Sustainable biomass production

S. Braconnier
Different definitions of biomass...

In Ecology, biomass is the total mass of living organisms measured in a population, or per area, or per other unit.

Currently, biomass is often associated to the production of bioenergy.

In Energy, this term includes all the organic matters able to produce energy either by direct combustion or after transformation.

This includes:
- wood (in logs, pellets or chips)
- by-products of wood from logging, sawmills and other wood processing industries
  - by-products from industry (sludges, pulps, grape seeds...)
  - products from conventional agriculture (cereals, oilseeds, stalks) + residues like straw, bagasse...
- organic waste such as municipal solid waste (sludges, garbages...)
Huge diversity of biomasses as well as their uses
Biorefinery of wheat:  
Objective = using all the components of wheat
MULTIPLE SUGARCANE-DERIVED PRODUCTS

Sugarcane

- Cane stalks
- Bagasse (Cellulose)
- Straw (Tops and Leaves) (Cellulose)
- Cane juice (Sucrose)

Current technology

Technology under development

3rd generation

- Sugar
- Ethanol
- Biopolymers (bioplastics, isoprene, etc)
- 2nd generation
- Bioelectricity

2nd generation

- Detergents & solvents
- Cosmetics
- Lubricants
- Flavors and Fragrances
- Food
- Drop-in fuels (diesel, jet fuel, gasoline)

(Source: G. Kutas, UNICAS, 2013)
Depending on the use, the quality of biomass is essential: case of sorghum for ethanol production

1. **2nd generation EtOH or methane production**: a biomass sorghum *poor in lignin* to increase digestibility in that case, Grain production is not essential.

2. **1st generation EtOH and/or cogeneration** (case of Brazil): a *sweet sorghum* with high biomass + high juice + high sugar + bagasse *rich in lignin* Grain production is not wishable.

3. **1st generation EtOH combining grain and fodder** (case of India): a *sweet sorghum* with high production of grain + high biomass + high juice + high sugar + bagasse *poor in lignin* Grain production is essential.
Sustainability...

meeting the needs of the present generation without compromising the ability of future generations to meet their needs

Taking into account 3 pillars:
A sustainable energy from biomass

Focus on biomass for energy

6 criterias for assuming the sustainability

1. Economic prosperity: insight into possible negative effects on the regional and national economy

2. Avoid competition with food, as well as local energy, medicines and building materials

3. Well-being: no negative effects on the social well-being of workers and local population taking into account working conditions, human rights, property rights...

4. GHG balance: compared to fossil fuels, GHG reduction > 30%

5. Biodiversity: no deterioration of protected area or valuable ecosystems

6. The environment: no negative effect taking into account waste management, use of agrochemicals, soil erosion, quality and quantity conservation of water resource, emissions into air...
Provision costs in Euro / 100 km

(Source: IFEU 2013)
### CO2 avoidance costs

<table>
<thead>
<tr>
<th>Field of measures</th>
<th>Costs (funding efficiency) (in Euro per tonne CO₂ saved)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving manner</td>
<td>6</td>
</tr>
<tr>
<td>Pellet heating</td>
<td>8</td>
</tr>
<tr>
<td>Zero energy houses</td>
<td>12</td>
</tr>
<tr>
<td>Vehicles</td>
<td>38</td>
</tr>
<tr>
<td>Refrigerators</td>
<td>100</td>
</tr>
<tr>
<td>Biofuels for transport</td>
<td>200</td>
</tr>
<tr>
<td>Photovoltaic</td>
<td>500 – 1000</td>
</tr>
</tbody>
</table>

(Source: IFEU 2013)

- Biofuels are more costly than fossil fuels
- There are many cost effective alternatives to save greenhouse gases
- Need for incentives (tax reduction, directives et cetera) to enforce a biofuel market
Many criticisms of biofuels (and sometimes biomass energies)

- Induce a dramatic competition food/fuel and in some cases water shortage in rural areas due to water demand for biomass production...

- Require more lands for producing feedstocks

- Result in displacement of people, illegal land appropriation by producers...

**Biofuels are not sustainable if social problems arise with local population**
Biofuels: social aspects

But there can be also improvements of life through biofuels

- Oil palm plantations: small holders = 40% of area
  40 families per km²

- Create jobs

- Social security

- Increase of welfare
  (housing, medical care, ...)

- Represent a permanent income

⇒ ⇒ There are many social aspects associated with biofuels and biomass production. Some of them have negative impacts, some have positive ones.
Biofuels: environments

Negative impacts

- Deforestation in Amazonia, Congo Basin, Indonesia, Malaysia...
- Impact on soils (erosion,...)
- Impact on water resource

Effect on biodiversity: only 15% of the rain forest biodiversity remains in an oil palm, orang utan, sumatra tiger... are threatened

Positive impacts

- Reduce GHG emission
- Climate change mitigation
We need a frame for estimating positive and negative impacts: LCA Estimation compared to a reference

<table>
<thead>
<tr>
<th>Product</th>
<th>Process</th>
<th>Equivalent Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude oil extraction and pre-treatment</td>
<td>Transport</td>
<td>Steam-power production</td>
</tr>
<tr>
<td>Processing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conventional feed production (soy meal)</td>
</tr>
<tr>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Conventional power production</td>
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<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Bio-Ethanol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gasoline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vinasse</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power</td>
</tr>
</tbody>
</table>

(Source: SWEETFUEL)
Biofuels: environments

(Source: SWEETFUEL)

- Seeds
- Miner. Fert.
- Pesticides
- Diesel fuel

Sweet Sorghum

- Grains
- Juice
- Bagasse

Combustion

- Power / Heat
- Bioenergy

Conversion

- Ethanol from grains
- Ethanol from juice

Lime

Auxiliary products

- Lime
- Mineral fertilizer

- Soy meal
- Convent. heat production
- Stillage
- Soy meal
- Fusel oils
- Convent. power production

(Source: SWEETFUEL)
Greenhouse effect

Source: IFEU 2009

Credits

Sweet Sorghum ethanol

Disadvantages

Balance

Fossil gasoline

Advantage for bioethanol

Expenditures

Machine work
Agricultural system
Transport biomass
Ethanol production
Transport ethanol
Ethanol usage

Credits:

Lime
Vinasse/stillage
Fusel oil
Power

Fossil fuel:

Fossil equiv. production
Fossil equiv. usage

Equals a ride with a compact car of about 53,000 km (> perimeter of the Earth)
Energy savings

Advantage for bioethanol

Disadvantages

Balance

Credits

Expenditures

GJ PE / (ha*yr)

Expenditures:
- Machine work
- Agricultural system
- Transport biomass
- Ethanol production
- Transport ethanol
- Ethanol usage

Credits:
- Lime
- Vinasse/stillage
- Fusel oil
- Power

Fossil fuel:
- Fossil equiv. production
- Fossil equiv. usage

Equal a daily hours usage of a 40 Watt bulb for roundabout 98 years

(Source: IFEU 2009)
### Different uses of sweet sorghum

- **Grains**: food, feed, fuel (1st G)
- **Juice**: sugar, fuel (1st G)
- **Bagasse**: Feed, pulp, bioenergy, fuel (2nd G) compost, fertilizer

### Different scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Juice</th>
<th>Grains</th>
<th>Bagasse</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Standard</td>
<td>1st G EtOH2</td>
<td>1st G EtOH2</td>
<td>Process energy &amp; bioelectricity</td>
</tr>
<tr>
<td>2 EtOH2 extended autarkic</td>
<td>1st G EtOH2</td>
<td>1st G EtOH2</td>
<td>2nd G EtOH2 (autarkic)</td>
</tr>
<tr>
<td>3 EtOH2 maximum fossil</td>
<td>1st G EtOH2</td>
<td>1st G EtOH2</td>
<td>2nd G EtOH2 (fossil fuel input)</td>
</tr>
<tr>
<td>4 Grains food</td>
<td>1st G EtOH2</td>
<td>Food</td>
<td>Process energy &amp; bioelectricity</td>
</tr>
<tr>
<td>5 Food &amp; EtOH 2</td>
<td>1st G EtOH2</td>
<td>Food</td>
<td>2nd G EtOH2 (autarkic)</td>
</tr>
<tr>
<td>6 Grains &amp; juice food</td>
<td>Food (fossil fuel input)</td>
<td>Food</td>
<td>2nd G EtOH2 (autarkic)</td>
</tr>
</tbody>
</table>
The results of the environmental implications depend on the specific conditions. Therefore, there is not only one result of an environmental assessment for sweet sorghum ethanol, but many. Need for life cycle assessment to quantify the environmental implications.

Bioeconomy in Argentina: Present and Future, 21-22 March 2013, Buenos Aires
**Biofuels: environments / GHG balances**

![Image of biofuel plants and graphs]

- **Advantages for biofuels**
  - Biodiesel sunflowers
  - Biodiesel rapeseed
  - Biodiesel canola
  - Vegetable oil sunflowers
  - Vegetable oil rapeseed
  - EtOH sugar beets
  - EtOH wheat
  - EtOH potatoes
  - EtOH corn
  - EtOH SRF
  - ETBE sugar beets
  - ETBE wheat
  - ETBE potatoes
  - BTL wheat / SRF

- **Disadvantages**
  - Biodiesel oil palm (nat. forest)
  - Biodiesel oil palm (peat forest)
  - Biodiesel oil palm (plantations)
  - Biodiesel oil palm (degr. land)
  - Biodiesel soy beans (nat. forest)
  - Biodiesel soy beans (degr. land)
  - EtOH sugar cane (nat. veg.)
  - EtOH sugar cane (degr. land)
  - Biodiesel Jatropha (degr. land)
  - Biodiesel Jatropha (shrubland)

**Pb of nature conservation**

- t saved CO2 equivalents / (ha × yr)
  - 14 - 95
  - 13

(Source: IFEU 2013)

*Bioeconomy in Argentina: Present and Future, 21-22 March 2013, Buenos Aires*
Environmental advantages and burdens

Same pattern for most biofuels for transportation

Need to identify all environmental implications and optimise the advantages and minimise the disadvantages

We have to go further!

Bioethanol from sugar beet versus gasoline

(Source: IFEU 2013)
The sustainability of the biomass is quite complex to assess...

It depends on the:

- nature of the biomass
- process of its transformation
- environment in which it is produced
- uses

...
Biomass: the reserves are huge and renewable...
## Project “Biomass for the future” (BFF)

<table>
<thead>
<tr>
<th>Coordinator:</th>
<th>INRA - Institut Jean-Pierre Bourgin (IJPB), Dr Herman HOFTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budget:</td>
<td>Total = ~ 30 million € for a contribution from the government ~ 10 million €</td>
</tr>
<tr>
<td>Duration:</td>
<td>= 8 years (2013-2020)</td>
</tr>
<tr>
<td>24 partners:</td>
<td>public institutions (INRA, CIRAD, Armines)</td>
</tr>
<tr>
<td></td>
<td>+ Private sector (from the sectors of breeding, thermoplastics compounds, cement, automotive parts, automotive, plant biotechnology etc..)</td>
</tr>
<tr>
<td></td>
<td>+ local authorities</td>
</tr>
<tr>
<td>2 objectives:</td>
<td>1. Development of local miscanthus (North of France) and sorghum biomass (South) production and valorization chains focused on heat-generation, anaerobic digestion and bio-based construction materials and plastics.</td>
</tr>
<tr>
<td></td>
<td>2. Creation of new varieties and culture systems for miscanthus and fiber sorghum, with improved lignocellulosic biomass yield, reduced environmental footprint and a composition tailored for industrial uses, including second generation biofuels and platform chemicals.</td>
</tr>
</tbody>
</table>
Contact: serge.braconnier@cirad.fr
www.sweetfuel-project.eu