



Biomass to energy an opportunity for Africa




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Biomass Energy)

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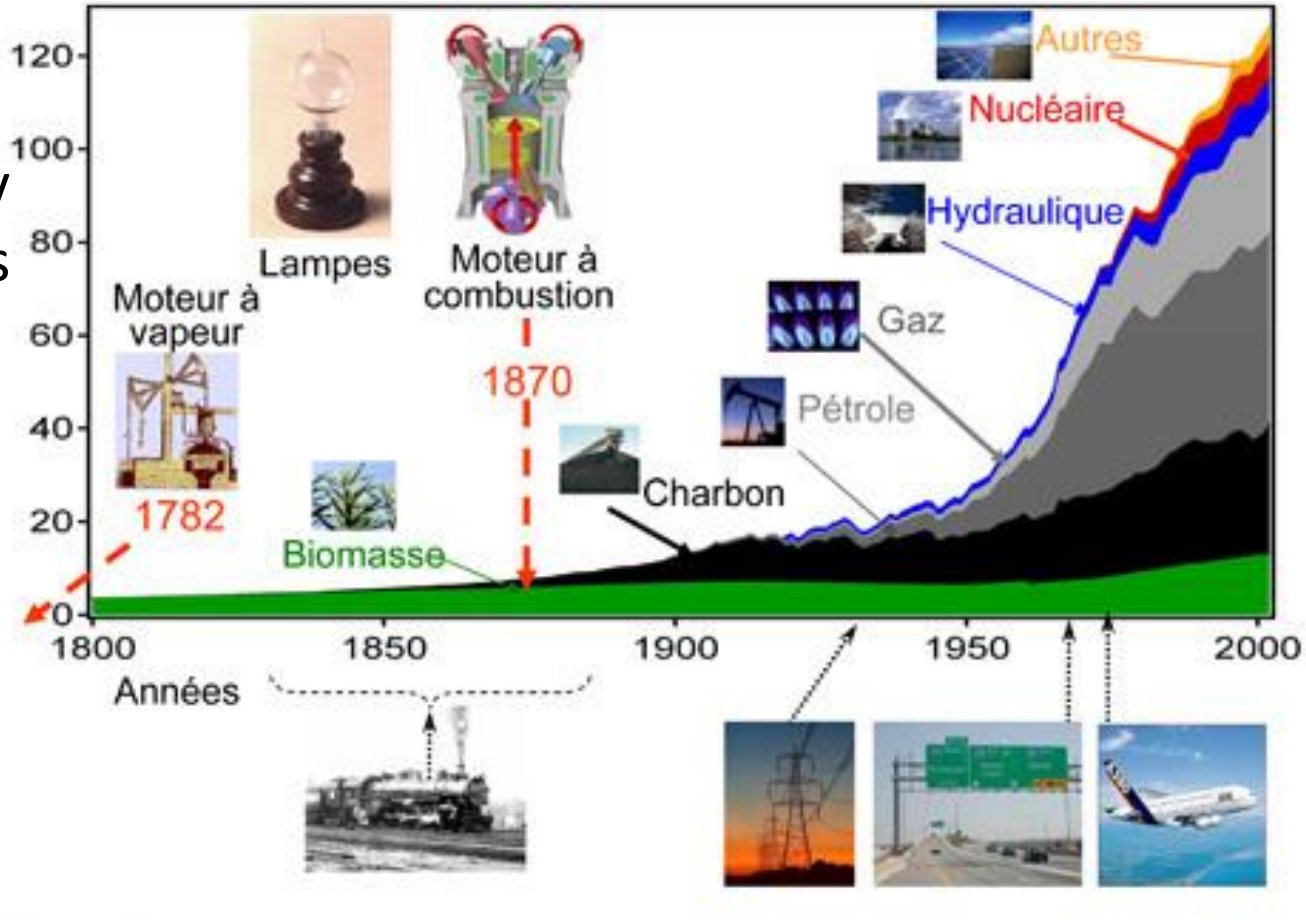
Outline

- Context and challenges
- Introduction
- Biomass definition
- Biomass issues
- Biomass technologies
- Bioenergy in Africa
- Biomass sources and potential in Africa
- Bioenergy policy initiatives in Africa
- Cases studies in ASUZ
- Conclusions and perspectives

The Challenges

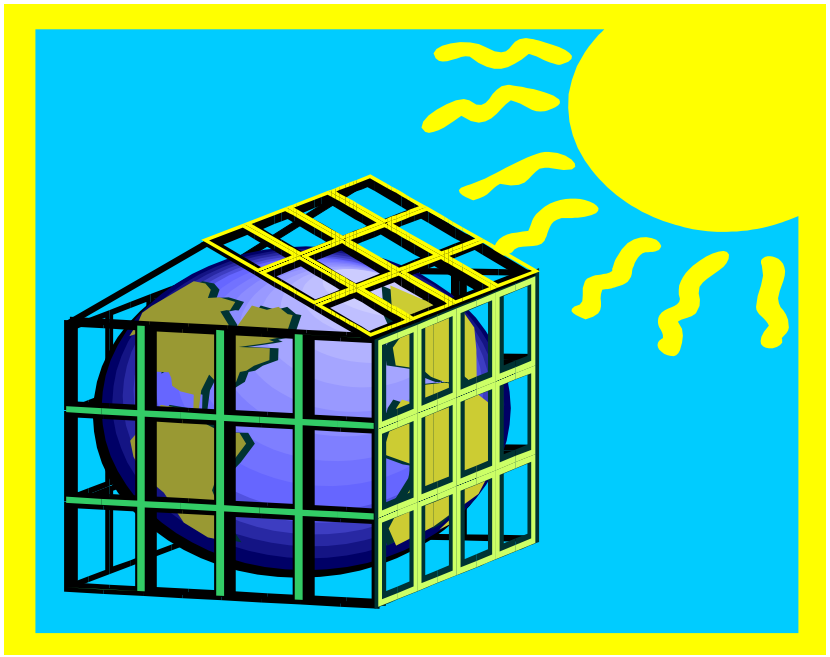
- Our growing dependence on energy is linked to 18th century discoveries and the resulting technologies.

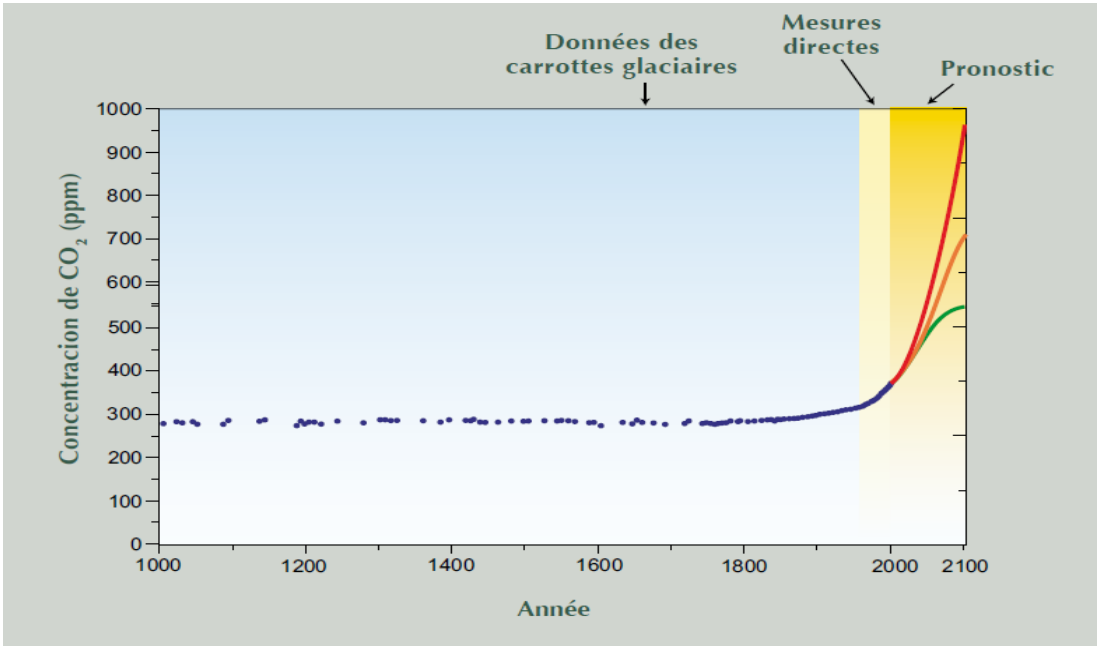


Source: Jean Marie Tarascon, leçon inaugurale,2010, Collège de France

The challenges

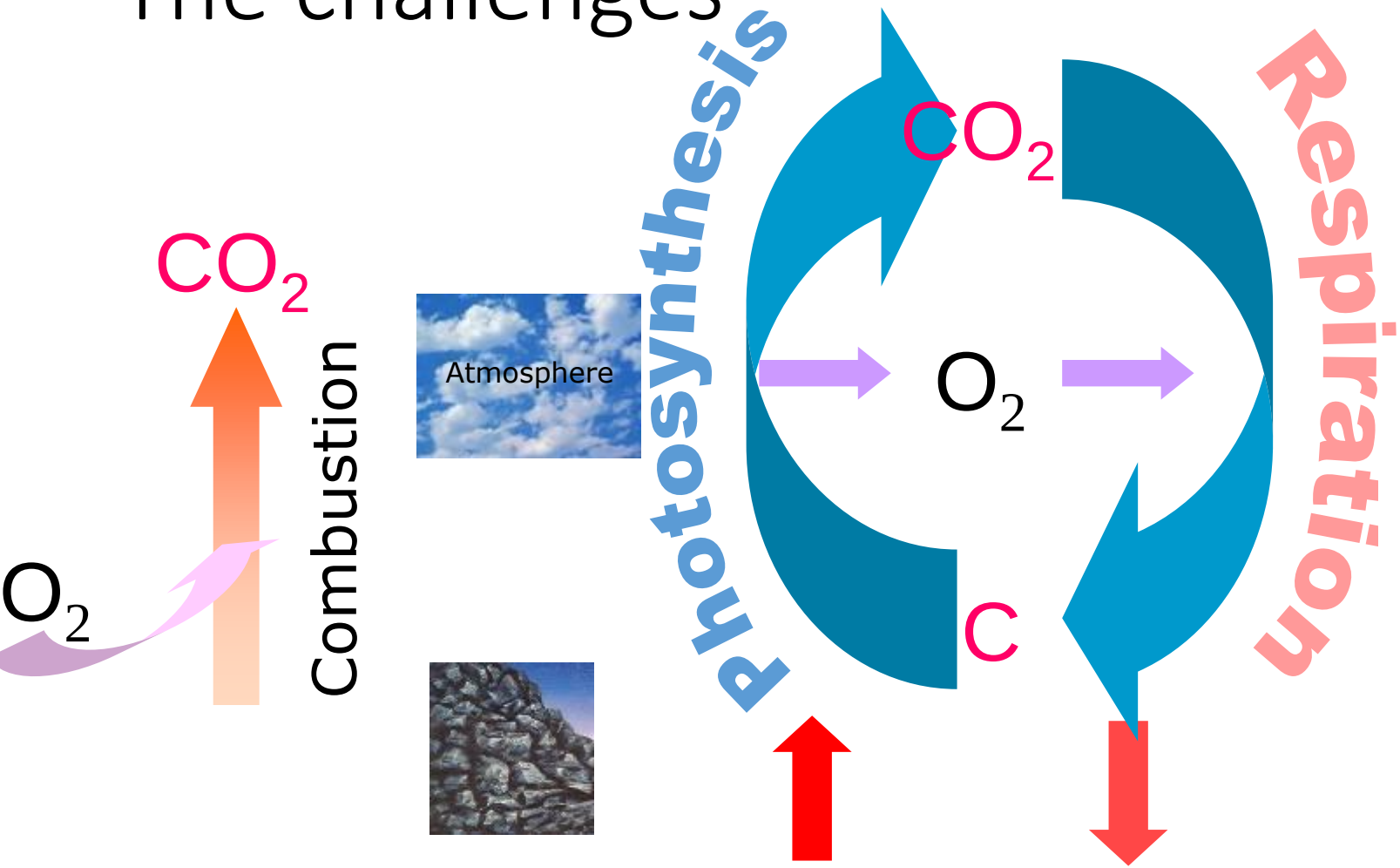
But two issues of concern





Increased greenhouse effect

The challenges



Unclosed cycle of energy vectors

Closed cycle life

Photosynthesis

In the process of photosynthesis, plants convert radiant energy from the sun into chemical energy in the form of glucose—or sugar.

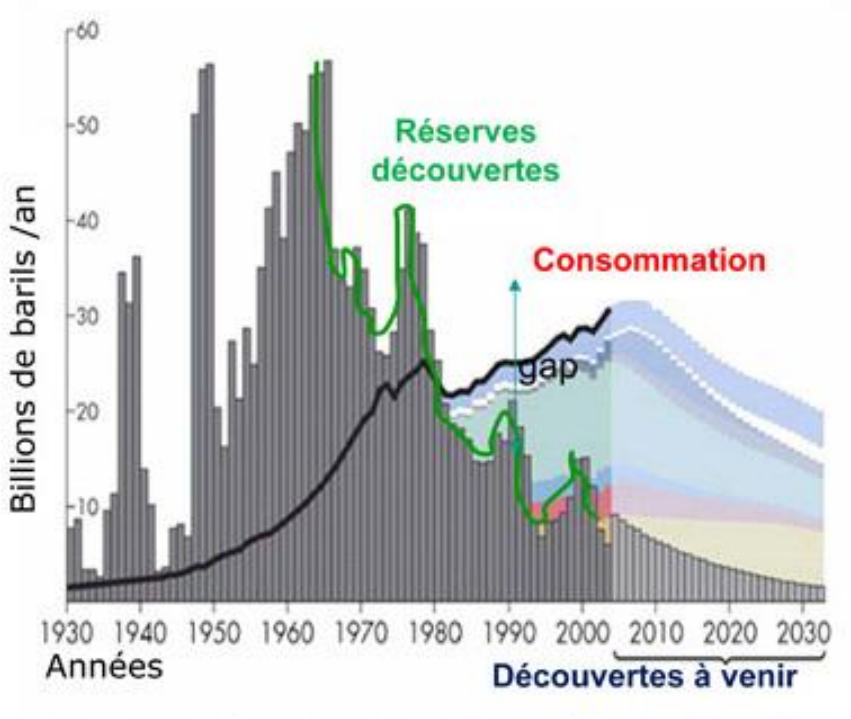
(water)	(carbon dioxide)	(sunlight)	(glucose)	(oxygen)
$6\,H_2O$	+ $6\,CO_2$	+ radiant energy →	$C_6H_{12}O_6$	+ $6\,O_2$

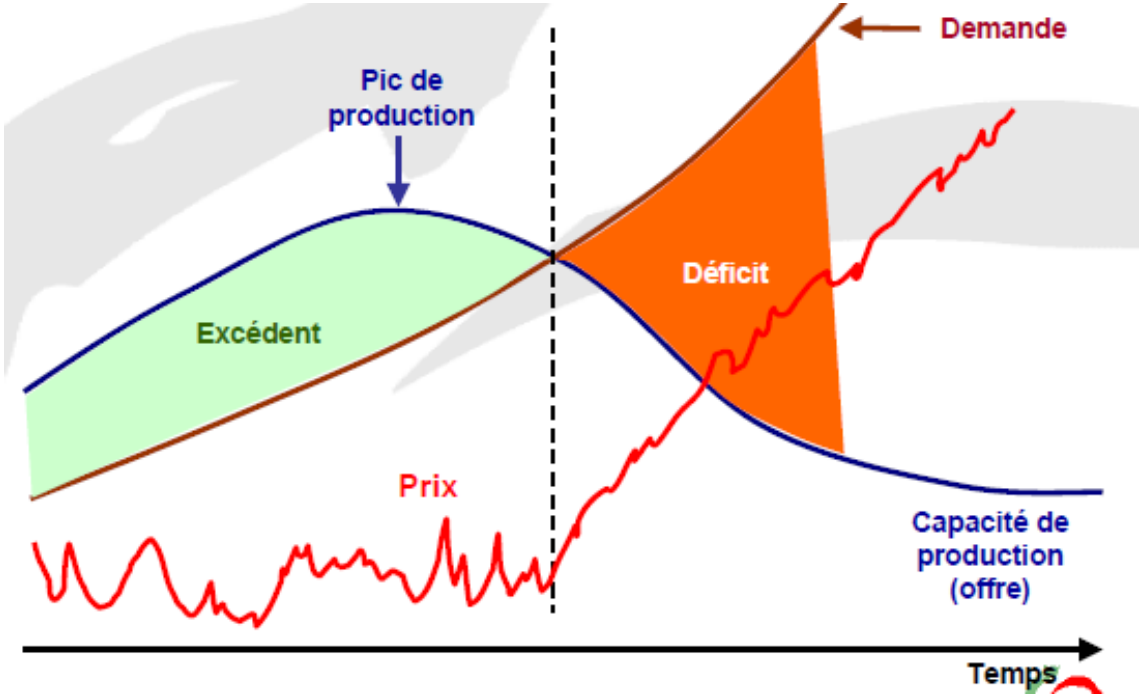
https://www.eia.gov/

The challenges

Fossil fuels

Unequal distribution on the planet
Price variability
In the long run, scarcity of cheap resources..



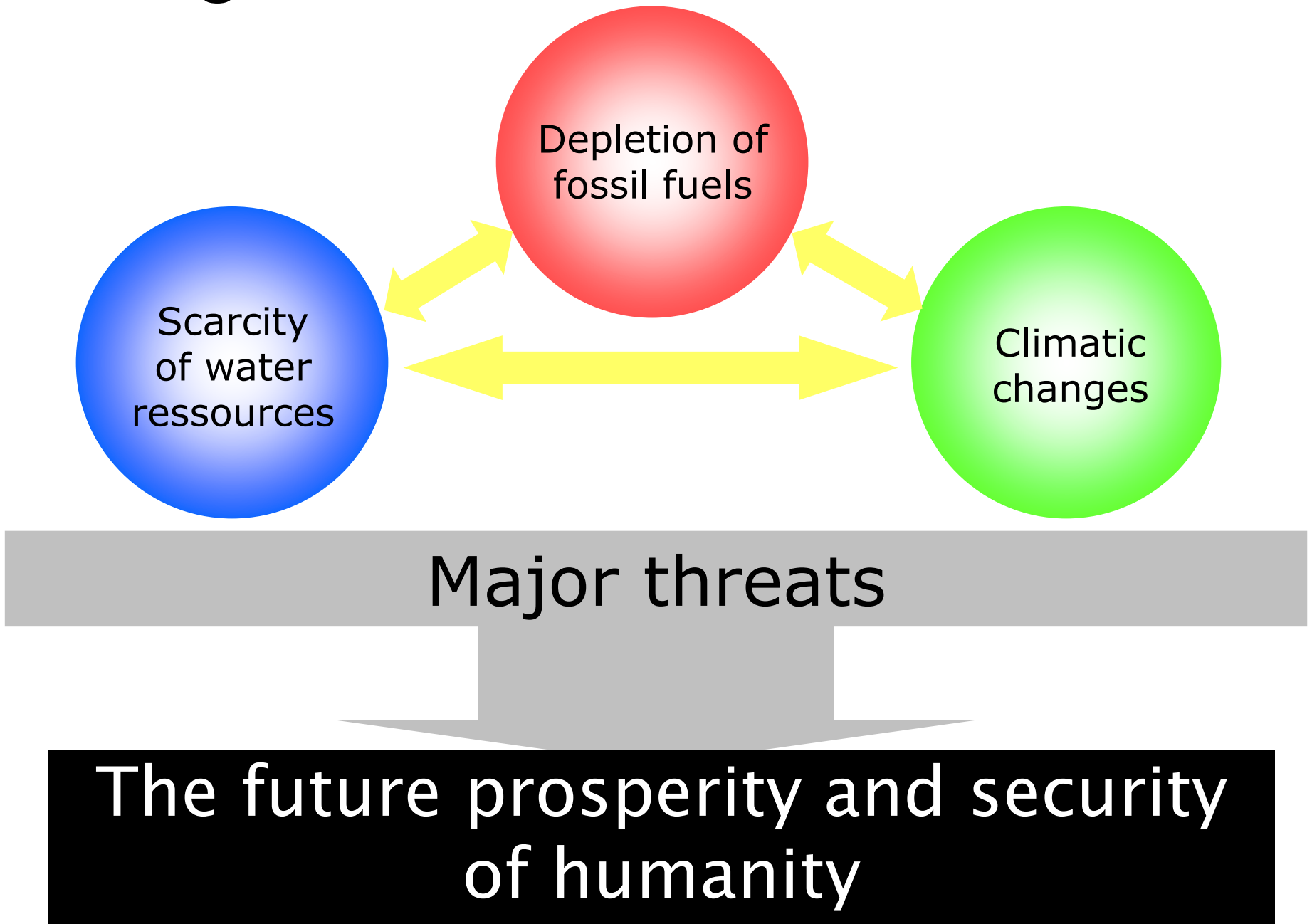


Source: Jean Marie Tarascon, leçon inaugurale,2010, Collège de France

The challenges

Energy poverty in some parts of the world

The challenges



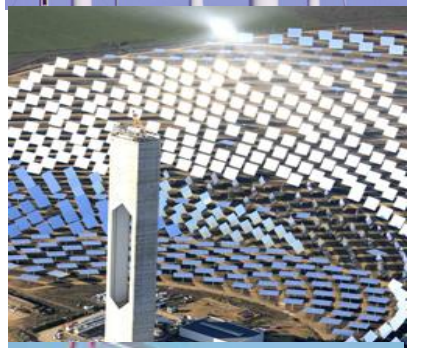
The challenges

…. Of energetic transition.

Most countries in the world have embarked on an "energy transition" – or are thinking about doing so – under the dual influence of the realization that fossil fuels are a limited resource, however long supplies might last, and, more recently, the growing awareness that they are adversely impacting the planet's climate. But what does an energy transition actually entail?

FOSSIL FUELS

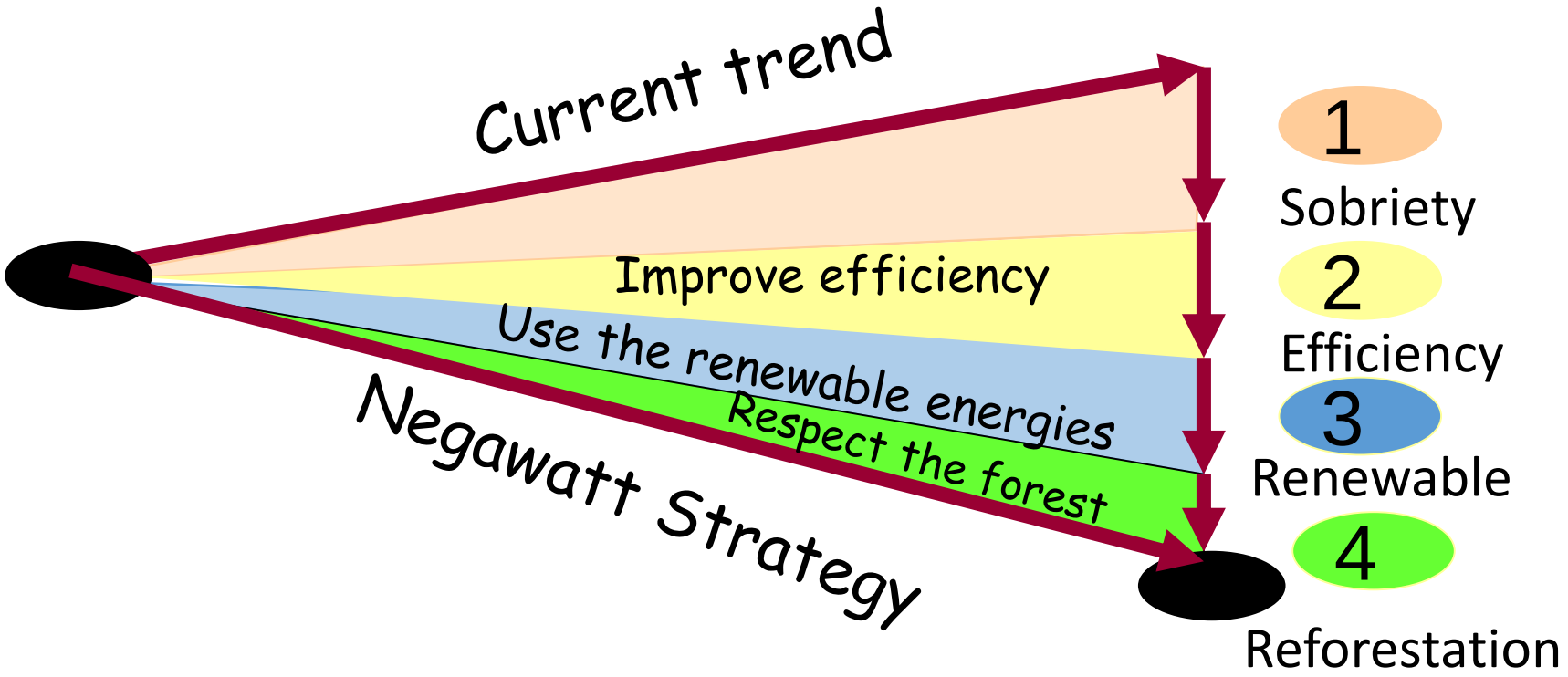
inévitable Paradigm Shift : Energy system changes



RENEWABLE ENERGIES

The challenges

…. Of energetic transition…The needs!



Introduction

Some statistics…

- 2.7 billion people use traditional biomass for cooking in 2009
- Over 4 million people die prematurely from illness attributable to the household air pollution from cooking with solid fuels (WHO, 2016).
- More than 50% of premature deaths due to pneumonia among children under 5 are caused by the particulate matter (soot) inhaled from household air pollution.
- Wood accounts for more than 80% of all primary energy in West African countries, followed by hydrocarbon imports between 15% and 19%.
- High potential in plant biomass (residues, plantations ...).

=> Moving from a domestic use of the BE to a more modern use allowing the development of economic activities (agricultural processes - artisanal-industrial).

Introduction

Africa: A region with the most significant amount of underutilized renewable energy sources, but … slow at mobilizing this potential.

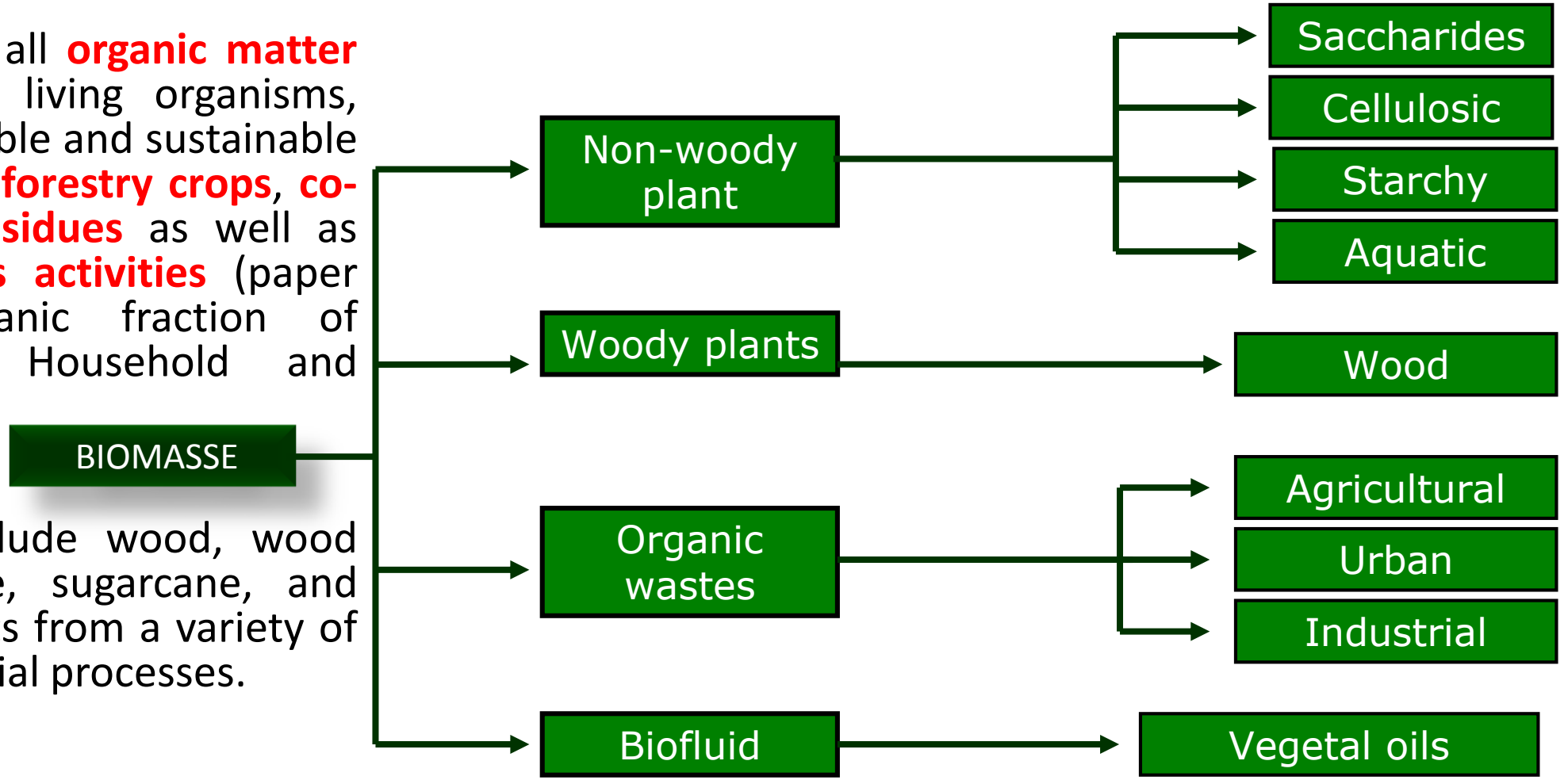
- Land available?
- Policies under development?
- Political good will?

Biomass definition

- **What is biomass?**

Biomass is defined as all **organic matter** directly derived from living organisms, accessible on a renewable and sustainable basis: **agricultural and forestry crops**, **co-products and crop residues** as well as **residues from various activities** (paper mills, sawmills, organic fraction of industrial waste , Household and agricultural ...) .

As a fuel it may include wood, wood waste, straw, manure, sugarcane, and many other by products from a variety of agricultural and industrial processes.



Biomass definition

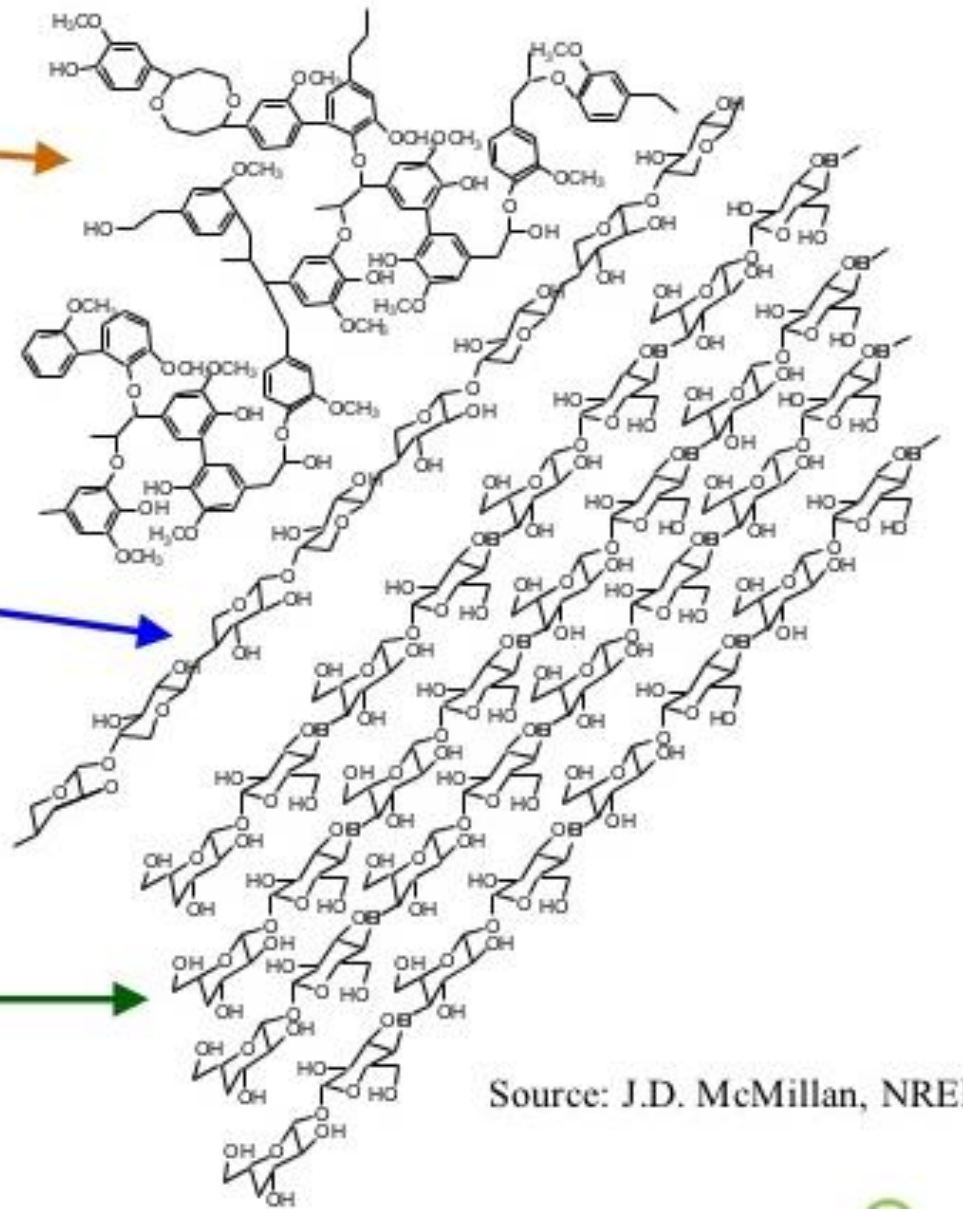
Biomass main constituents

Lignine: 15-25%

Hémicelluloses: 23-32%

Cellulose: 38-50%

Extractibles: 3-6%

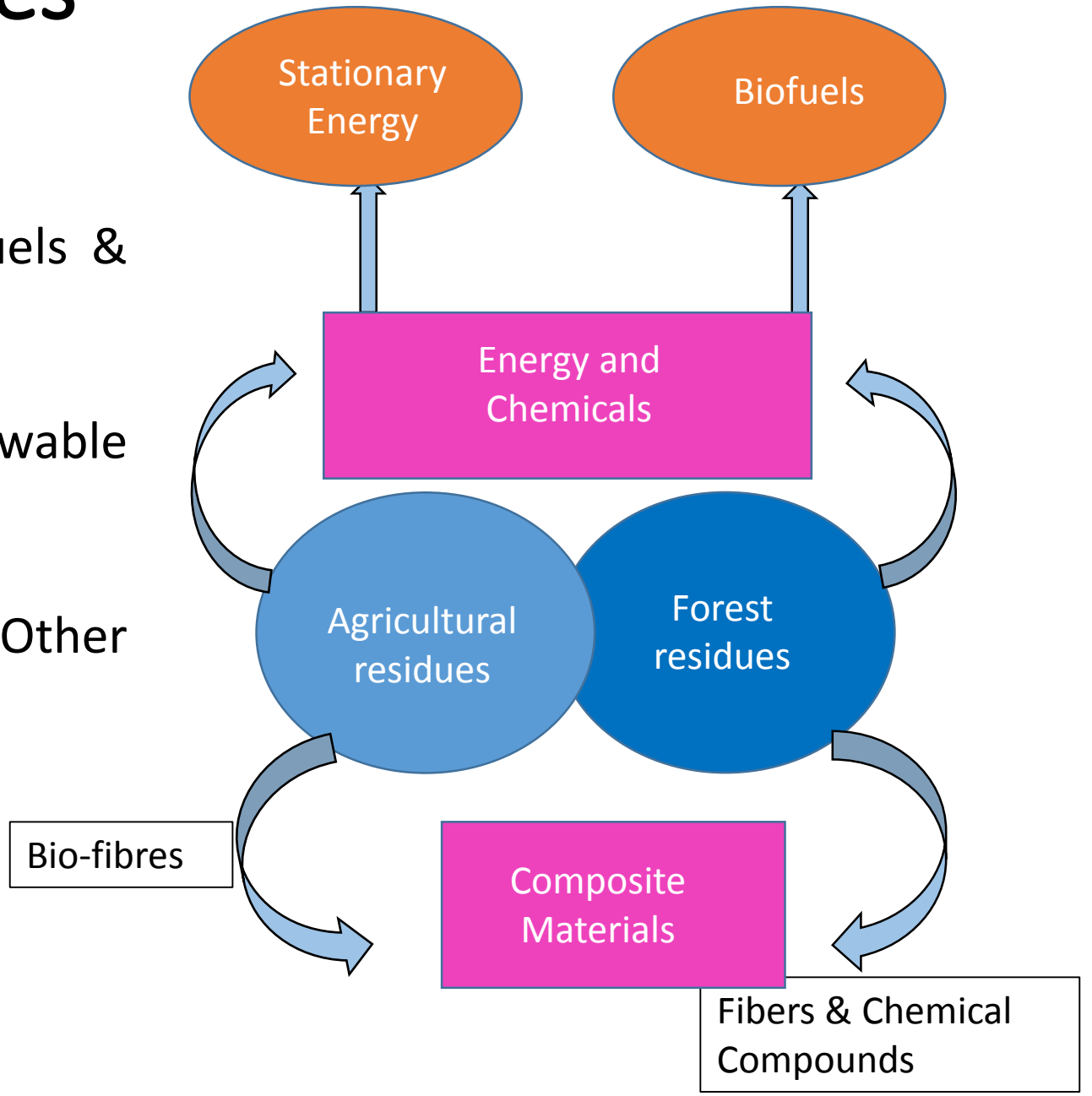


Source: J.D. McMillan, NREL

Biomass issues

Agricultural/Forest residues

- Use of biomass for the production of biofuels & biopolymers;
- Biomass is an important source of renewable energy;
- Chemical Derivatives (Essential Oils & Other Extractives)



Biomass issues

Factors affecting Options Choice

Biomass

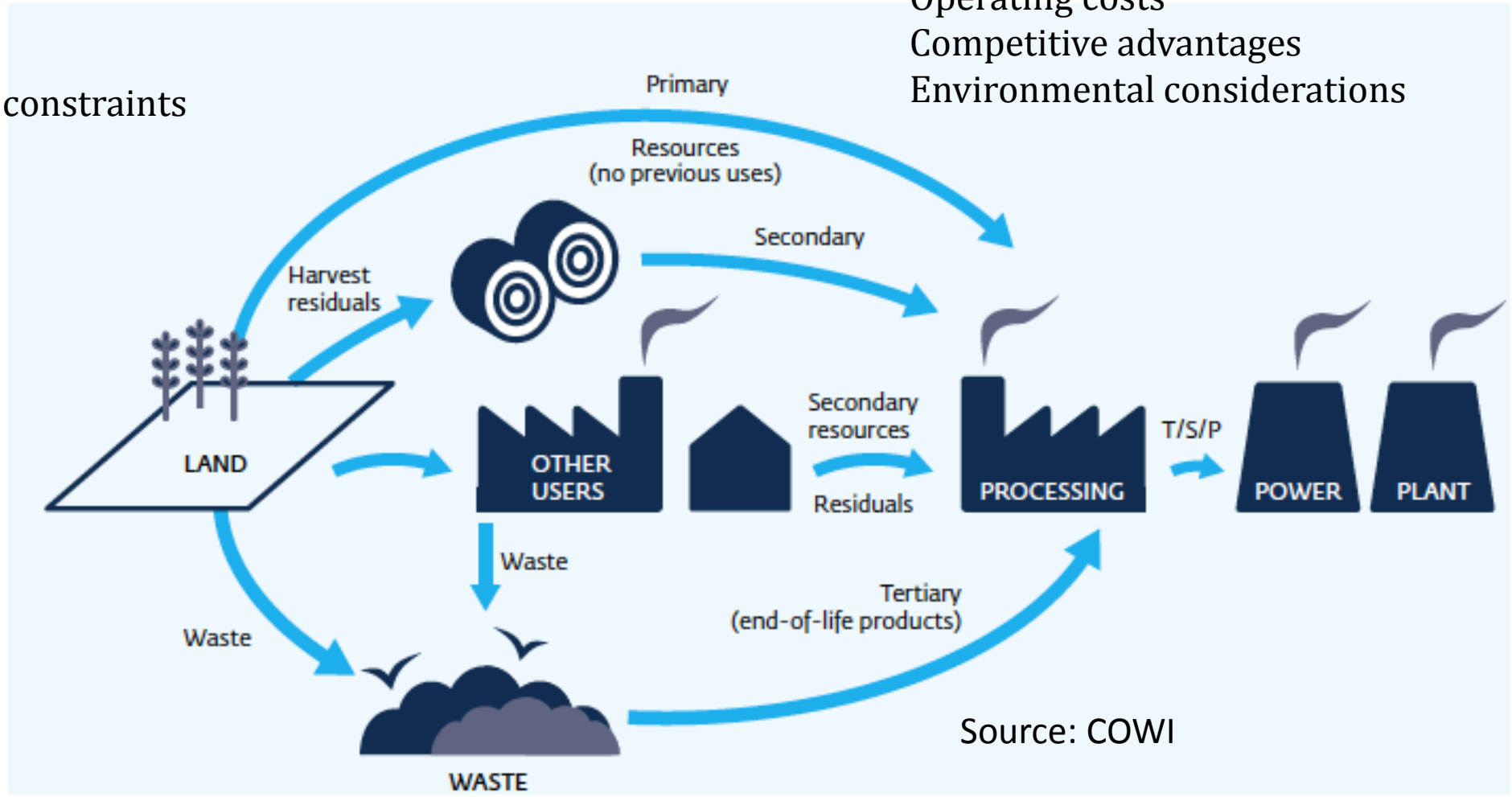
- Cost
- Quality (water content, contaminants, homogeneity)
- Volume & disponibility
- Sources of supply & external constraints

Processes

Proven technology
Capital investment
Efficiency, powerful
Operating costs
Competitive advantages
Environmental considerations

Products

Produits intermédiaires & coproduits (fibres résiduelles)
Quality criteria
Distribution / Market access



Source: COWI

Biomass issues

Financial considerations: Supply costs

Pre-stack

Estimate from the BiOS model

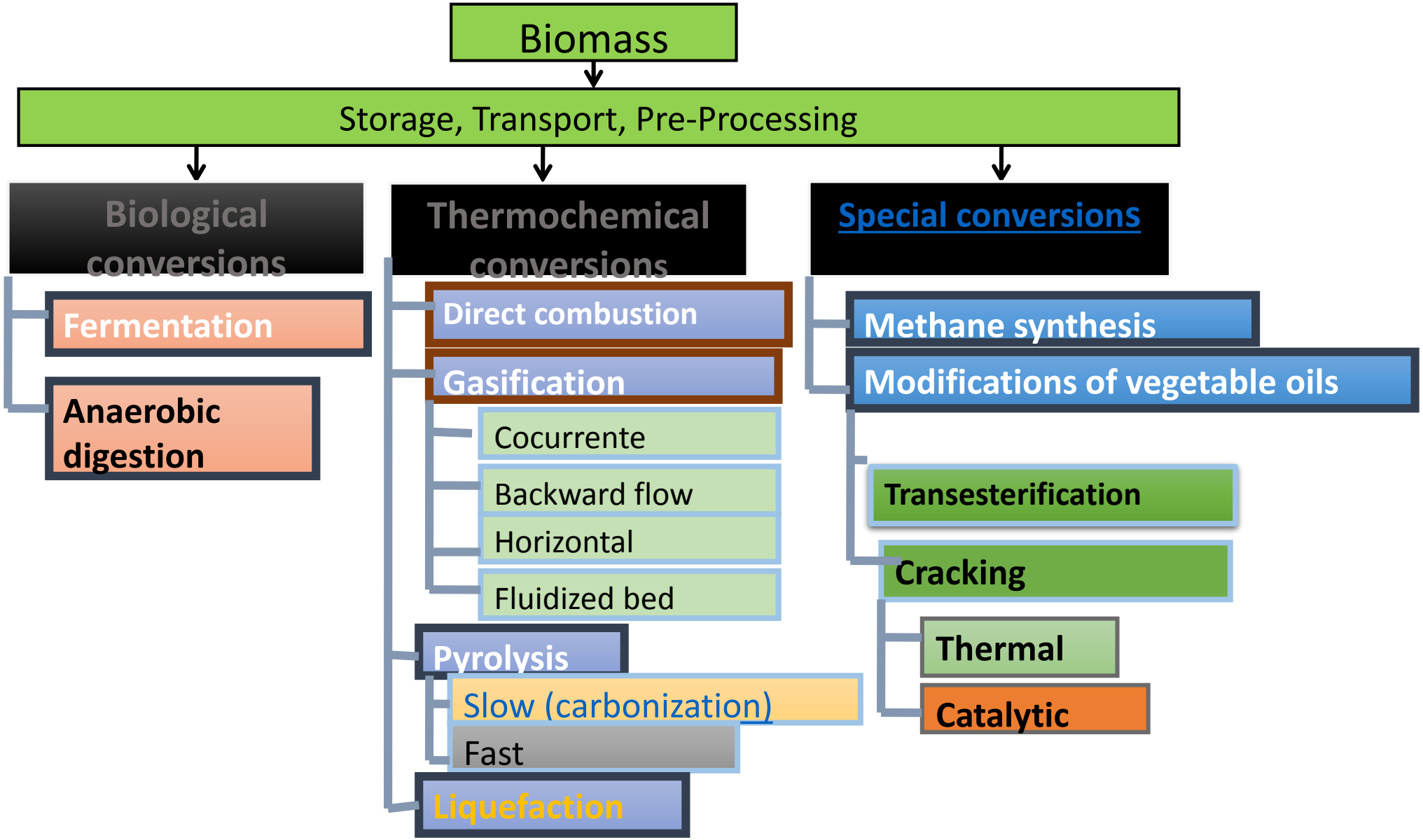
Transports:
For example, 120 km (one way), trailer with movable floor.

Grinding

Others:
-Road, supervision, overheads, maintenance, regulations, rights.

Biomass technologies

Routes for energy production from biomass



Biomass technologies

Final energy use

Production of:

- ✓ Cellulosic Ethanol
- ✓ Cogeneration
- ✓ Biogas
- ✓ Bio-oils
- ✓ Granules & energy logs








Biomass technologies

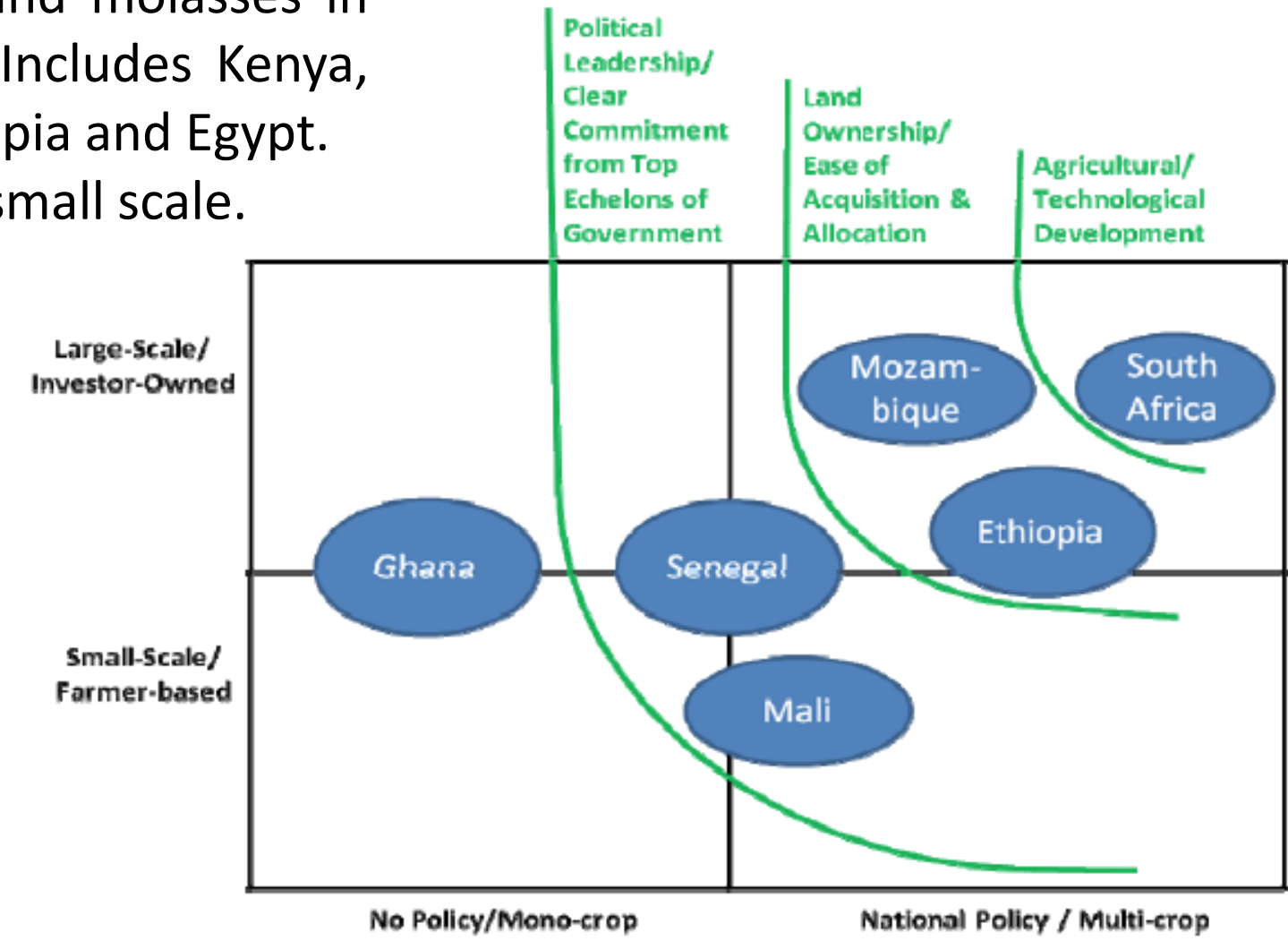
Routes for energy production from biomass

- **Biofuels** are liquid and gaseous fuels produced from biomass – organic matter derived from plants or animals (IEA).
- **Conventional biofuel** technologies include well-established processes that are already producing biofuels on a commercial scale. These biofuels, commonly referred to as **first-generation**, include sugar- and starch-based ethanol, oil-crop based biodiesel and straight vegetable oil, as well as biogas derived through anaerobic digestion.
- **Advanced biofuel** technologies are conversion technologies which are still in the research and development (R&D), pilot or demonstration phase, commonly referred to as second- or third- generation. This category includes biofuels based on lignocellulosic biomass, such as cellulosic-ethanol, biomass-to-liquids (BtL)-diesel and bio-synthetic gas (bio-SG)…such as algae-based biofuels and the conversion.

Biomass technologies

Routes for energy production from biomass

- Ethanol production from sugarcane and molasses in mainly Eastern and Southern Africa. Includes Kenya, Malawi, Zimbabwe, South Africa, Ethiopia and Egypt.
  - Much of the ethanol experience is on small scale.
- Capacity exist in most countries for the design and manufacture of small scale equipment for oil extraction and associated processes but not for transesterification.
- Majority of research institutions not well equipped and resourced to undertake specialised engineering research and development.



Source: The energy center , KNUST

Biomass technologies

Diagram of the ethanol production from biomass

Biomass

1. Pretreatment
Pastry
Make fiber accessible

2. Hydrolysis
Make sugar

- Glucose
- Xylose
- Mannose

3. Detoxification
Suitable solution for fermentation

4. Fermentation

Distillation

The first challenge to produce cellulosic ethanol is to extract the sugars from the wood.
The sugar content of wood can range from 60 to 80%(CTRI, Centre Technologique des Résidus Industriels, 2012).
Lignin (21-25%) is a phenolic polymer that is difficult to degrade.

Acid hydrolysis of cellulose using a microwave (120 ° C, 10 min) leads to 3 glucose.

Biomass technologies

Biogas (biomass)

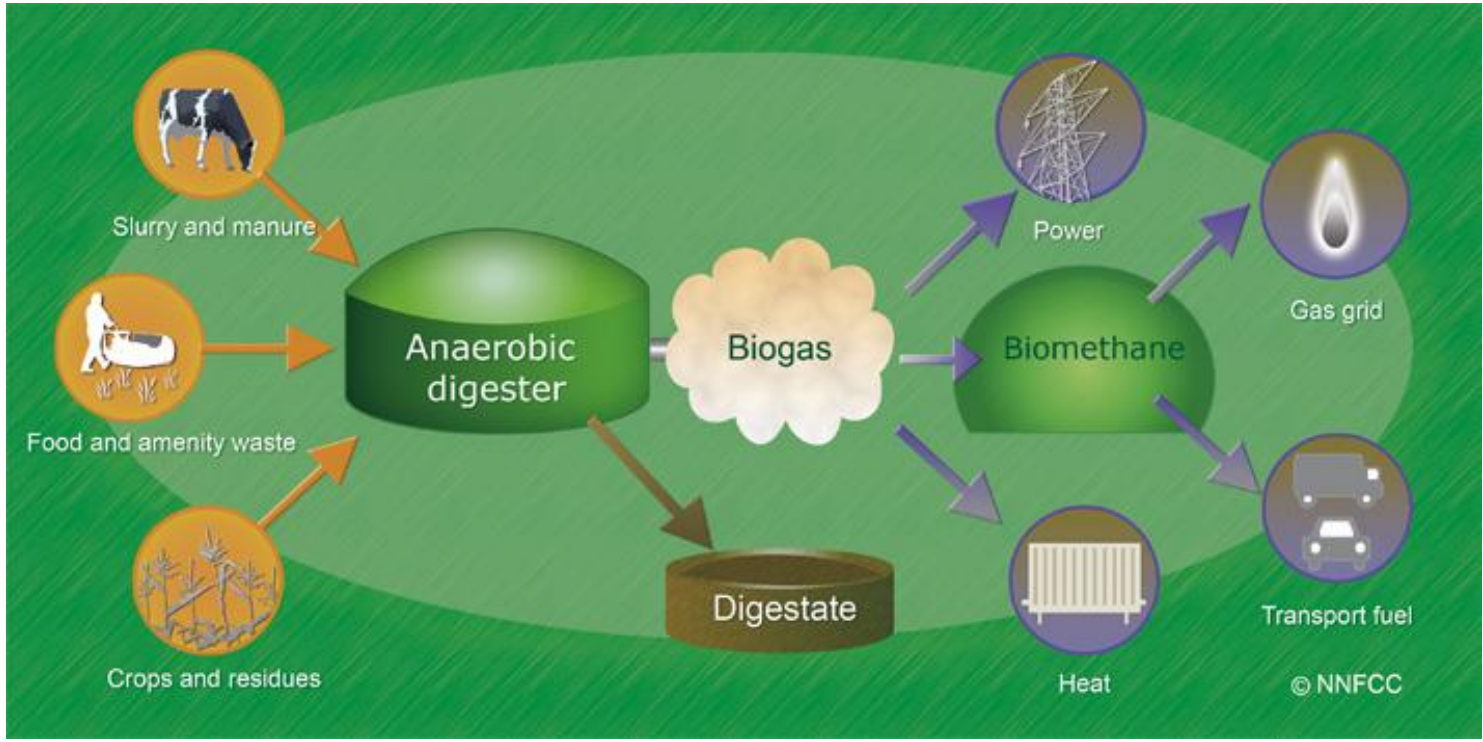
What is biogas?

Biogas is a gas that is formed by anaerobic microorganisms. These microbes feed off carbohydrates and fats, producing methane, CH_4 and carbon dioxides CO_2 as metabolic waste products. This gas can be harnessed by man as a source of sustainable energy.

Biogas is considered to be a renewable fuel as it originates from organic material that has been created from atmospheric carbon by plants grown within recent growing seasons.

Benefits of anaerobic digestion and biogas

- ✓ Production of renewable power through combined heat and power cogeneration
- ✓ Disposal of problematic wastes
- ✓ Diversion of waste from landfill
- ✓ Production of a low-carbon fertiliser
- ✓ Avoidance of landfill gas escape and reduction in carbon emissions



Source, Dr Marie SAWADOGO, 2IE, 2017

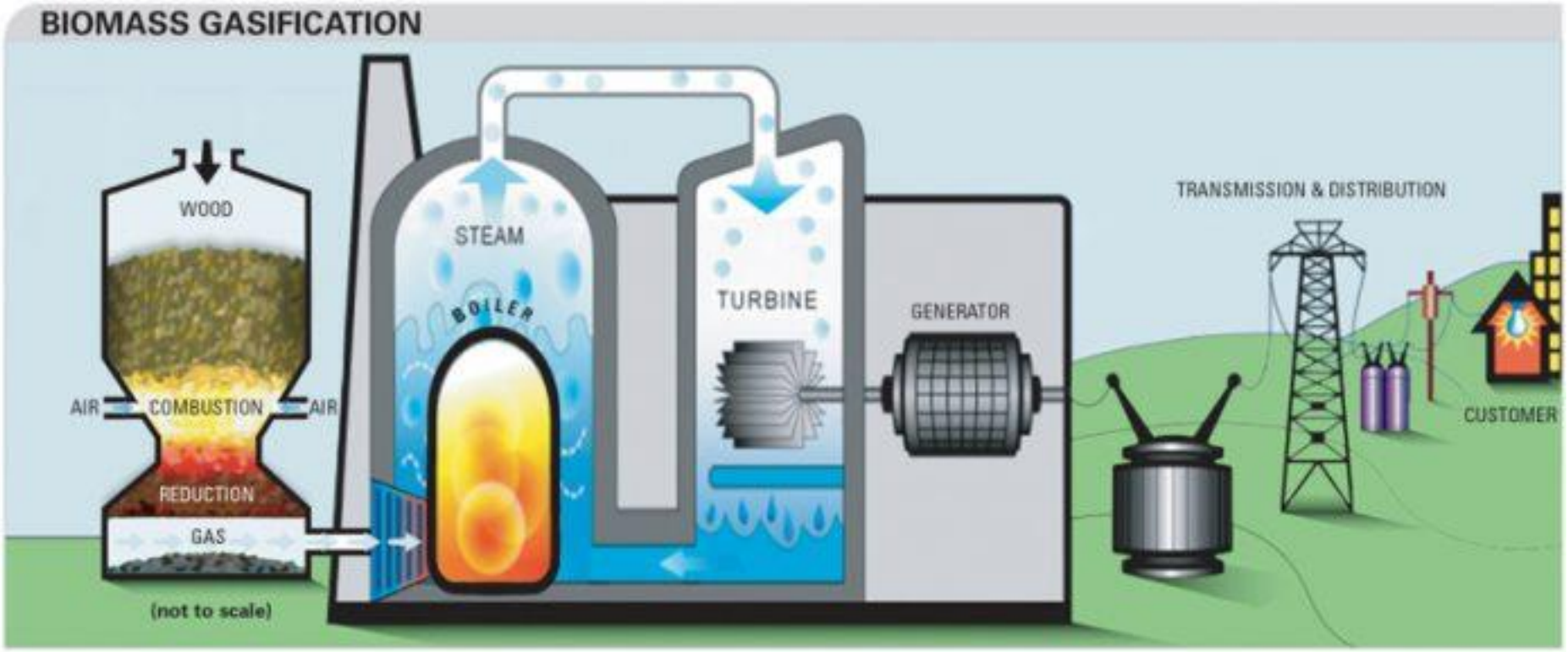
Biomass technologies

Gasification

Gasification occurs when biomass is transformed through a thermochemical process into fuel gas.

It is a highly versatile process because virtually any dry biomass feedstock can be efficiently converted to fuel gas.

The output of this process is referred to as bio-synthetic gas (syngas).



http://www.eco-globe.com

Biomass technologies

Solid biofuel

- ***Sugar cane bagasse***: Used in steam boilers in the sugar industry
- ***Briquettes, pellets…*** used in cookstoves, boilers…

Palm, cashew, Peanut shells

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

Biomass technologies

Solid biofuel

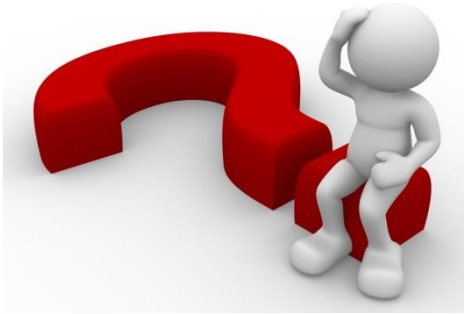
Saving Gambia's forests through eco-friendly briquettes & cookstoves

The Gambia is using groundnut shells, a waste by-product from peanut farming, to produce **eco-friendly fuel briquettes** that can be used in households, restaurants and industries for cooking and heating – as **an alternative to firewood and charcoal**.

« Avec 2.5kg de briquettes et la nouvelle cuisinière, on peut rapidement faire cuire un repas pour une très grande famille. C'est donc une bonne initiative et tous les Gambiens devraient les utiliser pour freiner la destruction de la forêt ».

Sources : Green et Vert et Green Africa Directory

Bioenergy in Africa



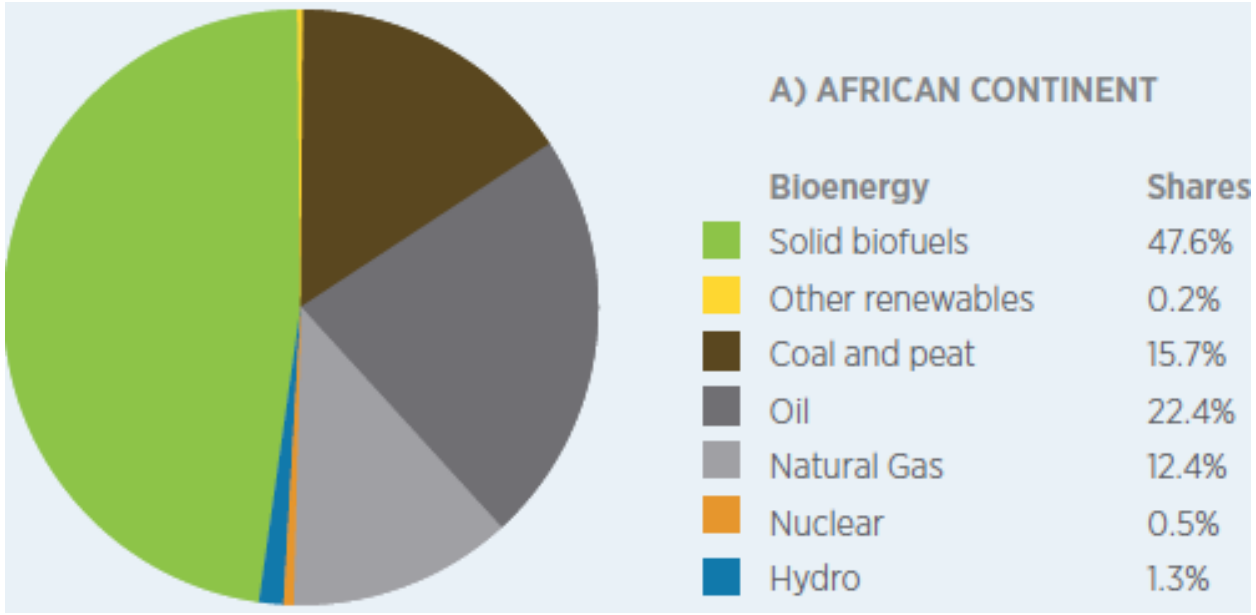
Key questions

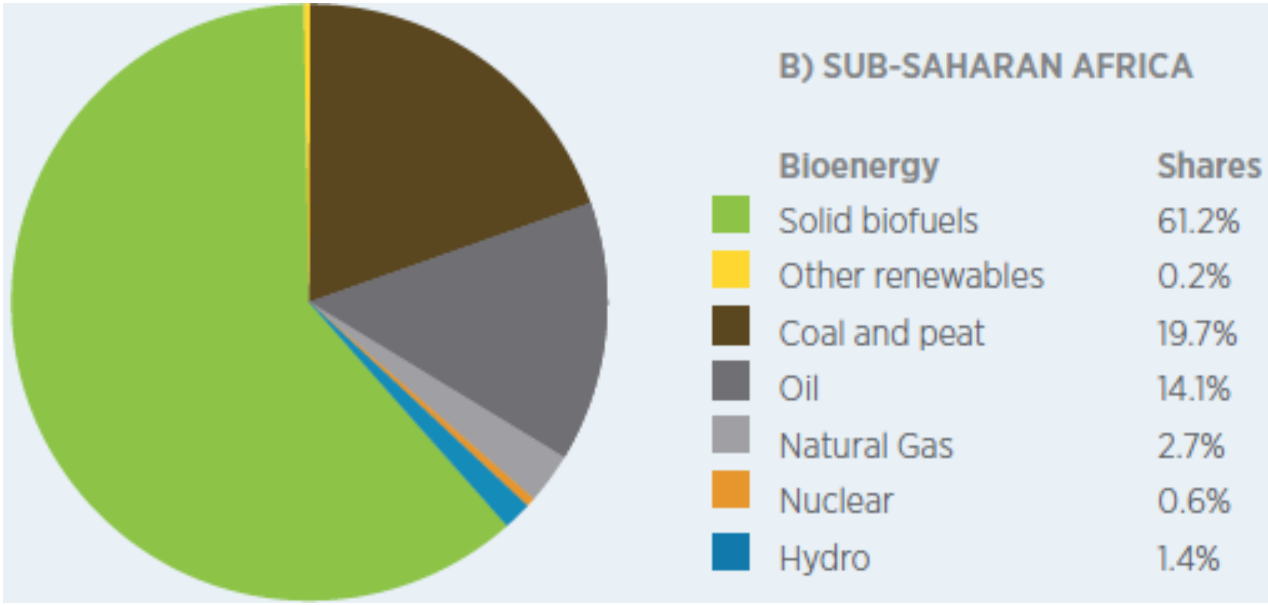
- Does bioenergy have a realistic role to play in meeting Africa's increasing energy needs, what is the potential, current and projected use?
- What are the opportunities of scaling-up bioenergy in Africa?
- What barriers hinder the implementation of improved and modern bio-energy, in Africa?
- What policies and regulatory frameworks have been developed to promote bioenergy use?
- What are the conditions for sustainable bioenergy sectors implementations in Africa?

Bioenergy in Africa

Key questions

- Biomass is a primary source of energy for close to 600 million people in African countries (IEA, 2007).





IRENA, 2013

Bioenergy in Africa

- **Traditional use vs modern use**

Traditional biomass use refers to the use of wood, charcoal, agricultural residues and animal dung for cooking and heating in the residential sector. It tends to have very low conversion efficiency (10% to 20%) and often unsustainable supply.





Bioenergy in Africa

- **Traditional use vs modern use**

Modern biomass technologies include **liquid biofuels produced from straw and wood**, **industrial cogeneration and biorefineries**, **biogas produced through anaerobic digestion of residues**, **pellet heating systems** and other technologies.

As a result of the negative health impacts of these methods (mainly related to smoke inhalation) and their environmental effects (e.g. forest degradation, emission of methane and black carbon), efforts are being made to introduce more efficient cooking stoves or to provide more modern alternative systems (IEA, 2016).

Bioenergy in Africa

- **Traditional use vs modern use**

Biomass is also used in **industries** that consume large amounts of heat (either hot water or steam) and have **large volumes of biomass residue at their disposal**, such as the paper and pulp industry and the wood-processing sector.

Other industrial processes, such as in the food and chemical sectors, could potentially provide a large market for biomass heating.

http://www.btgworld.com

Bioenergy in Africa

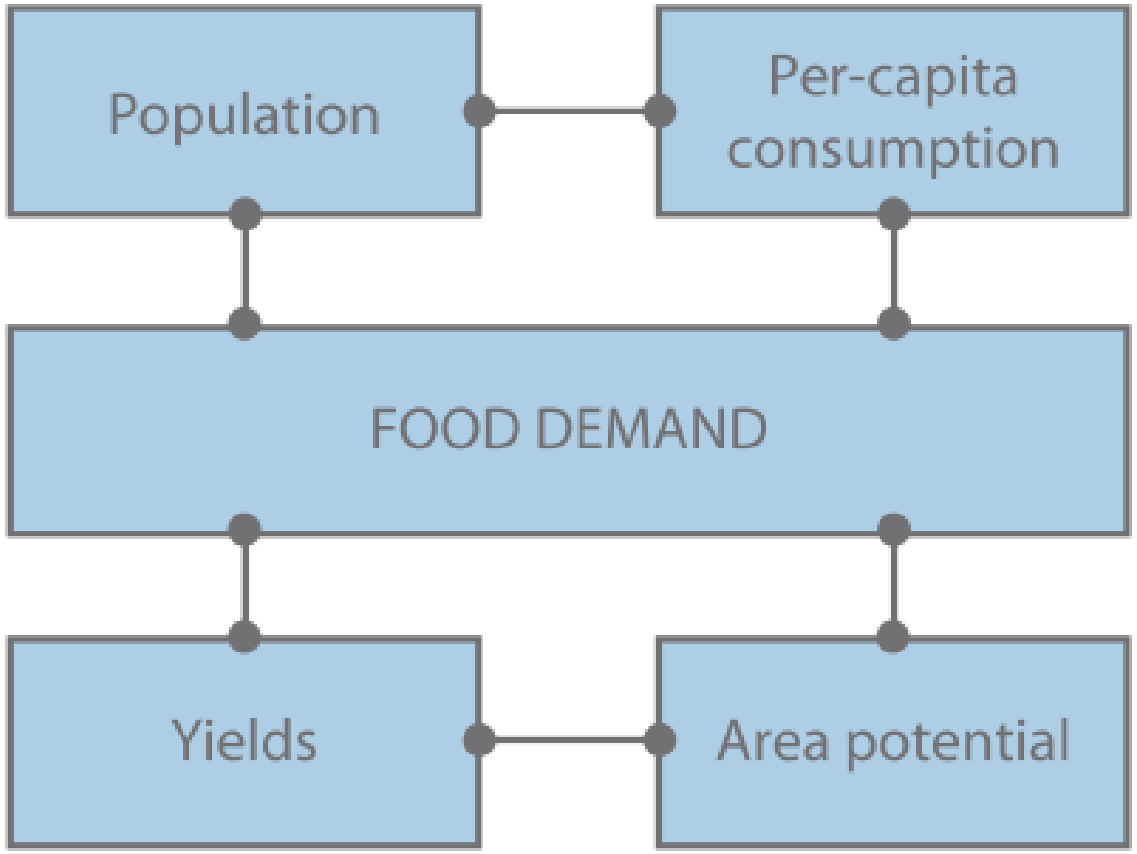
The availability of sufficient amounts of biomass resource is one of the key factors determining the potential role of bioenergy in the national or regional energy system.

What is the potential ??

It is important that the estimation of biomass potential takes into account the possible types and origins of biomass resource.

Biomass sources and potential in Africa

Important driving factors/criteria to consider when assessing biomass potential



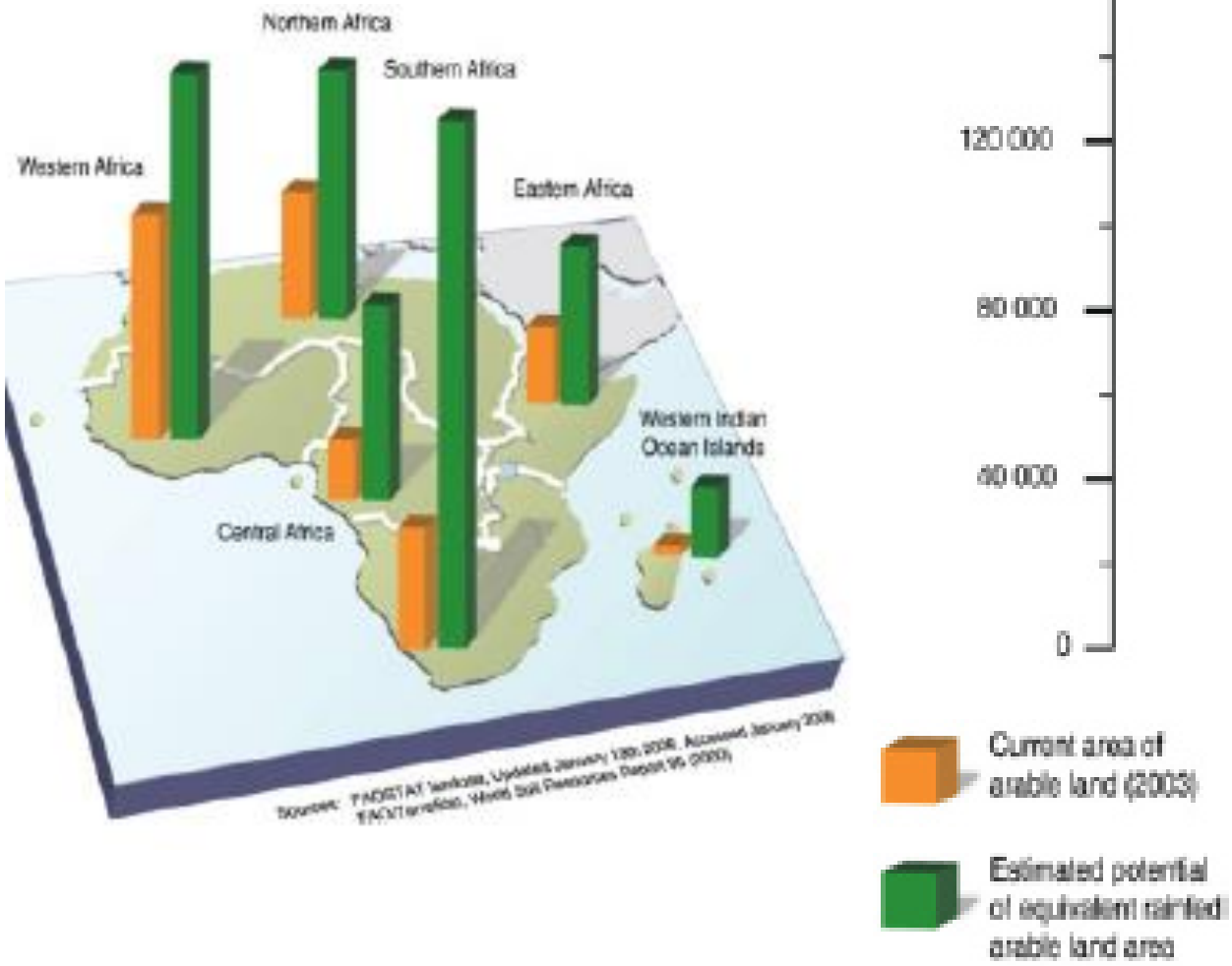
1. The calculated area potential for energy crops ranges between 1.5 million hectares (ha) and 150 million ha;

2. The various assessments indicate a potential in Africa by 2020 for:

- **energy crops** from 0 PJ/yr to 13 900 PJ/yr,
- **forestry biomass** between 0 PJ/yr and 5 400 PJ/yr
- **residues and waste** 10 PJ/yr to 5 254 PJ/yr;

IRENA, 2013

Biomass sources and potential in Africa

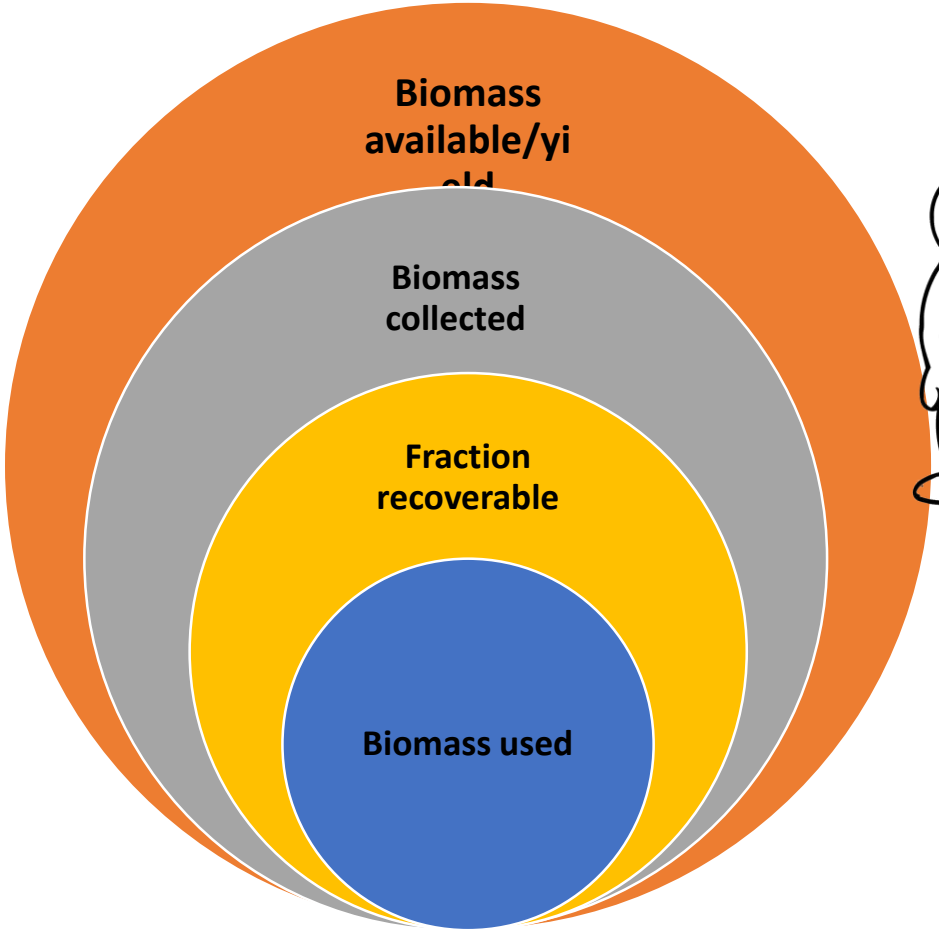


(Source: FAOSTAT, 2009).

FAO has estimated that the **potential additional land** area available for cultivation in Africa amounts to more than 700 million ha (FAO, 2009).

Biomass sources and potential in Africa

Disponibilité économique ?



Potential

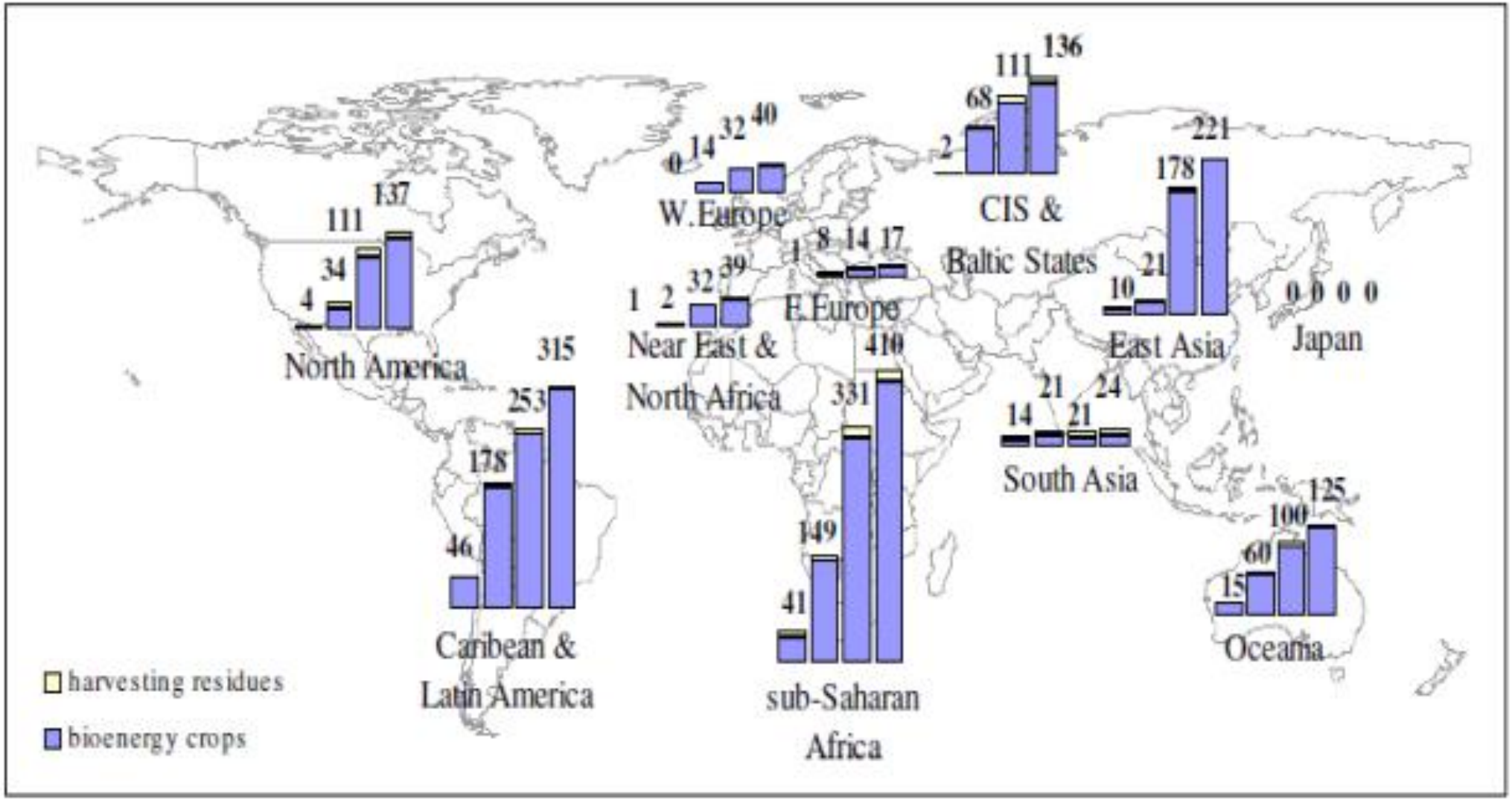
- **Collection/harvesting technology – efficiency**
- **Logistic…**

Plant

Potential Availability / Technical Availability / and Economic Availability

Biomass sources and potential in Africa

Africa has highest bioenergy potential



Source: Smeets et al. (2008)

Biomass sources and potential in Africa

Available feedstock

Biofuel
- Oil plam
- Jatropha
- Blanites

Bioethanol
- Sugarcane - Cassava
- Corn -Sweet sorghum

Gasification
- Rice husk
- Cotton stalk…

Biogas
- farm based products such as animal manure, agricultural by-products and farm based wastes, organic wastes from the food and feed industries as well
- municipal solid waste

Other
- Industrial wastes (cashew industry, oil industry…)

Bioenergy policy initiatives in Africa

African governments have implemented several initiatives such as **agro-ecological zoning to identify land available for food and for bioenergy production** and **mandates for investors to use part of the allocated land** to food production chain.

Environmental and socio-economic characteristics of the specific country considered.

- Regional, national and local environmental policy.
- Types of bioenergy, feedstocks and processing technologies.
- Types of agricultural and forestry management approaches, systems and practices implemented in bioenergy feedstock production.
- Scale and ownership of production.
- Logistics of biomass transport, particularly the means of transport and distances.
- Types of business model found along the bioenergy supply chain.

Bioenergy policy initiatives in Africa

- **Policy and regulatory support is necessary for the successful implementation of improved and modern bioenergy projects**

Continent level

The African Union Commission

Regional level

South African Biofuel Association, ECOWAS…

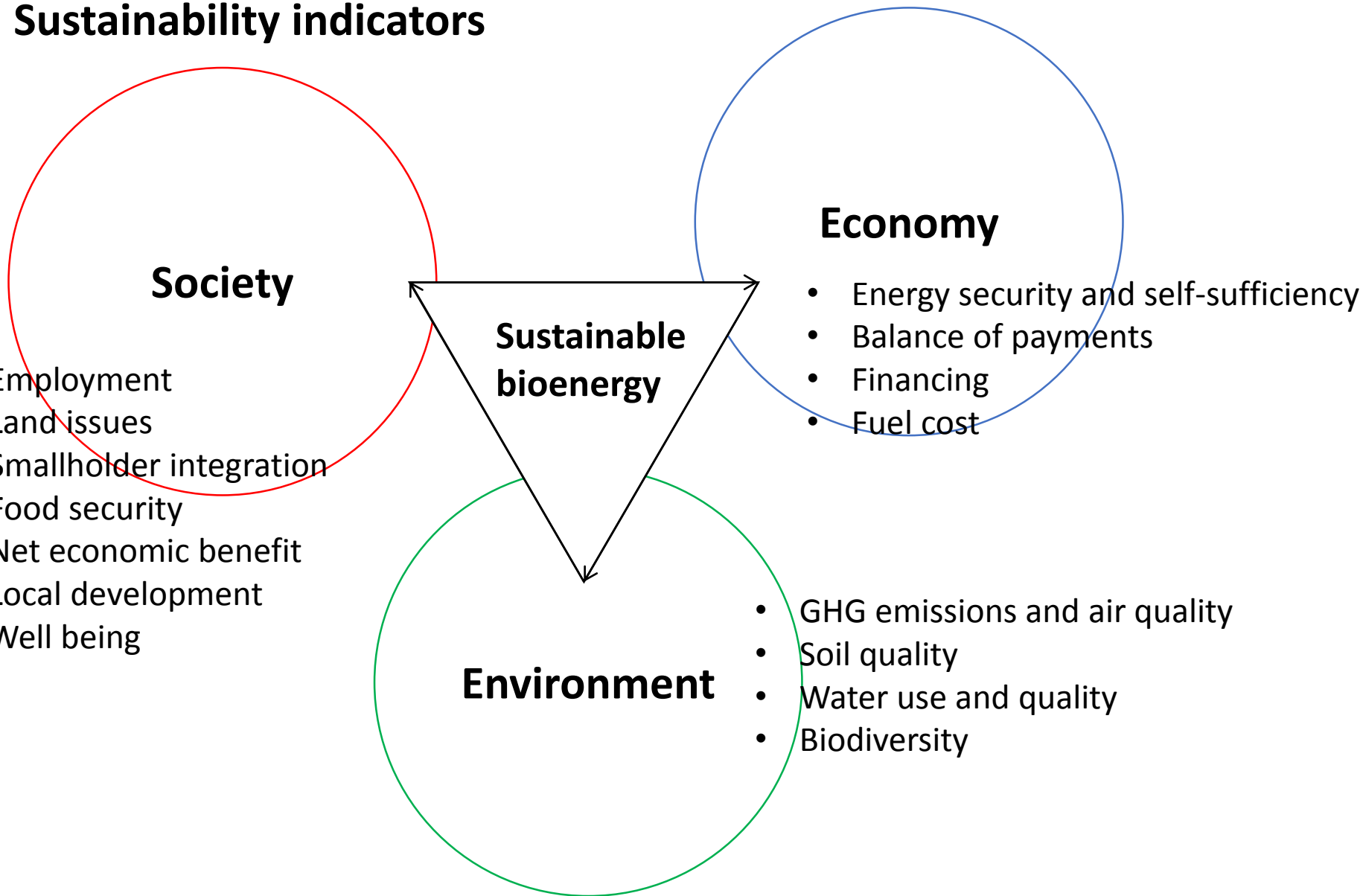
National level

Tanzania, Mozambique, South Africa, Burkina Faso, Zambia, Mali, Senegal…

NGOs

Sustainability of bioenergy sectors in Africa

- **Sustainability indicators**



- Employment
- Land issues
- Smallholder integration
- Food security
- Net economic benefit
- Local development
- Well being

- Energy security and self-sufficiency
- Balance of payments
- Financing
- Fuel cost

- GHG emissions and air quality
- Soil quality
- Water use and quality
- Biodiversity

Sustainability of bioenergy sectors in Africa

◆Food security vs bioenergy development in Africa

Food security is considered to be of key importance as regards bioenergy production, and it is highlighted that it should not compete with food production.

Bioenergy production carried out in a **sustainable way** can make a contribution to **improving food security**.

◆Logistical constraints to biomass supply chain

- Need to provide storage in response to the seasonal availability of biomass resources.
- The collection of feedstocks continues to pose the largest barrier, since agricultural production is mostly small in scale and geographically scattered.
- Inadequate infrastructure and logistical limitations, **the economically feasible transport range** is generally limited to a 25-75 kilometer (km) radius around the conversion plant.

Sustainability of bioenergy sectors in Africa

◆ **Competition with other socio-economic activities**

Poorly managed bioenergy expansion can have negative effects such as compromising **local access to land and food security.**

Availability of certain feedstocks may be limited due to competition with other biomass uses (e.g. animal feed).

◆ **Environmental concerns**

Overuse of national resources through deforestation and soil degradation. Threat to biodiversity conservation.

Some practices that seek to improve feedstock yields may lead to negative impacts such as eutrophication, or degradation of soil and water resources.

General Conclusions

Promoting Bioenergy in Africa can:

- ✓ Accelerate economic development, employment and income levels, thus reducing poverty.
- ✓ Improving access to energy, especially in the rural areas
- ✓ Improve energy security by diversifying energy sources in the region, while reducing oil imports.

◆ Diversifying and modernizing the agricultural sector:

- ✓ Expanding the range of economically useful crops and recycling agricultural residues enable small farmers to adapt to market conditions by changing crops and exploring new niches.
- ✓ Locally produced biofuels can also promote mechanization and small-scale irrigation, improving both production and yields.
- ✓ By-products can provide a source of fertilizer and energy, and smallholders will need to balance both uses.

General Conclusions

◆Land Systems Secure

✓ Access to land is a major issue in the development of bioenergy.

◆Production plant sizes

✓ A risk related to the development of bioenergy is the tendency to go to large industrial projects to obtain economies of scale.

◆Supply chain

✓ Collecting and mobilizing Biomass in the field costs almost nothing, but its mobilization (harvest / collection, transport, pre-treatment) has a non-negligible cost.

◆Data

✓ Comprehensive and accurate data on territorial potential, crop production, water resources and agronomic techniques are essential for decision-makers and for farmers to improve the profitability of their crops.

General Conclusions

◆ **Energy balance: "The energy balance of bioenergy sectors is it good?"**

✓ The level of the energy balance depends on the sector and the recovery methods considered, a specific calculation is often necessary to adapt to each specific case.
✓ An energy balance is the difference between the amount of energy produced by the system considered and the amount of energy consumed to obtain the biomass and to value it as energy.

◆ **Support for research and development**
✓ Bioenergy research is in an embryonic state in Africa.
✓ Research needs to broaden its scope to use traditional knowledge, identify optimal crop conditions, assess environmental impacts and determine production costs.

◆ **Drivers of Bioenergy in Africa**
✓ Rural development opportunities
✓ Energy security
✓ Energy access
✓ Economic development- job creation, improved education, improved income, net savings
✓ Low carbon emissions to the environment
✓ Infrastructural development
✓ Regulatory frameworks - Need for a continental policy & regulatory framework

Questions

- What are the constraints of bioenergy development in your countries?
- What are the promising paths for the development of bioenergy in Africa?
- How can by-products from the bioenergy industry contribute to the competitiveness and sustainability of the sector?
- Do bioenergy present risks or opportunities for the development of your countries?
- Which improvements for bioenergy policies in sub-Saharan Africa?

Big thanks to:

Dr Marie SAWADOGO
Assistant-professor in Industrial Engineering
Biomass Energy & Biofuel Laboratory
International Institute for Water and Environmental Engineering (2iE)

Thanks…!!!

Thank you for your kind attention!