Evaluation of biofuels sustainability: can we keep biofuel appropriate and green?

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Outlines

- State of biofuels in Africa
  - Biofuels initiatives in Africa
- Barriers to biofuels market penetration and policy incentives to stimulate the market.
- Sustainability dimensions of biofuels
  - Economic
  - Environment
  - Social
- Practices, processes and technologies that can make biofuels sustainable
- Concluding remarks

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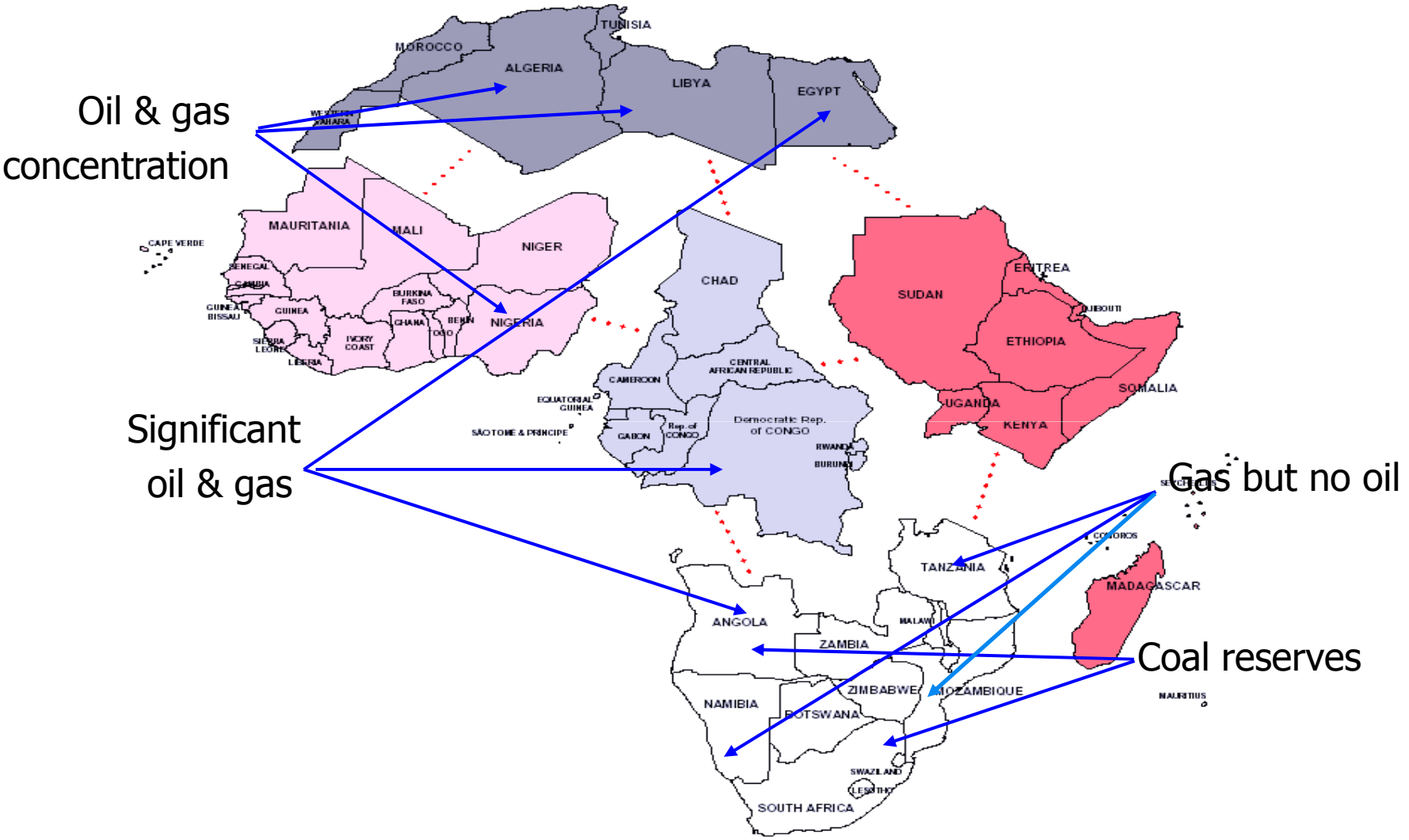
Distribution of Resources in Africa



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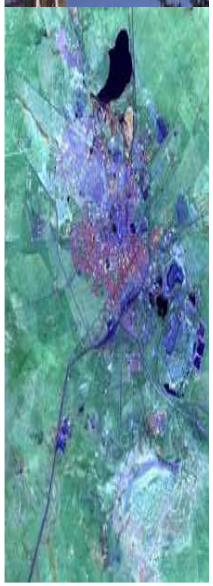
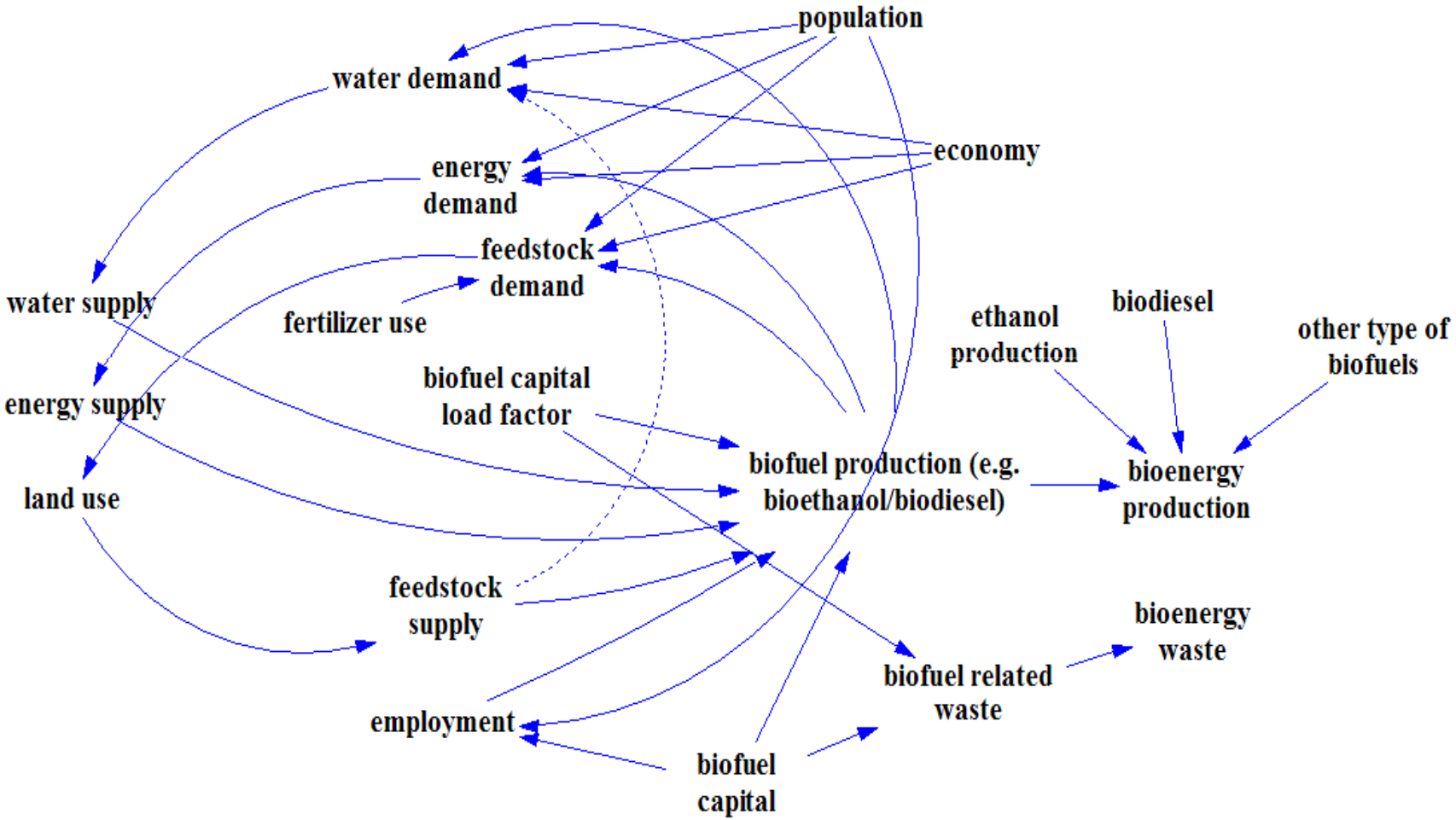


Relationship between energy and poverty reduction

Increase access to energy = economic development



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What are biofuels?

- Liquid, solid and gaseous fuel derived from organic matter-biomass-including plant materials and animal waste.
- First generation biofuels
- Second generation biofuels and
- Third generation biofuels

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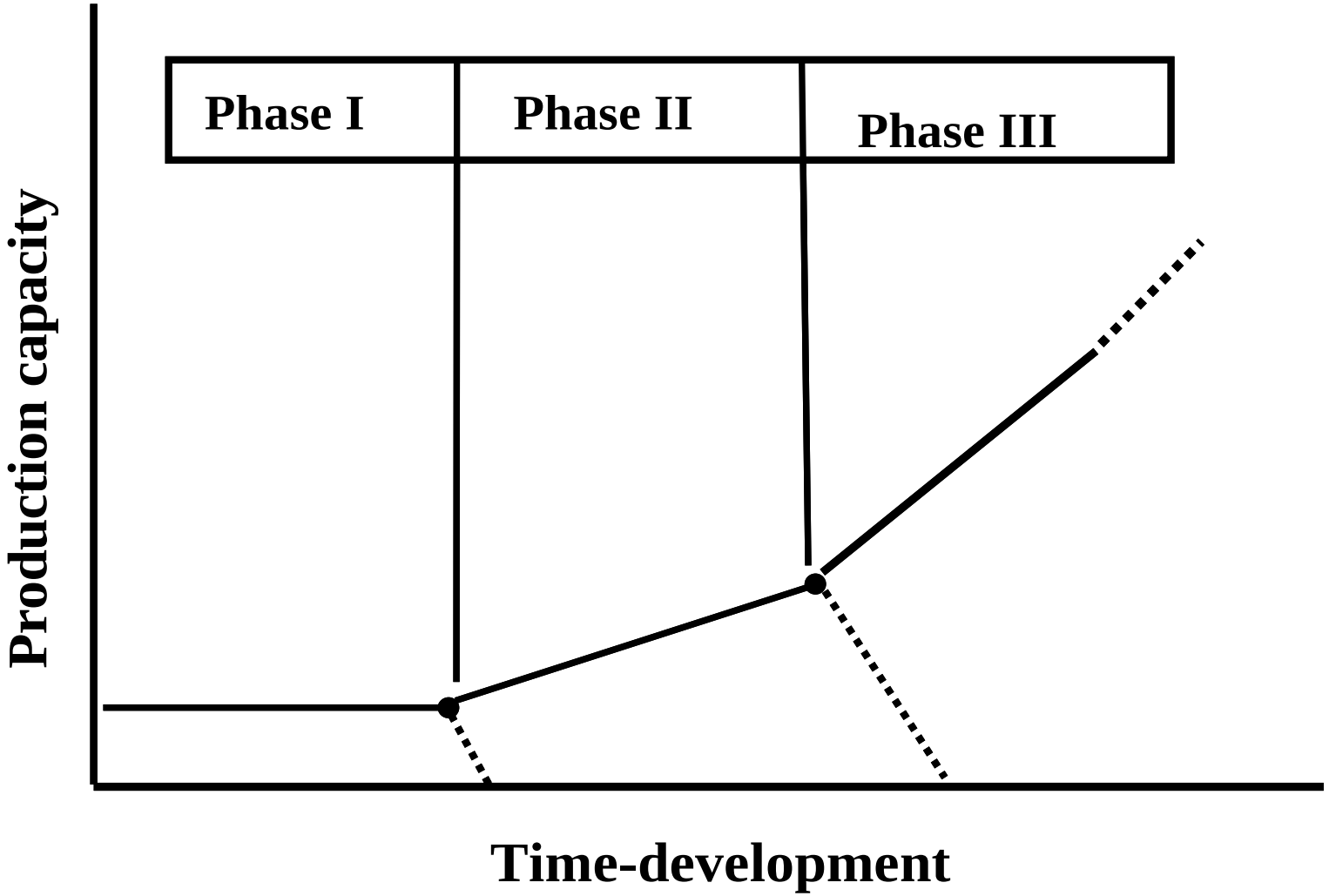
Biofuels developmental stages



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Biofuels developmental stages in Africa…explanation

Phase I consists of the very first ideas and thoughts of biodiesel being used as a fuel until the actual adaptation of the ideas on the part of decision makers who are then motivated to put these ideas into practice. The end of Phase I is the political decision to invest money and other resources into biofuel research.

Phase II is characterized by research efforts, pilot projects, setting of frame conditions (policy/strategy formulation) and financially supported technical trials.

Phase III is marked by a biodiesel economy based primarily on a feasible economic production, distribution and use of biofuel.

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State of biofuels in Africa…which country is doing what?

Many countries in SSA started a number of biofuels initiatives since the early 1980s.

- Malawi started producing ethanol in 1982
- Kenya, Zimbabwe, Uganda, Sudan also started similar programs . (Zimbabwe ethanol plant -Triangle Ethanol Plant, 60% of the whole plant is locally produced. The building was erected by local workers trained specifically for the job. It was estimated to be the lowest capital cost)
- In Uganda, the government is responsible for facilitating development
- Mali: A number of biofuel projects
- Tanzania: Multinational companies and NGOs acquiring land to grow energy crops
- Biofuels initiatives in Senegal, Mozambique, Mauritius, Ghana, South Africa, Ethiopia, Egypt, Namibia, Zambia, Nigeria,

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Ethanol production potential in Africa

- Looking at all biofuels product available, ethanol is the most promising product that can be produced from different materials by African countries

Country	Raw material	Biodiesel (ML)	Ethanol (ML)
Benin	Cassava		20
Burkina Faso	Sugarcane		20
Ivory Coast	Molasses		20
Ghana	Jatropha	50	
Guinea Bissau	Cashew		10
Mali	Molasses		20
Malawi	Molasses		146
Kenya	Molasses		413
Ethiopia	Molasses		80
Niger	Jatropha	10	
Nigeria	Sugarcane		70
Sudan	Molasses		408
Swaziland	Molasses		480
Senegal	Molasses		15
Tanzania	Molasses		254
Togo	Jatropha	10	
Uganda	Molasses		119

Jumbe et al., 2009

Barriers to market penetration of biofuels

Country-type	Institutional/policy hurdle	Technical hurdle	Economic hurdle	Financial hurdle	Information hurdle	Capacity hurdle
Type A	**	*	**	**	*	*
Type B	**	**	**	**	**	**
Type C	***	**	***	***	***	**
Type D	***	***	***	***	***	***

Low:*, Medium: **, High: ***

Country classification according to biofuels barriers to market penetration in Africa

Type A: Technologically advanced developing countries, with well diversified and fairly comprehensive industrial, energy and R&D infrastructures: only South Africa

Type B: Technologically advancing developing countries, which are industrialising fairly fast, but are still quite limited in the diversification of their industrial, energy and R&D infrastructure e.g. Egypt, Morocco, Algeria

Type C: Slowly industrialising developing countries, with still very limited infrastructure in industry, energy and R&D, such as Nigeria, Mauritius, Libya

Type D: Technologically least developed countries: Most SSA Africa countries, e.g. Ethiopia, Chad, Burundi, Mozambique, Cote ‘de’ voire, Niger, DR Congo, Somalia, Mali, and Sudan.

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Biofuel sustainability

- It is often described as comprising 3 dimension

- Economic
- Environment
- Social

} Interlinked

- Most of on-going or completed work so far focus on defining Environmental & Social sustainability issues

- The themes, criteria & indicators of Environment, Social and Economic sustainability will be translated by Govs into policies and instruments that shape the market penetration of biofuel

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Environmental and socio economical concerns around the continent

Environmental issues

Energy balance; Air quality; Soil erosion and degradation; water use and water contamination; biodiversity

Social issues

Fuel versus food; Employment; Equity; Land; Poverty

Economic issues

Costs; Technological capability (developing countries)

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Renewable policy design should reflect the following fundamental principles:

- Removal of non-economical barriers e.g. Administrative hurdle, lack of information and training and tackling social acceptance issue-to improve market and policy functioning
- Predictable and transparent support framework to attract investments
- Introduction of transitional incentives, decreasing over time to foster and monitor technological innovation and move technologies quickly towards market competitiveness
- Development and implementation of appropriate incentives guaranteeing a specific level of support to different technologies based on their level of maturity
- The due consideration of impact of large scale penetration of RET on the overall energy systems

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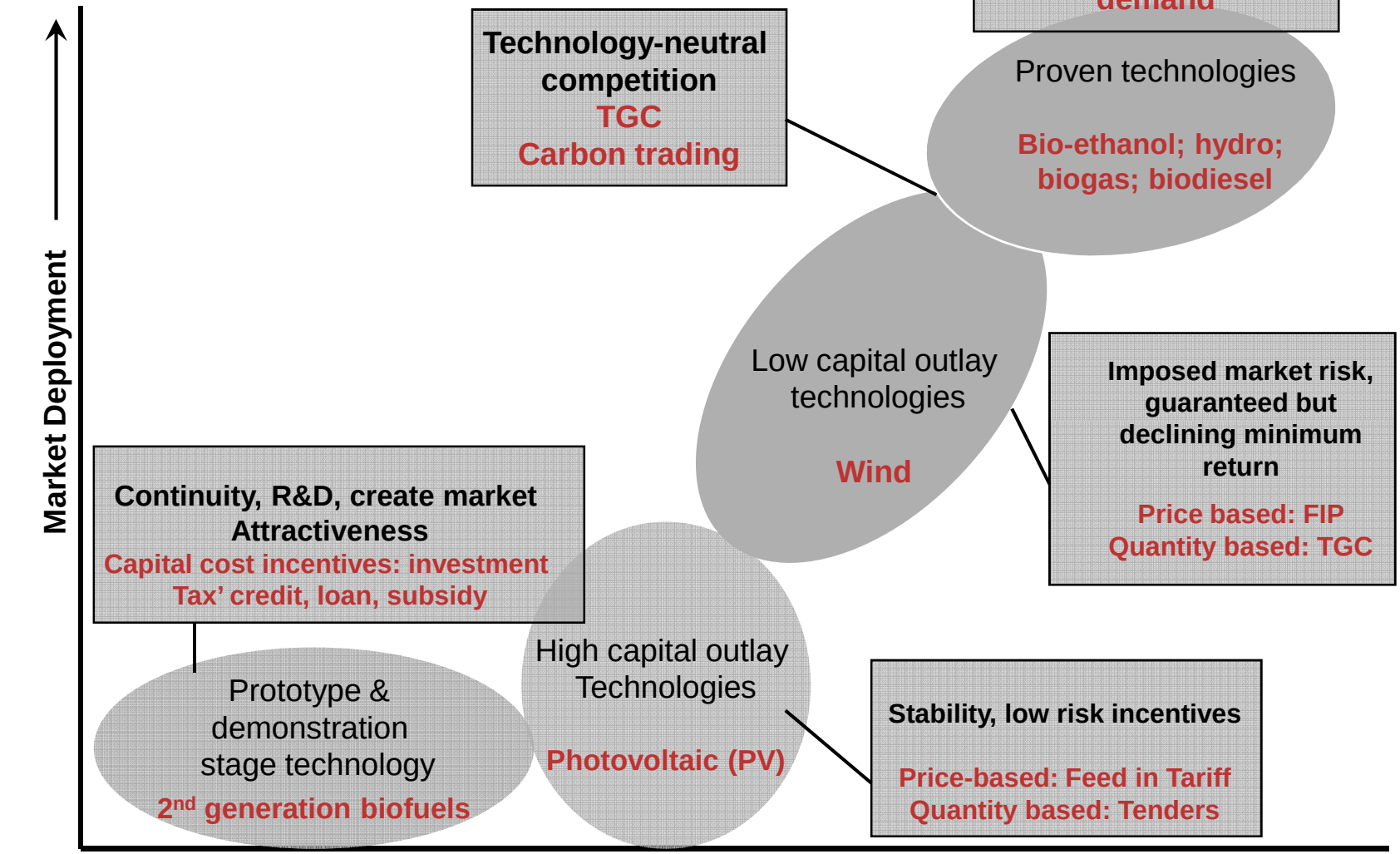
Combination framework of policy incentives as a function of technology maturity



(FAO, 2009)

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The sustainability issues…

- In African countries, fossil fuel prices fluctuation, climate change, increased in the standard of living of rural communities. ... are drive to increasing interest in biofuels.
- Most developed countries are moving from voluntary legislation to obligatory legislation imposing market share of biofuels in the transport sector
- To meet these share, EU in 2010 for example , will have to import feedstock (and/or biofuel) from elsewhere, due to lack of sufficient arable land for energy crops (and the well established regulations safeguarding forests and governing land use)
- African countries are at the various stages of initiating commercial production of biofuels to capture the benefits of its value chain, e.g.
- Potential suppliers of feedstock from large scale plantation of energy crops driven by demand in EU and USA.

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The sustainability issues…

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- **China** has acquired seven million acres in the Democratic Republic of Congo to grow the world's largest palm oil plantation for motor fuel. It is also negotiating for five million acres in Zambia to grow jatropha.
- **Britan's** CAMS Group has bought 112,000 acres for jatropha in Tanzania. Sun Biofuels, also of the UK, has bought 13,500 acres in Tanzania for the same purpose. Trans4mation Agric-tech has secured 25,000 acres in Nigeria.
- **Sweden's** Skebab has purchased 247,000 acres in Mozambique.
- **Germany's** Flora EcoPower has lined up 32,000 acres in Ethiopia

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Sustainability issues….around the continent

Tanzania Suspends Biofuels Investments, "Reacting to mounting pressure from farmers and environmental groups citing concerns over food shortages, the Tanzanian government has reportedly suspended all biofuel investments in the country and halted land allocations for biofuel development"

A flurry of foreign investment in Jatropha for use as a biofuel feedstock has caused concern in Tanzania.

The Tanzanian government has no policy or framework governing biofuel developments, and this is central to issues surrounding the biofuel industry in Tanzania."

Maize excluded from ethanol production in South Africa amid food security concern

Land ownership issue in a lot of countries. E.g. SA,

In Ethiopia, arable land and wooded areas are being cleared without taking into consideration the loss to biodiversity. Environmental impact assessments are not required or are performed in an ad hoc manner.

Sustainability issues….around the continent

The Ethiopian Biofuels Development and Utilization Strategy is encouraging large scale production of biofuels without conducting proper land inventories. For instance, Flora Eco Power Ethiopia, operated by a German private company, purchased 200,000 ha to plant castor seeds for biodiesel production. By 2008, they had cultivated 15,000 ha in several Woredas in East and West Hareghe Zones. They cleared 10,000 ha of virgin forestland.

One hectare of trees can offset up to 200 tonnes of carbon a year (according to University of Leeds on African forests)

The developers have the tendency to raise the hopes and temporarily win the support of local communities by enticing the villagers with the promise of jobs and income.

Land stripped for biofuel production near Alipe, Northern Ghana.

Bypassing official development authorization and using methods that hark back to the darkest days of colonialism, this investor claimed legal ownership of these lands by deceiving an illiterate chief to sign away 38 000 hectares with his thumb print.

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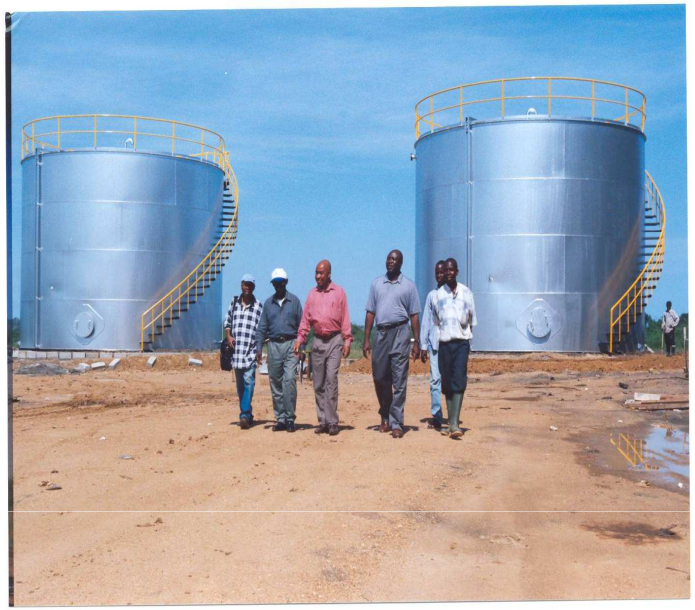
Sustainability issues….around the continent

Ghana biodiesel experience ?



360,000 tons/annum Anuanom Industries' biodiesel processing plant

Zimbabwe inaugurated the country's and Africa first ever commercial biodiesel plant. The US$6 million biodiesel plant which processes jatropha, cotton seed, sunflower and soya, among others has the capacity to produce 100 million liters annually if fully operational (The Zimbabwe gazette, 2007) ?

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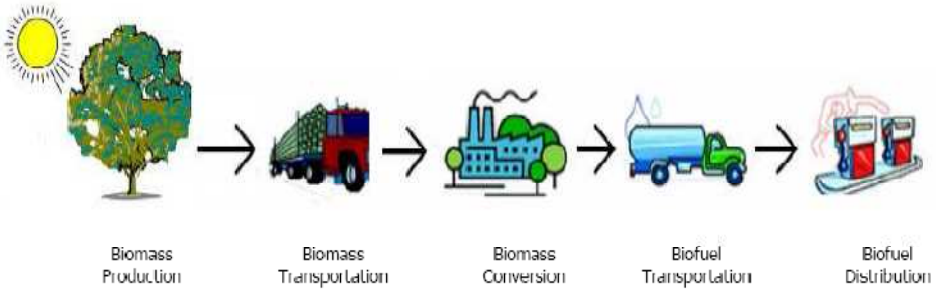
Can biofuel mitigate climate change?

To access net effect on GHG gas

Consider the entire fuel cycle (life cycle), from feedstock production, transportation to final consumption

'Well-to-wheels approach'



GHG balance differ widely depending on:

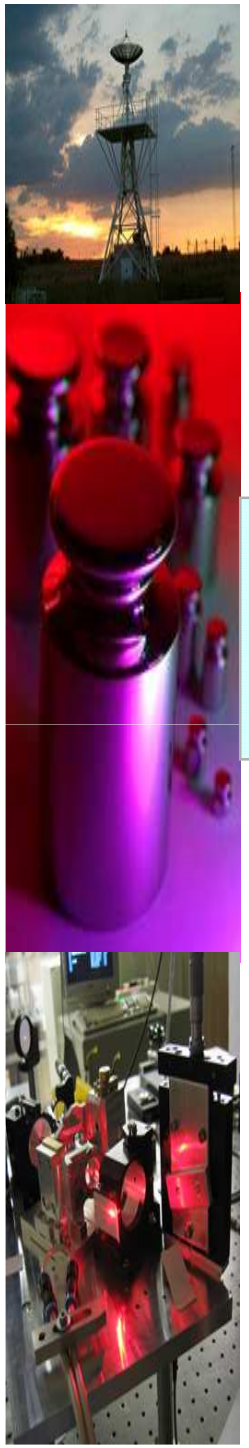
- **Type of crop**
- **Location**
- **Feedstock production and fuel processing (conversion technology)**

A significant contributor to GHG = Qty of fossil energy {feedstock production + transport including for fertilizer & pesticide manufacture, for cultivation and harvesting of the crops and or in the biofuel production plant itself}

+ Emission of nitrous oxide ≈ 300 X (CO_2)

Producing first generation biofuels reduces emission by 20-60% (most efficient systems)
Brazilian model and 2nd generation typically reduces emission by 70-90%
(excluding Carbon release due to land-use change)

(forest + grassland ⟶ feedstock OR ⟶ crops displaced by feedstock production)



How will biofuel production affect water resources?

During biofuel production, water is used in large quantities for mixing, washing and for evaporative cooling

The biggest impact however is from irrigation:
Plants like Jatropha grown in semi-arid areas may require some irrigation

sugar cane, oil palm and maize have relatively high water requirements and are best suited to high-rainfall areas, unless they can be irrigated

More environment friendly crops; use less fertile/unproductive lands e.g. Jatropha, Tree, Grasses

The availability of water resources may constrain the production of biofuel crops in countries that would otherwise have a comparative advantage

Producing more biofuel crops also affect: water quality; e.g. converting pastures or woodland to feedstock field may increase problems of : soil erosion and runoff or excess N and K into surface and groundwater.

Pesticides and other chemical can wash into water-bodies

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Impact on production systems (soils and biodiversity)?

Change in land use and Intensified agric. Practices affect fertility and productivity of soil (soil conditions)

This depend on the way the land is farmed ! !! !!!

Various farming techniques can reduce adverse impacts or even improve environmental quality while still increasing biofuel crop production. ….?

Biofuels can affect wild and agricultural biodiversity-how?
... restoration of degraded land

Monocropping and Genetic diversity of crops can be compromised (biodiversity loss) through large scale production

Many current biofuel crops are well suited for tropical areas, and this creates an economic incentive to convert natural ecosystems into plantations or peatlands causing a loss of wild biodiversity in these areas.

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How could an environmental sustainable biofuel production be ensured?

The environmental concerns about biofuel feedstock production are the same as for agricultural production in general, and existing techniques to assess the environmental impact offer a good starting point for analysing the biofuel systems

The adoption of "good practices" in:

- **Soil; water and crop protection,**
- **Energy and water management**
- **Nutrient and agrochemical management**
- **Biodiversity and landscape conservation**
- **Harvesting, processing and distribution**

• Establishing sustainability criteria & standards accompany with training and support for implementation

• Payments for environmental services may serve as instrument

payment or direct compensation by the users of the service for the maintenance or provision of an environmental service to the providers of the same.

• Policies that will recognise the international consequence of biofuel development

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One of the greatest costs in an ethanol plant is the energy it takes to generate the heat needed for the process. As a result, ethanol producers are continually motivated to reduce energy costs and improve efficiency, productivity and environmental stewardship

Processes and technologies that can dramatically improve efficiency, lower energy & water demand, and further reduce the environmental footprint of biofuel production…

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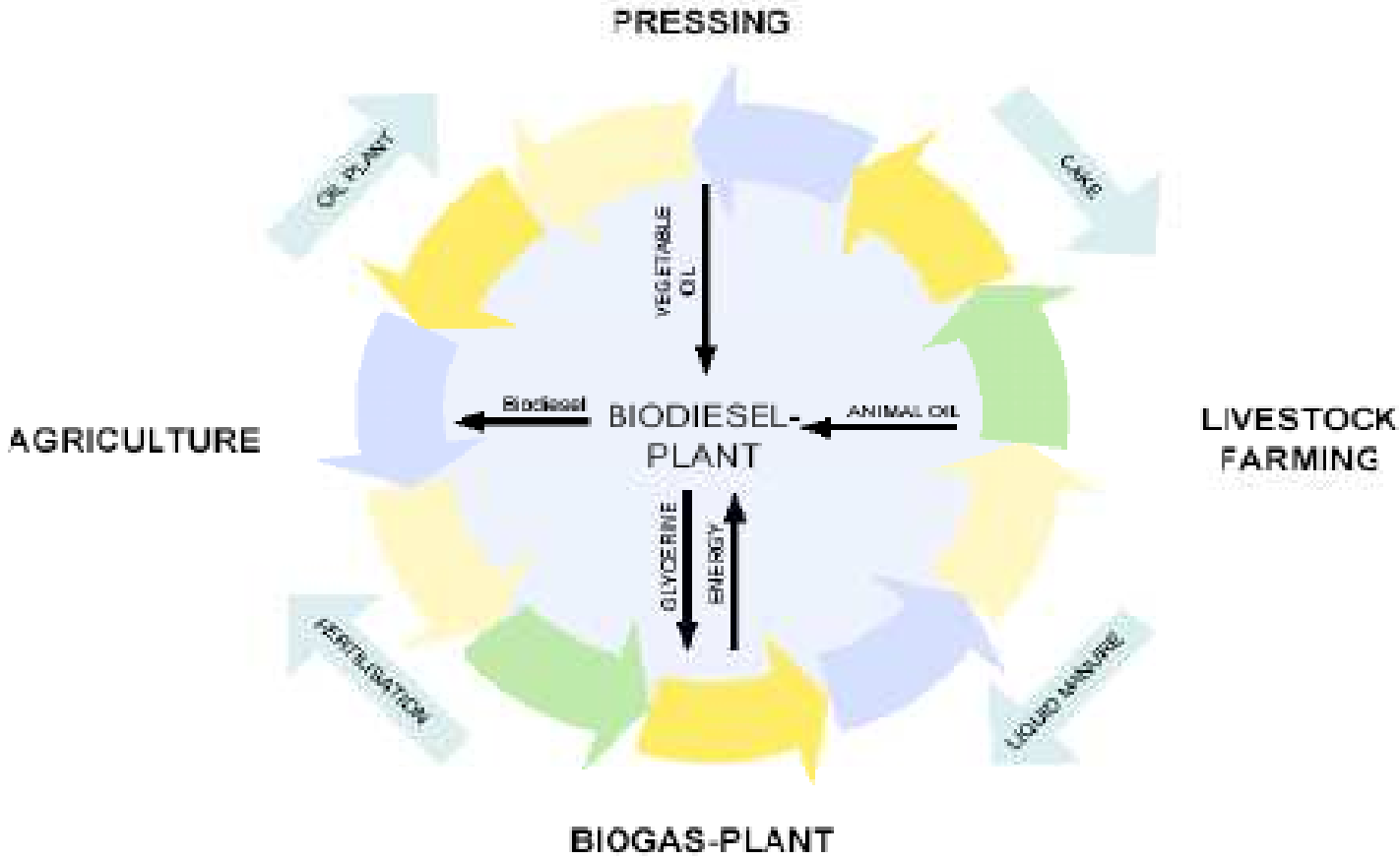
Closed loop recycling management of agricultural oil-mill based biodiesel plant



This is a biodiesel plant located very close to an agricultural area with an integrated oil mill. This kind of practice increases the regional creation of value and at the same time, introduces biodiesel production in a closed loop recycling management cycle

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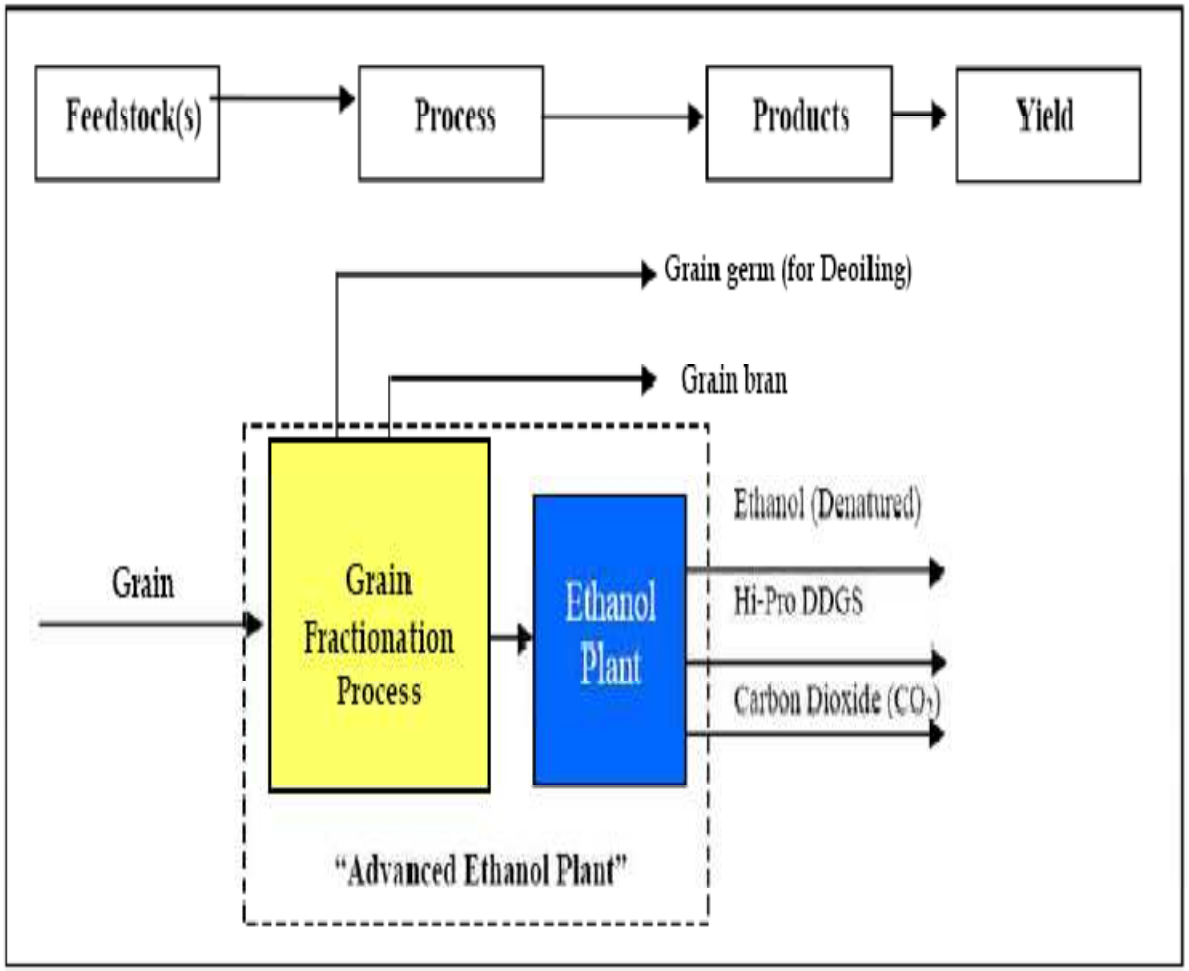
An advanced ethanol plant, where fibre fractionation for steam generation was added to the existing conventional plant

- Process efficiency,
- reduced emissions & -
- reduced energy use/costs by 30- 35%
- less overall NOx emissions

-Expand the range of product and quality

-amortize energy usage across more products

- improve environmental Impact of plant



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Combined Heat and Power (CHP)

- CHP can help meet corporate environmental goals and enhance a company image
- A CHP systems can reduce energy consumption by about 15% (EPA, 2008)
- A CHP system combines electricity and steam in a plant, recovering waste heat for heating, cooling and dehumidifying
- CHP provides a number of benefits including:
  - Energy saving of 10-25%
  - Ensuring continual plant operation in the event of electrical supply cut off
  - Opportunities to partner with municipal utilities ot rural cooperatives to leverage resources
  - Reduced carbon dioxide emission
  - Ensuring optimal use of available energy resources by increasing fuel options

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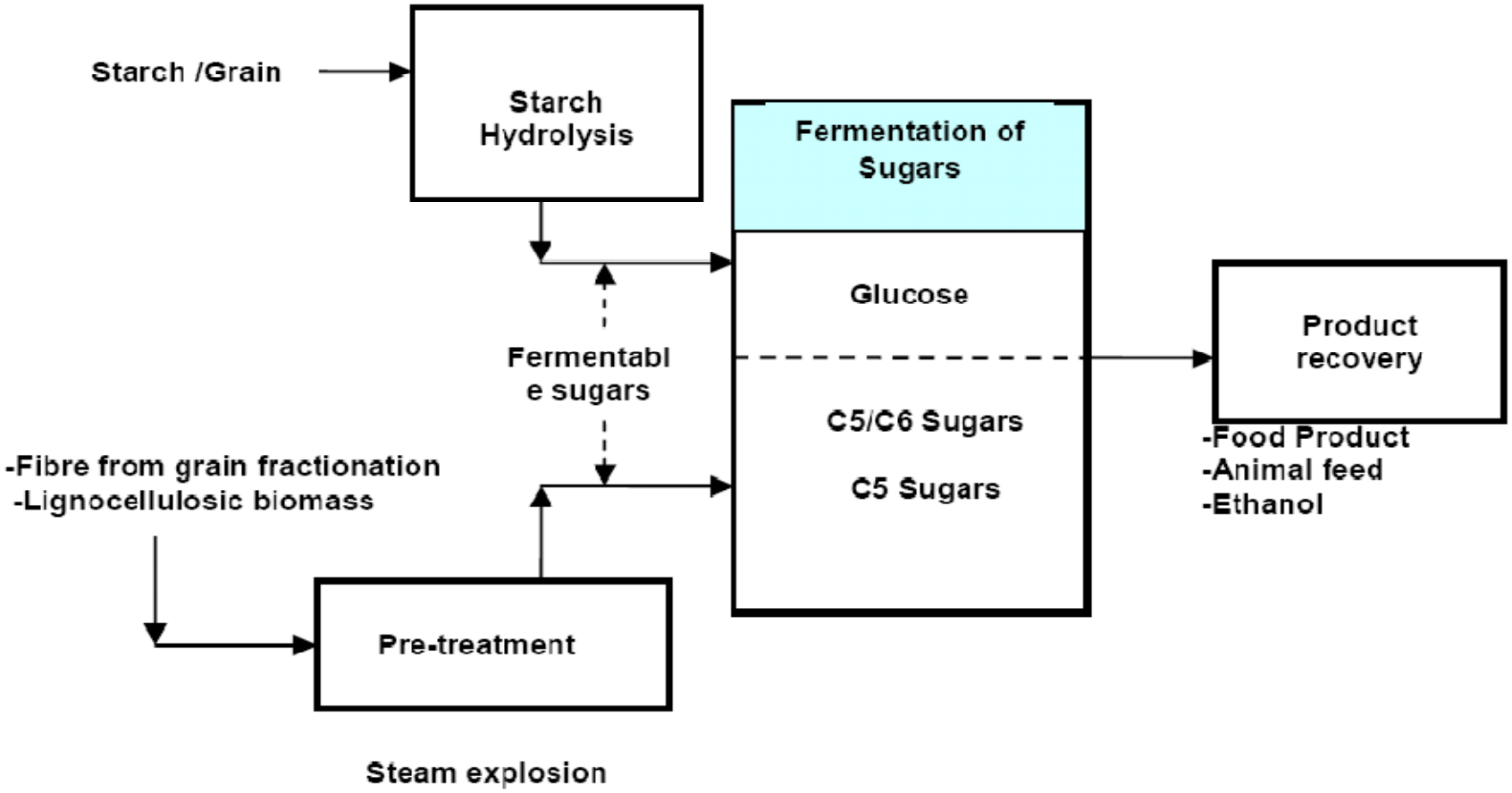
Integrated starch and cellulose fermentation plant, based on the conventional dry-mill ethanol, where the fractionated fibre from grain is used in addition to starch for ethanol production

This option shows the most promise for commercialisation of cellulosic ethanol production, because it is the least capital intensive approach

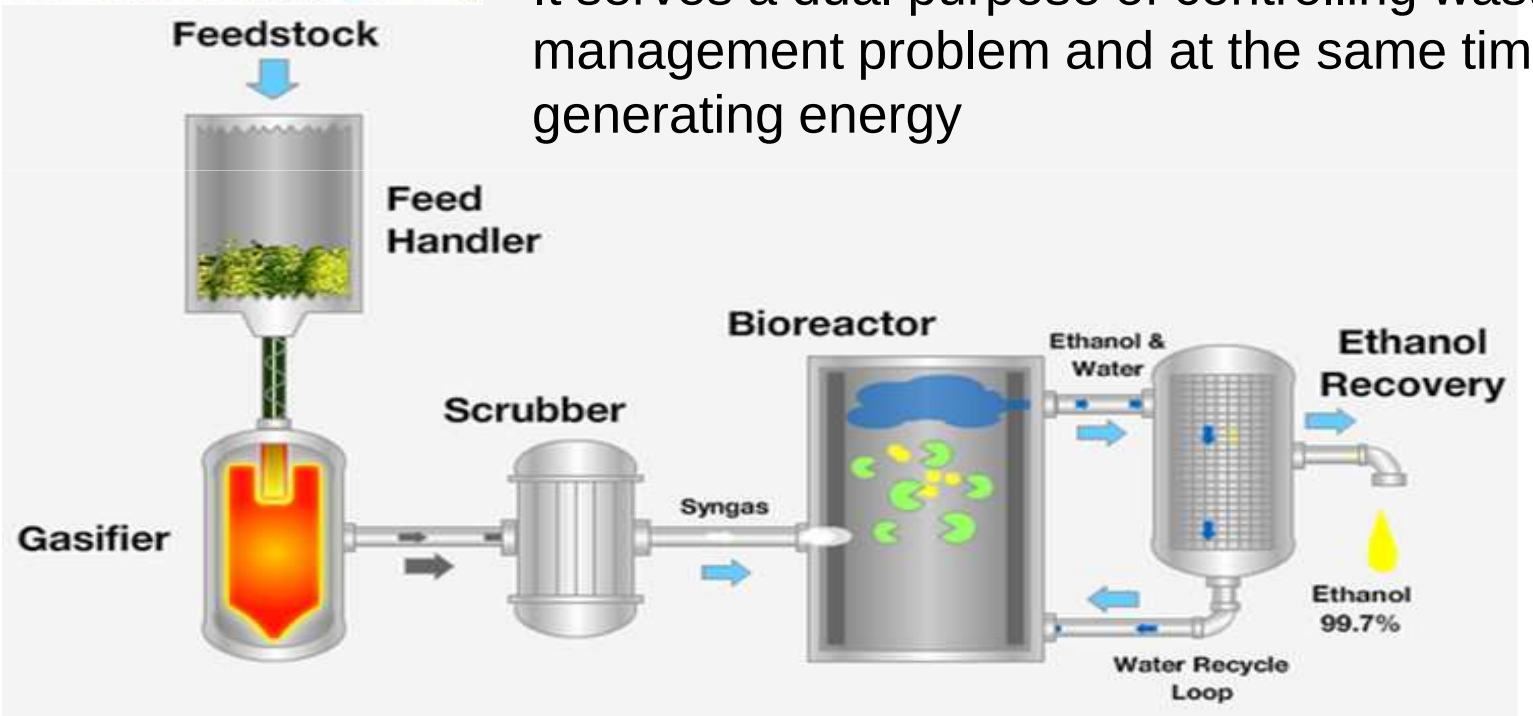
Future feedstock diversification to other sources of lignocellulose also become a possibility for the hybrid ethanol plant, to allow for flexibility of supplies in case of drought or to avoid the woes of having only a single supplier of input goods.



Garbage-Based Biofuel Might Be A Golden Ticket for Clean Energy

Replacing gasoline with second-generation biofuels derived from processed waste could reduce global emissions by as much as 80%.

It serves a dual purpose of controlling waste management problem and at the same time generating energy



- Char the left over used as a soil amendment to increase fertility

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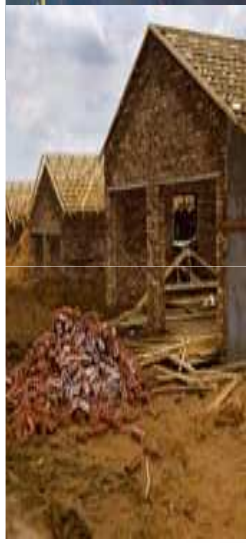

In conclusion…

- Biofuels could be instrumental to achieving sustainable development in Africa.
- The challenge of development of biofuels is to:
  - avoid falling into the international trade models of fossil fuels
  - which has not benefited African countries, even those that are oil producers
  - given priority to strengthening local production to satisfy national need and benefits at local level
  - international trade could be considered but only as a secondary option

- Agricultural practises (crop management) such as:
  - Reduced and conservation tillage
- African Conservation Tillage work (ACT) http://act-africa.org/
  - Network initiated in 1998 in Harare,
  - GTZ, FAO, the Southern & Eastern Africa based FARMESA, the Zimbabwe Farmers Union and the South African Agricultural Research Council (ARC).

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In conclusion…

- Conservation tillage is a soil management practices:
  - leaving soil residue to improve soil fertility and
  - enhance organic carbon in the soil

- The principal benefits of conservation tillage are:
  - reduces pesticides and fertiliser run off
    * reducing rainfall runoff by 60% and
    * Reducing soil loss/erosion by >90%

- improved soil structure and water conservation

- Additional potential benefits include:
  - reduced fuel consumption, planting and harvesting flexibility,
  - reduced labour requirements

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In conclusion…

- Appropriate policies (criteria & indicator relevant to local situation) should be put in place to address social, environmental and economic issues.
- Extensive work on prioritised pathways of biomass growing, conversion & use, should be undertaken for different regions in Africa
- Market demand for biofuels-initially geopolitical and climate change driven and now institutionally-endorsed will have to happen in parallel
- The involvement of all relevant stakeholders including industrial partners, international organisations is essential to ensure the practical feasibility of sustainability standards and instruments

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