Energy Applications & Energy Efficiency (1)

Daniel Ayuk Mbi EGBE

African Network for Solar Energy (ANSOLE)

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ASP Online Lectures, 29 July 2021

Daniel Ayuk Mbi EGBE (Bridging People)

- Born on 20th of May 1966 in Mambanda-Kumba, Cameroon
- French Baccalaureat and English Advanced Level: 1986
- BSc in Chemistry and Physics at the then University of Yaounde in 1991
- Diplom (1995), PhD (1999) and Habilitation (2006) at the FSU Jena, Germany
- MPI-P Mainz (2006), TU Eindhoven (2006-2007), TU Chemnitz (2007-2008),
- **JKU Linz (Since 2009) +Energieinstitut an der JKU as from October 2021**

- **Board member of World University Service (WUS) e.V.**

- Initiator of German-Cameroonian Coordination Office (KBK)
- Initiator and international coordinator of ANSOLE & Chairperson of ANSOLE e.V.
- Member of Migrations-und Integrationsbeirat der Stadt Jena
- Board member of MigraNetz Thüringen e.V.
- Initiator and coordinator of BALEWARE

- **Independent evaluator for various international institutions in capacity building issues**
- Research Agenda committee member of PAUWES in
- **First Distinguished Brian O´Connell Visiting Fellowship for African Scholars of the University of the Western Cape, South Africa**
- Visiting Professor at various African Universities

- Published till date125 peer-reviewed articles, H-index= 31 Citations > 3500
- Speak more than 5 languages
- Father of 4 children, believing christian
- **Hobbies: Cooking, jogging and dancing Salsa**

Sustainable Development Goals (2016-2030)

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

https://www.bertelsmann-stiftung.de/fileadmin/files/user_upload/Sustainable_Development_Report_2019_Complete.pdf

AFRICAN NETWORK FOR SOLAR ENERGY (ANSOLE)

www.ansole.org

- Initiated on 4 November 2010 in Sousse Tunisia by D. A. M. Egbe (Coordinator)
- Launched on 4 February 2011 at Johannes Kepler University Linz, Austria
- Registered as NGO (ANSOLE e.V.) on 26 January 2012 in Jena Germany
- **Focus: Training, Education and Research (+ Entrepreneurship) in Sustainable Energies**
- > 1120 members in 45 African and 31 non-African countries
- Members from > 300 universities
- So far (co)organized 30 scientific events in 16 countries
- Has graduated 13 PhDs) and 1 MSc thru its 3 fellowship programs (2011-2016)

→ **INEX** (intra-African Exchange)

→ **ANEX**´(Africa-North Exchange)

→ **ANSUP** (ANSOLE Sur-Place)

- Facilitator of joint research proposals within Africa and between Africa and Europe.
- ANSOLE office in Jena Germany: Focal Point for People of African Origin (AMAH-Project)

BRIDGING AFRICA, LATIN AMERICA AND EUROPE ON RENEWABLE ENERGY AND WATER (BALEWARE)

- Initiated on 29 May 2015 in Curitiba Brazil by D.A. M Egbe (Coordinator)
- Platform under ANSOLE
- Officially launched on 12 Dec 2016 in Arusha, Tanzania,

www.baleware.org

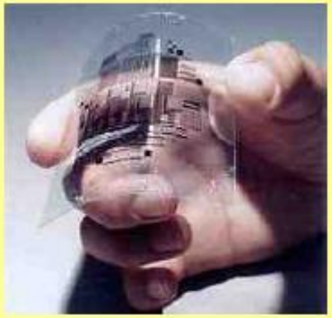
Organic Semiconductors

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

Organic materials

Organic light emitting diodes

Photovoltaic cells



Transistors and memory

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 >17 %
- •Perovskite Solar Cells: η >20 %

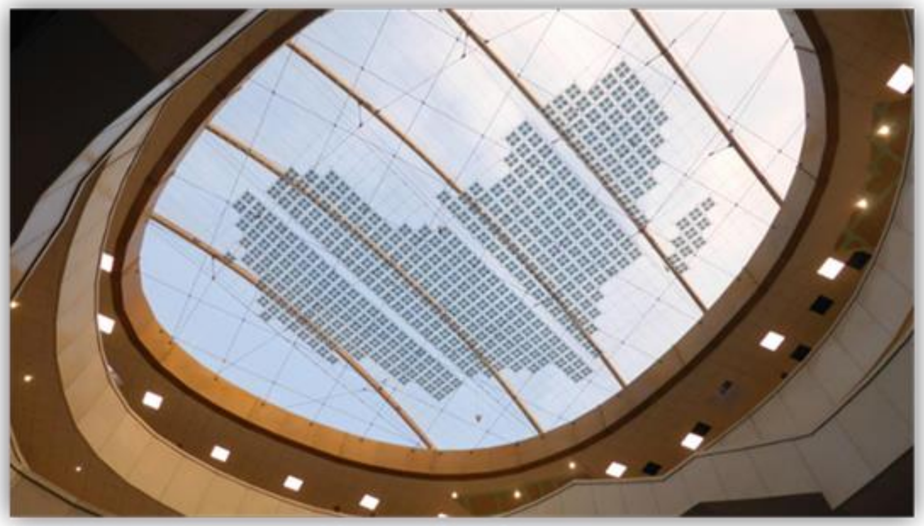
Energy Payback Time:

OPV: 100 h << 1 year

Silicon: 1-3 years

Wind: 18 months

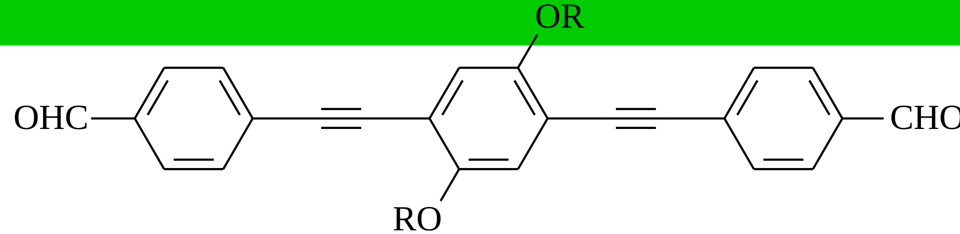
Organic Photovoltaics (OPV)



Solar charger utilizing a flexible OPV panel (*left*),[1] and OPV installation at the African Union's Peace and Security building in Addis Ababa (*right*).[2]

[1] https://infinitypv.com/products (Jan. 2018)

[2] http://www.osadirect.com/news/article/1519/ (Sep. 2015).




Science & Art

nature photonics

ARTICLES

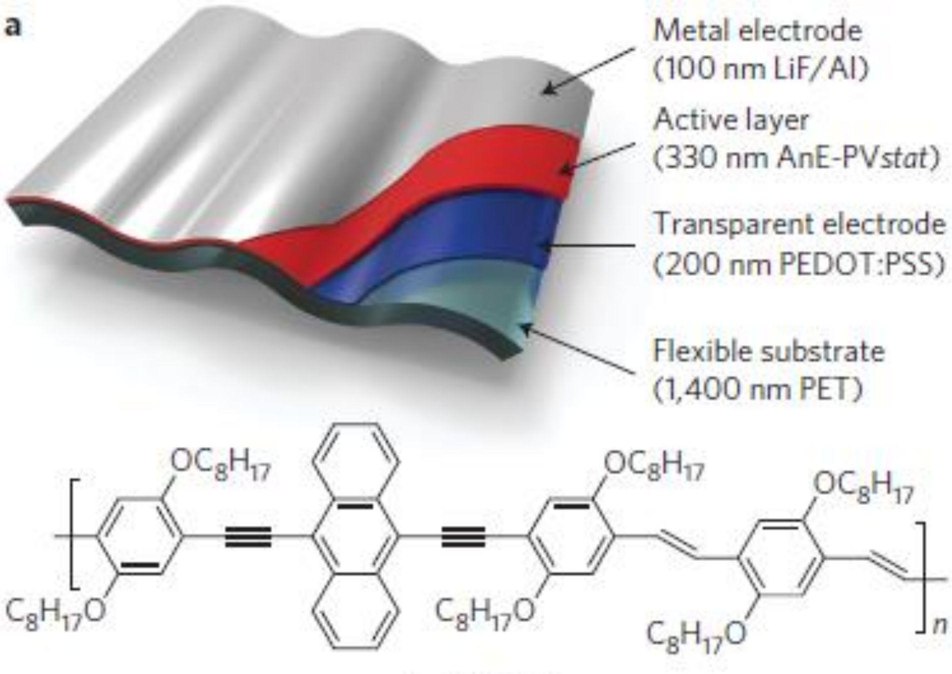
PUBLISHED ONLINE: 28 JULY 2013 | DOI: 10.1038/NPHOTON.2013.188

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.

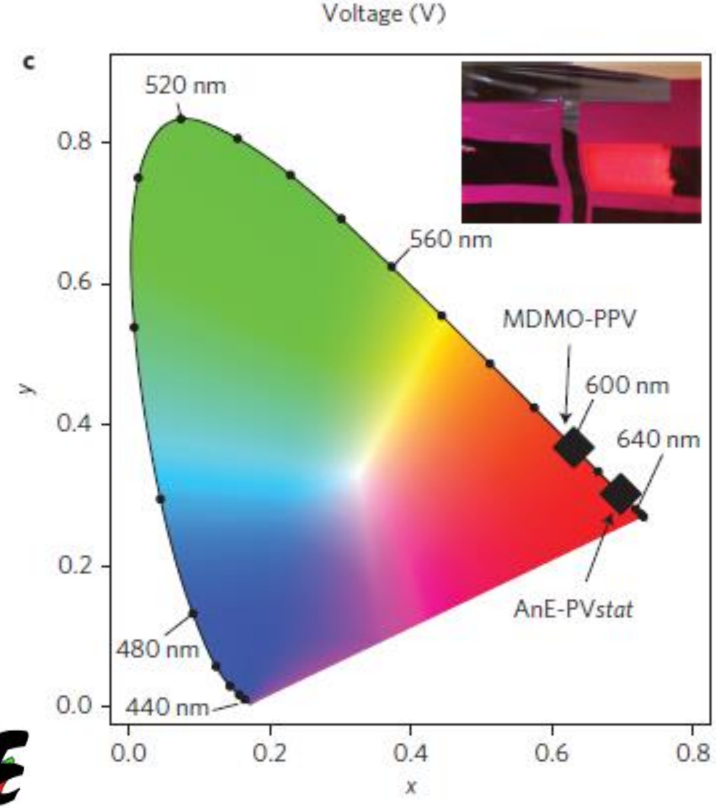
a



AnE-PVstat

S. AAZOU (ANEX, Morocco-Austria)

c



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

R&D in Africa

13.4%
of world's population

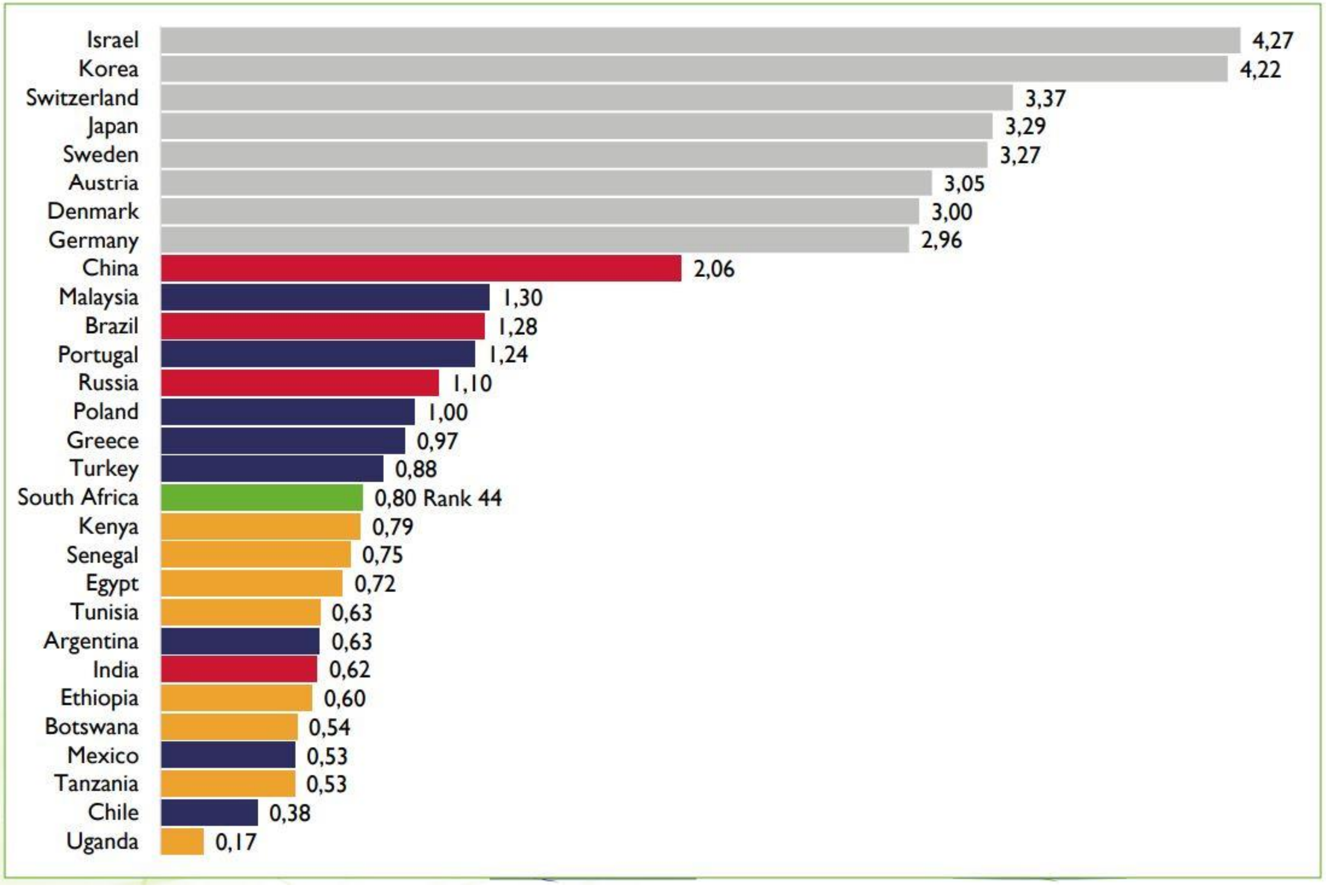
92
researchers per million inhabitants

1.4%
global scientific publications

0.41%
of GDP spent on R&D as compared **to 2.1%** for Asia **and 2.4%** for North America and Europe

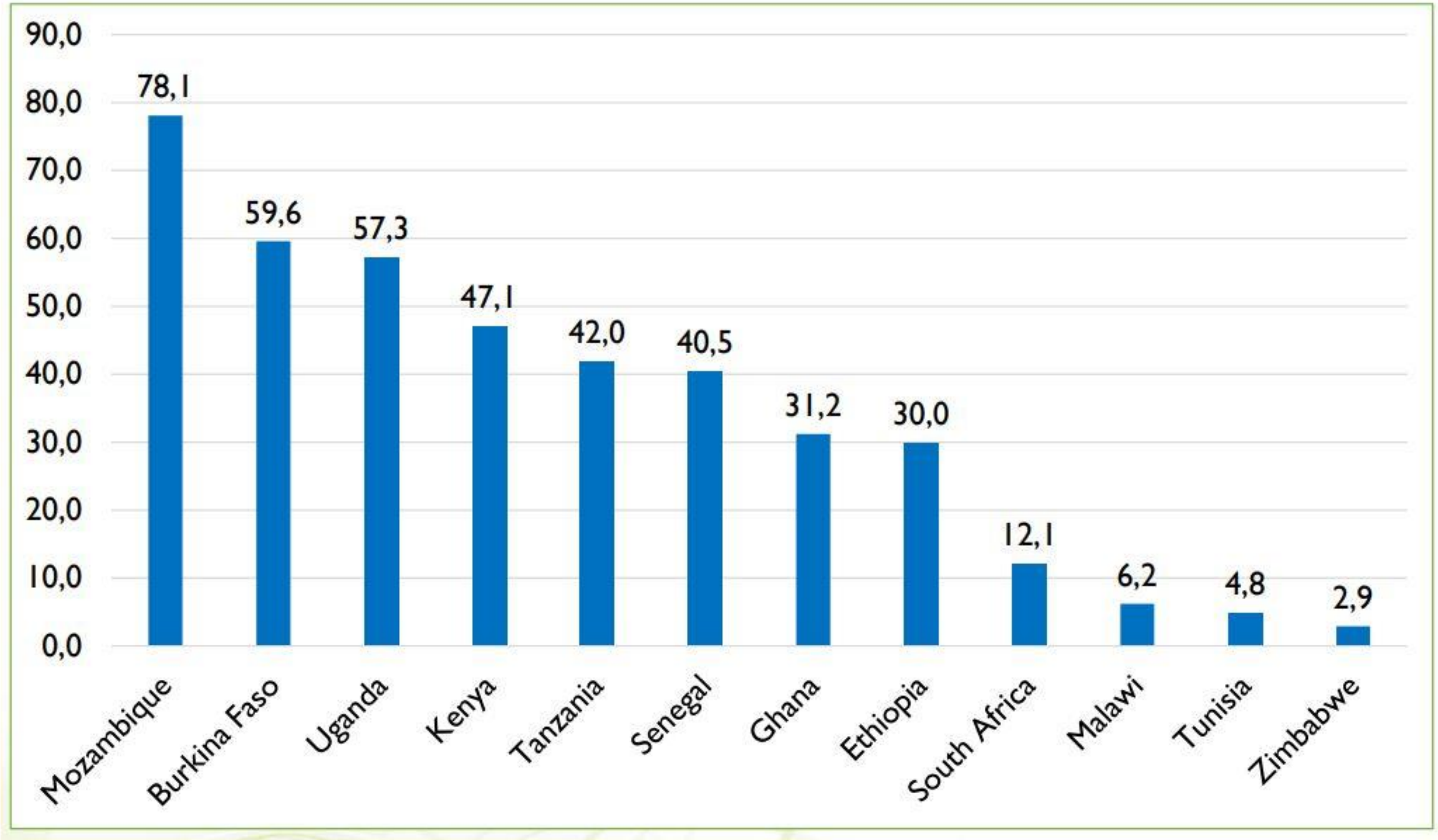
The PASET Regional Scholarship and Innovation Fund
PASET
An Africa-led initiative to bridge the skills gap in Applied Sciences, Engineering, & Technology

Investment in Research and Development as % of GDP



Skupien, S. Lecture at Africa Day 2019 in Jena Germany

Share of external research and development funding in %



Skupien, S. Lecture at Africa Day 2019 in Jena Germany

Self-perceived challenges to careers of young researchers

Challenges to their careers ...	Overall rank	Rank by age		
		39 and younger	40 to 50	Older than 50
Lack of research funding	1	1	1	1
Lack of funding for research equipment	2	2	2	2
Balancing work and family demands	3	6	3	3
Lack of mentoring and support	4	4	3	4
Lack of mobility opportunities	5	5	5	5
Lack of training opportunities to develop professional skills	6	3	4	6
Lack of access to library and/or information sources	7	7	6	7
Limitation of academic freedom	8	9	7	8
Job insecurity	9	8	8	10
Political instability or war	10	10	9	9

Source: Beaudry, Mouton, Prozesky (ed) 2018: The next generation of scientists in Africa

Necessary measures to attain international standards

-**Conducive study and research environment**:

- Available permanent and environment-friendly electrical energy
- Permanently clean and functional sanitation and clean environment
- Health and safety regulation taken serious!
- Permanent maintenance and repair entity
- Permanent easy acessibility of high speed internet
- **Online subscription to the worldwide renowned scientific journals**

-**Strong "Independent" country-based and Africa-based research funding mechanisms (at least 1 % of GDP allocated to R&D)** in addition to foreign funding mechanisms

- Early training of research student in writing of publications and research grants

-**Adopt the 4th industrial revolution (4IR) in all HE processes**

- Knowledge acquisition is not limited to a lecture room (classroom)
- The World (digital World) is the classroom of the future
- The Lecturer or supervisor takes the role of a mentor. He or she is ready and is not ashamed to learn from the student.

-**Strong regional, continental and international scientific cooperations**

-Internationalisation of the HE system by incorporation of international scientists

-**Always think of the SDGs in every action!!!**

Energy Applications & Energy Efficiency

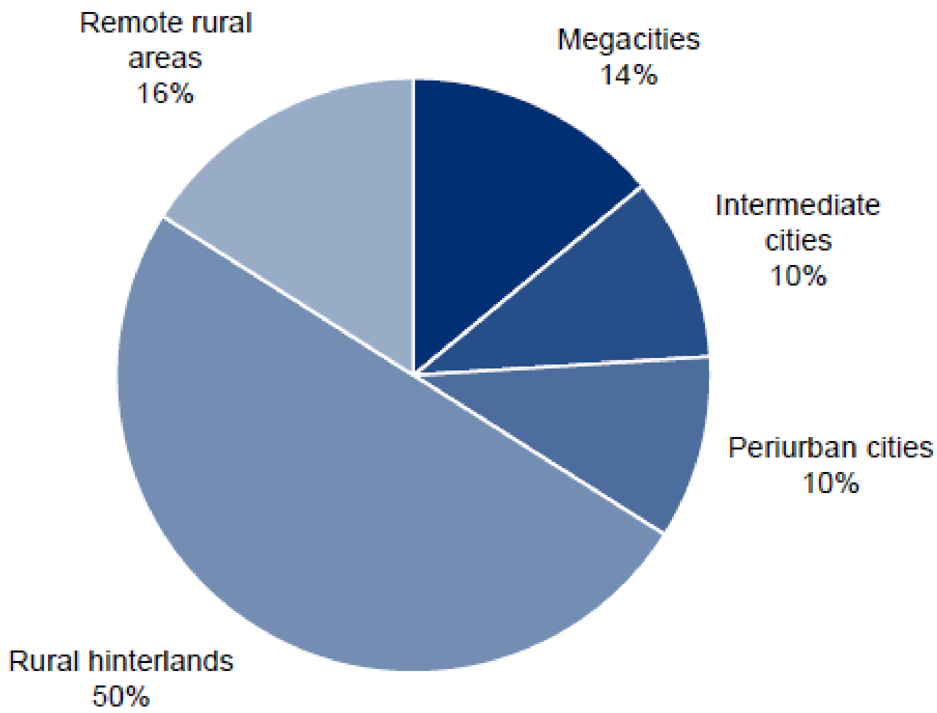
Slides obtained from lectures of the following:

Dr Anne Riahle, CEO of AERE France
Prof. Yao Azoumah, PAUWES, Tlemcen, Algeria
Prof. Daniel Yamegueu,2ie Ouagadougou Burkina Faso
Prof. Yacouba Koulibaly, 2ie Ouagadougou Burkina Faso

Energy context in Africa

Africa : unequal access to energy (rural vs urban)

Electricity access in 2014 - Regional aggregates			
Region	Electrification rate %	Urban electri-fication rate %	Rural electri-fication rate %
Africa	45	71	28
Sub-Saharan Africa	35	63	19



SUB-SAHARAN POPULATION DISTRIBUTION BY SETTLEMENT TYPE
SOURCE: FOSTER AND BRICENO-GARMENDIA, 2010.

©LESEE-2iE

Energy context in Africa

The role of Renewables

Under the United Nations (UN) Sustainable Energy For All (SE4ALL) initiative, the international community established a <u>target to double the share of RE (over 2015 levels) to 36% by 2030.</u>

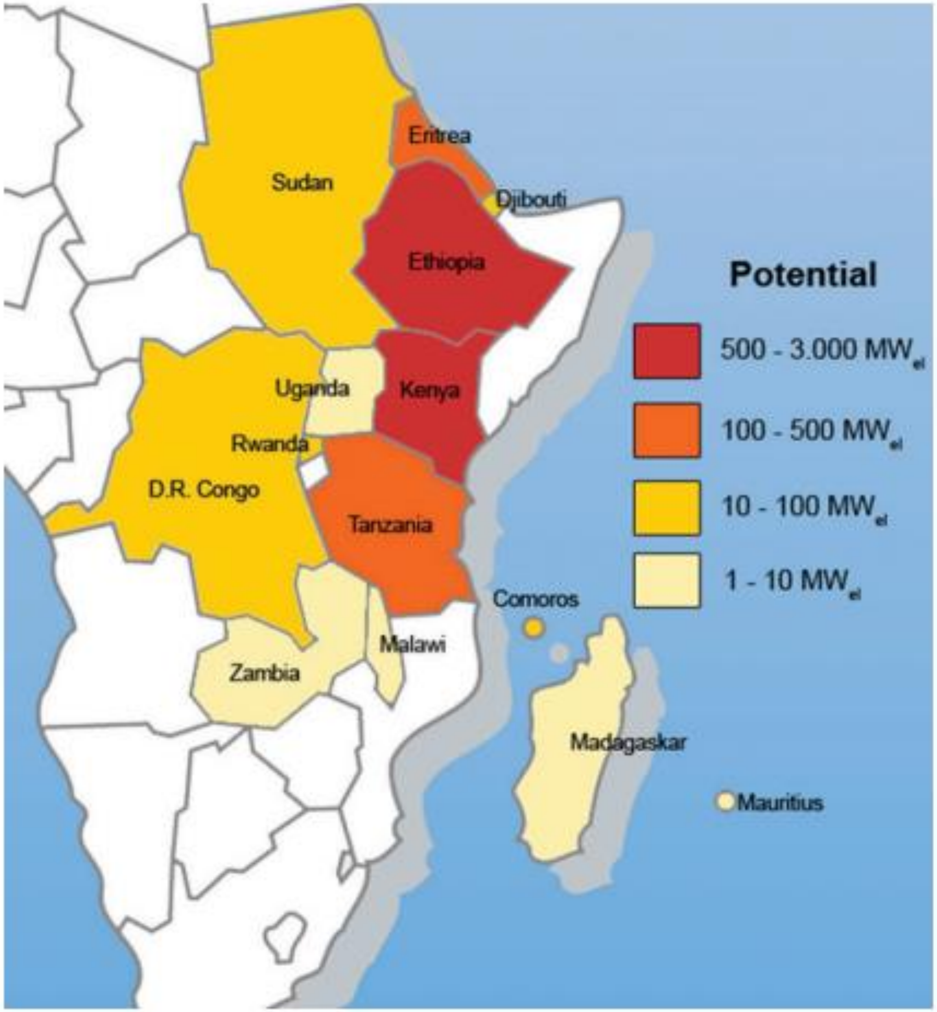
- **Renewables are key to the goal of ensuring "access to affordable, reliable, sustainable and modern energy for all" included in SDG 7 – one of the 17 SDGs adopted in 2015 by the international community**
- **Meeting SDG 7 on energy reinforces a wide range of other key goals. Renewables contribute to environmental sustainability, create conditions to further human development by facilitating access to basic services, improving human health and enhancing incomes and productivity.**
- **Renewables also create new jobs and spawn new local industries.**

Renewable Energy Potential in Africa

Pan African University
Institute of Water
and Energy Sciences

Energy resources in Africa

Energy potentials : renewable energy resources (geothermal)



Geothermal energy

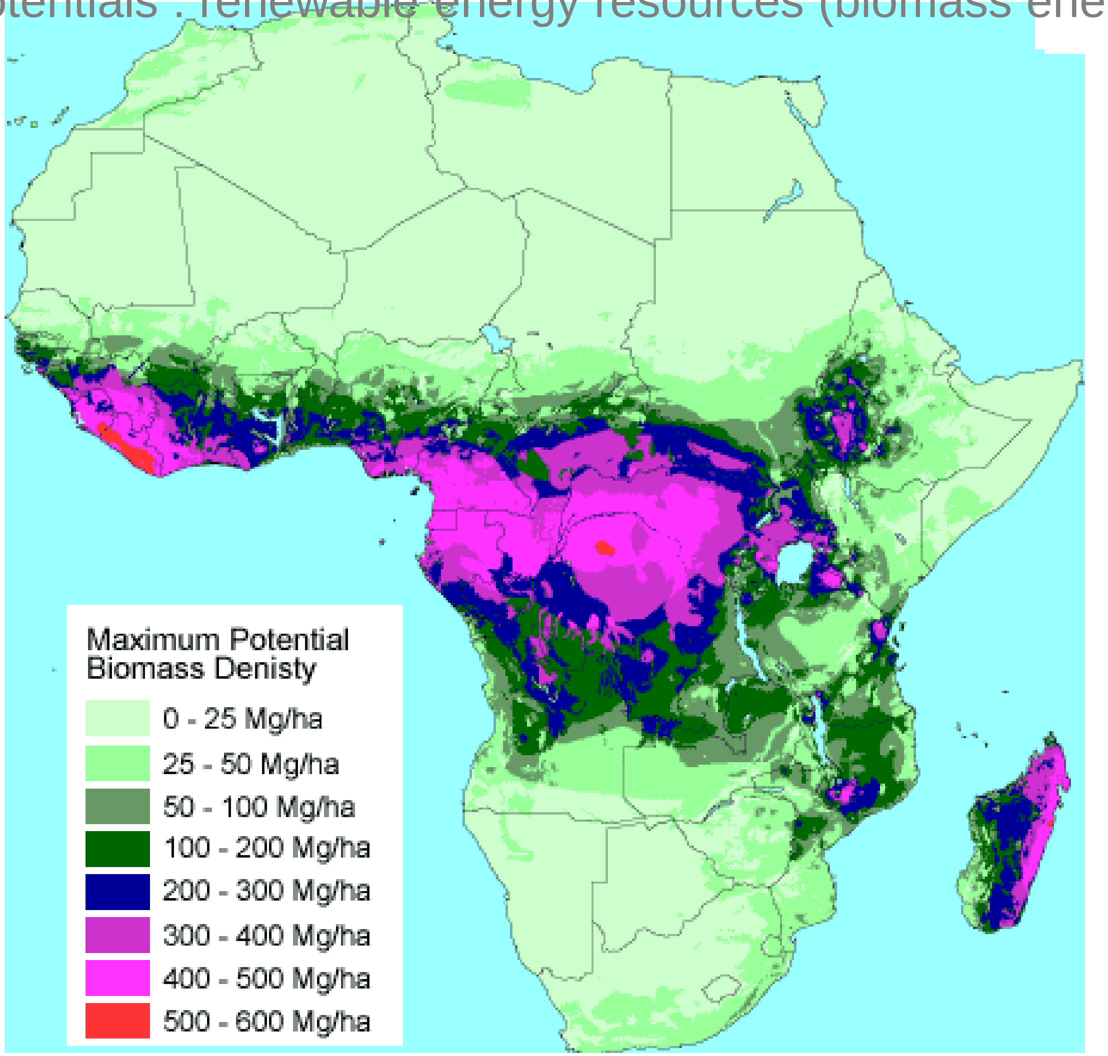
More concentrated in Eastern Africa

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,

Rapid deforestation due to need for cooking wood and cooking charcoal

- Solar Cookers + Fireless Cookers and Wood-Saving Stoves can slow down deforestation.
- Reafforestation is a must!!

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

www.adesolaire.org

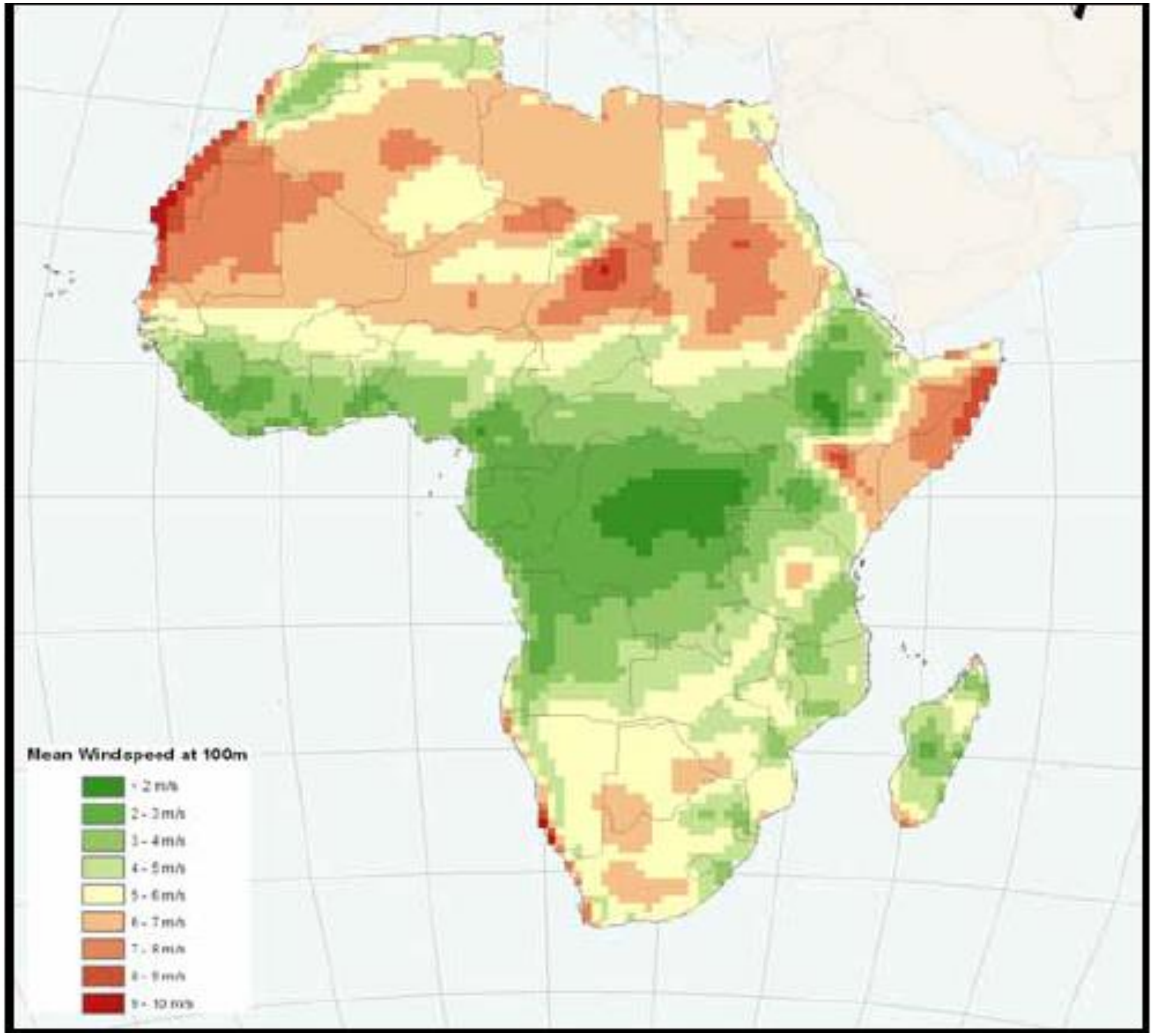
Pan African University
Institute of Water
and Energy Sciences

Energy resources in Africa

Energy potentials : renewable energy resources (wind energy)

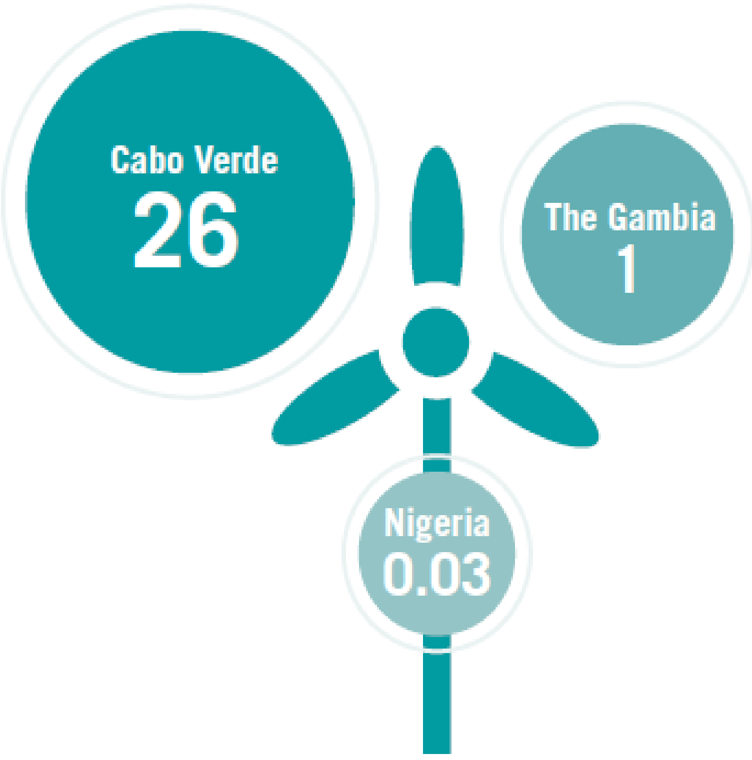
Wind energy
20% of global energy

More concentrated in northern and southern parts of the continent



PAUWES, Prof. Yao Azoumah,

Renewable energy resources potential in Africa



Power capacity(MW)

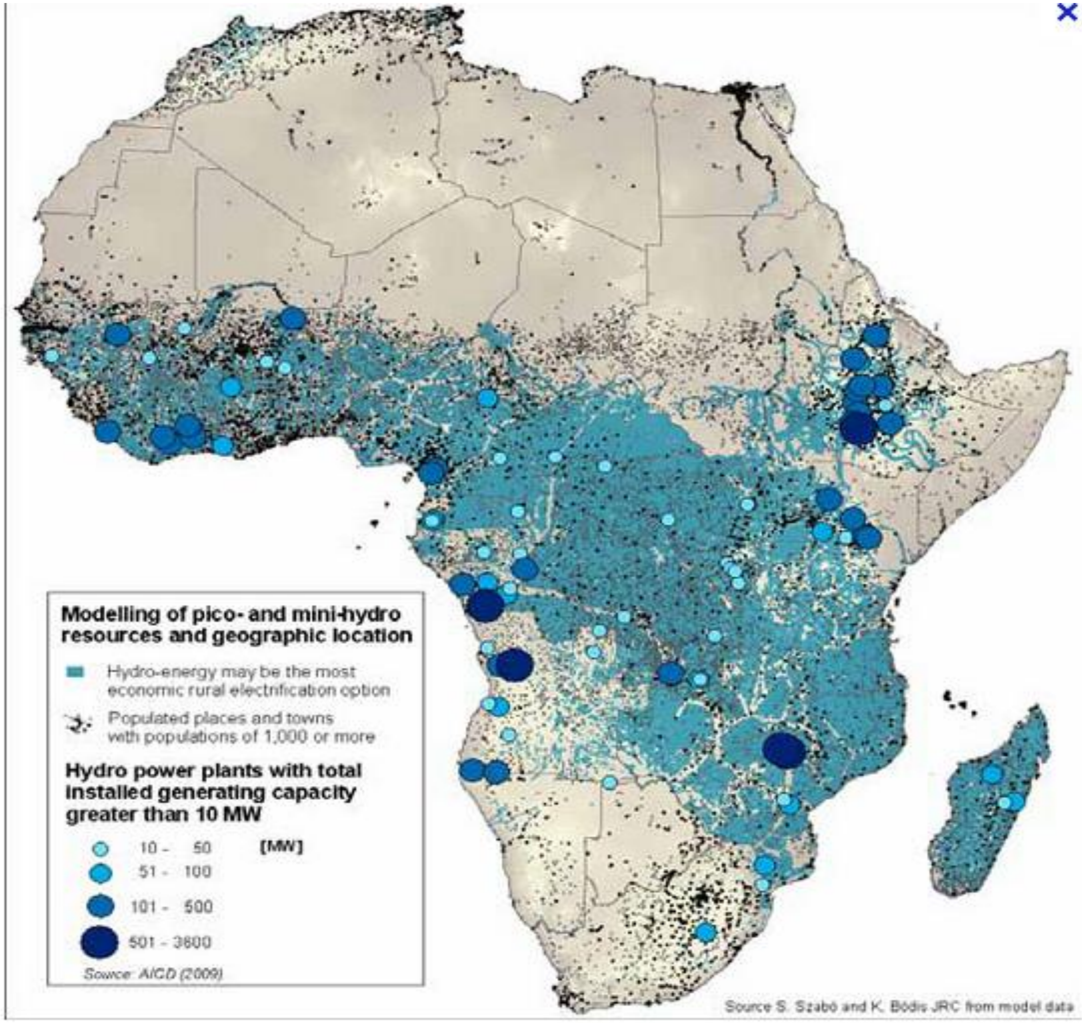
- **Potential for wind power generation is generally best along the coasts of ECOWAS member states,**
- **Mean wind speed at 50m averages above 6 m/s in many countries of Ecowas (eg. Mali, Niger, Senegal, Gambia, Ghana, Togo, etc.)**
- **Cabo verde, has been highilited (by AfDB) as having the best wind potential in west Africa,**
- **Few member states have significant experience with wind power to date, interest is growing, with several major projects having come on line recently or in the pipeline**

Pan African University
Institute of Water
and Energy Sciences

Energy resources in Africa

Energy potentials : renewable energy resources (hydro energy)

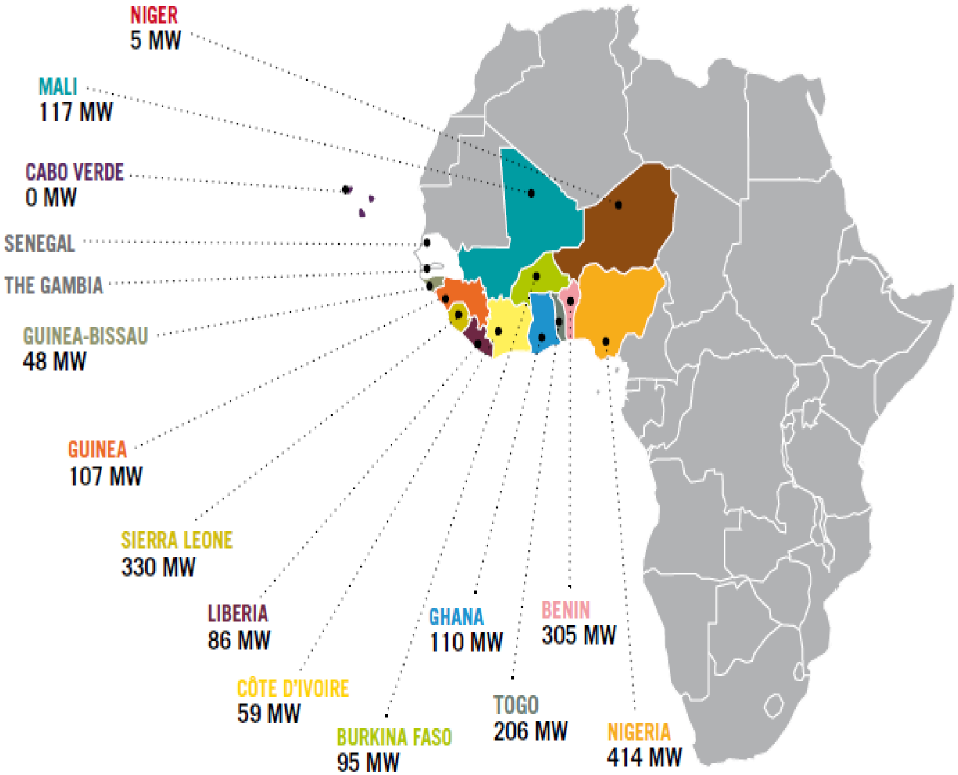
Hydro production potential of 1440 TWh/year



PAUWES, Prof. Yao Azoumah

Renewable energy resources potential in Africa

✓Hydropower / ECOWAS



Estimated Small-Scale Hydropower Potential

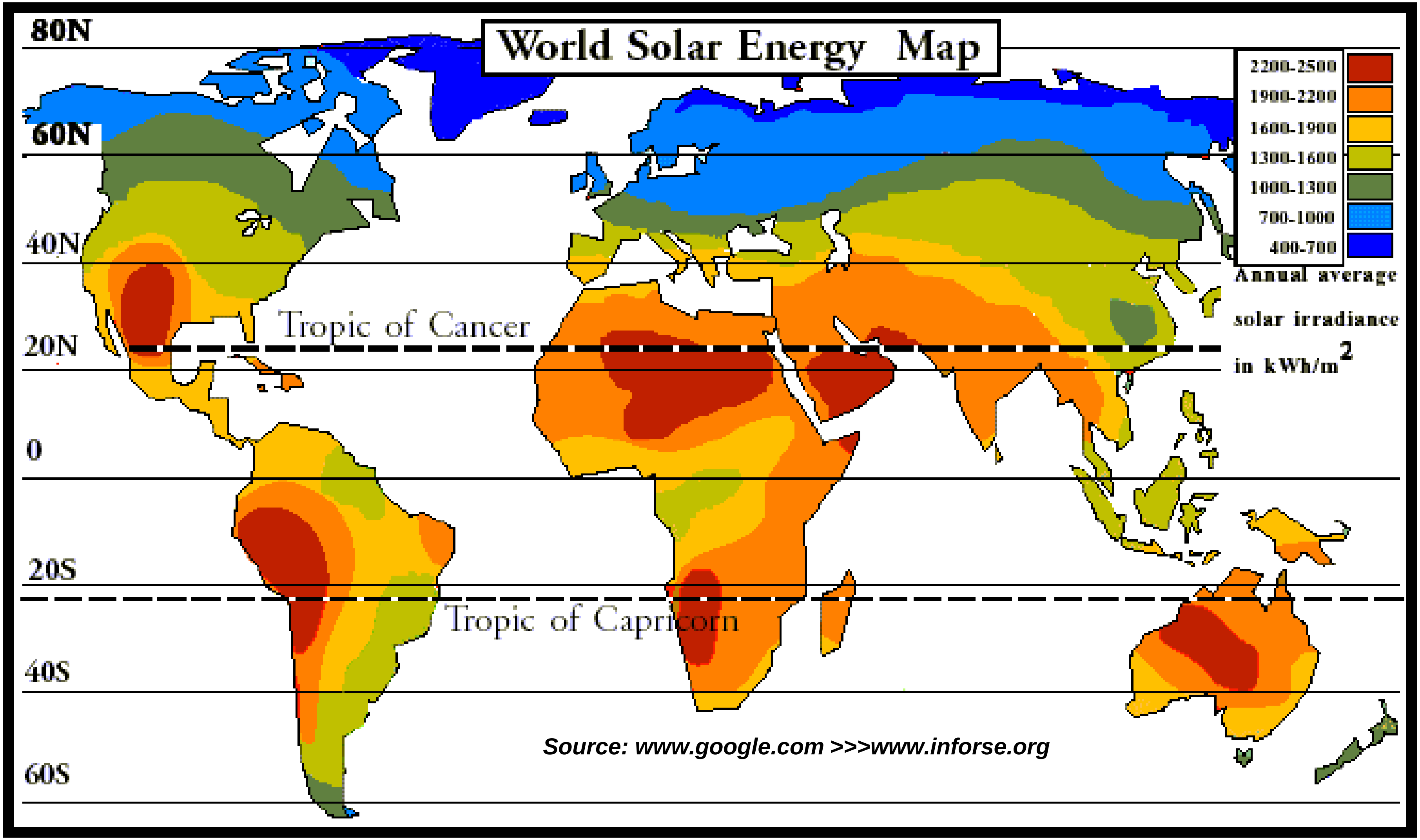
- Hydropower is the most well established and widely used RE technology in west Africa

  In most member states, Hydropower represents the only RE technology currently being implemented on a commercial scale.

- With a region-wide hydropower potential of some 25 GW, only 19% is exploited (2014)

- Ghana, Guinea, and Nigeria have particularly significant resources

- Most Member States demonstrate potential for small-scale hydropower development

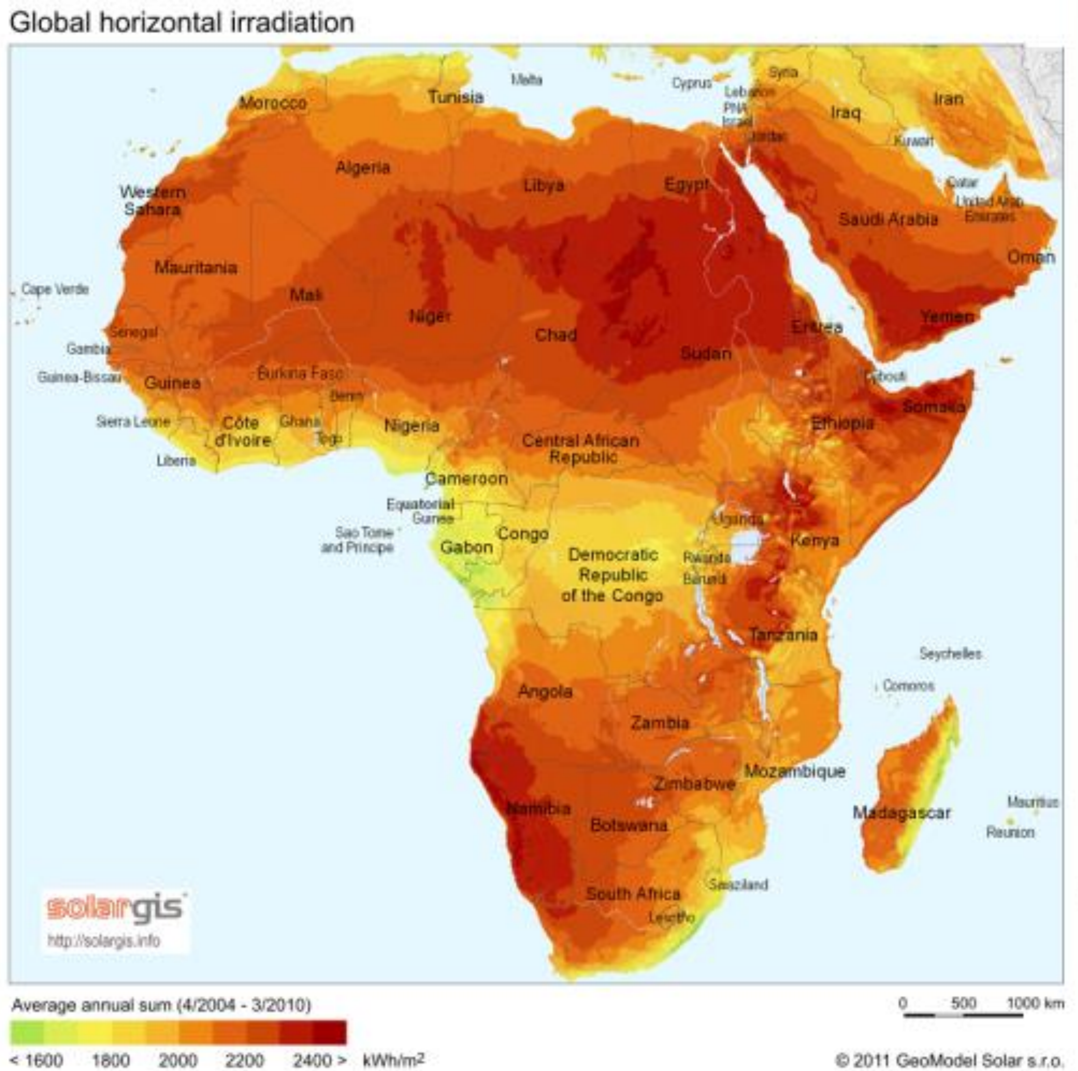


PV Technologies: silicon technology adaptable to specific African environments, Concentrated and Highly Concentrated Photovoltaics, Concentrated Solar Power, 3rd generation solar cells (Organic, DSSC, Perovskites)

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,

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

Hallertauer Erfindung reißt den deutschen Bierhimmel auf

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

drink green
Solarbier®
Gebraut mit der Kraft der Sonne
STEN mit 24 Flaschen
SCHAFT „drink green“
Umweltbilanz pro Flasche Bier
Felsenbräu
Normale Produktion
2 g CO_2
73 g CO_2
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.
Solarbier
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:

TUM
Technische Universität München

FACHHOCHSCHULE
TECHNIKUM WIEN

www.solar-food.com

Energy Intensity

Area/Country	Energy Intensity (2009) ktoe/M$
ECOWAS	0,56
China	0,46
USA	0,16
Latin America	0,13
EU	0,11
Japan	0,09

How much energy is consumed to produce a unit of economic output?

Which losses from the production to the consumption ?

Low energy intensity = a more efficient economy

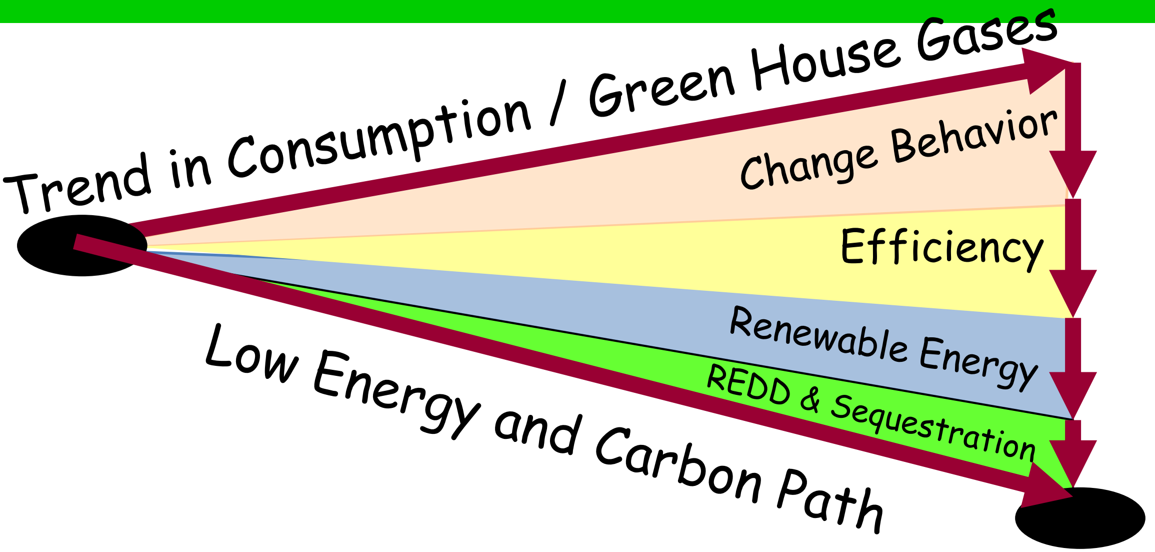
→ In the electricity sector, about one third of power generated is lost before it reaches clients

Energy Savings

Possible to **save 30 to 40%** of the energy in West Africa

25% savings for electricity ↔ **4 000 MW** of power

- High efficiency lamps (LED, CFL)
  - Savings of 10% of power
  - Annual CO_2 reduction of 1 $MtCO_2eq$
- Improvement of the electricity distribution network
  - 10 to 20% energy savings (15-40% lost today)
  - Annual CO_2 reduction of 2 $MtCO_2eq$
  - Savings of power of 1 400 MW



ENERGY EFFICIENCY, A KEY TOOL FOR OTHER POLICIES

Source : SEEA-WA, CEREEC

What prevents energy efficiency development?

Numerous barriers

- Limited political awareness
- Limited consumer awareness
- Lack of a supporting incentive structure
- Lack of specific financial mechanisms to capture the economic potential of savings
- Technical barriers

- **Second-hand market to regulate**

No general recipe to remove these obstacles

A PROPOSAL: THE AFRICAN ENERGY AWARD®

A continuous improvement award, made to identify, evaluate and share the best pratices

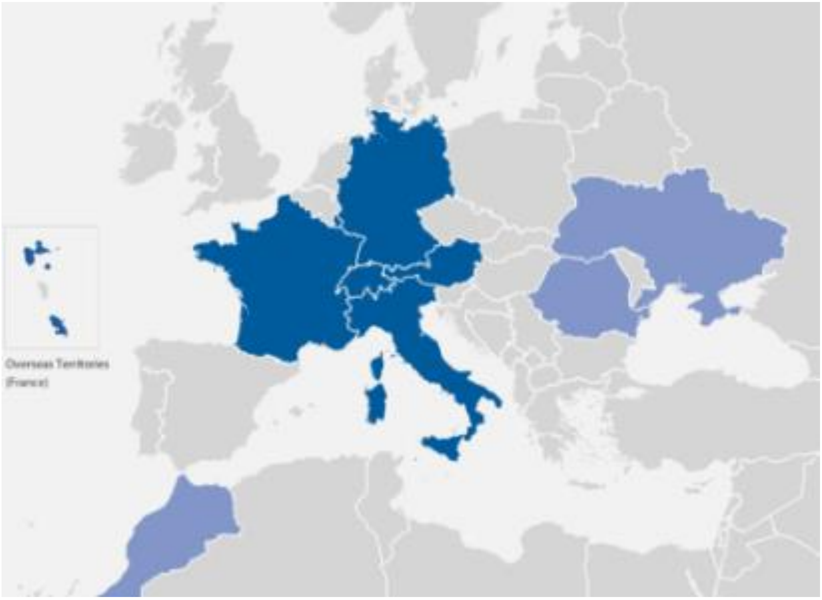
A policy of continuous improvement

The European energy award®

- Award for energy actors, countries and communities, declined for every country

Country	Population	Participating communities
Germany	23 M	320
France	10 M	118
Swizerland	5,3 M	637
Austria	1,9 M	194
Luxembourg	0,6 M	96
Italy	0,5 M	29
Liechtenstein	0,04 M	11
Monaco	0,04 M	1
« Pilot » countries	2,2 M	9

european energy award



Thermal Regulations in Buildungs

In sub-Saharan Africa and all tropical countries, air conditioning is the largest energy consuming item in buildings.

When air conditioning is not available, thermal discomfort is such that some houses are unbearable.

In order to save Energy, one must avoid as much as possible using active air conditioning and use passive air conditioning instead.

Golden rule : Before cooling one must avoid heating.

Before building a house, energy consumption and thermal comfort must be considered.

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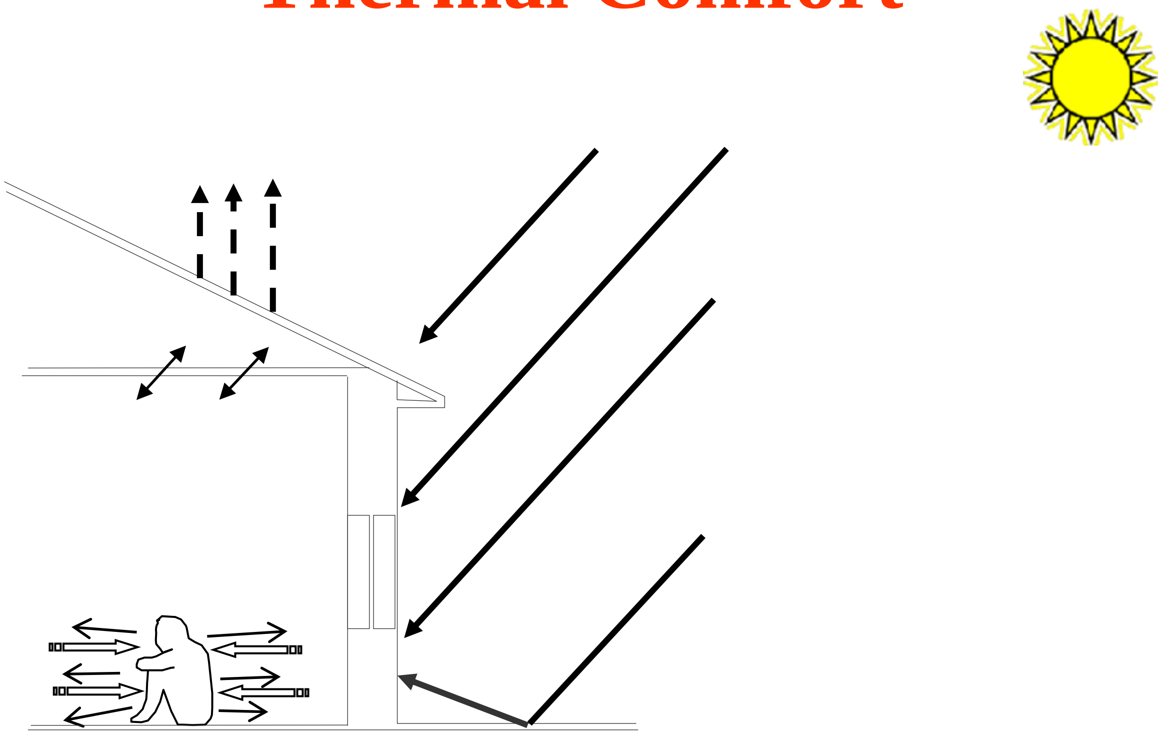
Thermal Comfort



- Thermal comfort is the state of satisfaction felt in a thermal environment.
- It is achieved when the body feels neither hot nor cold.

Thermal comfort

Thermal comfort can be achieved by using:

- Passive air conditioning or green architecture
- Appropriate equipment for air conditioning
- Adequate ventilation
- Etc.

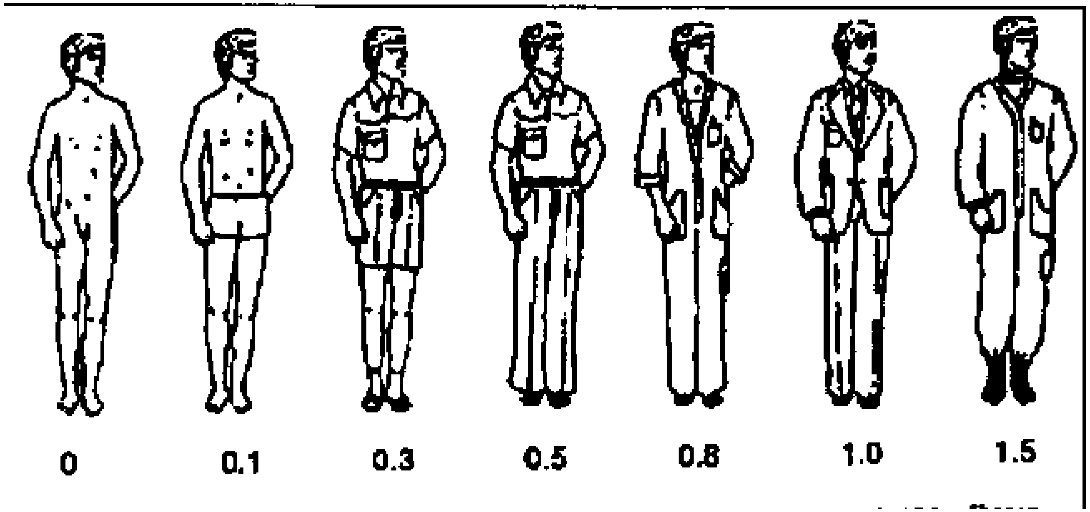
Thermal comfort

TC is a subjective notion.

It depends on age, sex, geographical origin, clothing, physical activity, health etc.

TC depends also on objective conditions such as:

- **Temperature of the ambient air**
- **Humidity of the ambient air**
- **Air velocity**

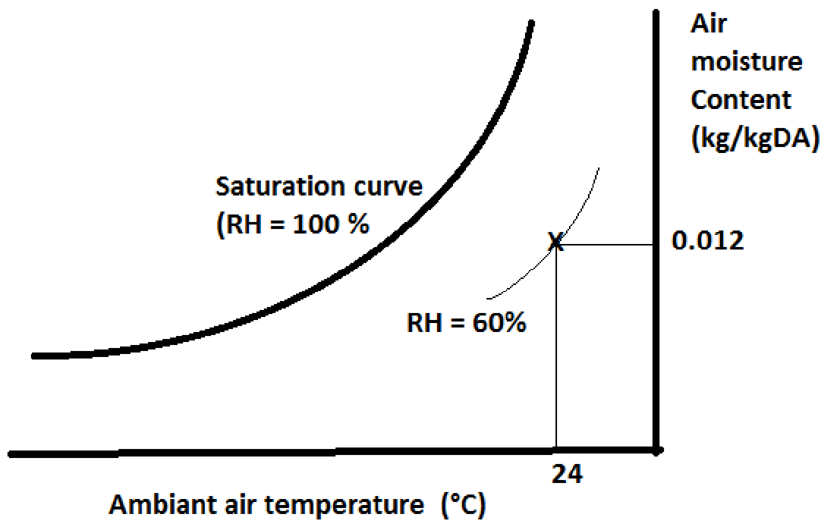


Thermal comfort

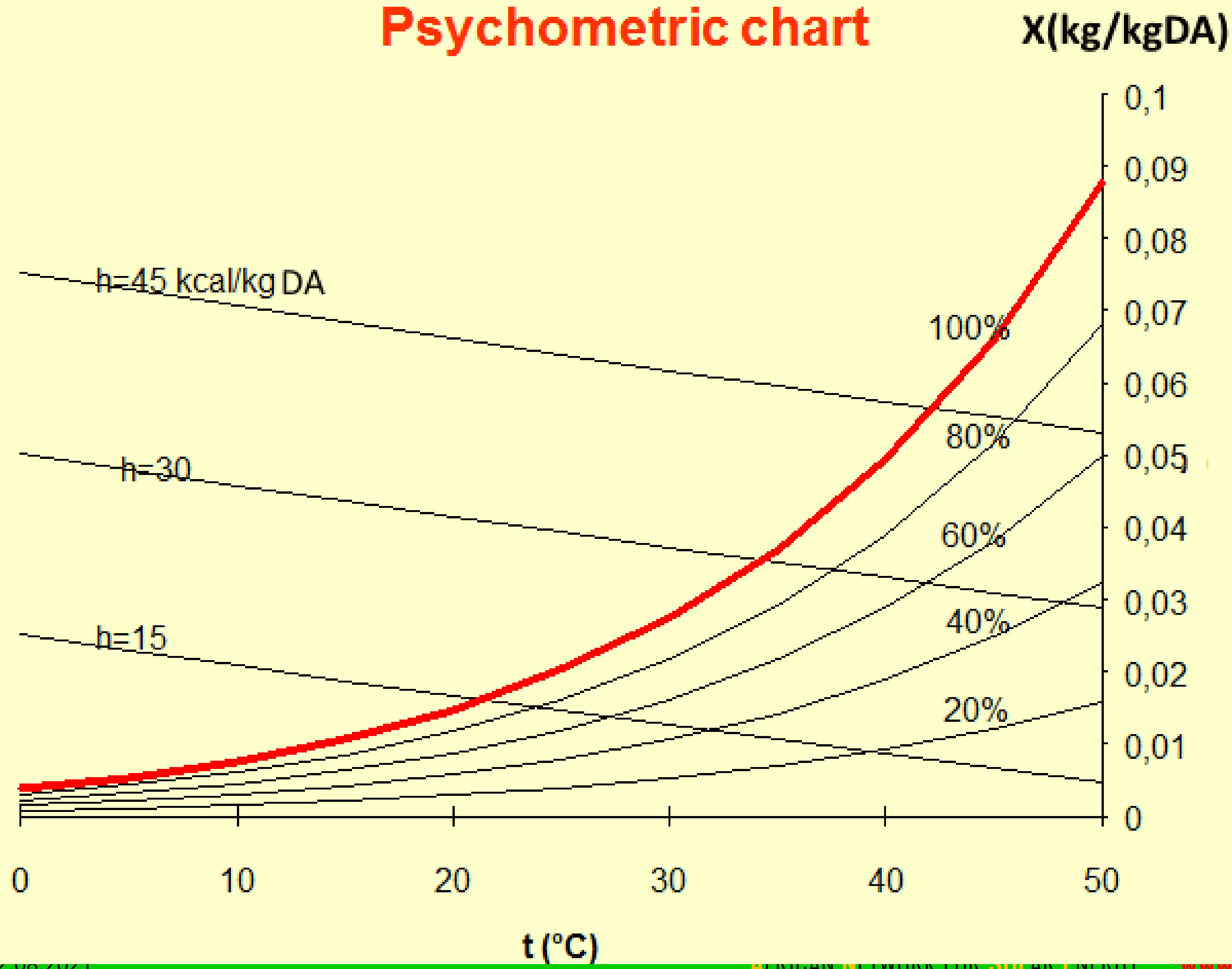
In order to characterize TC, **temperature and humidity are generally the main parameters** that are considered.

Air velocity and radiant temperature are equally important even if they are often neglected.

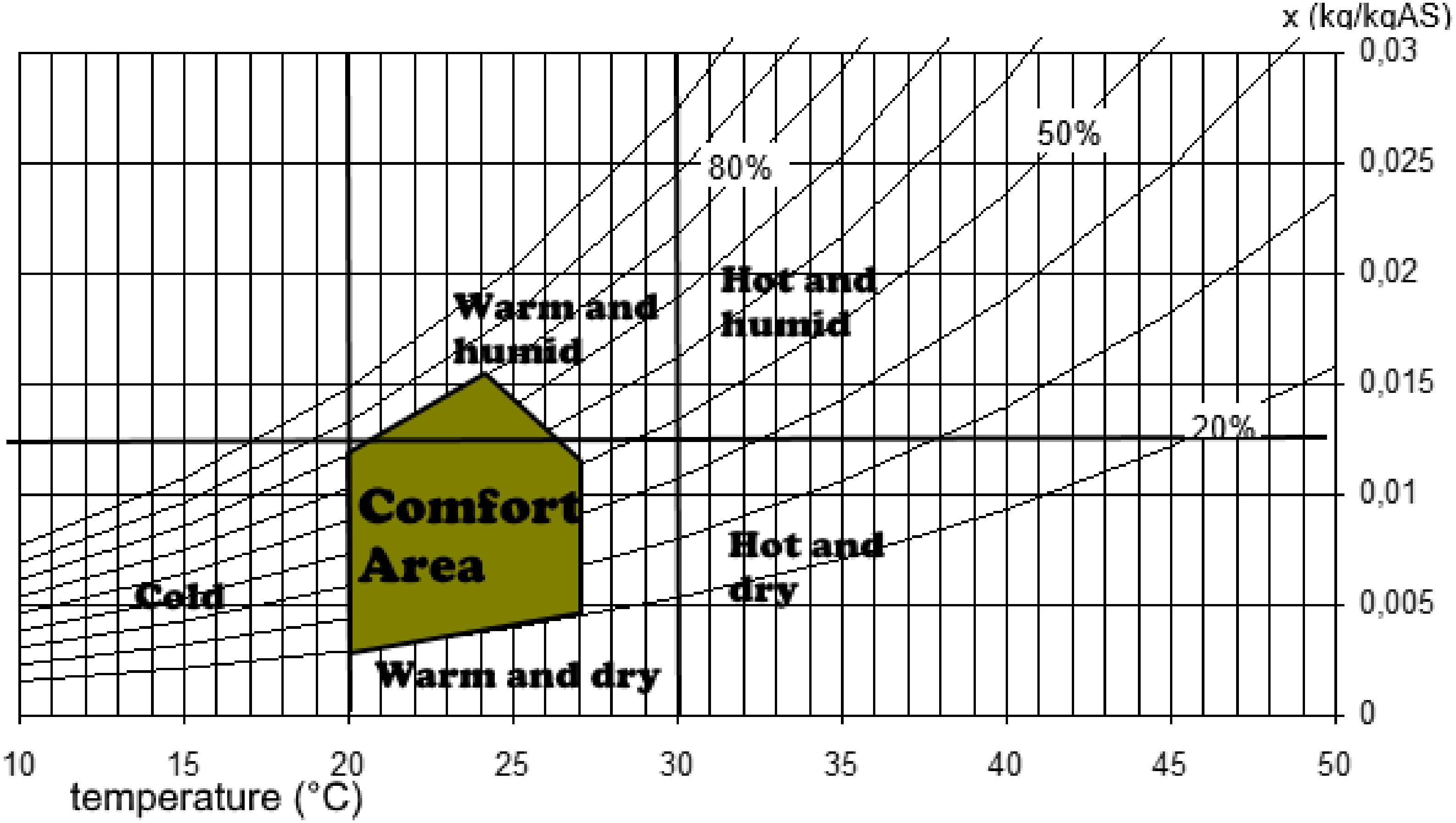
Optimal conditions for TC are close to **24 °C, 50%.**



Psychometric chart



Thermal comfort



Comfort zone =

20°C < Temperature < 27°C
20 % < Air Humidity < 80 %

Thermal Comfort

Measurement of thermal comfort using the PMV and PPD indexes

The sensation of heat and cold is determined by a thermal equilibrium depending on various parameters such as :

- Metabolic rate (M)
- Activity (W)
- Clothing (Icl, fcl, tcl)
- Objective parameters (Temperature (ta), humidity(Ps), wind velocity (V))
- Etc.

The PMV (or Predicted Mean Vote) is the index of comfort calculated using these parameters :

$$\mathbf{PMV = f(M, W, I_{cl}, f_{cl}, t_a, t_r, V, P_s(t_a), h_c, t_{cl})}$$

Thermal comfort

PMV et PPD

The PMV is given in a scale of sensation ranging from -3 to +3

-3	-2	-1	0	+1	+2	+3
cold	cool	Slightly cool	Neutral	Slightly warm	Warm	Hot

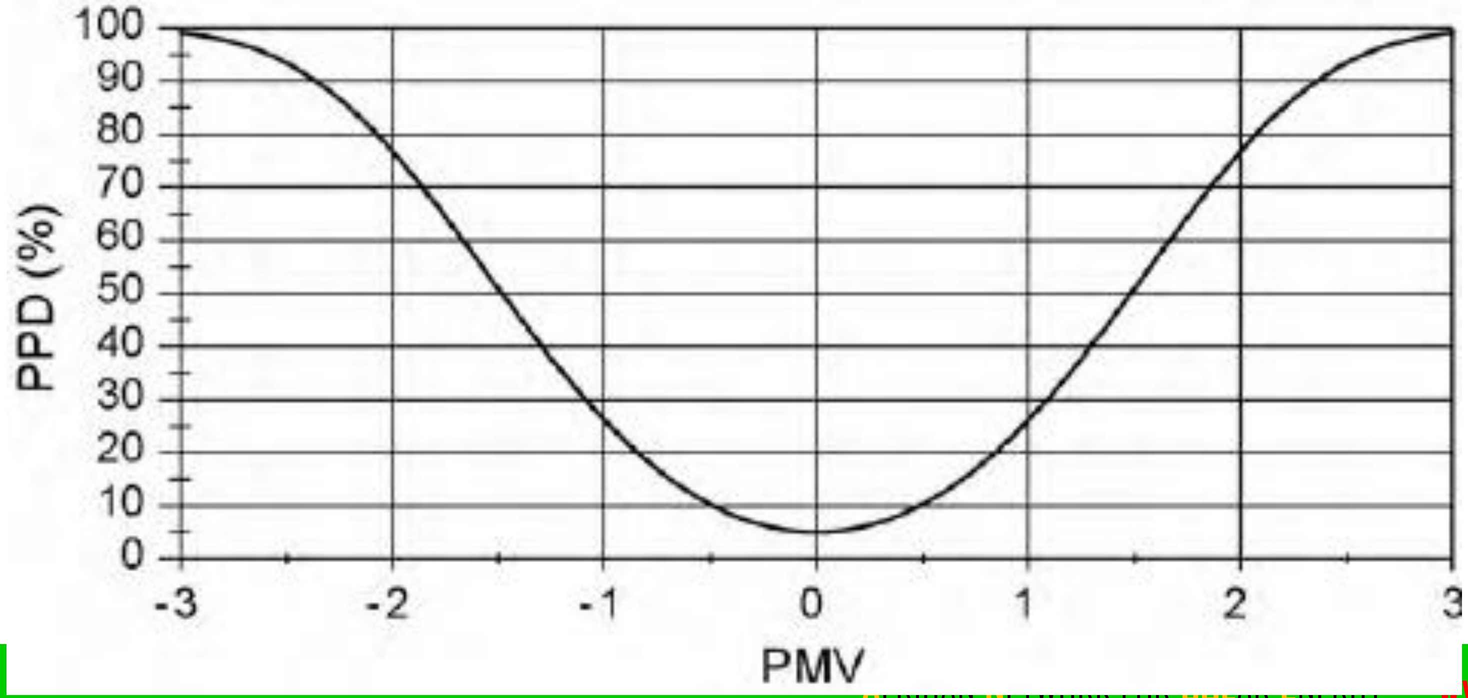
From the parameters that influence the comfort one can calculate the level of comfort of a given atmosphere.

The PMV can also be used to find the conditions needed for thermal comfort (PMV = 0) in a given location.

Thermal comfort

PDD (Predicted Percentage Dissatisfied) Index

The PPD is the index (or percentage) of dissatisfied people, who feel too cool or too warm in a given location.
This is the percentage of people who will feel hot or cold.



Building Materials and Thermal Comfort

The properties of building materials plays an important role in thermal comfort.
The most common housing materials are:

- **Clay**
- **Compressed earth**
- **Laterite**
- **Cement**
- **Sheet metal**
- **Wood**

Building Materials and Thermal Comfort

Cement Block

BTC

BLT

Earth

- roofing

Profil ondulé (Alu-Zinc; Acier Galvanisé)

Profil trapézoïdal (Alu-Zinc; Acier Galvanisé)

Building Materials and Thermal Comfort

In a building, thermal insolation depends mainly on the thermal conductivity of materials (λ)
In the other hand, dense and heavy materials will store the freshness of the night thanks to their high inertia (ρc)

The two most important parameters of building materials, with respect to thermal comfort are then the thermal conductivity (λ) and the thermal inertia (ρc)

Building Materials and Thermal Comfort

The diffusion of heat which is the result of the two effects is given by

$$a = \lambda / \rho c \quad m^2/s$$

"a" is called the thermal diffusivity of the construction materials.

Phase shift and damping of the thermal wave in buildings depends chiefly on diffusivity.

Building Materials and Thermal Comfort

Material	Thermal conductivity	Density	Specific heat	Diffusivity	Effusivity
	λ $(W \cdot m^{-1} \cdot K^{-1})$	ρ $(kg \cdot m^{-3})$	Cp, $(J \cdot kg^{-1} \cdot K^{-1})$	α, $(m^2 \cdot s^{-1})$	β, $(J m^{-2} K^{-1} s^{-0.5})$
Brick (outer)	0.77	1,750	1,000	4.40E-07	1,161
Brick (inner)	0.56	1,750	1,000	3.20E-07	990
Concrete block (heavy)	1.75	2,300	1,000	7.61E-07	2,006
Concrete block (light)	0.20	600	1,000	3.33E-07	346
Mineral wool (quilt)	0.042	12	1,030	3.40E-06	23
Plaster (dense)	0.57	1,300	1,000	4.38E-07	861
Plaster (light)	0.18	600	1,000	3.00E-07	329
Plasterboard	0.21	700	1,000	3.00E-07	383
Steel	50	7,800	450	1.42E-05	13,248
Wood	0.13	500	1,000	2.60E-07	255

Building Materials and Thermal Comfort

In order to design an effective building one need to choose carefully the materials that will be used.

In tropical regions the most important is to have materials that will

- **Reflect the sun radiation.**
- **Insulate the house from the external air heating**
- **Store the nocturnal freshness at night for daytime**
- **Reduce the indoor air temperature**

Building Dynamic behaviour

Heat sources in a building :

- Direct and/or indirect solar radiation
- Direct and convective atmospheric air exchange
- Internal sources

1. Atmosphere

Through the:

Walls

openings

floor

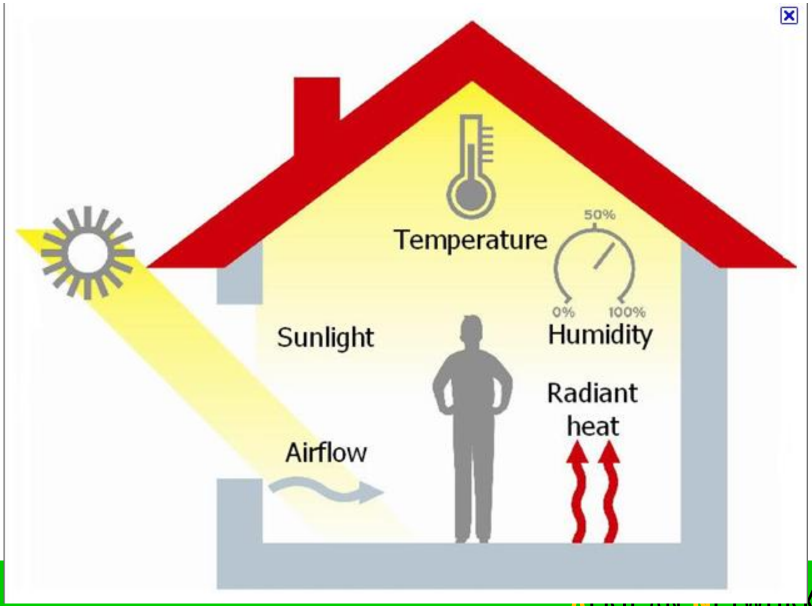
ceiling

Air renewal

2. Sun

Through the:

Walls, Openings



3. Internal sources

Individuals

Electrical equipment

Lighting

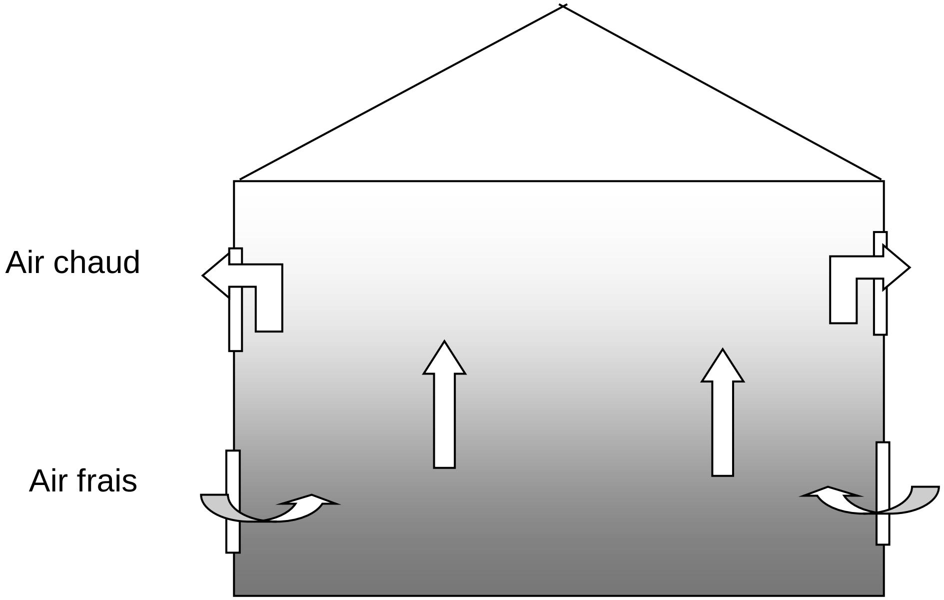
Any heating item inside the building

Building Design in tropical regions

Passive air conditioning buildings design

Building Design in tropical regions

Natural ventilation using thermosiphon process



Warm and cold air can be used to provoke air circulation in a thermosiphon process

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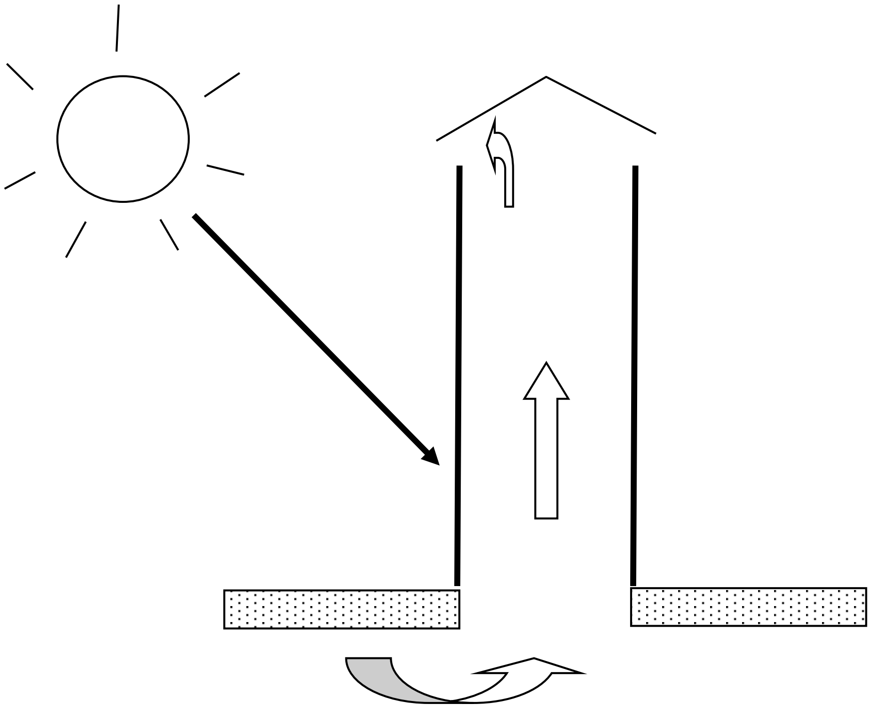
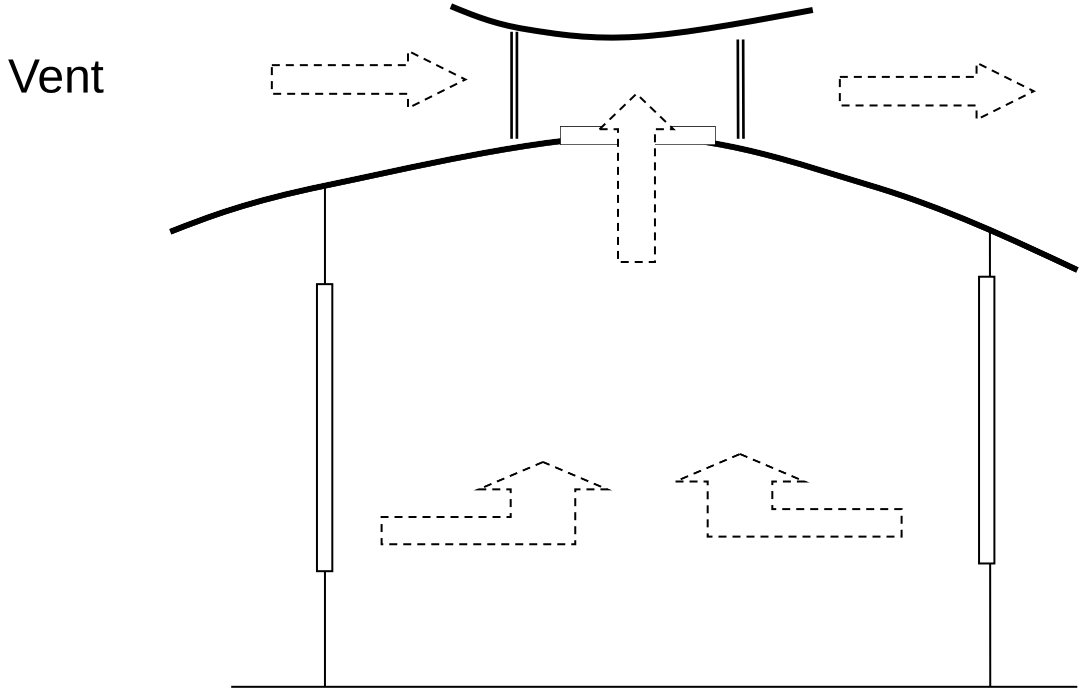
Natural ventilation

4. Solar chemneys



Building Design in tropical regions

Natural ventilation using Venturi effect



Venturi effect is another process to induce air circulation

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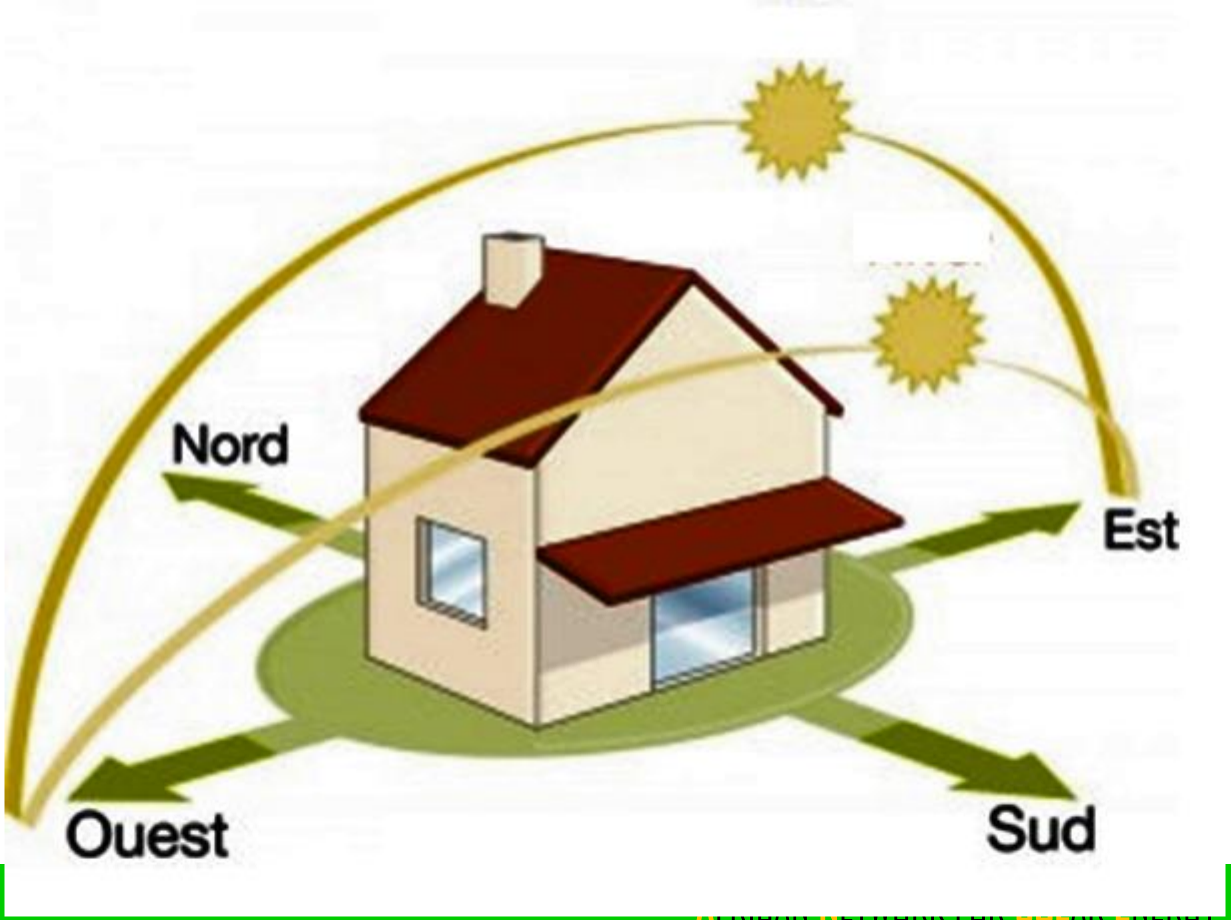
Patio cooling

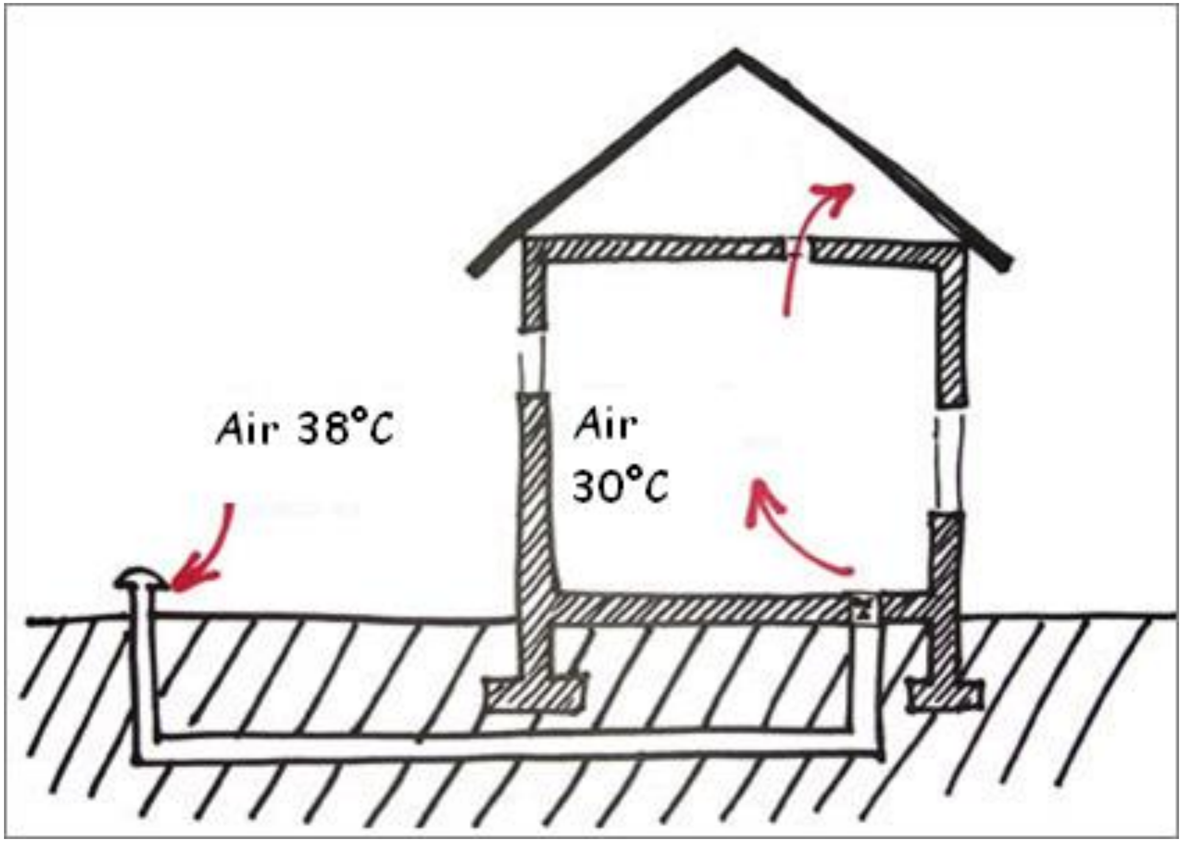
Building Design in tropical regions

Building Directions



Building Design in tropical regions

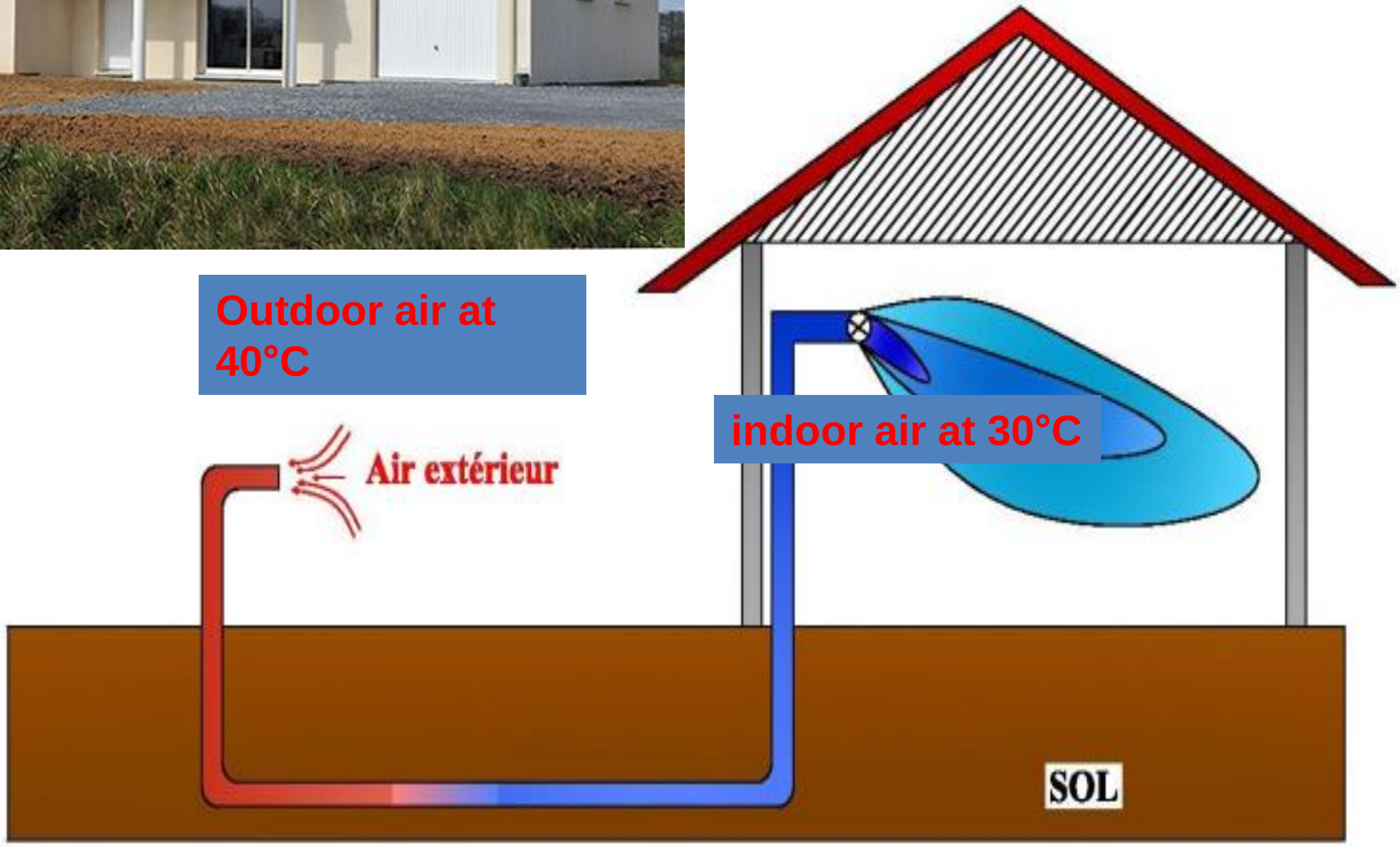
Canadian wells



It is used to cool the internal air by cooling the air injected into the building after cooling in the ground

Building Design in tropical regions

Use of Canadian well to cool down the houses



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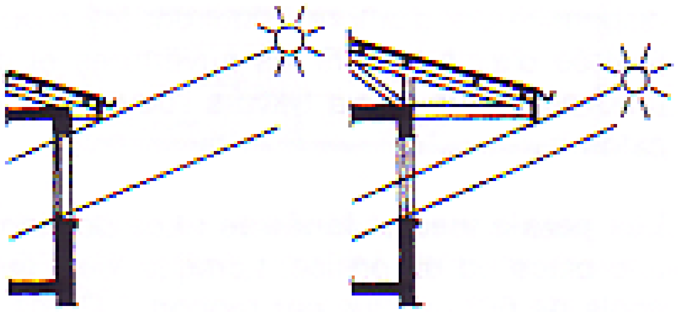
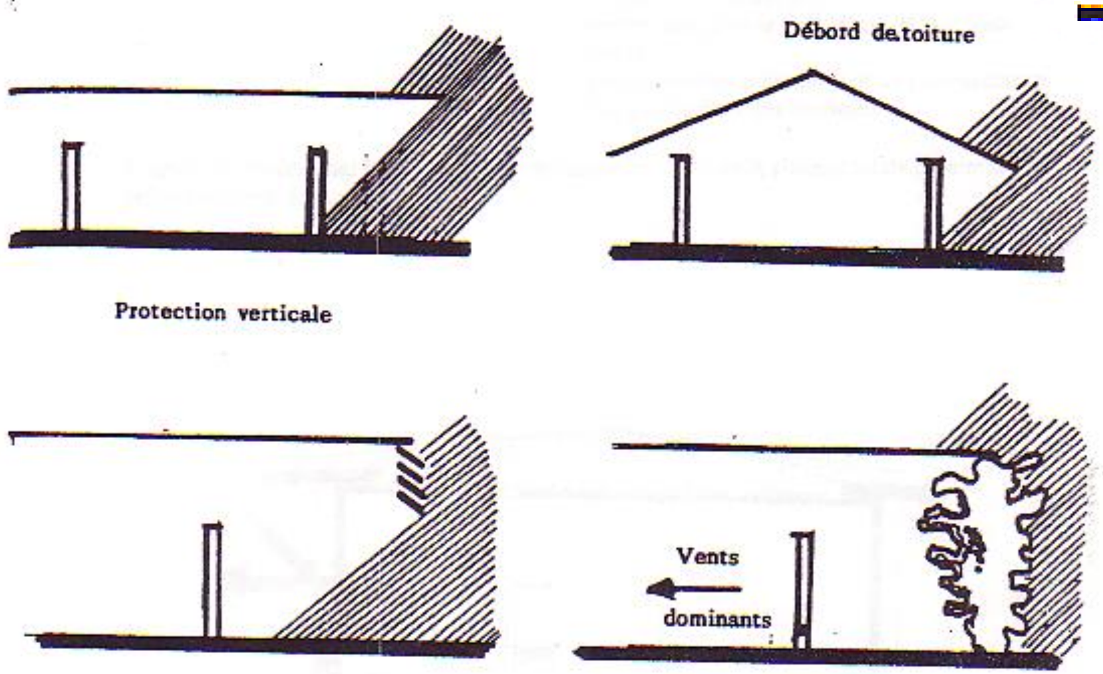
Masks and sunscreens





Building Design in tropical regions

What you need to know about green architecture for good TC

When designing a house one should think of :

The enveloppe of the building (direction and compactness)

The inertia (or weight of walls and whole building)

The insulation (roof especially)

The use of natural winds for ventilation

The colors of roof and walls to reduce the influx of sun radiations

The use of patios, evaporative coolers and Canadian wells will help as well.

Contact

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