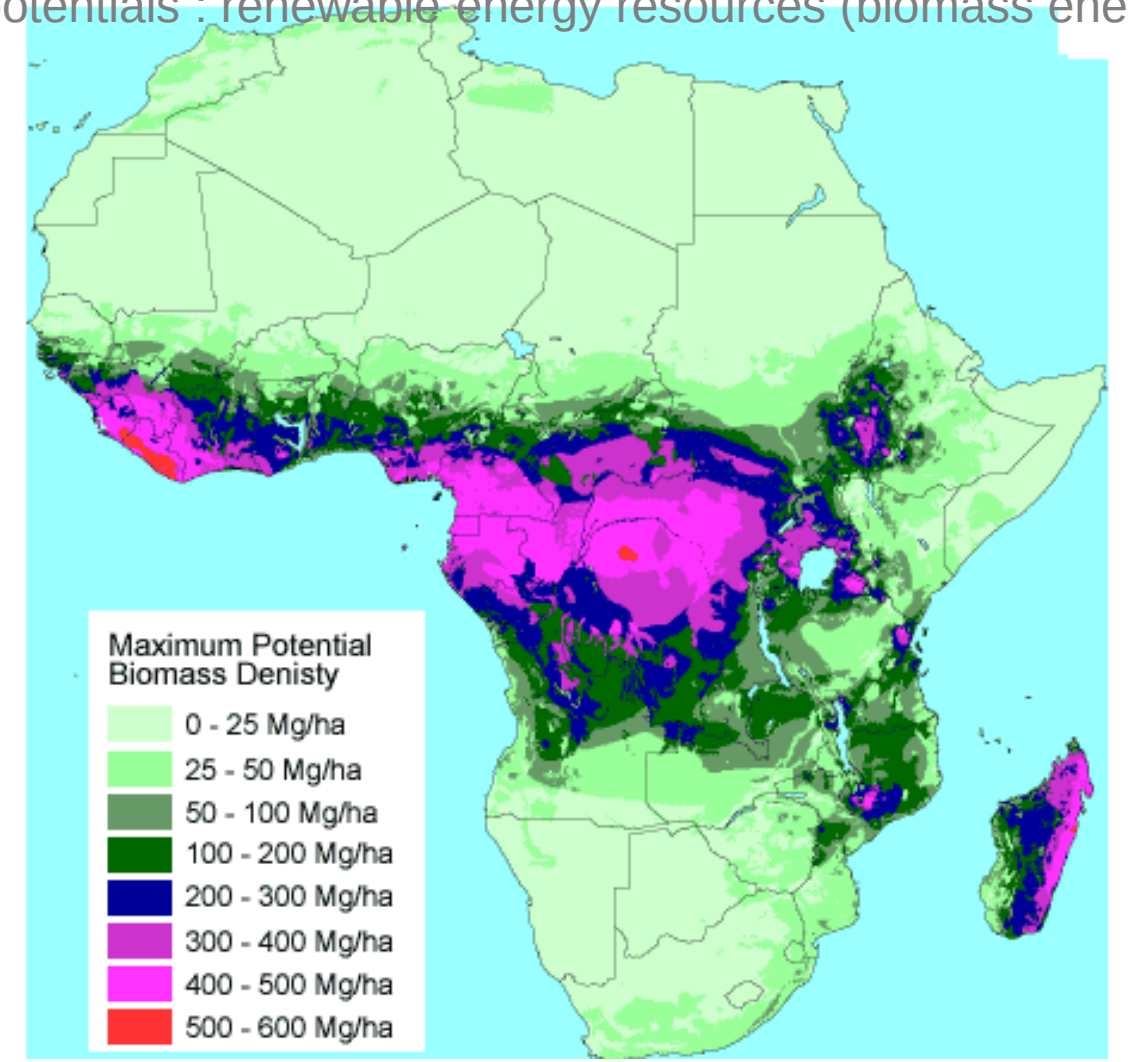


PAUWES, Prof. Yao Azoumah,

Pan African University
Institute of Water
and Energy Sciences

Energy resources in Africa

Energy potentials : renewable energy resources (biomass energy)



Biomass energy

25% of the global biomass reserves

PAUWES, Prof. Yao Azoumah,

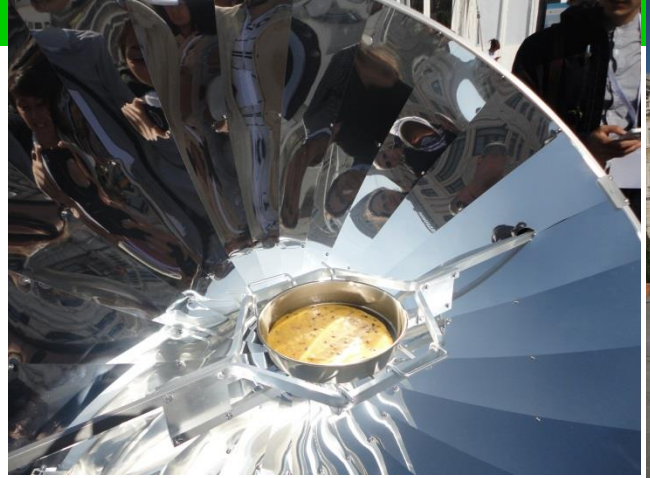
20. Internationale Solarkochertagung, Altötting, 20-21. April 2013

21. Internationale Solarkochertagung in Altötting (25-26. April 2015)

21.Int. Solarkochertagung: Ms Regula Ochsner, CEO of the swiss organisation ADES (Association pour le Développement de L´Energie Solaire) presenting the successful implementation of solar cookers in Madagascar. **www.adesolaire.org**

ADES
ADES

Mahajanga
Antananarivo
Antsirabe
Morondava
Fianarantsoa
Morombe
Toliara
Ejeda



TriesteNext, Trieste, Italy 26-28 September 2014

Public Educational Mission of ANSOLE

UNESCO World Science Day, 10 Nov. 2014, UCLAN, Westlakes, Britain

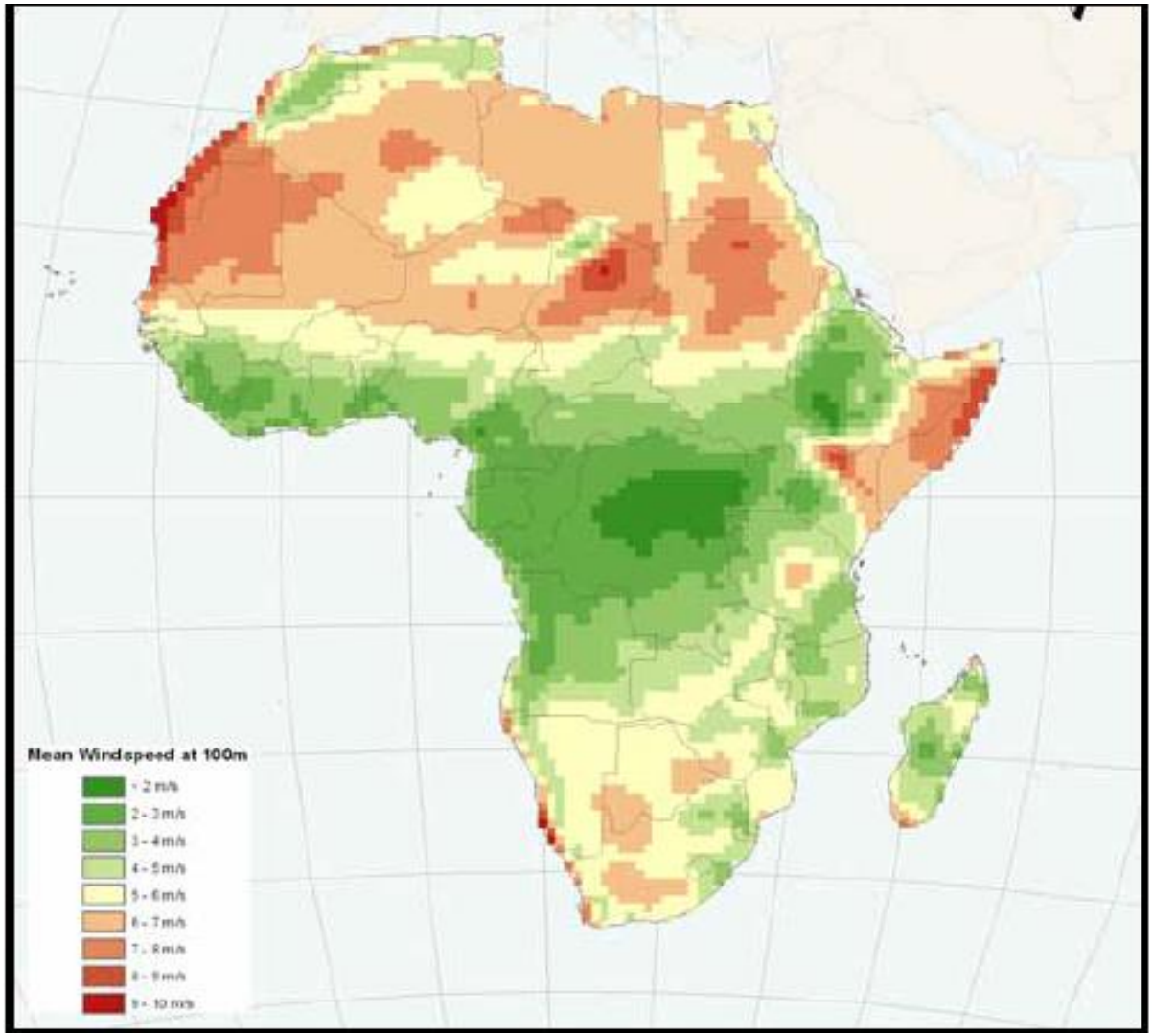
Pan African University
Institute of Water
and Energy Sciences

Energy resources in Africa

Energy potentials : renewable energy resources (wind energy)

Wind energy
20% of global energy

More concentrated in northern and southern parts of the continent



PAUWES, Prof. Yao Azoumah,

Energy resources in Africa

Energy potentials : renewable energy resources (wind energy)

Country	Potential (m/s)	Number of Wind Pumps
Botswana	2-3	200
Burundi	>6	1
Djibouti	4	7
Eritrea	3-8	<10
Kenya	3	272
Morocco	>10	-
Mozambique	0.7-2.6	50
Namibia	-	30,000
Rwanda	-	-
Seychelles	3.62-6.34	-
South Africa	7.29-9.7	300,000
Sudan	3	12
Tanzania	3	58
Uganda	4	7
Zambia	2.5	100
Zimbabwe	3-4	650

Pan African University
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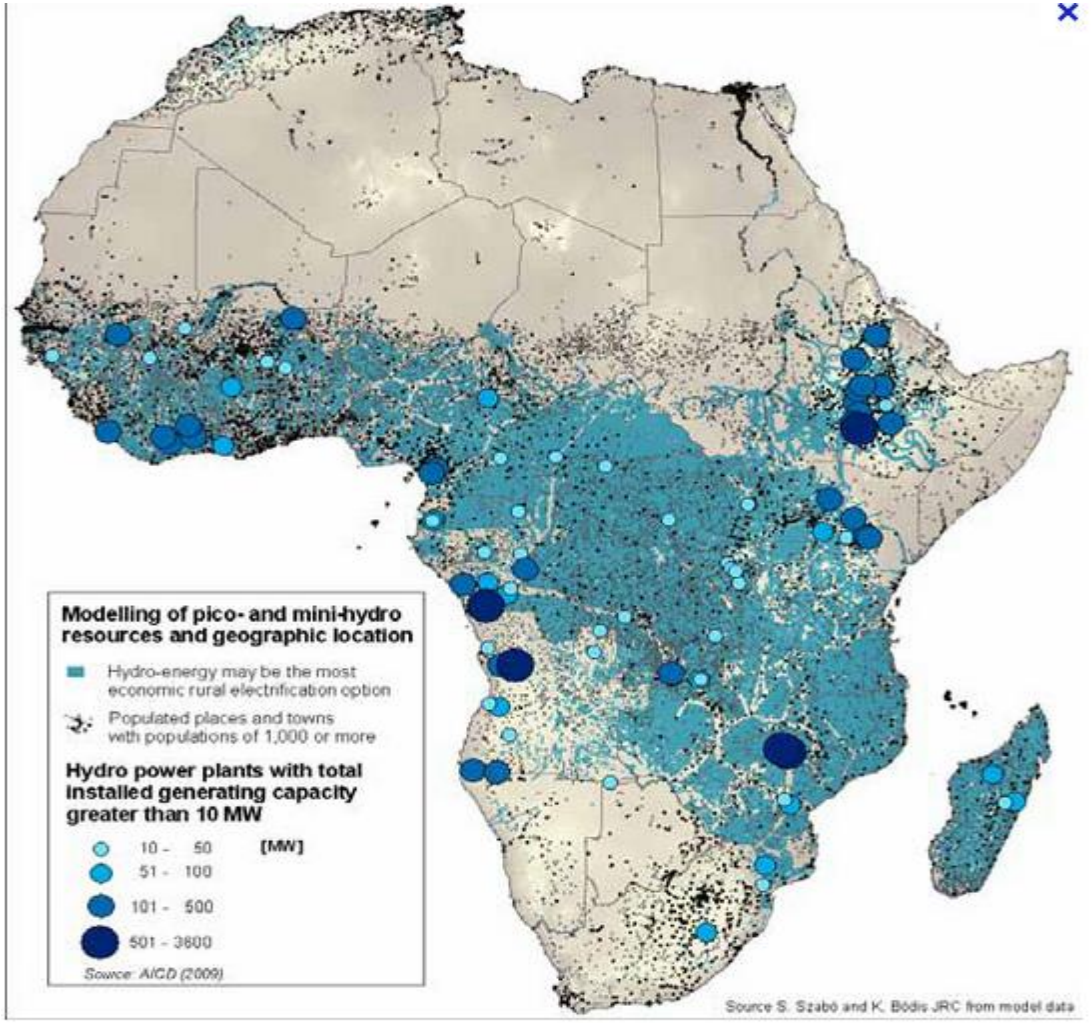
and Energy Sciences

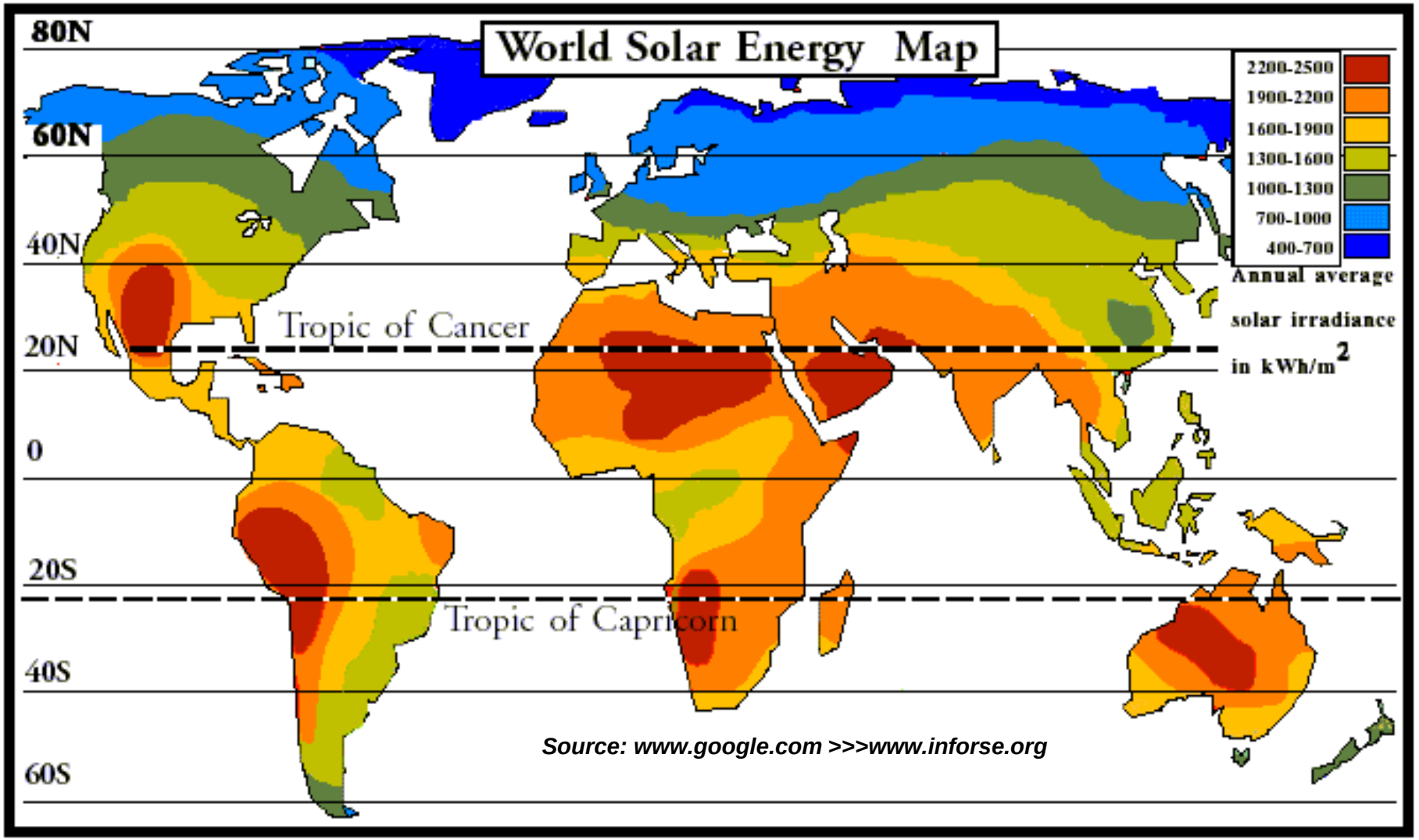
Energy resources in Africa

Energy potentials : renewable energy resources (hydro energy)

Hydro production potential of 1440 TWh/year



PAUWES, Prof. Yao Azoumah

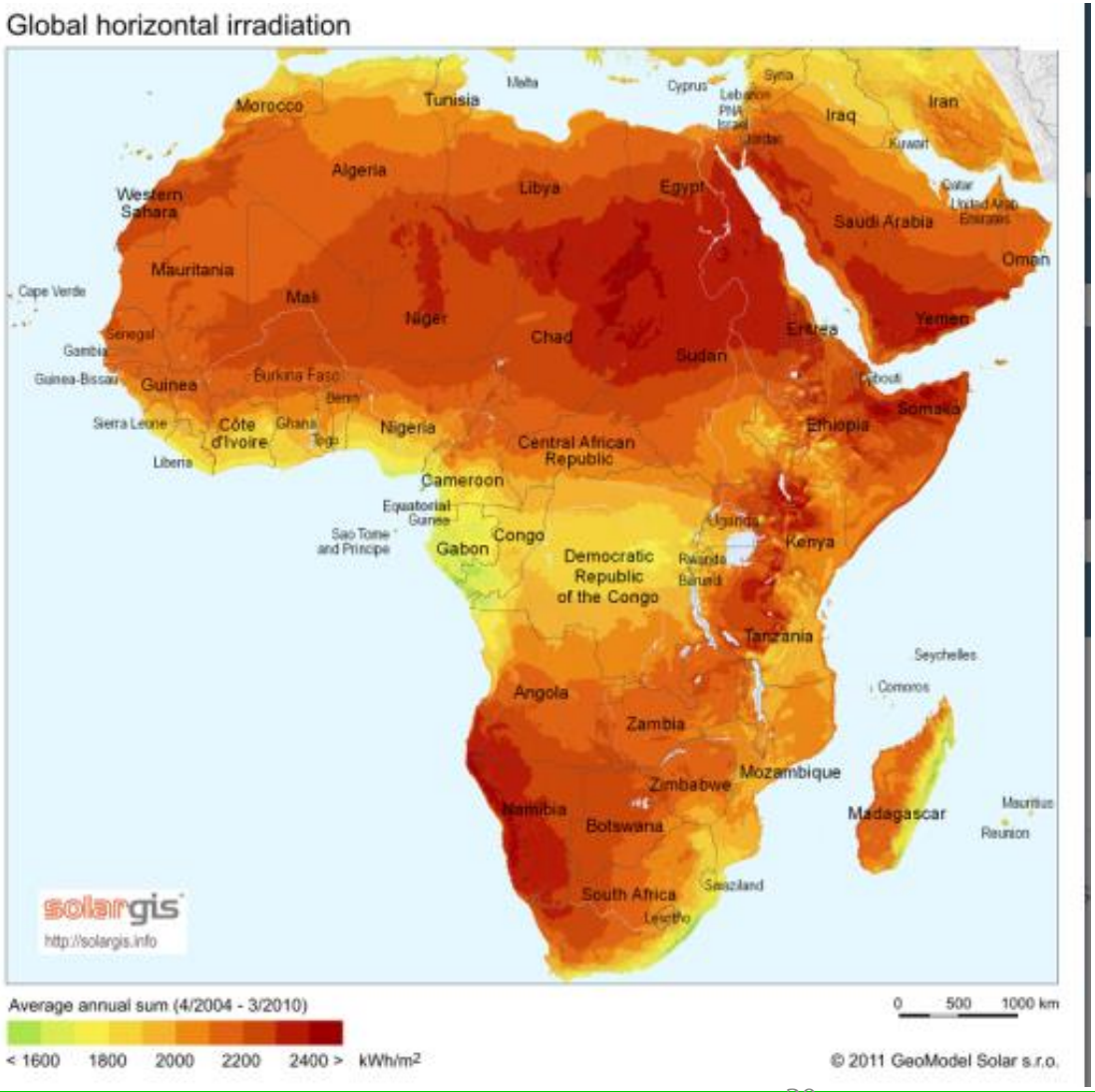


PV Technologies: silicon technology adaptable to specific African environments, Concentrated and Highly Concentrated Photovoltaics, Concentrated Solar Power, 3rd generation solar cells (Organic, DSSC, Perovskites)

Energy resources in Africa

Energy potentials : renewable energy resources (solar energy)

Solar energy: 74% of the continent receives more than 1900 kWh/m²/year



PAUWES, Prof. Yao Azoumah,

An appropriate and adaptable technology takes into account:

- Environmental and climatic conditions
  >high temperatures
  >long raining seasons,
  >dusts
  > etc.
- Societal behavior

- Purchasing power

According to the PhD thesis (2018) of Cristina Cabo Landeira of the University of Santiago de Compostela (USC):

“PV systems design optimization as function of the climatic conditions”

Polycrystalline silicon solar cells are recommended for all climatic conditions

Example of an adaptable and affordable technology

Easy transportation of a rolled up 135 W panel on a motorbike

Solamander 36 W photovoltaic panel mounted on a corrugated roof and held in place with nails

Solamander 135 W photovoltaic panel mounted on a corrugated roof

Founder of the „**Solarbier**“ concept: **Hubert Brandl**

Freitag, 25. März 2011 — DIE SEITE 3 — Der Pfaffenhofener | Seite 3

Hallertauer Erfindung reißt den deutschen Bierhimmel auf

Mit Solarbier und exquisitem Weißbierpils lässt Hubert Brandl für Freunde des Gerstensafts die Sonne aufgehen

Solarbier
Gebraut mit der Kraft der Sonne
drink green
TEN mit 24 Flaschen
CHAFT „drink green“
Umweltbilanz pro Flasche Bier
Felsenbräu
Normale Produktion
2 g CO2
73 g CO2
98 % weniger Umweltbelastung
Felsenbräu: drink green!
Schmeckt gut. Jeder Schluck ein Beitrag zum Umweltschutz.
Prost!
DIE UMWELTBRAUEREI
FELSEN BRÄU
Frische aus Franken. Das Beste am Tag.
FELSEN
ROCK 33
Edel Pils
Gebraut nach dem bayerischen Reinheitsgebot von 1516.

Solar Food Concept

FRITZ MÜHLENBÄCKEREI

Natürlich aus Tirol
Starkenberger Bier

WILDKAFFEE RÖSTEREI

Hergestellt mit der Kraft der Sonne
Solar-Food
und regenerativen Energiequellen

Certification institutions:

Technische Universität München

FACHHOCHSCHULE TECHNIKUM WIEN

www.solar-food.com

- **The appropriate use of the abundant solar energy can be regarded as a solution to the African energy problem. This requires highly qualified human resources at all levels.**
- **Presence of local qualified skills lead to acceptance of renewable energy technologies and reduction of energy end-price.**

Dr Akinwumi Adesina, President of African Development Bank, during 53rd Annual Meetings of the Board of Governors this year in Busan, South Korea:

„Africa must prepare its people for the jobs of the future, not those of the past. Africa must accelerate higher education, and vocational and technical training in building the skills of the future. In particular, greater emphasis should be placed on digitalisation, mathematics, material sciences, biotechnology, engineering, artificial intelligence, robotics and quantum computing. These areas will dominate the industrial revolution in the near future. And Africa must not be behind.

….

The continent needs to be strong in research and development. And this is a significant challenge. According to UNESCO, regional averages of GDP shares committed to R&D are 2.1% for East Asia and the Pacific, 2.4% for North America and Western Europe, and **a vanishing 0.4% for Sub-Saharan Africa**“

- 70 % of the research on renewable energy is theoretical.
- Lack of funds for experimental research!

Some Solution Approaches

- Pan African Universities (PAU) from the African Union (eg. PAUWES)
- African Centres of Excellence (ACEs) financed by the World Bank Group
- African Centre of Excellence (ACEs) financed by the African Development Bank
- Scientific Networks (ANSOLE, BALEWARE, MSSEESA, etc.)

ANSOLE: **A**frican **N**etwork for **So**lar **E**nergy

BALEWARE: **B**ridging **A**frica, **L**atin America and **E**urope on **Wa**ter and **R**enewable **E**nergies Applications

MSSEESA: **M**aterials **S**cience and **S**olar Energy Network for **E**astern and **S**outhern **A**frica

MSSEESA

- A network of 5 Universities: Nairobi, Eldoret (Kenya), Makerere (Uganda), Dar Es Salam (Tanzania) and the University of Zambia
- Funded by ISP (SIDA)
- -Sharing of Laboratory Equipments
- Exchange of students
- Joint event
- The coordination rotates after 3 years (a weakness of the network!)

Objectives of ANSOLE

Fosters technical and vocational education and training(TVET) in renewable energies (RE) at various skill levels (***capacity building***)

Fosters (experimental) research activities in RE & Water among African scientists and non-African scientists involved in the education of African students and experts (***capacity building***)

Promotes and encourages the use of RE in Africa (***public education, substainable development, business mediation, environmental protection***)

BRIEF HISTORY

- Initiated on the 4th of November 2010 in Sousse, Tunisia
- Launched on the 4th of February 2011 at LIOS, JKU Linz, Austria
- Registered as „ANSOLE e.V.“ on the 26th of January 2012 in Jena, Germany

Participants at the Launching of ANSOLE on the 4th of February 2011

Stand July 2018

ANSOLE has >1100 members in:

44 African Countries: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Chad, Central African Republic, Congo-Brazzaville, Democratic Republic of Congo, Cote d´Ivoire, Djibouti, Egypt, Ethiopia, Gambia, Ghana, Guinée Conakry, Kenya, Liberia, Lesotho, Libya, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Sudan, South Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe.

31 non -African Countries: Albania, Austria, Belgium, Britain, Canada, Chile, China, Czech Republic, Dubai, Estonia, Finland, France, Germany, India, Ireland, Italy, Luxembourg, Jordan, Malaysia, Mexico, Holland, Palestine, Portugal, Russian Federation, Saudi Arabia, Scotland, Spain, Sweden, Switzerland, Taiwan,Turkey, and USA

Members from > 300 Universities

Logos of Institutional/Company Members

UPPSALA
UNIVERSITET

DLR Deutsches Zentrum für Luft- und Raumfahrt

Institut für
Vernetzte Energiesysteme

Membership to ANSOLE

Any individual or corporate person supporting the goals of the network can become a member, either by downloading, filling and then sending the membership application form to the coordinator (daniel.egbe@ansole.org) or by filling the online interactive membership form.

Membership fees

- *Personal member (Africa)*: 20 €/year
- *Personal member (rest of the World) and ANSOLE e.V. member*: 30€ /year
- *Institutional member*: 200€/year
- *Company member 600€/year*

Activities of ANSOLE

(Co)Organisation of RE conferences, symposia, workshops & summer schools

- *Cameroon 2011,2012,2016 & 2017 (2X); Morocco 2013; Tunisia 2013 & 2017; Kenya 2013, South Africa 2013,*
- *Ghana 2014, Algeria 2015, Tanzania 2015 & 2016, Egypt 2016, Burkina Faso 2017, Germany 2017*
- *Upcoming events: Nigeria 2018, Austria 2018, Germany 2018, Kenya 2018, Cameroon 2018*

Assisting in the organization of non-ANSOLE RE related events worldwide

- *Hamburg 2011, Giessen 2012, Brussels 2012, Istanbul 2013, Berlin 2014, Dresden 2014, Tlemcen 2016, Brussels 2017*

Training, Education & Research

- *„Sur-Place" scholarships for Bachelor, Masters and PhD students*
- *Mobility scholarships for Masters & PhD students:*
  - **INEX**: Intra-African Exchange
  - **ANEX:** Africa-North Exchange
  - **ALAMEX:** Africa-Latin America Exchange (upcoming)

-ICTP funding (2011-2016)
- Now seeking for other funders

- Organisation of Vocational Training Programmes in cooperation with existing training institutions
- *Mediation of students & researchers from Africa and elsewhere to African & non-African research institutions*
- *Facilitation of research consortia within Africa and between Africa and Europe (research proposals)*

Organisation of study visits in Germany and elsewhere

- *Visit of PAUWES Science Slam Winners 2015 in Thuringia and Bavaria (May 2016)*

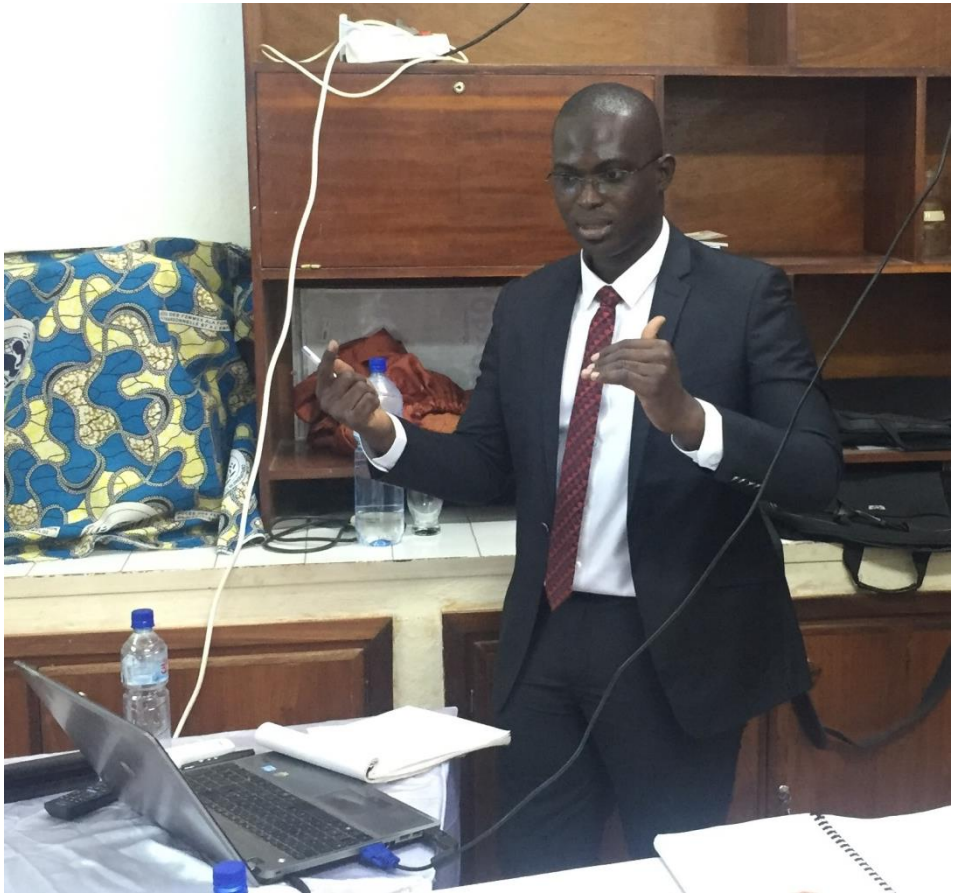
AFRICA-NORTH EXCHANGE (ANEX)

Egyptian PhD Fellow, Dr. Shaimaa Ali Mohamed: From experimental work at the Johannes Kepler University Linz, Austria to PhD defense at Benha University, Egypt on 24 May 2015

INTRA-AFRICA EXCHANGE (INEX)

Cameroonian PhD Fellow, Dr. Joël Hervé NKUISSI TCHOGNIA: From experimental work at the University of Mohammedia in Morocco to PhD defense at the University of Yaounde I in Cameroon in Oct. 2016

ANSOLE SUR-PLACE (ANSUP)



Beninese PhD Fellow, Dr. Alain Tossa at 2iE Ouagadougou Burkina Faso: From experimental research to PhD defense on 26 January 2017

Some ANSOLE Graduates in 2017

Upcoming Events

- ANSOLE DAYS 2018, 2-6 Sept, Mbouo Bandjoun, Cameroon (www.ansole.com)
- Summer School on SDG6, 22-30 June 2019, NUST, Windhoek, Namibia
- International Conference on Sustainability: Water & Renewable Energy (ICS:WARE 2019), 1-3 July 2019, NUST, Windhoek, Namibia
- ANSOLE DAYS 2019, Accra Ghana (Venue and date are still to be fixed)

Thank you for your attention