Economic Viability and Social Impact of Renewable Energy Deployment in Africa

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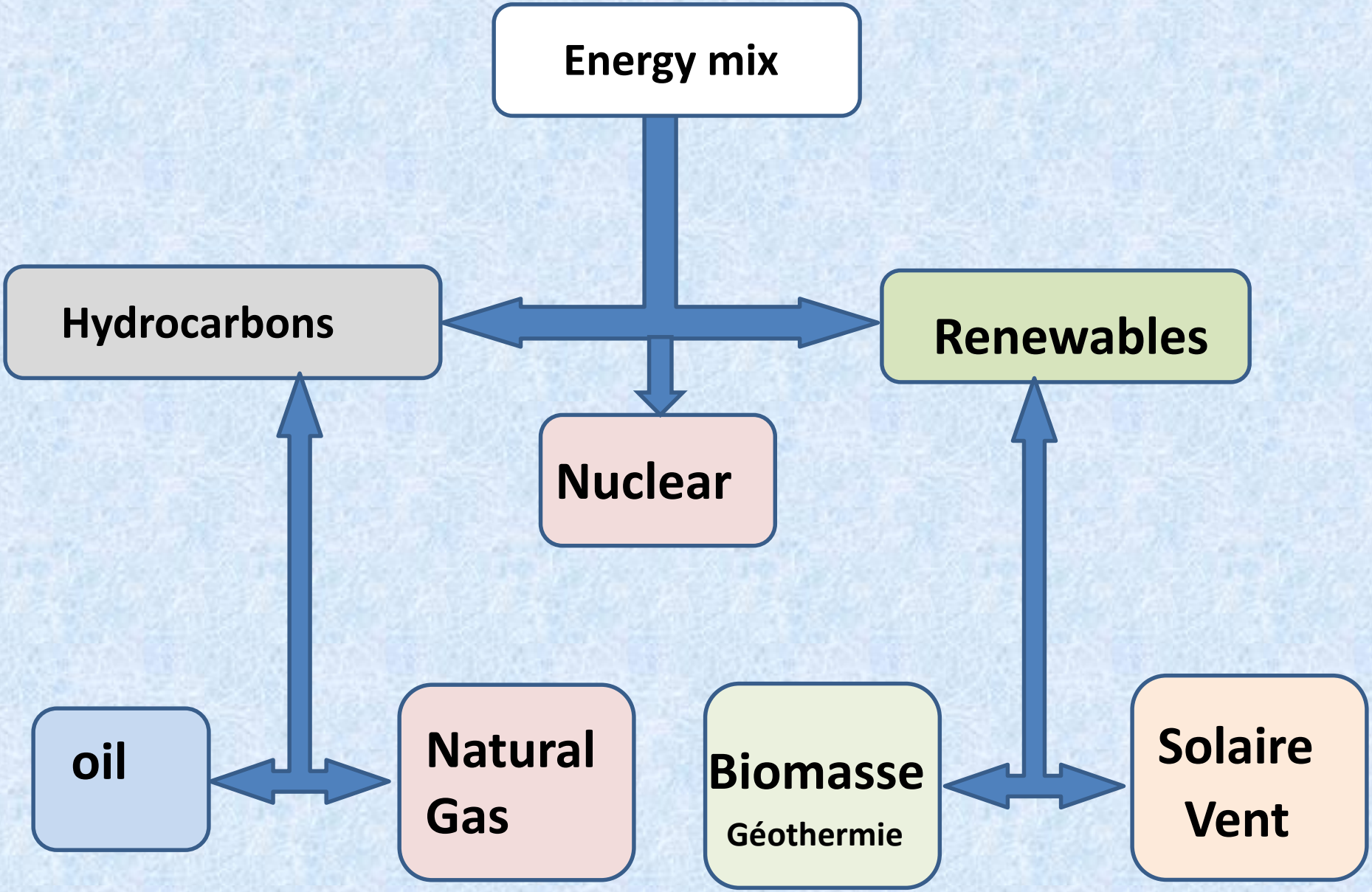
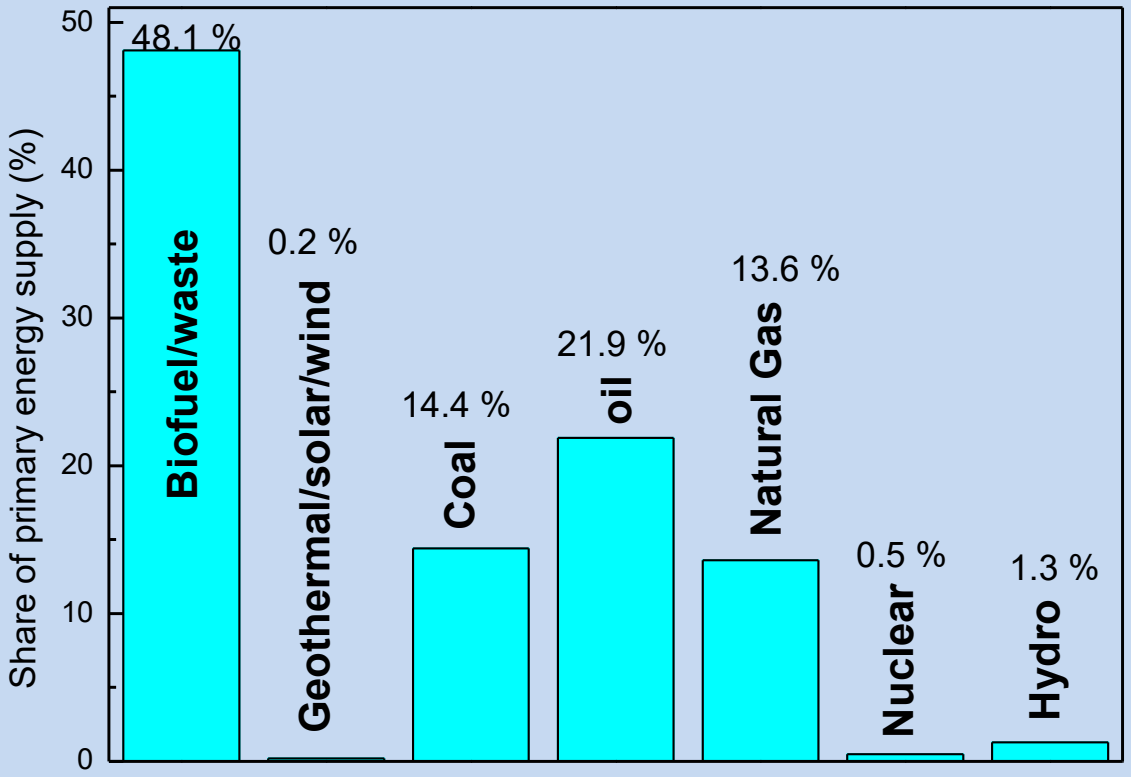
Plan

1. African Energy Sector: Actual State
2. Reasons for Renewable Energy Deployment
3. Strategy for Energy Deployment
4. Renewable Deployment
5. Economic Issues
6. Social Impact
7. Conclusion

1. African Energy Sector: Actual State


Energy mix
Hydrocarbons
Renewables
Nuclear
oil
Natural Gas
Biomasse
Géothermie
Solaire
Vent

Africa Primary Energy Supply

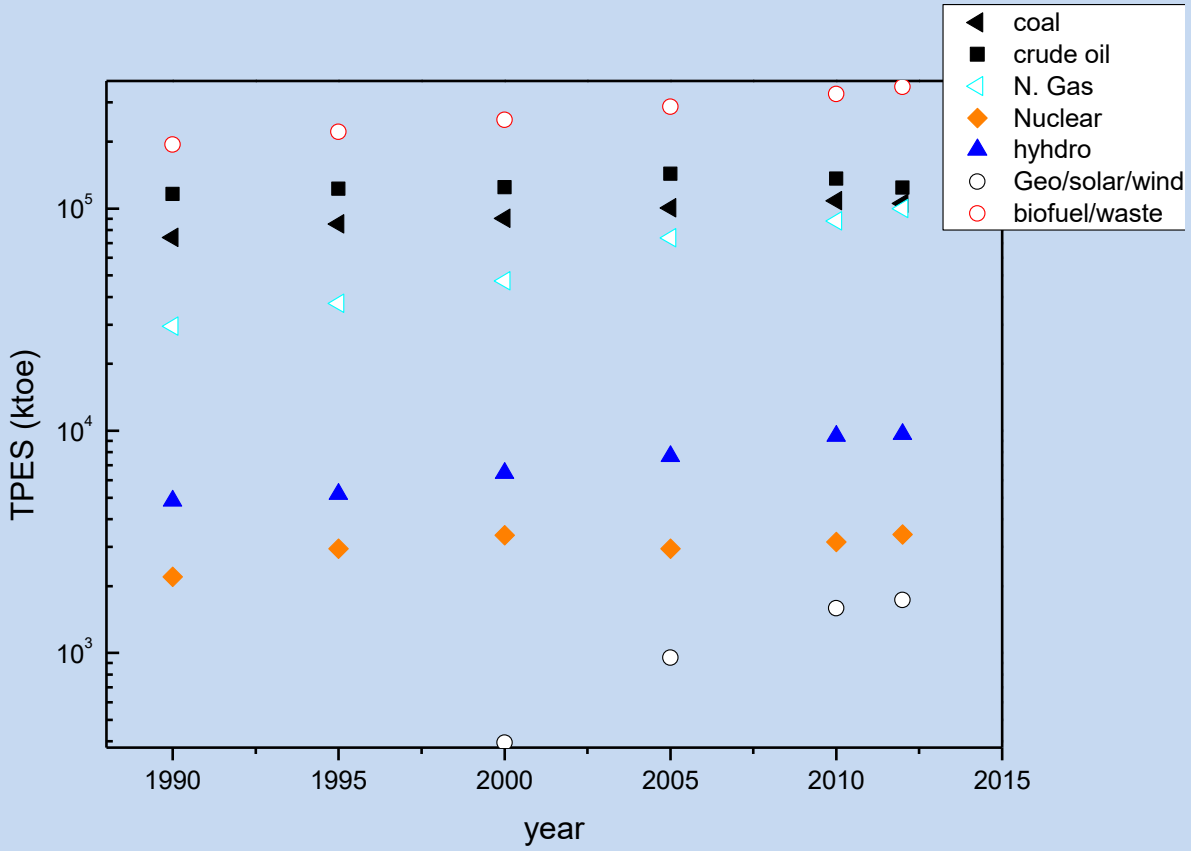


The main energy sources are:

- **Biofuel**
- **Coal**
- **Nuclear**
- **hydrocarbons**
- **Hydro**
- **Other renewables (solar, geothermal, wind)**

Africa Primary Energy Supply

Evolution of the primary energy mix



- **Biofuel:** the most used and there is an increase in its use
- **Renewables (geo, solar and wind): increase in its share**

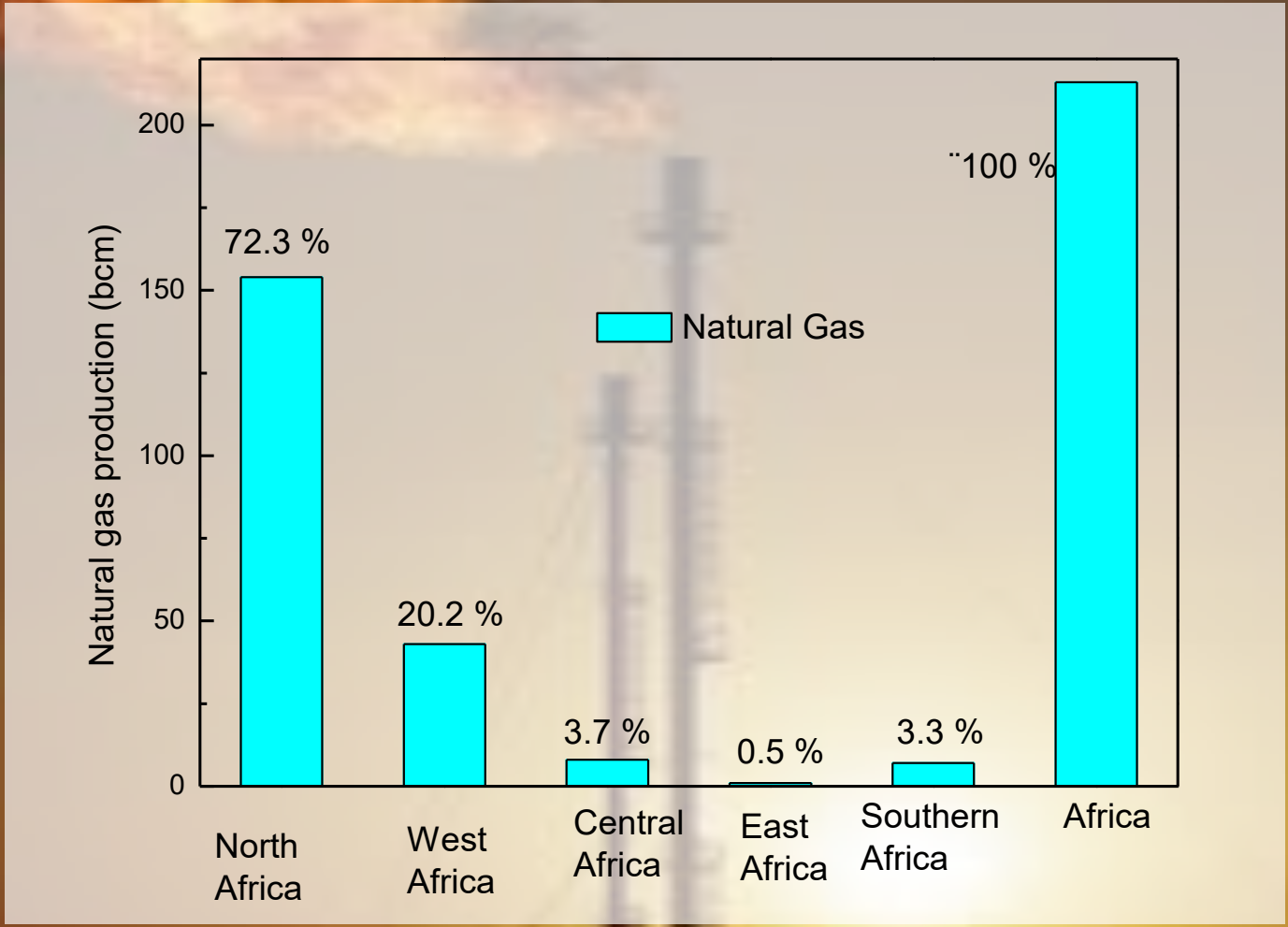
Hydrocarbon in Africa

Oil Reserves (billion barrels)	
Africa	126.72911
Algeria	12.2
Angola	9.06
Benin	0.008
Cameroon	0.2
Chad	1.5
Congo (Brazzaville)	1.6
Congo (Kinshasa)	0.18
Cote dIvoire (IvoryCoast)	0.1
Egypt	4.4
Equatorial Guinea	1.1

Oil Reserves (billion barrels)	
Ethiopia	0.00043
Gabon	2
Ghana	0.66
Libya	48.47
Mauritania	0.02
Morocco	0.00068
Niger	0.15
Nigeria	37.14
South Africa	0.015
Sudan and South Sudan	5
Tunisia	0.425

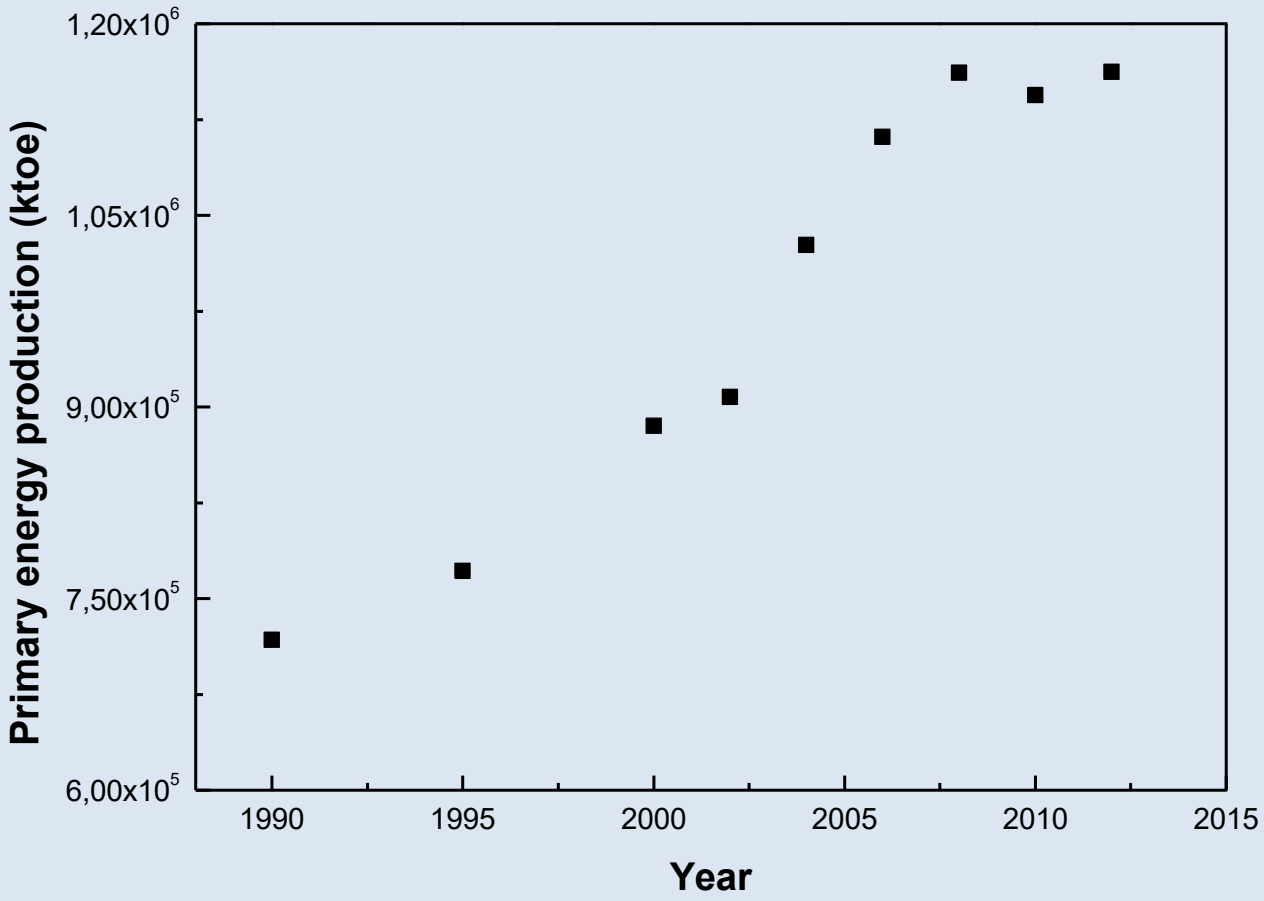
Hydrocarbon in Africa

Natural Gas Reserves (billion barrels)



The major resources are found mainly in northern Africa

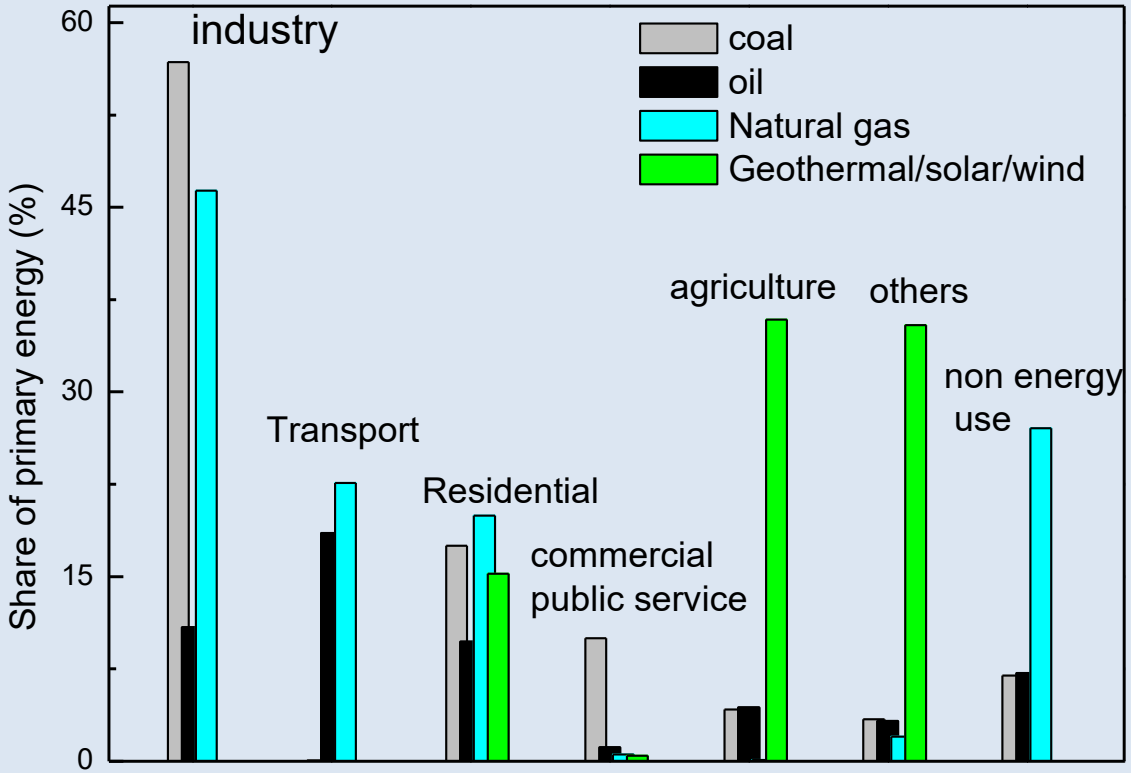
Primary energy in Africa



The production levels off

Primary energy use by sector in Africa

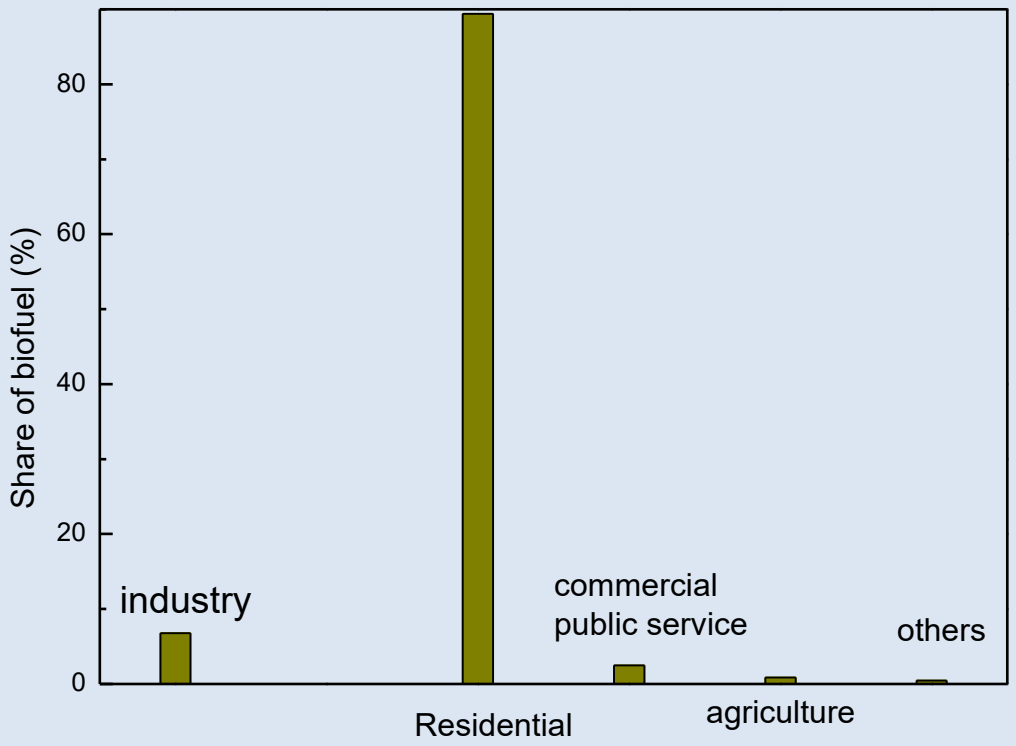
Case of Coal, Oil , Natural Gas and Renewables



- Natural Gas and coal play an important role in the industry and transport
- Renewables are more used in agriculture and to some extend in the residential

Primary energy use by sector in Africa

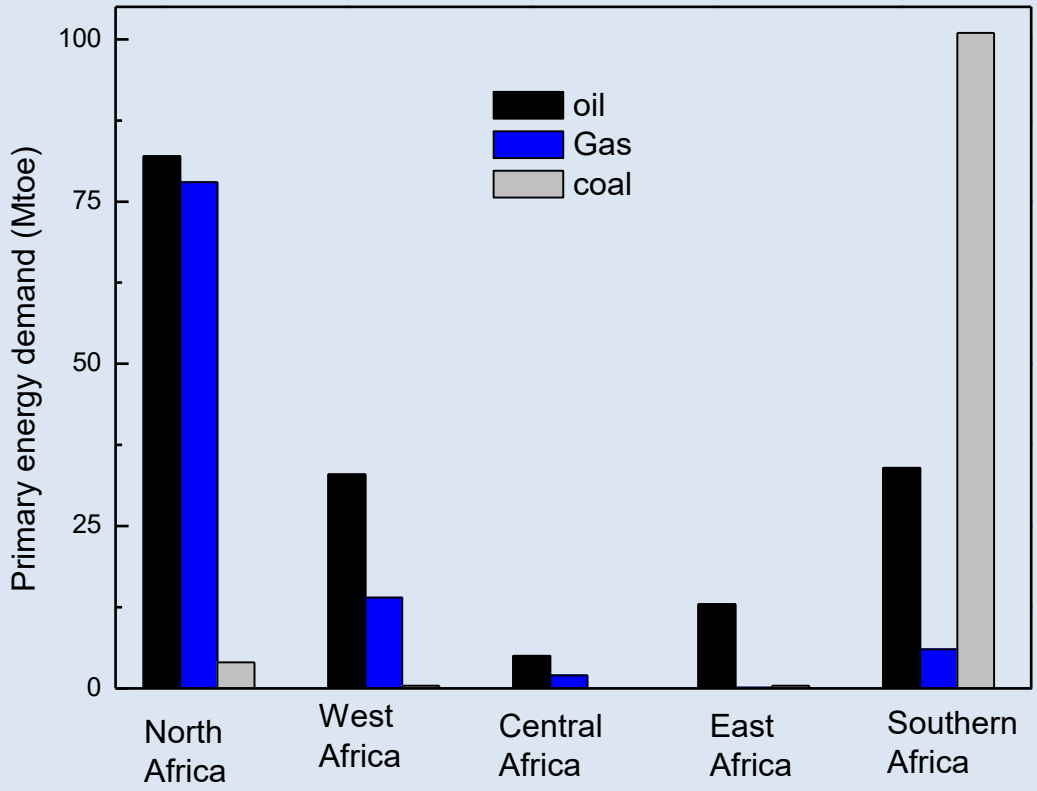
Case of biofuel



Biofuel is used mainly in the residential sector

Energy demand in Africa : importance by region

Case of hydrocarbons



North Africa: particularly rich in Oil and Gas

Southern Africa: particularly endowed with important coal resources

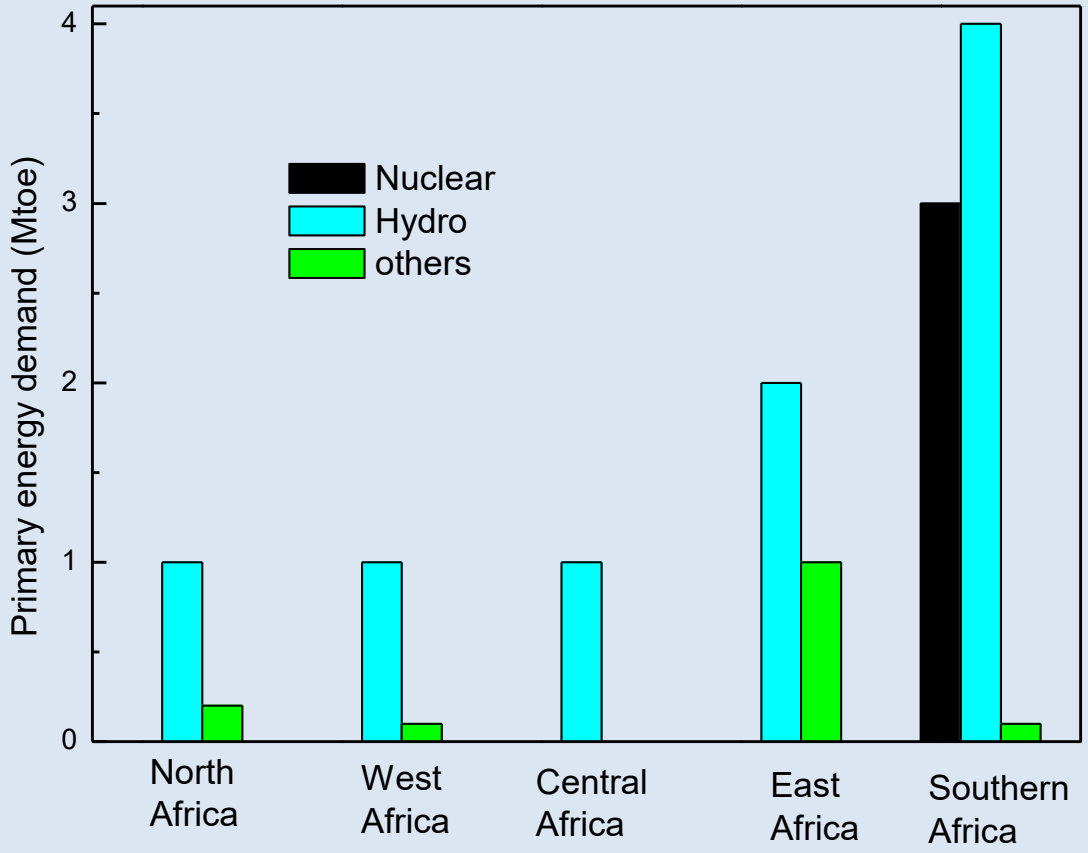
Central and Eastern Africa: limited hydrocarbon resources

Energy demand in Africa : importance by region

Case of nuclear Hydro and other renewables

Nuclear: South Africa

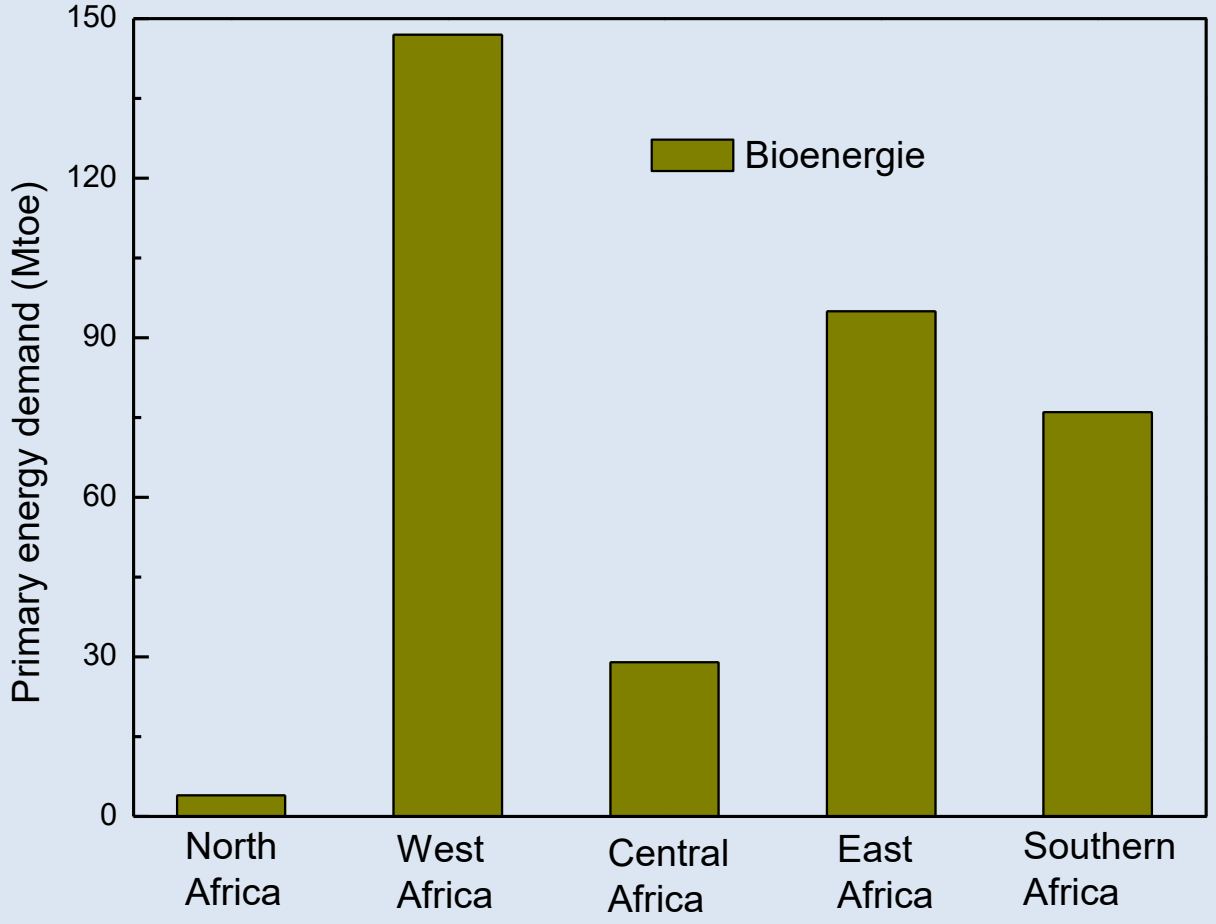
Hydropower: important potential not fully exploited



Other renewable: include mainly solar PV, thermal solar, geothermal and wind
important potential still practically untaped

Energy in Africa : importance by region

Case of biofuel



Extensively used in the sub-Sahara region, more particularly West Africa

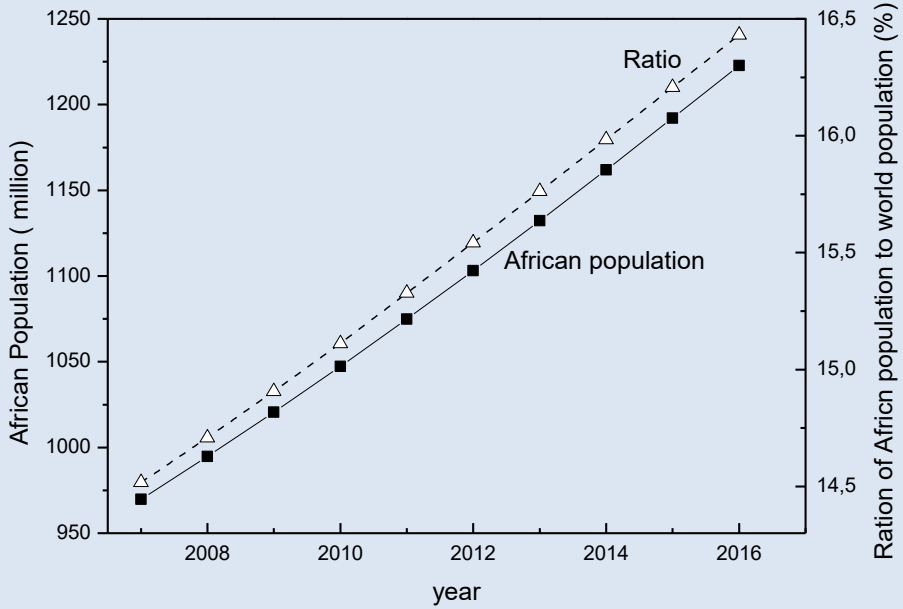
Its use in North Africa is limited

2. Reasons for Renewable Energy Deployment

Reasons for Renewable Energy Deployment in Africa

1. **Exploding Energy Needs**
   a. Population Growth –Urbanization
   b. Change of Way of Life
   c. Improvement in Quality of Life
2. **Issues with Actual Power System**
   a. Energy Deficit
   b. Disparity in Energy Access
   c. Grid Technical Problems
   d. Health Risk & Energy use
3. **Climate Change**
4. **Renewable Energy Potential**
5. **Hydrocarbons role** Backbone of the national development
6. **Economic growth** No economic growth without energy

Reasons for R.E. Deployment : Population Growth & Urbanization



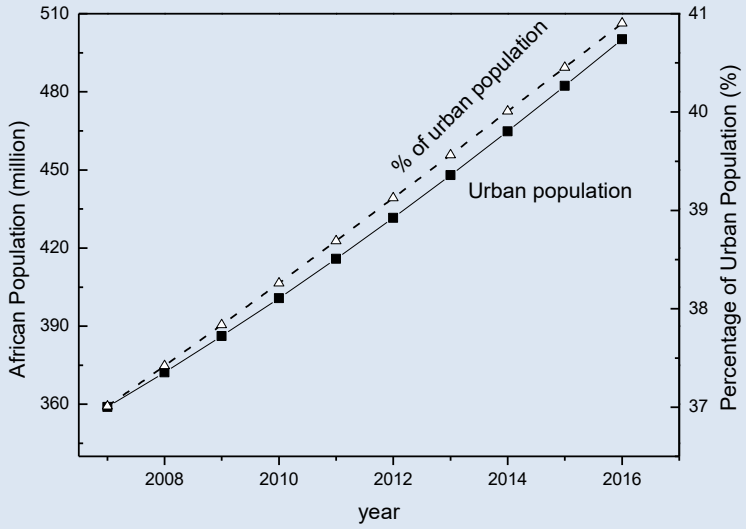
Of the world population Africa population represents :

1. 14.5 % in 2007
2. 16.4 % in 2016

In the last ten years, The increase in the population of :

1. Total Africa is 26.09 %
2. Urban Africa is 39.36 %
3. Rural Africa is 17.72 %

Rural exodus



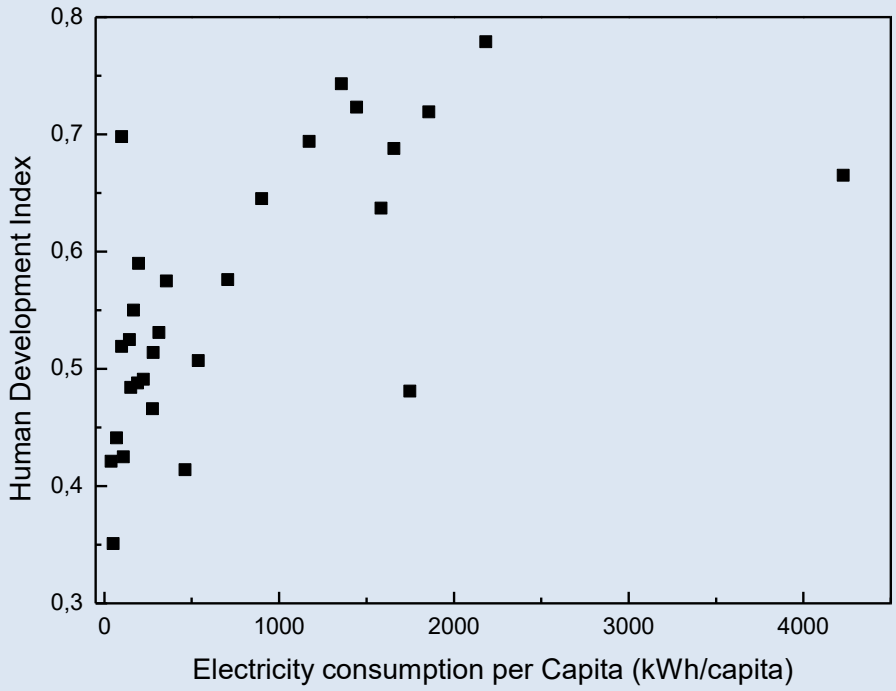
Drivers for R.E. Deployment : Change of Way of Life

Both the husband and the wife work

Need energy for household charges

Reasons for R.E. Deployment : Improvement in Quality of Life

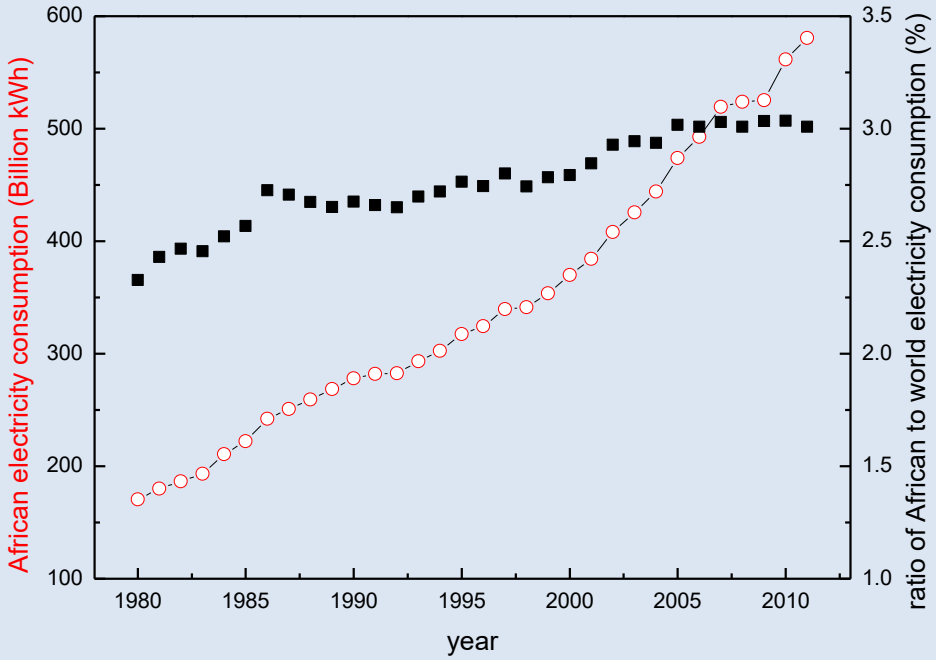
Energy consumption increases with increasing HDI

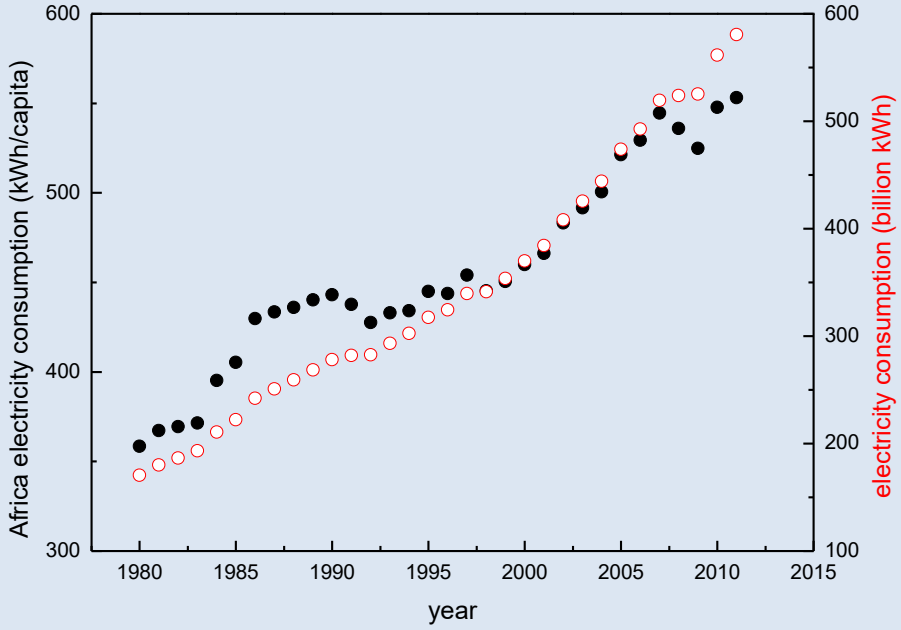


Issues with Actual Power System: Energy Deficit

Africa represents more than 16 % of the world population

But consumes only 3 % of its electricity





There is no real increase in consumption per capita

Issues with Actual Power System: Disparity in Energy Access

The African power system is a centralized system → suitable for high population density location.

However Africa is characterized by:

- Two desert lands that are scarcely populated with isolated dwellings
  1. The Kalahari desert in the south
  2. The Sahara desert in the north

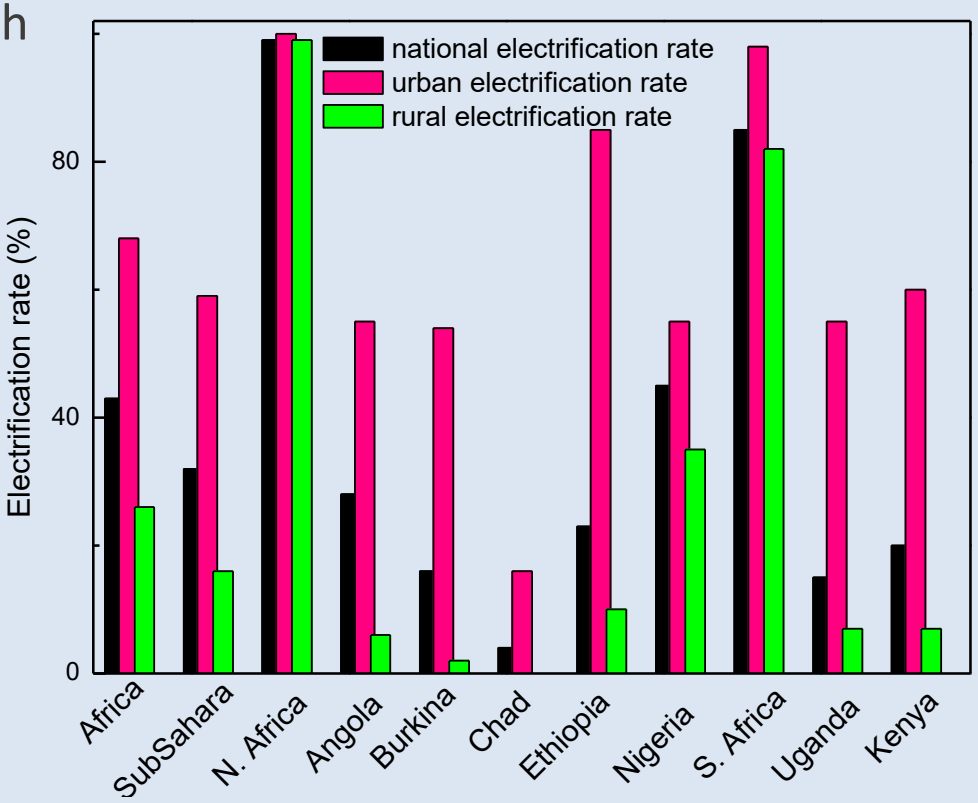
- A large rural population (≈ 60 % of the population)

↓

a centralized power system is not viable in these regions

↓

Poorer electricity access for these regions



Issues with Actual Power System: Grid Technical Problems

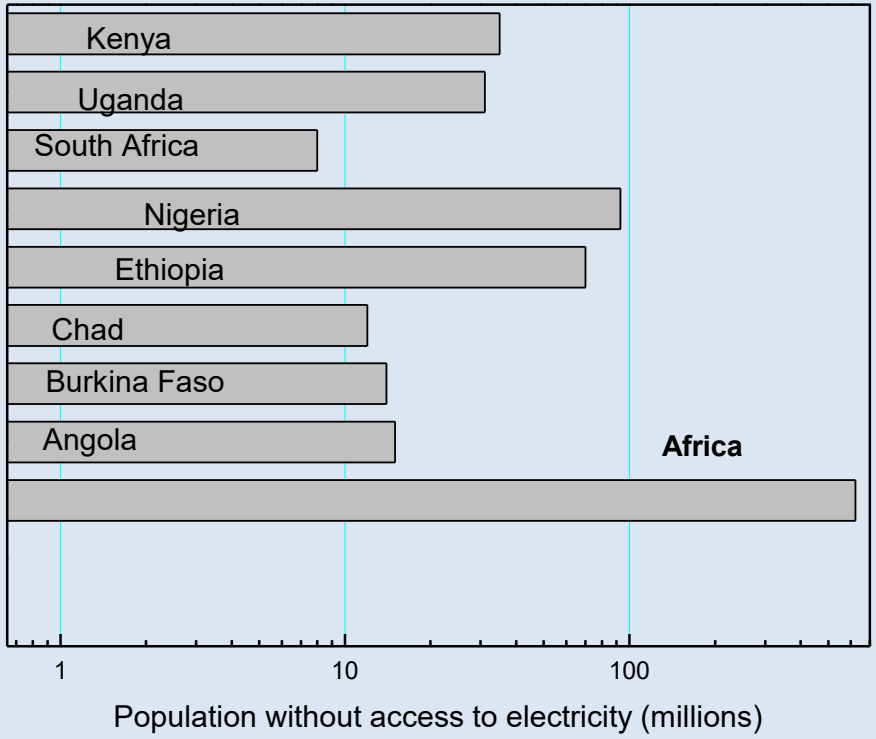
1. Limited access to electricity

Cause of the limited access to electricity → A severe lack of suitable electricity infrastructure

Africa suffer from a severe lack of access to electricity

↓

More than half of the African population has no access to electricity



Nigeria:

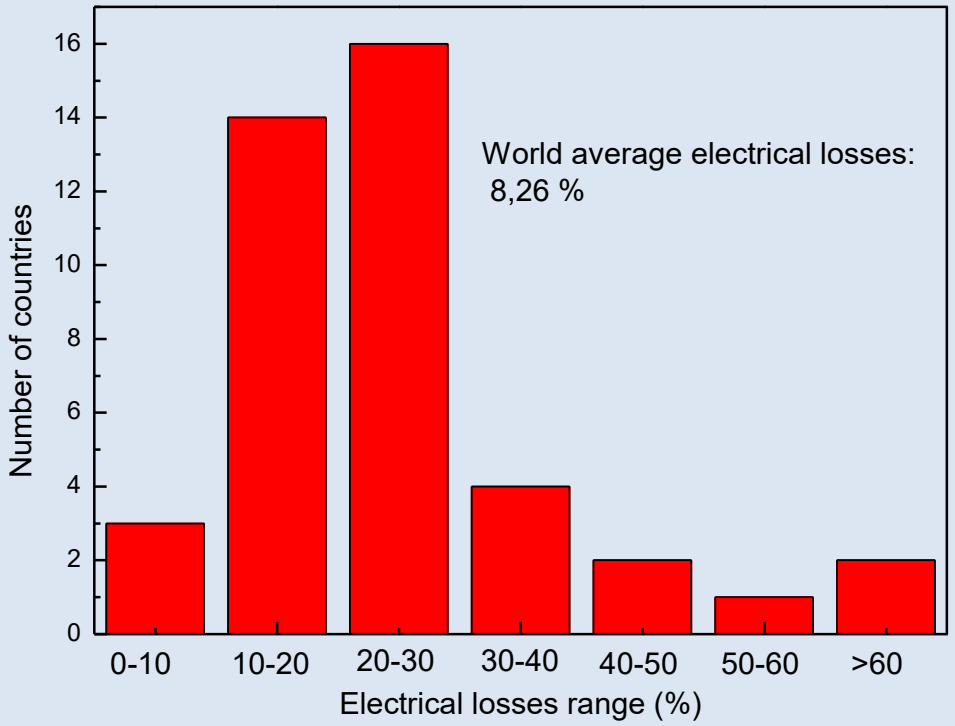
1. Hydrocarbon rich country
2. About 100 million people have no access to electricity

Issues with Actual Power System: Grid Technical Problems

2. Losses and outage

Cause of losses and outage → Transmission and distribution networks aging and poorly maintained

95 % of the African countries experience electrical losses larger than the world average



Countries with lowest losses

1. South Sudan 5.74 %
2. Mauritius 6.20 %
3. South Africa 8.39 %

Countries with highest losses

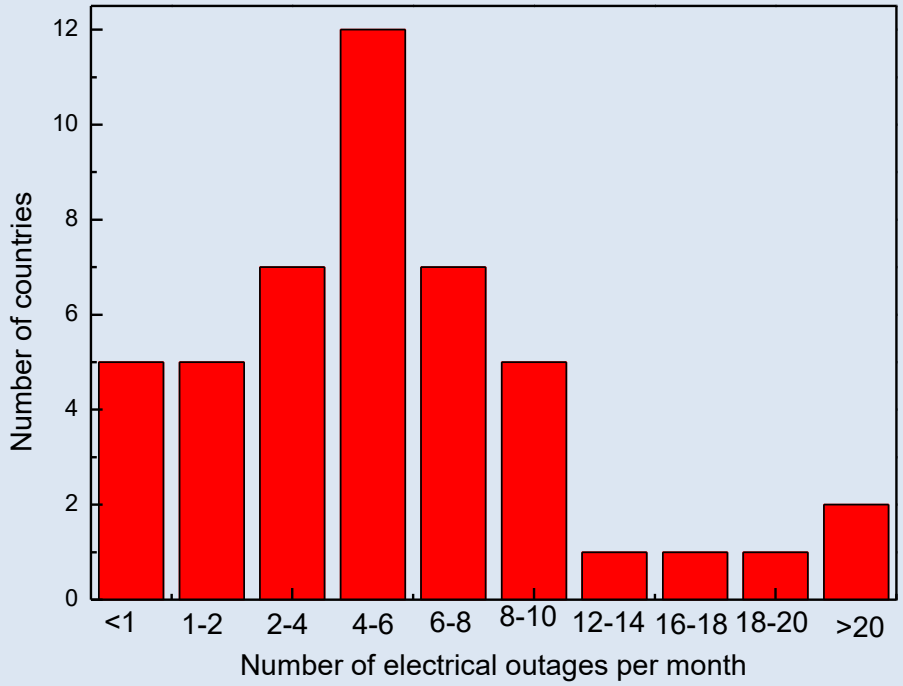
1. Libya 69.70 %
2. Togo 72.54 %

No data available for 12 countries

Issues with Actual Power System: Grid Technical Problems

2. Losses and outage

- System suffers from high frequency and high duration of interruptions



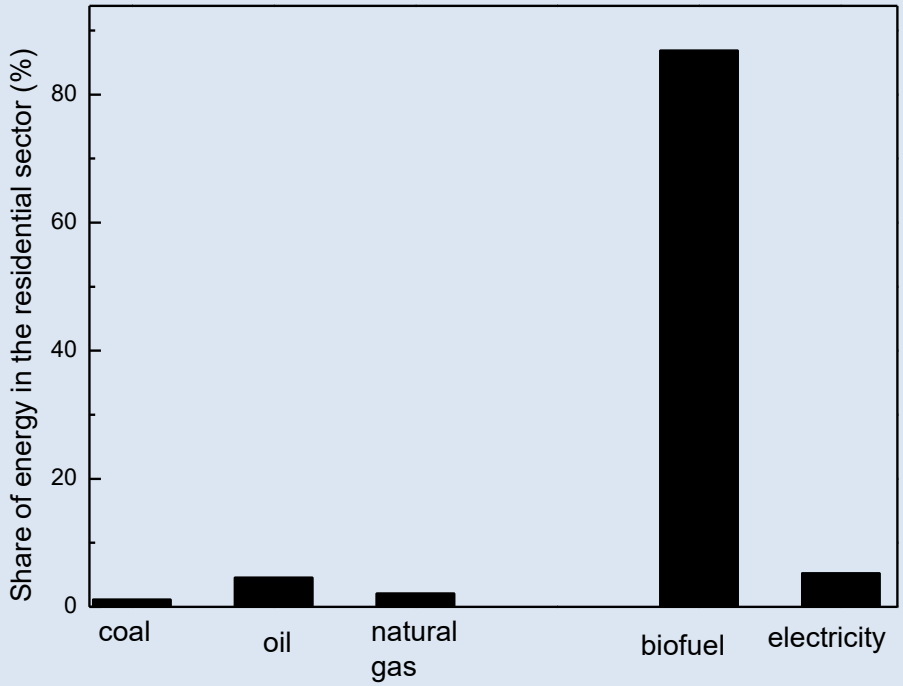
- Power outage

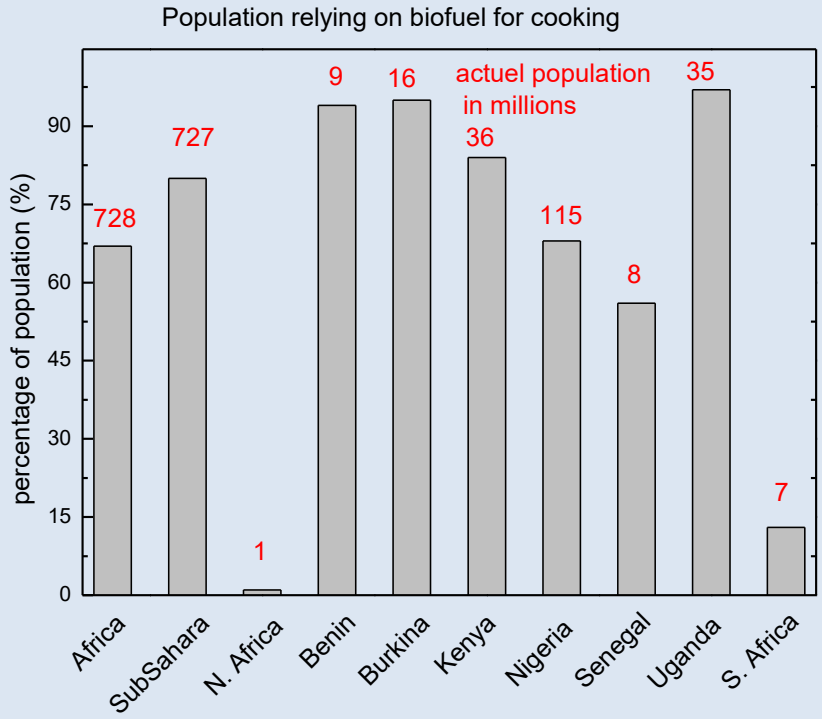
Senegal 45 days/year
Burundi 144 days/year
Tanzania 63 days/year

Issues with Actual Power System: Health Risk & Energy use

1. Cooking

Biofuel use – mainly fuel wood and charcoal – outweighs demand for all other forms of energy combined





The reliance on Biofuel for cooking is:

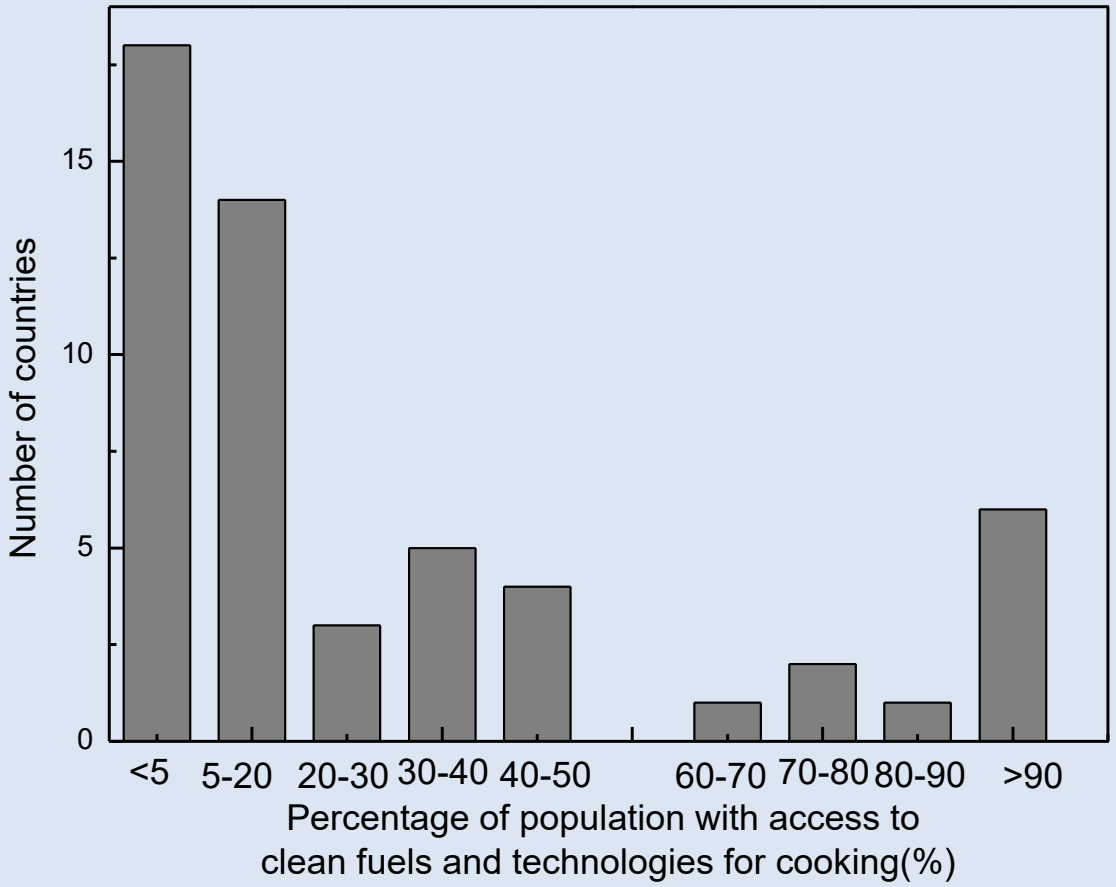
1. Very strong in Africa
2. About 60 % of the population rely on it

Issues with Actual Power System: Health Risk & Energy use

1. Cooking

Problems

- Pollution
- Health problems related to indoor smoke
- Deforestation



Modernizing the technologies is necessary

Climate Change

Africa is not a huge contributor to greenhouse emission → Africa is particularly vulnerable to the impact of climate change

The Fifth Intergovernmental Panel on Climate Change (IPCC) identifies Africa as the region at greatest risk from global warming

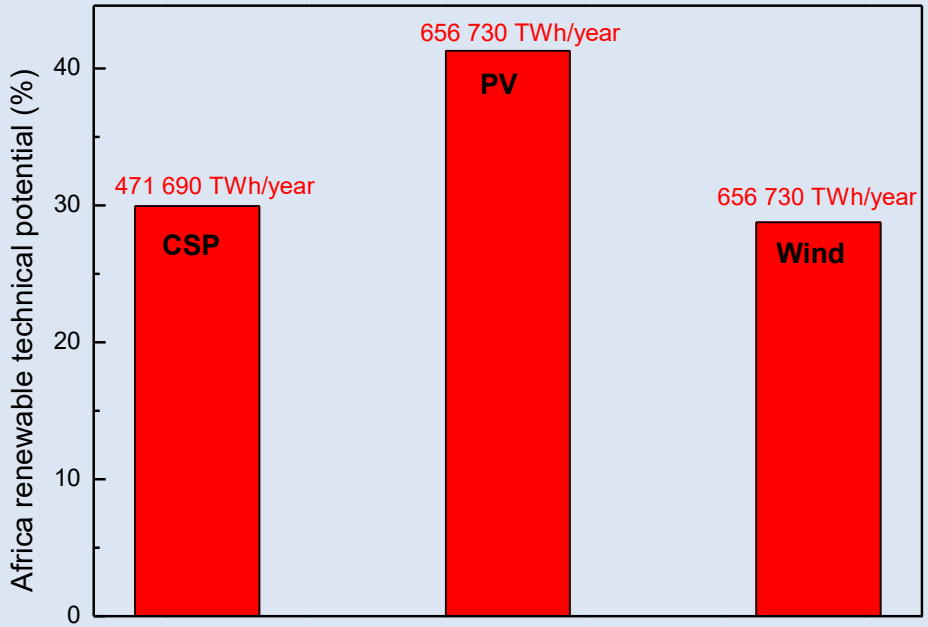
COP21 & Intended Nationally Determined Contributions

- In the framework of climate change mitigation all the African countries (except Libya) have agreed to engage in the INDCs.
- The ambition of the INDCs is to reach COP 21 goals, more particularly in keeping the average global temperature increase by 2100 to well below 2°C
- 60 % of the African countries have ratified the process and submitted their NDC.
- All the African countries NDCs have taken the deployment of renewable energy as the mean to address climate change

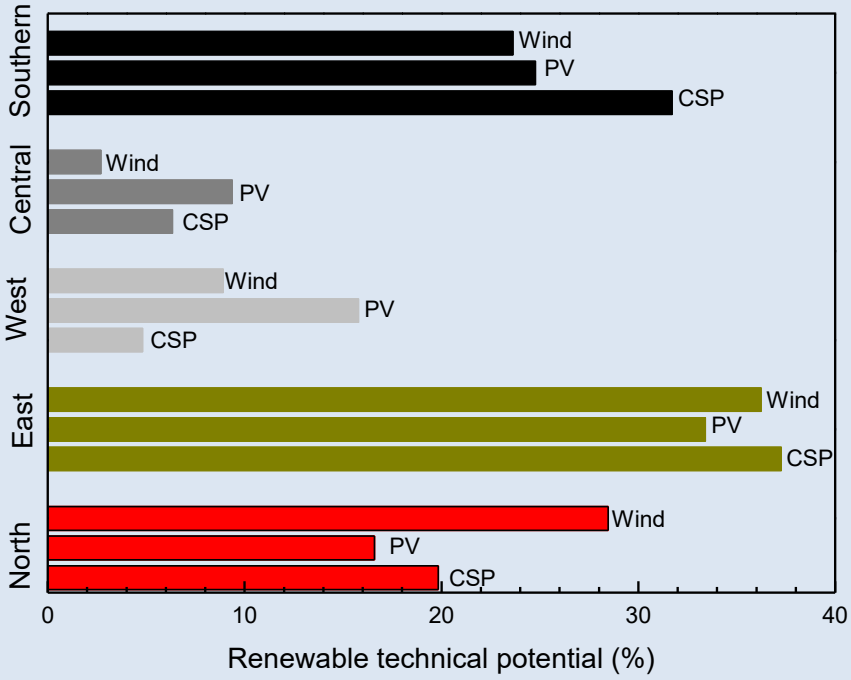
Renewable Energy Potential

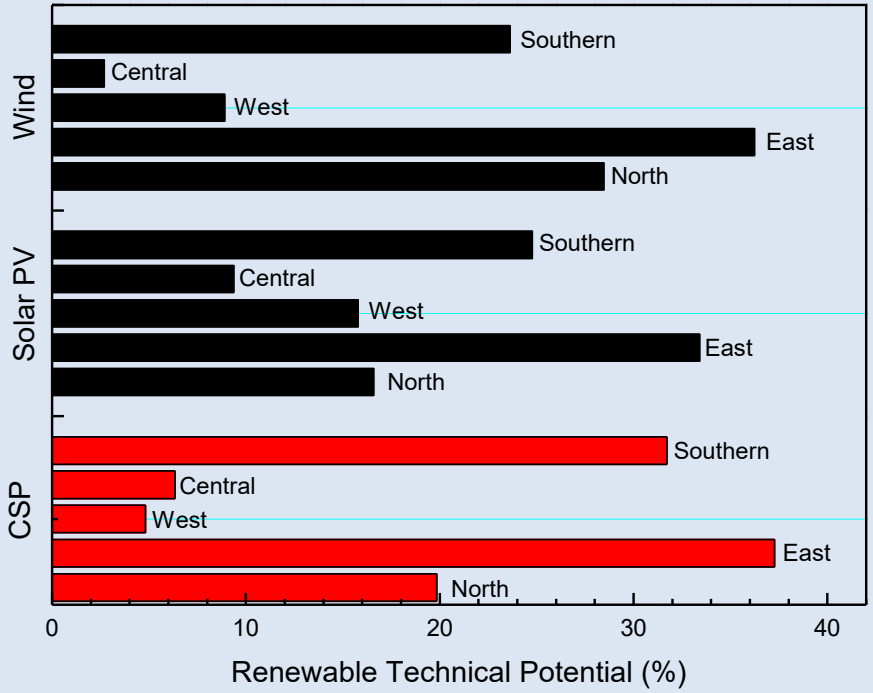
Africa has a very important untapped renewable potential

GHI (kWh/m2. year)	DNI (kWh/m^2 year)
1600 - 2700	900 - 3200



Renewable Energy Potential





3. Strategy for Energy Deployment

Strategy for Deployment

Two options for clean renewable power generation:

I. Business as usual: implementation through large centralized grid connected power plants

Drawbacks:

1. The solution is not adapted to deserts
2. Studies show (IEA) that energy poverty will get worse by 2030.
3. universal access to electricity won't be achieved until 2080.
4. Universal access to clean cooking facilities would occur only in 150 Years from now

II. Innovative approach: implementation through a mixture of technologies

1. Large scale centralized grid
2. Mini-grids
3. Off- grids

Meet the Universal access to clean electricity by 2030

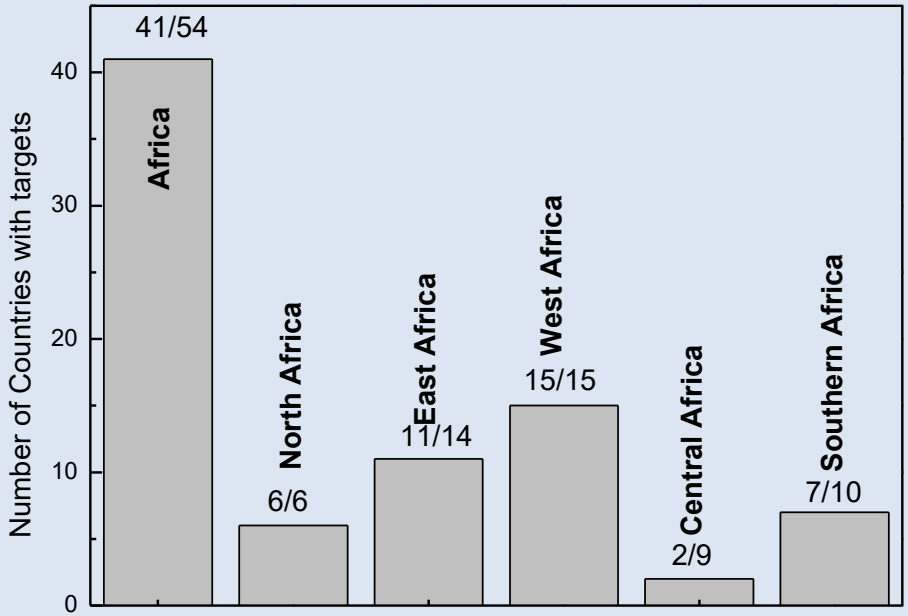
Drawback: more expensive

Strategy for Deployment

Sound development of Renewable energy → Policy instrument → National Energy Program

The National Energy program includes:

1. Targets
2. Support policies
   a. Regulatory policies
   b. Fiscal Incentives



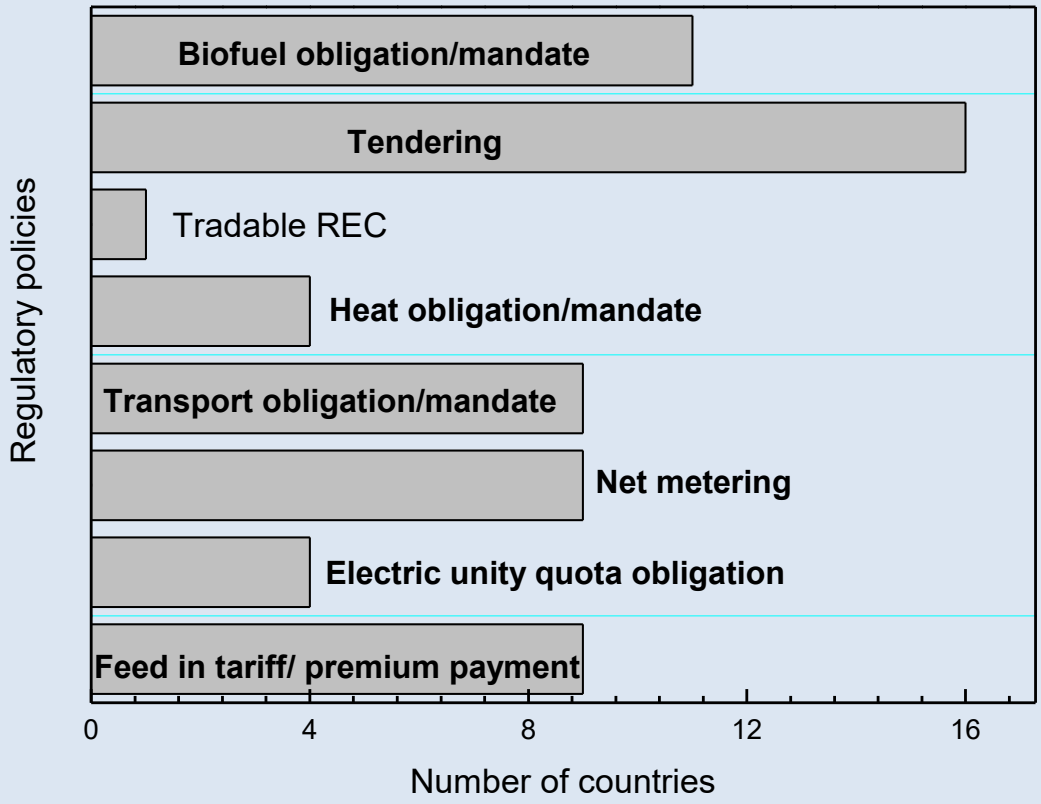
Targets

A. Features:
   1. Specific
   2. Realistic
   3. Achievable
   4. Date or time bound

B. Africa:
   1. Most of the countries adopted one
   2. Most of the time not binding

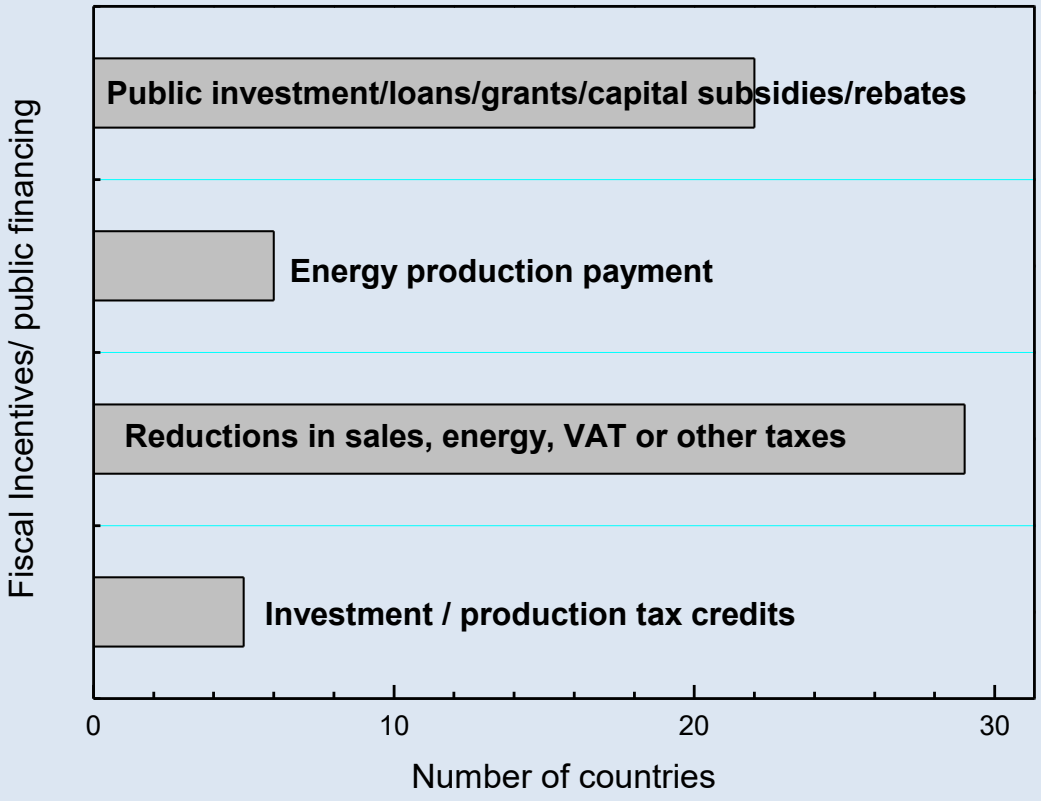
Regulatory policies

1. Feed-in-Tariff/Premium payment
2. Electric Unity Quota Obligation/RPS
3. Net metering
4. Transport Obligation/Mandate
5. Heat Obligation/Mandate
6. Tradable REC
7. Tendering



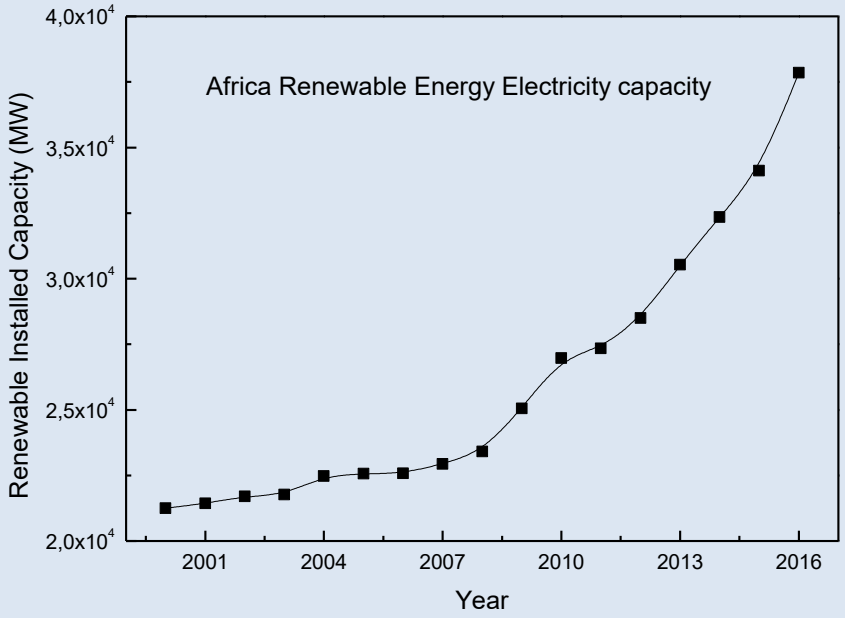
Fiscal Incentives and Public Financing

1. Investment or production tax credits
2. Reductions in sales, energy, VAT or other taxes
3. Energy production payment
4. Public investment, loans, grants, capital subsidies or rebates



4. Renewable Energy Deployment

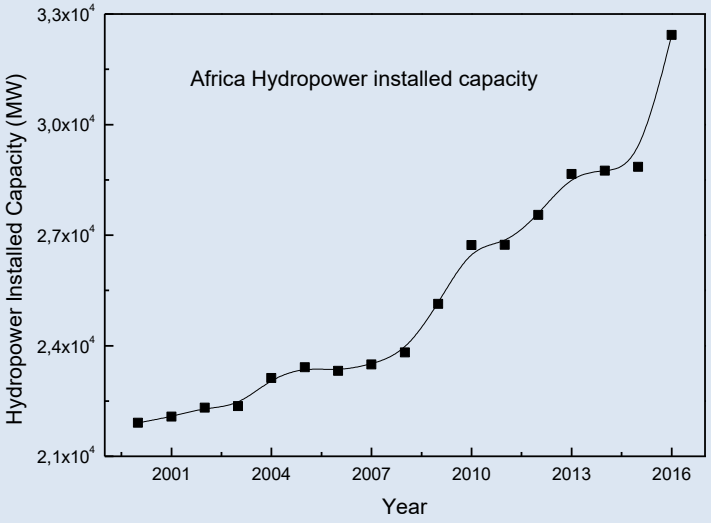
Electrical Installed total renewable energy capacity

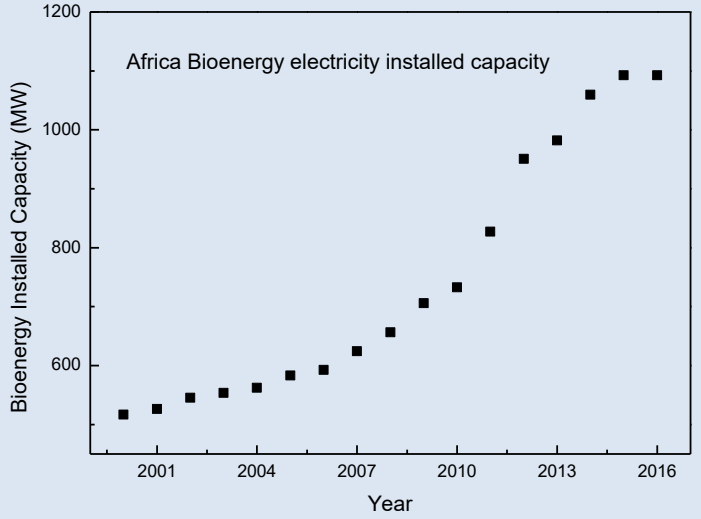


Pour 2016, the installed capacity for Africa represent a mere 1.90 % of the world installed capacity

Country	ratio of the total African capacity 2016
Ethiopia	11.04 %
South Africa	10.63 %
Egypt	9.60 %
Dem. Rep. Congo	7.02 %
Morocco	6.38 %
total	44.67 %

Installed Hydro and bi-oenergy capacity for electricity generation





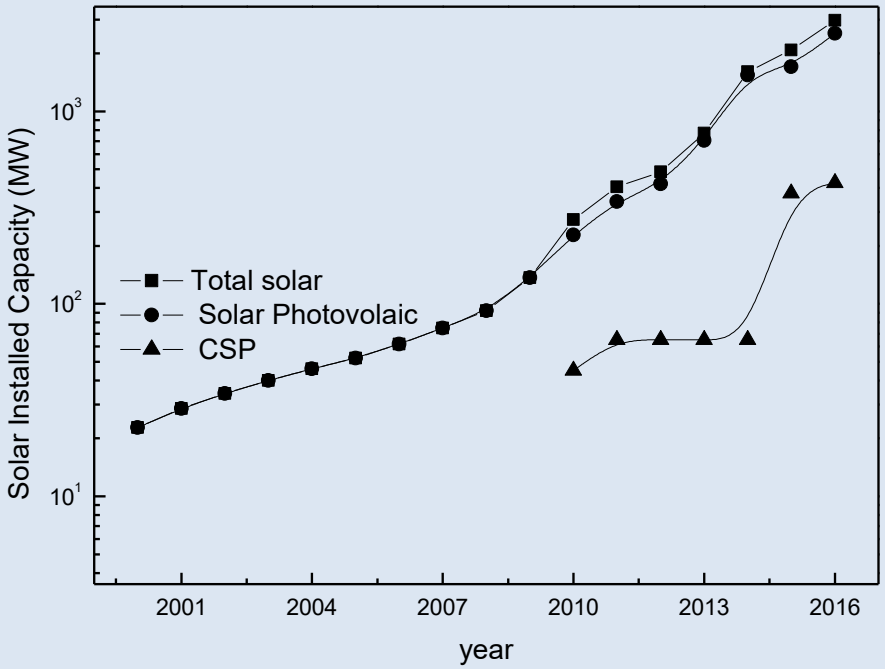
Installed African capacity relative to the world installed capacity (2016)

Hydropower 2.6 %
Bio-energy 1.02 %

country	Ratio to Africa 2016
Ethiopia	11.80 %
South Africa	10.60 %
Egypt	8.79 %
Dem. Rep. congo	8.29 %
Zambia	7.36 %
Total	46.84 %

country	Ratio to Africa 2016 bio
Sudan	17.46 %
South Africa	13.16 %
Swaziland	11.24 %
Zimbabwe	9.14 %
Mauritius	8.96 %
Total	48.12 %

Installed solar capacity for electricity generation



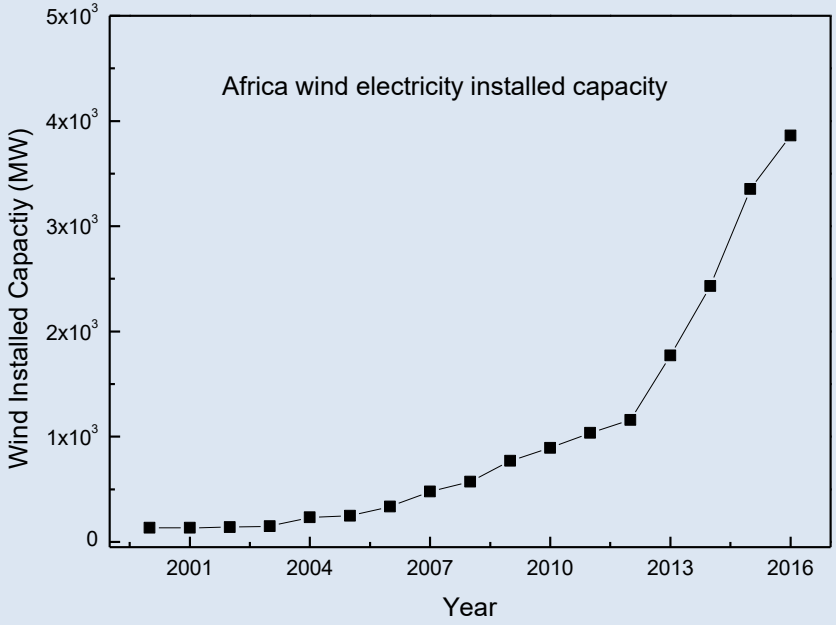
Africa capacity relative to the world capacity 2016:

Solar PV	**0.88 %**
CSP	8.73 %

country	Ratio to Africa 2016 PV
South Africa	60.82 %
Algeria	8.60 %
Ethiopia	2.75 %
Senegal	2.12 %
Egypt	1.53 %
Total	75.82 %

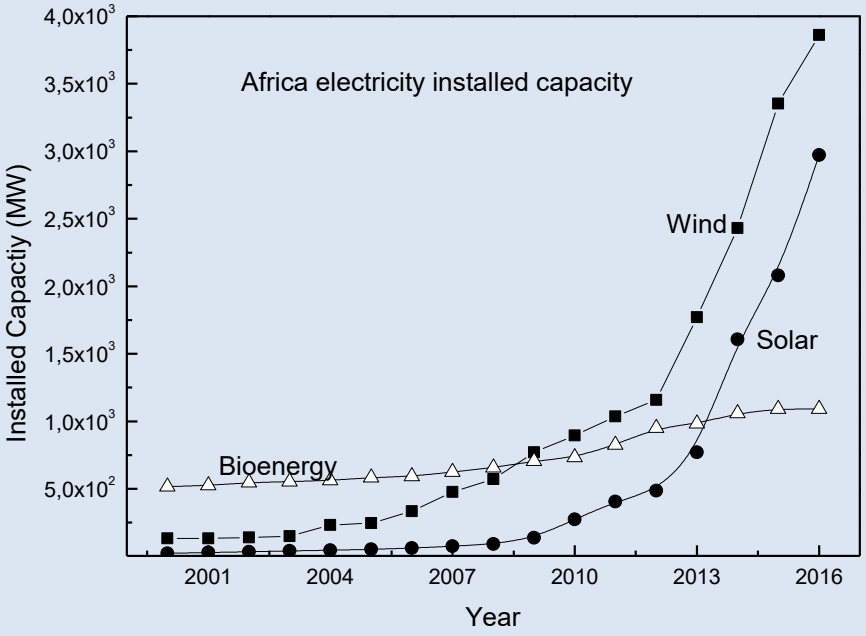
country	Ratio to Africa 2016 CSP
South Africa	47.06 %
Morocco	42.35 %
Algeria	5.85 %
Egypt	4.70 %
Total	100 %

Installed wind capacity for electricity generation



Africa wind capacity relative to the world wind capacity 2016: 0.83 %

country	Ratio to Africa 2016
South Africa	38.14 %
Morocco	24.18 %
Egypt	19.42 %
Ethiopia	8.29 %
Tunisia	6.34 %
Total	96.47 %



5. Economic Issues

Installation cost and funding

- Capital Investment are primordial to renewable energy deployment
- Wind installation cost is the lowest, but PV is not too far
- CSP technologies remain high

Wind system	Installation cost ($/W)
On shore	1.36 - 1.69
Off-Shore	4.615 - 6.647

CSP system	Installation cost ($/W)
Parabolic trough	
No storage	4.3 - 14.2
6 hours storage	3.6 - 17
Solar Tower (with storage)	
6 - 7.5 hours	6.35 - 7.5
12-15 hours	9 - 10.5

PV system	Installation cost ($/W)
PV utility-scale	1.35 - 4
Solar home system (<1 kW)	4.3 - 14.2
Solar home system (>1 kW)	3.6 - 17
Grid connected roof top (>1 kW)	2 - 3
Mini-grid system	2.5 - 2.9

Installation cost and funding

Renewable energy deployment is Capital investment intensive; → Funding opportunities focused on or related to renewable energy should be sought.

Funding instruments: Loan, equity, rebate, Subsidy, Awareness & Training, Equipment, grant, Technical support, Feasibility studies

Financing bodies : development finance institutions (DFIs), local public or private sector investors

Development Finance Institutions:

1. World Bank
   a. Climate Investment Fund (CIF)
   b. Strategic Climate Fund (SCF)
2. Green Facility for Africa (GFA)
3. African Development Fund (ADF)
4. International Climate Fund (U.K.)
5. African Development Bank (AfDB)
   a. Sustainable Energy Fund for Africa (SEFA)
6. Global Environment Fund (GEF)
7. Global Energy Efficiency and Renewable Energy Fund (GEEFREF)
8. African Development Bank Partial Risk Guaranties (PRG)
9. Global Environment Facility Trust Fund (GEFTF)

Levelised energy cost and viability economic

- Solar PV and Wind system connected to the grid are competitive with Gas turbine
- Geothermal , bio-power and hydropower connected to the grid are competitive with gas turbine and combine cycle
- Minigrid and off grid, though they offer flexibility, remain expensive by comparison to grid connected

On Grid (REN 21)

Technology	LCOE ($/kWh)
On grid solar PV	0.06 - 0.26
CSP	0.28 – 0.33
On Grid Wind	0.05 – 0.17
Geothermal	0.045 - 0.13
Biopower	0.04 - 0.18
Hydropower	0.04 – 0.22

Conventional source (IEA)

Technology	LCOE ($/kWh)
Gas turbine	0.10 – 0.15
Combined cycle	0.055 – 0.10
Coal	0.045 – 0.05

Off grid or mini grid (IEA)

Technology	LCOE ($/kWh)
Small solar PV	0.30 – 0.32
Small wind	0.25 – 0.26
Small hydro	0.25 – 0.28

Renewable Energy Viability

Different local aspects could affect the economic viability of renewable energy deployment:

1. The conversion technology in association with the local technical potential of the renewable energy source.
2. The local cost of material, labor and other matters that vary locally.
3. The location of the power system in relation to the transmission lines and to the consumers

Viability	Bad	Good	Very good	Excellent
Solar PV (GHI) (kWh/m^2 year)	Below 1000	1000 - 1500	1500 - 2500	2500 - 3000
CSP (DNI) (kWh/m^2 year)	Below 1800	1800 - 2000	2000 - 2500	2500-300

Irena

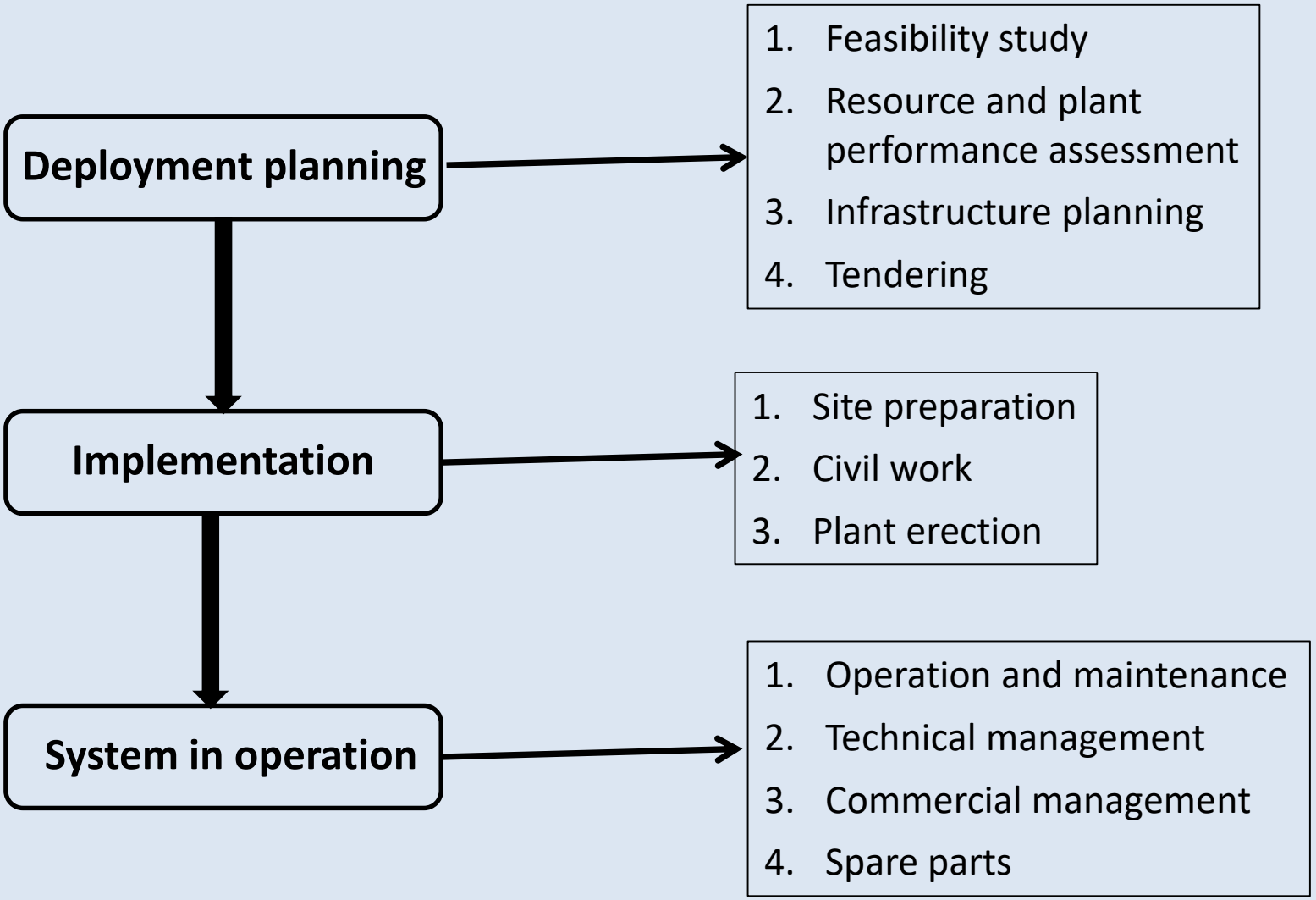
Viability	Bad	Good	excellent
Wind speed (m/s)	Below 4	5-7	Above 7

Irena

6. Social Impact

Renewable Energy Deployment Supply Chain

Renewable deployment impacts on the contribution to industrial development and job creation are positive. These impacts occur at different levels



Renewable Energy Deployment Supporting Process

For the deployment to be successful, there should be a sound supporting process :

1. Policy making (deployment policies
2. Financial services (investment promotion)
3. Education and capacity building (qualified manpower and technology transfer.
4. Research & Development (innovation and growth)
5. Consulting
6. SME/SMI (sub-contracting, O&M)
7. Renewable Energy or related Industry (equipments, spare parts)

Renewable Energy Deployment Social Impacts

- Access to modern, clean and affordable energy technology
- Achieving the objective of Universal access to modern energy services by 2030
- Access to modern reliable energy :
  1. can improve people health by enhancing health services (use of modern medical equipment for diagnostic and treatment)
  2. avoid death and illnesses resulting from the use of bio-fuel in cooking and kerosene lamps use in lighting, both sources of home pollution .
- Access to reliable modern technology energy can:
  1. Help attract foreign investors and developers
  2. Eliminate time people spend collecting firewood
  3. Reduce time women spend on cooking with inefficient stoves
  4. Fight against deforestation.

Renewable Energy Deployment Social Impacts

- Increase rural electrification:
  1. Improve the rural population health and wellbeing
  2. Enables farms to produce more and contribute to the agro-industry process

- Access to affordable energy allows the electrification of the large number African schools that has actual no electricity. This will result in:
  1. increasing the availability of the school structure
  2. Improving the education level
  3. Including the information technology as a new learning tool.

- Providing electricity at home allows the children to do their home work and to be more studious

- Access to energy creates employment opportunities

Technology	Operation (jobs/MW)	O&M (jobs/MW)
Wind onshore	6 - 24	05 – 0.7
Solar PV	28.8 – 69.1	0.70 – 0.73
CSP	18 - 36	0.54 – 1.33

7. Conclusion

Conclusion

Africa actual energy power is

1. Unevenly distributed (more to urban)
2. Distribution system is aging (losses and outages)
3. Energy residential techniques are not modern: inefficiency and health risks
4. Energy deficit: hampering the sustainable economic growth and the educational system

The energy potential of Africa is important:

1. Hydrocarbons: exported to ensure the national development
2. Renewable energy: important untapped potential

All African countries have engaged in the development of renewable energy → National Energy Programs

Conclusion

National Energy Program:

1. Strategies were adopted
2. Targets were fixed
3. Regulation policies and financial incentives were set

Economy:
Solar PV energy and wind energy are competitive and economically viable

Social impact:
Many benefits for the human well being and for the economical development


Thank you for your attention