Life Cycle Assessment and Sustainability calculations for biofuel supply chains

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Greenhouse Gas emissions from biofuels and bioenergy
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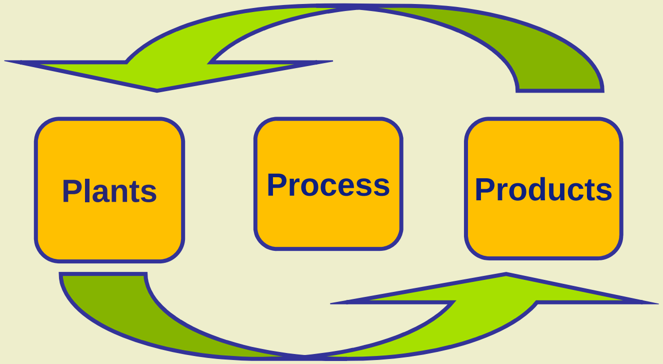
Porter Alliance

The Porter Alliance is an association of leading science institutions in the UK, including Imperial College London, Rothamsted Research, The Institute of Biological, Environmental and Rural Sciences (IBERS), The John Innes Centre and the Universities of Cambridge, Southampton and York.



- We consider the whole supply chain for biofuels, from agronomic considerations through processing to end fuel format
- Rely on LCA methodologies to evaluate and make comparisons to “prove “ the ghg balance benefits of advanced technologies
- We use quantitative sustainability criteria to manage research and development
- Also consider wider industrial applications of crops (food, feed, fibre, fuel) and supply chain co-products

Presentation Overview

- Bioenergy and Biofuel terminologies
- LCA overview
- Sustainability Overview
- Biofuel supply chains

Interest in bioenergy and biofuels

Global interest and initiatives in bioenergy and biofuels have set out to address:

- **Environmental** issues such as climate change – biofuels have potential to provide greenhouse gas savings and improve air quality
- **Energy** issues - security of supply/reduce dependence on fossil fuels (finite resource)
- **Social** issues - employment, rural development

Bioenergy and Biofuels terminologies

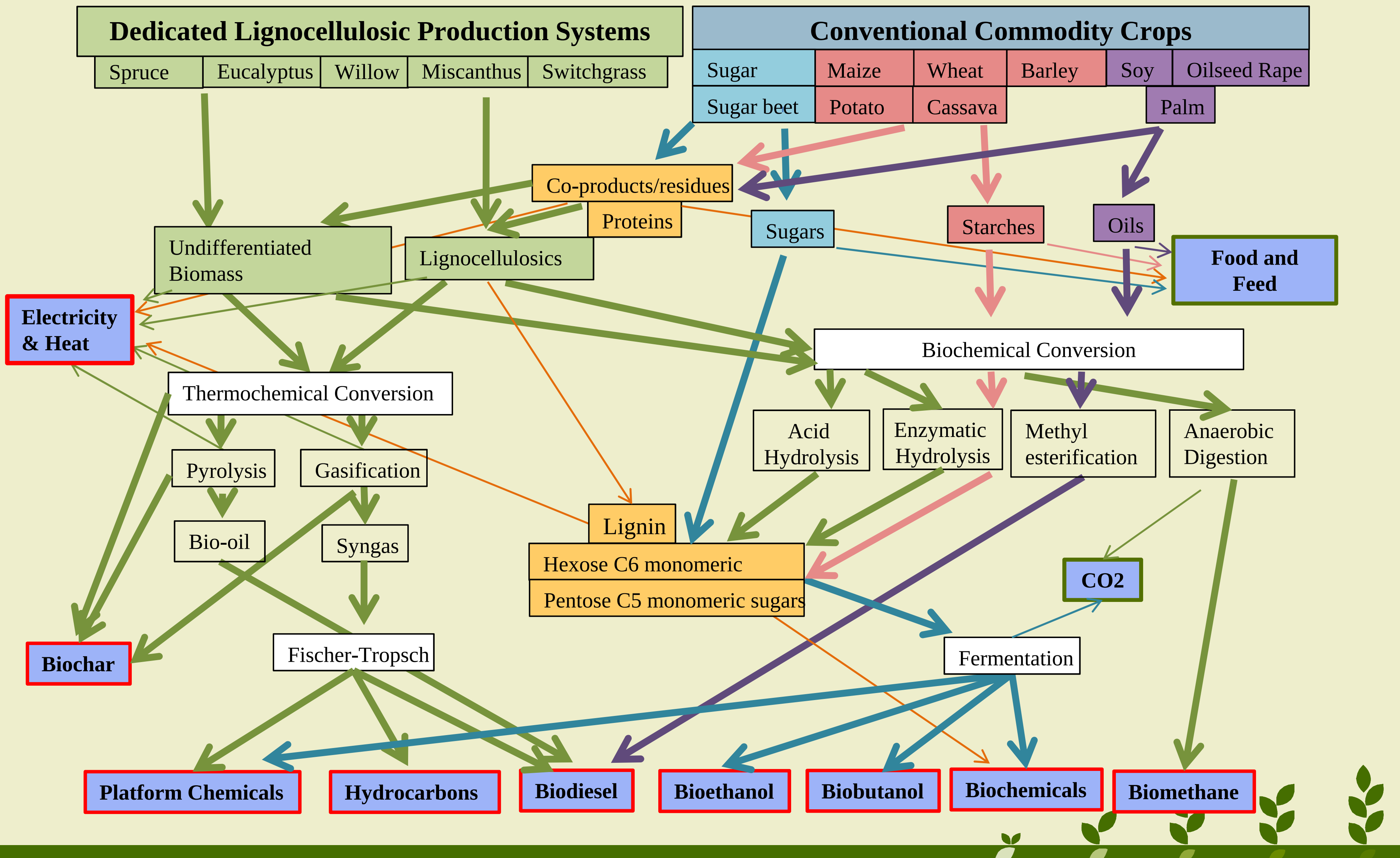
Current Energy Services are derived from:

1. **Heat**
2. **Electricity**
3. **Transport**

In many parts of the world these services are reliant on fossil sources

- **Bioenergy** can come in multiple forms or be transformed into multiple forms:
  - Solid ~ ‘biomass’
    - Wood (chips, pellets), energy grasses [lignocellulosic materials]
    - Charcoal, Char
  - Liquid ‘biofuels’
    - Petrol and diesel replacement options (bioethanol/biodiesel)
  - Gaseous fuels
    - ‘biogas’ from anaerobic digestion (mostly CH_4)
    - ‘syngas’ or ‘producer gas’ from themochemical decomposition

Feedstock and technology pathways for bioenergy



Focus on biofuels - terminologies

Technology pathways to bioenergy: multiple feedstock and conversion pathways possible; opportunities to increase feedstock production efficiency and conversion efficiency; technologies in various stages of development – can cause confusion in understanding assessments and outcomes

- **‘1st Generation’ or ‘current’ technologies**

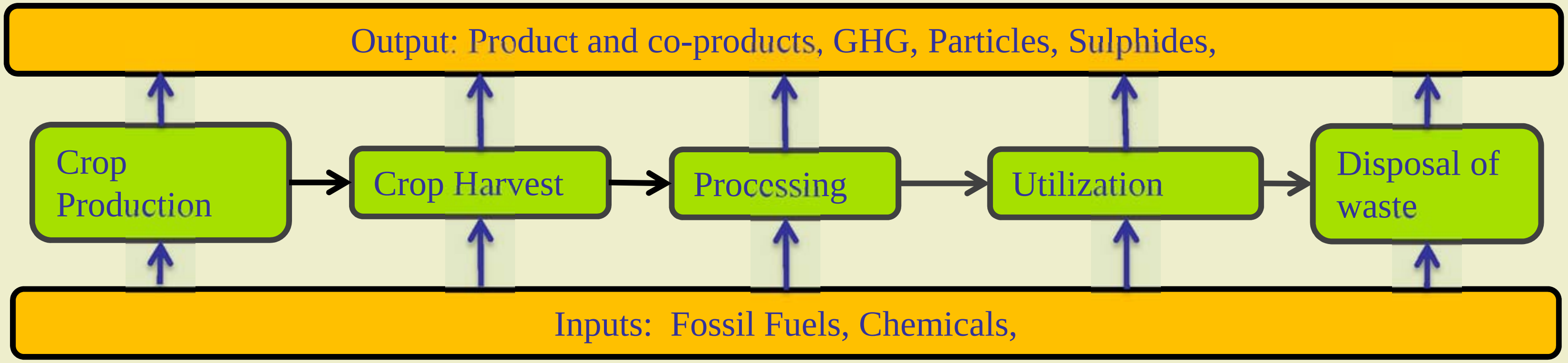
  - commercially available now to replace existing petroleum and diesel liquid transport fuels
  - generally use commodity crops as feedstocks (some exceptions e.g. UCO)
  - bioethanol produced by fermentation of C6 sugars
  - biodiesel produced by methyl esterification of vegetable oil triglycerides

- **‘2nd Generation’ or advanced technologies**

  - some commercial availability – still requires significant investment
  - utilise non-food crops, co-products and waste
  - biochemical routes e.g. lignocellulose ethanol
  - thermochemical routes e.g. syn-gas, bio-oil

Life Cycle Assessment overview

Using Life Cycle Assessment (LCA) or "Cradle to Grave" assessment of the environmental input of a product.



Impact category: Global warming potential (GHG calculation)

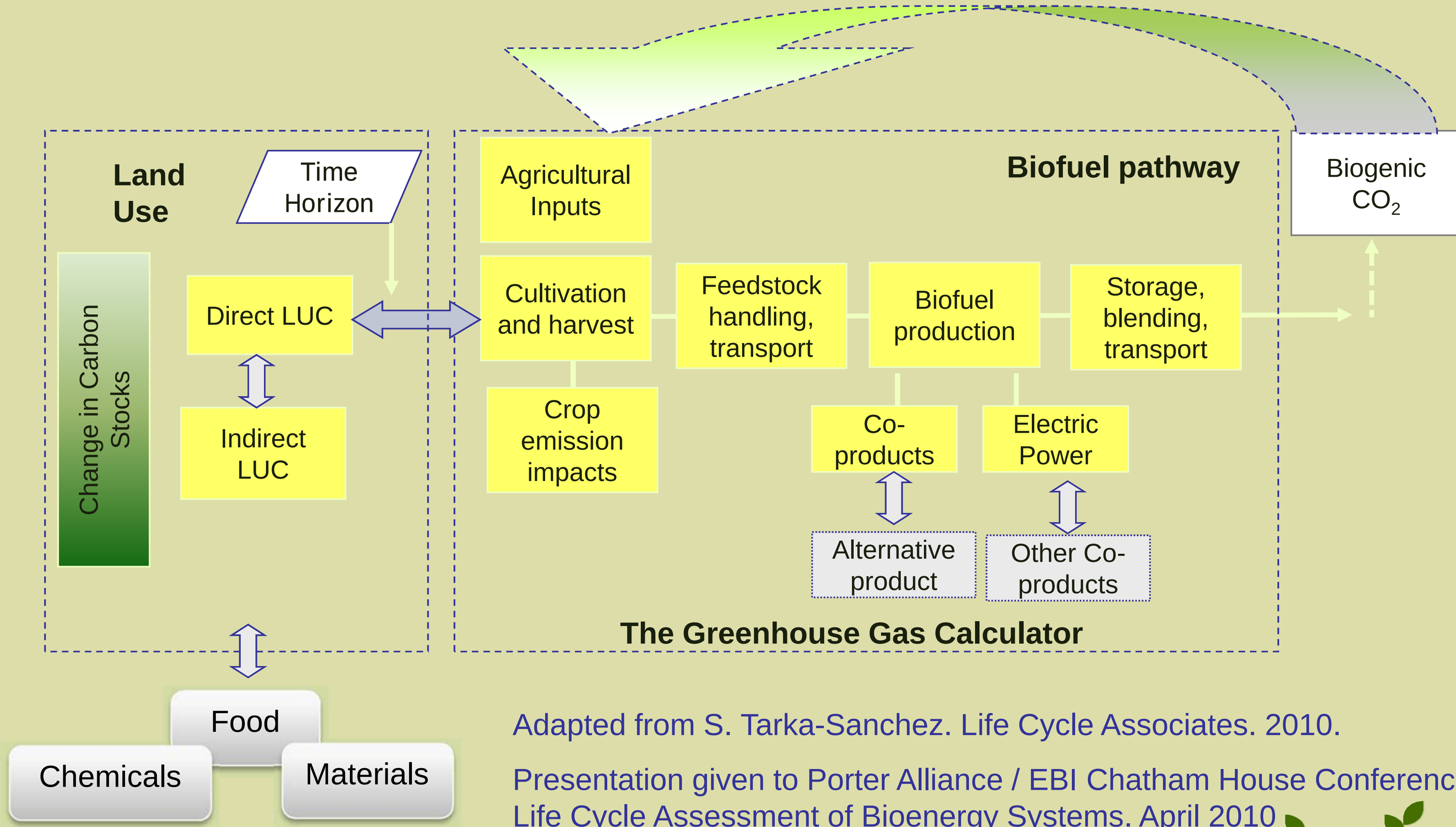
(can also be used to define energy consumption; acidification; smog; ozone layer depletions; human toxicology; pollutants; eutrophication and eco-toxicological impacts)

LCA Calculation decisions

Life Cycle Assessment decisions – goal and scope

- **functional unit** (final unit of measurement; depends on perspective and questions being addressed)
- **systems boundaries** (must be clearly defined; relevant and consistent)
- **reference systems** (provides comparison; must be clearly defined and have the same systems boundaries)
- **allocation of co-products** (depends on boundary setting; various methods used – still uncertainty on methodologies)

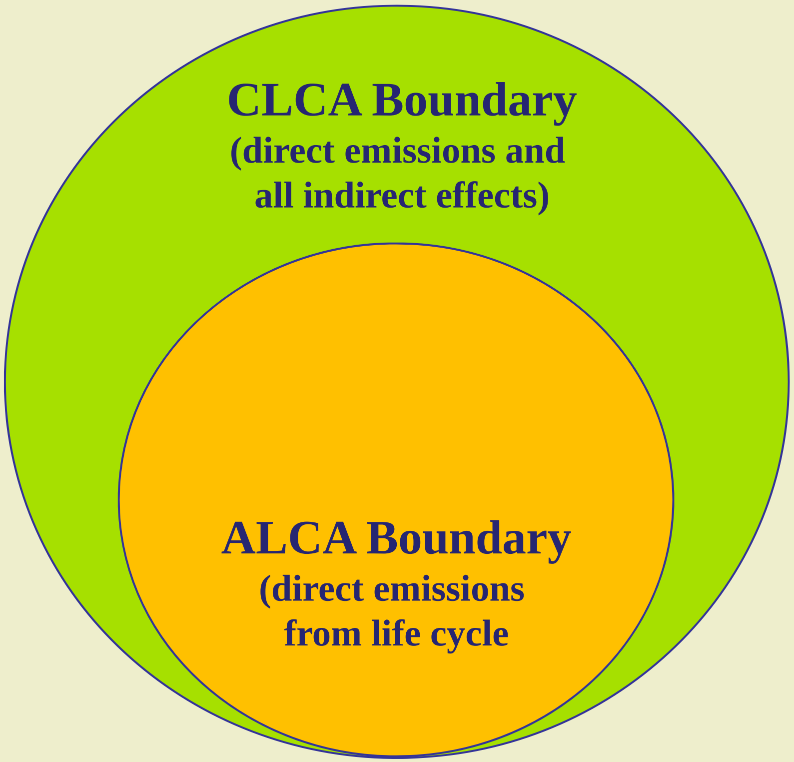
Land Use and Biofuel Systems



Adapted from S. Tarka-Sanchez. Life Cycle Associates. 2010.

Presentation given to Porter Alliance / EBI Chatham House Conference on Life Cycle Assessment of Bioenergy Systems. April 2010

GHG Calculation Methodologies



ALCA – Attributional Life Cycle Analysis

Provides information on impacts of all processes used to produce (consume and dispose of) a product

CLCA – Consequential Life Cycle Analysis

Provides information about consequences of changes in level of output (consumption and disposal) of a product, including effects inside and outside the life cycle of the product

CLCA has wider scope . Approach often used in policy making, instead of looking at specific supply chains

From Tipper, R.; Hutchinson, C. and Brander, M. (2009)
“A practical approach for policies to address GHG emissions from indirect land use change associated with biofuels” Technical Paper TP-080212-A, Ecometrica Press.

Methodological Issues which can impact outcomes

Impact Review - Key considerations

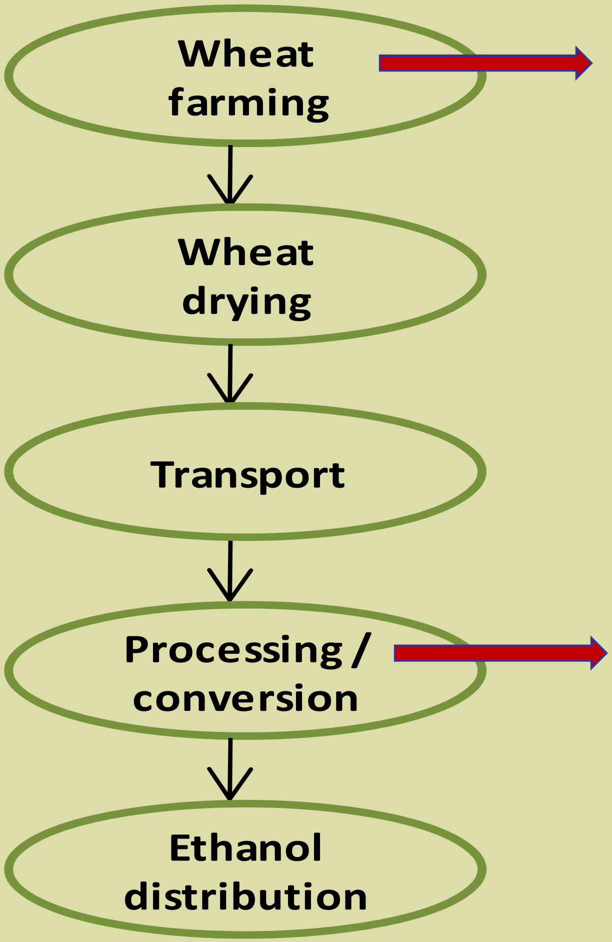
- co-product value and allocation
- how to allocate carbon lost from deforestation between LUC causes (e.g. timber extraction; agricultural expansion for food production) and the for ILUC?
- how to rationalise the relationship between increased demand for crops for biofuels and increased agricultural yields?
- how to define directly, the relationship between increased demand in one region leading to supply in another region?
- how to “decide” which type of land is converted to agriculture?
- how to take into account the use of agricultural land that would otherwise have been abandoned? How to define the value of regenerating land?
- how to take into account the effect of sustainability criteria?

Ewout Deurwaarder, European Commission, Feb 2009

- how to evaluate technological developments in biofuel production and land use implications in timeframe for targets

Methodological Issues which can impact outcomes – dealing with co-products

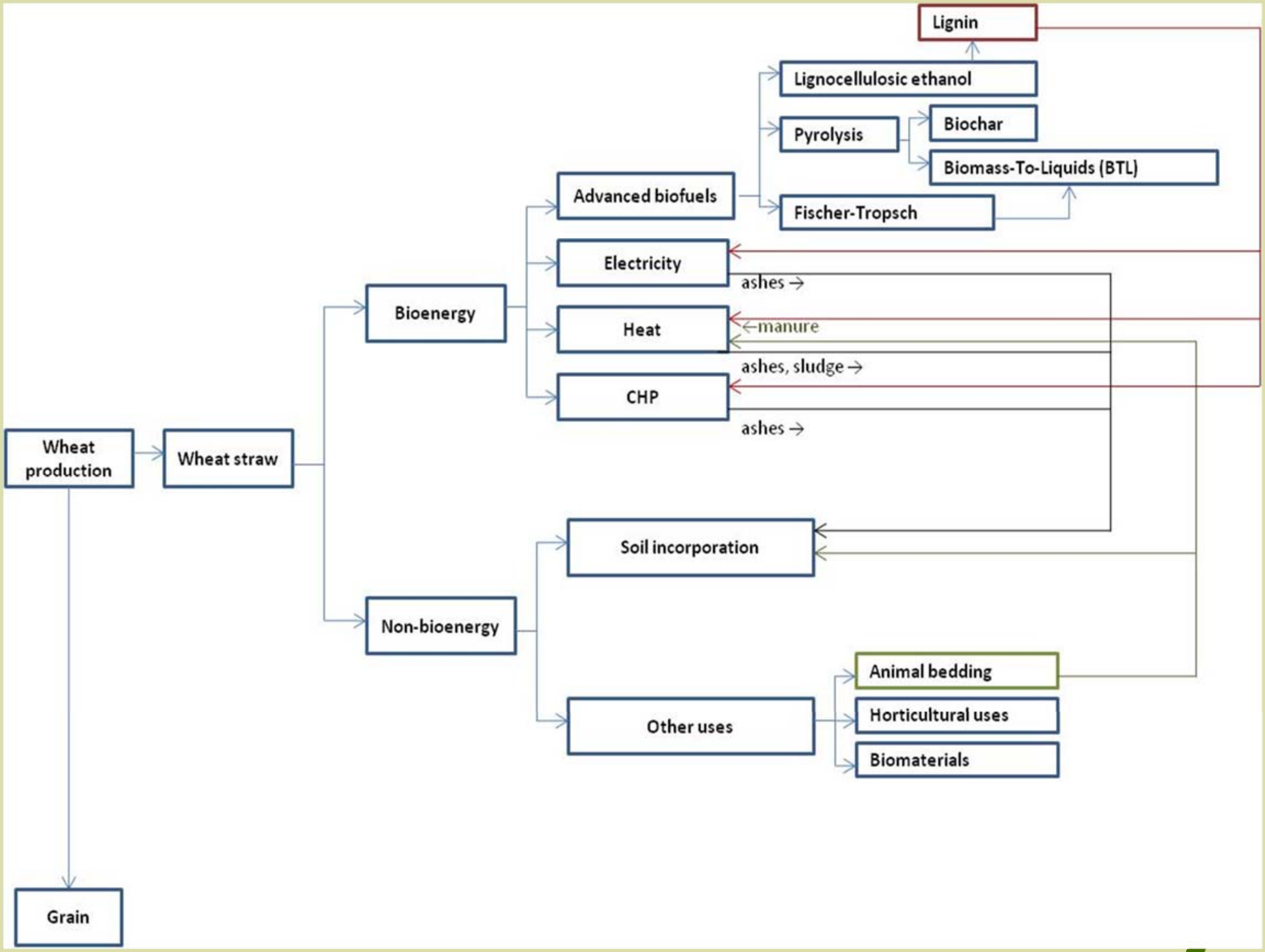
Consider: LCA of wheat grain used for the production of ethanol



Wheat farming produces both grain and straw; straw has a number of potential uses
e.g. has value to the farmer if ploughed back in; market value as animal bedding and use in horticulture; as a biomass feedstock for heat and electricity; future potential as lignocellulosic ethanol feedstock

Conversion of wheat grain to ethanol also produces Distillers dried grain and solubles (DDGS) and CO_2.
DDGS has value as an animal feed and can be used as residue biomass for electricity and heat; future potential for CO_2 as fuel feedstock

LCA for wheat straw co-product: potential uses



Methodological Issues which can impact outcomes – Indirect Land Use Change (ILUC)

The expansion of agricultural land as an indirect consequence of increased land use for the production of bioenergy (biofuel) feedstock

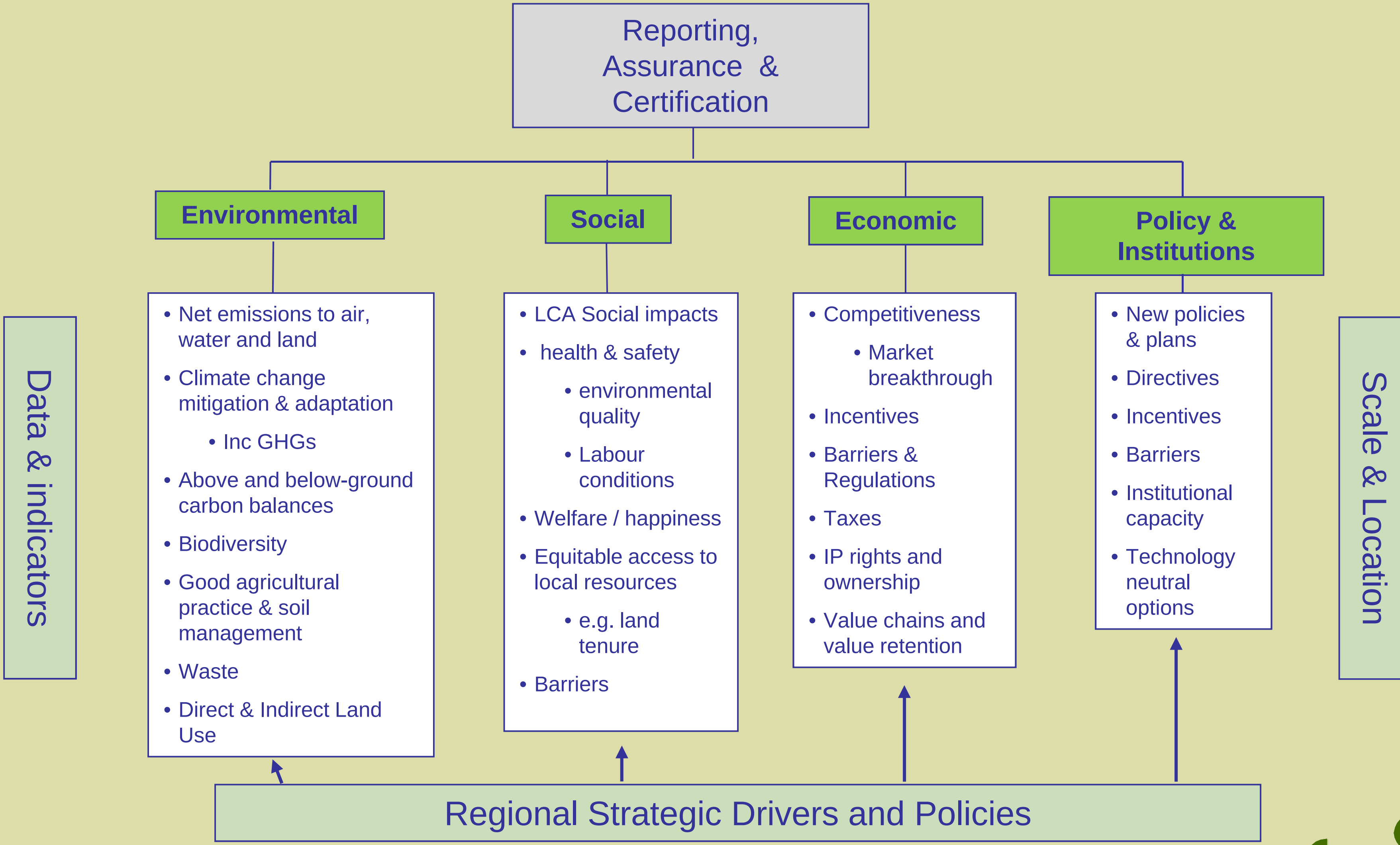
- ILUC cannot be directly observed or monitored
- Highly contentious issue – uncertainty as to the best way to deal with ILUC in policy
- Current EU Policy options – awaiting decision - June 2011?
  - Do nothing and continue to monitor
  - Raise GHG thresholds for biofuels
  - Impose additional sustainability criteria for biofuels
  - Impose a differentiated ILUC factor for biofuels
- Applied to biofuel feedstocks – ILUC for biofuels is LUC for other agricultural crops – current biofuel crops may be used for food, feed or biofuel
- Needs a better understanding of LUC for agricultural industry

Sustainability Overview

Biofuel feedstock production, use and development is not just about GHG emissions. We also need to address

- the needs of the expanding global population: providing food, services and quality of life
- management of resources: fossil resources, carbon stocks, soils, water, (precious metals)
- management and maintenance of natural habitats which provide environmental services and for human needs: biodiversity

Balancing environmental, economic and social issues for sustainable biofuel development



Diaz-Chavez, 2007

Sustainability Overview

- **Regional strategic drivers and Policies**

  - may already be in existence for agricultural production on a country by country basis addressing different aspects of sustainability e.g. Environmental Stewardship schemes in the EU which encourage farming practices which enhance biodiversity

  - Local legislation for socio-economic considerations must be considered sensitively as priorities can vary greatly and are under the governance of the individual country

- **Use of certification and assurance schemes**

  - generally crop (feedstock) specific e.g. Assured Combinable Crops Scheme (ACCS); Better Sugar Cane Initiative (BSI); RSPO (Roundtable for Sustainable Palm Oil; RTRS (Roundtable on Responsible Soy); Forest Stewardship Council (FSC).

BUT *Institutional and policy components never addressed as an intrinsic component of sustainability assessment. Monitoring and verification of schemes – who carries this out?*

UK RTFO - Sustainability Reporting

Takes a 'meta-standard' approach which benchmarks Certification schemes against 7 principles, each further defined by indicators and criteria

Environmental Principles - Feedstock Production

- will not destroy or damage large above or below ground carbon stocks
- will not lead to the destruction or damage to high biodiversity areas
- does not lead to soil degradation
- does not lead to the contamination or depletion of water sources
- does not lead to air pollution

Social Principles – Feedstock and Biofuel Production

- does not adversely affect workers rights and working relationships
- does not adversely affect existing land rights and community relations

Benchmarked standards which meet the required level of sustainability are defined as 'Qualifying Standards'

Sustainability – UK RFA research

The Renewable Fuels Agency* - the RTFO biofuels regulatory body in the UK for the last 3 years. Within research re-mitt, has also undertaken studies to assess the impact of the RTFO:**

- Studies carried out address environmental, social and economic sustainability models and methods of major biofuel supply chains
- Case studies "Exploring the sustainability of Argentine Soybean Production"
- "Agricultural production models and methods for UK biofuel' which explores variations in farming and plantation management techniques (including scale of production areas) for nine crop/country combinations
  - Oilseed rape: UK, France, Germany
  - Soy: US, Argentina
  - Palm: Malaysia, Indonesia
  - Sugarcane: Brazil
  - Sugarbeet: UK

http://www.renewablefuelsagency.gov.uk/page/rfa-research

*****AS OF 1st April 2011 the UK Department of Transport will assume responsibility for the duties of the RFA**

Sustainability – UK RFA research

For the reporting period 2009/10 of the RTFO, soy was the largest individual feedstock

- 480 million litres reported
- 30% of overall biofuels supplied
- majority from Argentina (replacing the United States as the predominant origin of soy supply to the UK biofuels market)

RFA Case Study "Exploring the sustainability of Argentine Soybean Production"

Major conclusion of study: *The soybean industry has the potential to achieve positive changes in Argentina and the correct usage of the agricultural expertise developed in the industry could be an essential tool for achieving long-term sustainability.*

Summary

Porter Alliance

- We often work in ‘silos’, assessing impacts of scenarios for a particular feedstock, technology and/or supply chain
- Understanding complex interactions and outcomes of developing technologies and supply chains is often based on models and future scenario predictions - these need to be transparent and accessible to ‘non’ modellers
- Agriculture and science are never static! We are in a process of continuous development in our understanding of the potential of agriculture (both land and crop) to provide feedstocks for with greater yield and multiple uses – *NEEDS INVESTMENT*
- The management of land and land use change is a key concern for the future, not just for the provision of feedstocks for bioenergy but also if all our food and material demands (and *lifestyle* expectations) are to be met
- Wider sustainability issues and the sensitivities of growing specific crops in a given land area also need to be considered e.g. Impact on biodiversity, water availability (ecoservices) and socio-economic considerations

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