JRC Scientific and Technical Reports

Proceedings of the 1st JRC Workshop on Green Chemistry

Editors Paolo Pizziol & Philippe Loudjani

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Workshop on

Green chemistry future and its possible impact on agriculture: the whole farm geo-traceability concept

Ispra, Thursday 22 January 2009

Building 58a Room 12A

Background

Fossil petroleum resources will gradually be replaced by sustainable resources derived from nature including trees, plants and food/biorefinery wastes. Chemicals determined to be hazardous to the environment will have to be substituted (cf. REACH legislation). Biomass is an interesting starting material for transportation fuels because it is renewable.

All these circumstances are drivers for change (shift from petrochemicals to green chemicals) and therefore the European Commission has taken initiatives to enhance market demand for bio-based products, in order to exploit their (in principle) positive environmental impact. However a forward look is needed to assess the impact of a massive production of green chemicals on world wide agriculture, to allow agriculture to lead the change and not just to pay the consequences.

In this view, current debate on biofuels (namely on sustainability criteria definition) can encompass green chemistry as links and overlaps of production processes can occur (e.g. biorefineries). Experiences and case studies can be shared and exploited to prevent negative impact on agriculture and wildlife. Sustainability criteria fulfillment certification can also become an issue unless global monitoring or control system is outlined and prioritized.

The information produced at farm level during the feedstock production process can be suitable, if appropriately traced, to assess production process sustainability against the criteria defined in the legislation. Historical information, GIS technology and remote sensing can also enhance the temporal and spatial dimension of the relevant information to be collected. All this translates in the whole farm traceability concept. Whole farm traceability is recognized as a multi-purpose tool, regardless of the technology chosen, to achieve farming system optimization, support cross compliance implementation, and ensure product quality certification and verification of environmental sustainability criteria for biomass production.

Therefore JRC/GEOCAP action will launch a project to fill information gaps and to build the sound information basis and record keeping system for the verification of environmental sustainability criteria for biomass production. At the same time, another project will be launched to identify the information at farm level to be produced and collected in support of a Regional Quality Certification system.

The workshop objective is to assess the impact on agriculture and wildlife of an expanding agro-chemicals market, the possibly in comparison with the current expansion of biofuels market, taking into account the higher variety of plants and products, and the expected (longer) time frame. The debate could also provide with new elements to complete current EC policy and research initiatives on green chemistry.

Agenda

Morning presentations 9h00-12h50

Chairman: Jacques Delincé

1. **Introduction to JRC Agriculture Unit**
Jacques Delincé- EC/JRC/IPSC/ Agriculture Unit Head

2. **Participant Industries self-introduction.**

3. **Introduction to whole farm geo-traceability concept**
Paolo Pizziol- EC/JRC/IPSC/Agriculture Unit/GeoCAP

4. **Green Chemistry: today and tomorrow**
James Clark- Green Chemistry Centre - University of York

5. **Green Chemistry: overview on existing policy instruments and possible scenarios. The LEAD initiative.**
Tomas Jonsson – European Commission DG ENTR:

6. **Green Chemistry: the KBBE initiative.**
Jens Hoegel – European Commission DG RDT

7. **Green chemistry: sustainability certification perspective on the basis of biofuels experience**
Norbert Schmitz – MEO Consulting

8. **Green Chemistry: an agricultural production chain for biolubricants**
Luca Lazzeri – Council for Research in Agriculture -Industrial Crops

9. **Site-specific balances: NEB and CO2eq reduction**
Lorenzo D'Avino Council for Research in Agriculture -Industrial Crops

LUNCH 13h00

Debate 14h00-15h30

Facilitator: Simon Kay
(JRC/IPSC/Agriculture/GeoCAP Action Leader)
Discussion on the presentations contents, in particular:

- *Pros* and *cons* of a 'global'(meaning 'biomass irrespective of its use) certification perspective
- Monitoring/control *versus* certification
- Whole farm geo-traceability in monitoring or certification context

Conclusions 15h30

Rapporteur: Philippe Loudjani
(JRC/IPSC/Agriculture/GeoCAP/API WP Leader))
Synthesis of the discussion possibly specifying iresearch & policy needs

END 16h30

EXECUTIVE SUMMARY

Green chemicals are a great opportunity for agriculture sector. Experts in chemistry, agricultural research, EU policy and chemical industry have been invited to discuss green chemistry future perspectives. Their testimonial is that biomass availability is actually not the limiting factor to cover the need of chemical products. But, there are today insufficient instruments for the promotion of green production processes and to encourage the use of green products as input for fertilizer and phytosanitary controls. In general, together with the existing effective and targeted policies, LEAD and KBBE, more consistency in EU policy is still needed (harmonization of sustainability criteria, set-up of certification schemes relying on GIS technology). An urgent work on standardization of 'green process' assessment methods is requested to pave the way for reliable certification schemes capable of guiding consumers' choice and strengthening consumer level responsibilities.

Climate change has forced all world governments to strengthen and revise their environmental policies to reduce CO2 emissions. Investing in renewable resources is the solution to mitigate climate change impacts. Oil prices rise in 2008, even if not caused directly by shortage but mainly speculation, has increased attention towards alternative sources for energy and alternative feedstock for plastic and chemicals. In addition, waste management is a world-wide problem needing urgent solutions to prevent irreversible damage to the planet. Biomass production offers an alternative source of raw materials with low ecological impact and high environmental benefit in terms of GHG balance (i.e. potentially sustainable). However, biomass production can lead to social, economical and environmental damages (expropriation, deforestation, food shortage…) if not managed appropriately. It implies that biomass production should be supported by record keeping technology and reliable certification procedures.

EU scientists, industry and policy makers met on 22nd January in Ispra to debate the impact of a shift to green chemistry on future agriculture. Green chemistry itself presents a great opportunity for agriculture as it can act as a driver to minimize the environmental footprint of agricultural processes. The discussion ranged from technology deployment and development, to certification challenges, moving across the main EC initiatives in the area, the Lead market and KBBE (Knowledge-Based Bio-Economy) initiatives.

Invited speakers were James Clark, professor at York University (UK), acknowledged expert on chemicals production from plants and Director of the Centre for Green Chemistry. Norbert Schimtz is partner in MEO Consulting (DE), currently performing a study on feasibility of a world wide accepted and harmonized certification procedure for sustainable production of biofuels. Luca Lazzeri (IT) has recently contributed to trigger a biofuel/biolubricants chain in Italy based on a newly introduced crop, Brassica carinata. Tomas Jonsson is a European Commission official, DG ENTR, in charge of LEAD initiative. Jens

Hoegel is scientific officer in DG RTD charged of KBBE program. Paolo Pizziol is responsible of geo-traceability within MARS (Monitoring Agricultural Resources) Unit in the Joint Research Centre.

Hereafter are summarized the main outcomes of the meeting.

1. Among multiple drivers for change, the most important is to support the chemical industry to switch from fossil feedstock to renewable resources *(J. Clark):* however, this process needs to be accompanied by appropriate and consistent legislative framework, starting from harmonised sustainability certification procedures and an appropriately technology-based (GIS) agriculture to prove sustainable farming practice and prevent land displacement effects. For such purpose, we could use the Whole Farm Geo-traceability approach which is a tool enabling farmers and public services, when linked to national GIS- geodatabases, to link production practices and inputs to a specific land plot, with the aim to check and certify cross compliance, Good Agriculture Practices and other similar existing and forthcoming rules for sustainable agriculture *(P. Pizziol)*
2. Potential benefits for the chemical industry are wide-ranging. Currently, many pressures are on the chemical industry, ranging from energy cost and saving to new legislation requirements (REACH). In addition, consumer awareness has started to play an active role in the whole debate, and the perception of chemical industry as the major Earth polluter is now wide-spread. Furthermore, a very concerning issue is that many raw materials used in chemistry (e.g. Ni, Zn, Cu, Ag, ...) are running out, while in the meantime their prices grow exponentially *(J. Clark).*
3. 90% of organic chemicals are based on petroleum feedstock (although representing only 5% of used petroleum). Modern technology allows the conversion of organic carbon from plants into plastics and other chemicals. Metabolites (e.g. plant waxes) can be extracted from biomass of industrial crops and bulk chemicals from processing (e.g. glycerol). The present limitation is the range of extraction/processing technologies available, and not specifically the feedstock – eliminating the need for specific plant breeding, at least for bulk chemicals. The issue is to make the chemical processing greener, reducing energy, solvent and water use. Substitute products derived from biomass (like solvents, adhesives etc.) should be incentivized and the legislative approach should not be just forbidding 'problematic' substances (REACH purpose), but also focusing on the processes. 'Green Companies' should be rewarded and agreed methods to gauge how 'green' chemicals are (based on carbon footprint or energy demand etc.) need to be developed and agreed upon *(J. Clark).*
4. The LEAD market initiative has been set up to boost market prospects for bio-based products and to remove obstacles to their success. Bio-based products refer to non-food products derived from biomass (plants, algae, bacteria, crops, trees, marine organisms and biological waste from households, animal and food production). The Advisory Group set up on the basis of this initiative

will assist concerned services and policy makers in moving towards standards definition, policy coherence, certification schemes, product labels, public procurement, public awareness etc. The focus is presently on biochemical products (biosolvents, biolubricants etc.) and enzymes. A significant issue is to avoid competition between food/non-food, whilst supporting the exploitation of wood, wood waste, non food plants etc *(T. Jonsson)*.

5. Research is needed to establish new sources of biomass and products since the range of process technologies and raw materials chosen will affect levels of sustainability. This is the reason why the Commission has set up the Knowledge Based Bio Economy (KBBE) initiative. The main focus of 2009 research (Call for Biorefineries) is on the sustainability criteria for biomass production and in particular on the sustainability assessment up to the farm gate *(J. Hoegel)*.

6. Presently, major sustainability issues are minimum GHG savings, safeguarding natural land, sustainable cultivation of agricultural land, and ensuring social standards. In present agricultural commodity markets, incentives for sustainable production are not set. Sustainability requirements set by policy can help to overcome this market weakness. Certification is one possible appropriate instrument to differentiate between "good" and "bad" biomass. However, a certification scheme that covers the relevant sustainability requirements and information about GHG emissions does not currently exist *(N. Schmitz)*

7. In Italy, a complete production chain has been established to produce bio-lubricants from *Brassica carinata*, cultivated over an area of 1500 Ha. Biolubricants production cost is currently 30% higher compared to petrochemical products, but performance is comparable and pollution impact lower (for example, one ha of Brassica carinata represents a carbon sink of 4000 kg of CO2). However, since this plant is not a plant officially registered (the procedure is a bit time consuming) it prevents from promoting this crop for biolubricants and bio-fertiliser production and to grant green market support (such as the ones granted to implementation of renewable energy programs across the EU), or to access to 2nd pillar funds *(L. Lazzeri)*

8. Moreover, to expand its market share (or even to create a new market) a green product needs to be certified and pertinent information for the consumer presented in a standardized manner (labeled). To achieve this, a commonly agreed method for GHG calculation is required and also for other aspects such as recycling content, disposal practices, and so on, to estimate environmental impact or footprint. This lack of harmonization is not at all a minor issue. In addition, an easy labeling approach (e.g. grading household goods on energy consumption) is mandatory to be accepted by consumers. *(N. Schmitz)*

9. Different perceptions of sustainability concept among EC services lead to inconsistencies in some legislations (e.g. big transformation plants, favored in the Renewable Energy legislation, are economically sustainable but may have a more significant environmental impact compared to small plants based close

to biomass production areas). Many EU policy areas refer to sustainability criteria, but how consistent are they? *(L. Lazzeri)*

10. Industry (including farmers) needs more motivation, means more explicit incentives, to adopt green processes and produce green products (J. Clark). For example, the majority (93%) of inputs in the food chain occurs at farm level, but there are no EU incentives in using plant-derived fertilizers *(L. Lazzeri)*.

11. Sustainability certification, for a considered crop or plant, is only meaningful if it is extended to all its uses, rather than restricted to niche areas such as the bio-fuel production *(N. Schmitz)*.

12. Geo-traceability is an essential tool to identify land (easy identification of 'no-go' areas, land history etc.), to protect high carbon stock areas, and to manage crop segregation when it is necessary (e.g. when a harvest can also imply different chemical composition) (N. Schmitz). Geo-traceability is potentially achievable but has to be motivated, perhaps through financial incentives or income support through facilitated access to quality chains and specific subsidies. *(P. Pizziol)*

13. Consumers can also play an active role in green chemistry spreading out, especially for what concerns the recycling of wastes. However, they need to be guided by appropriate labeling on goods and legislative framework (e.g. mandatory waste separation in fast food restaurants) *(J. Clark)*.

14. In conclusion, green chemicals are a great opportunity for agriculture sector. However, there are today insufficient instruments for the promotion of green production processes and to encourage the use of green products as input for fertilizer and phytosanitary controls. In general, together with the existing effective and targeted policies LEAD and KBBE, more consistency in EU policy is still needed (harmonization of sustainability criteria). An urgent work on standardization of 'green process' assessment methods seems a logical development to pave the way for reliable certification schemes capable of guiding consumers' choice and strengthening consumer level responsibilities.

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Workshop on Green Chemistry

22/01/2009

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Introduction to whole farm geo-traceability concept

Paolo Pizziol –
European Commission - Joint Research Centre

Abstract

GIS/ICT –based agriculture record keeping systems can prove sustainable farming practice and prevent land displacement effects, the most unwanted effect of any possible non-food use of land. For such purpose, Whole Farm Geo-traceability is a tool enabling farmers and public services, when connected and interfaced to national geodatabases, to link production practices and inputs to a specific land plot, with the aim to check and certify cross compliance, Good Agriculture Practices and other similar existing and forthcoming rules for sustainable agriculture

Introduction to whole farm geo-traceability concept

Paolo PIZZIOL
EC JRC IPSC
Agriculture Unit

Outline

- Farm traceability rationale
- ICT deployment in farm business
- 3° millennium agriculture challenges
- green chemistry opportunity

Objectives & regulatory requirements resulting in traceability implementation at farm level

High food safety	Food Law EC.178/2002; GMO traceability EC.1830/2003
High quality products	Bovine identificatic EC.95/2001; Food safety EC.95/2001; Packaging materia EC.1935/2004; Ingredients EC.89/2003; Hygiene pack EC.852/200
High quality Environment	Cross compliance EC.178/2003; Organic farming EC.2092/1991; GMO release EC. 18/2001; Pesticides proposal Com.372/2006
Farmers' awareness	FASystem EC.1782/2003; RDP Training EC.1698/2005
Farmers' competitiveness	FAServices EC.1698/2005
Rural sustainability	RDP EC.1698/2005

From traceability to Whole farm geo-traceability

Traceability

Food traceability

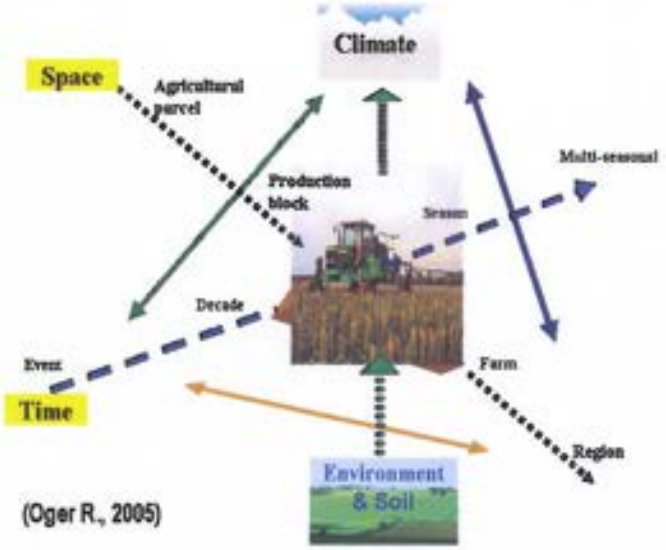
Geo-traceability=

- –Farm level traceability=
- –Internal traceability=
- –On-farm traceability=
- –Whole farm traceability=
- –Whole farm information management=
- –Whole farm geo-traceability

Geo-traceability: definition

Geo-traceability is based on the contribution of geographical data related to production parcels to classical traceability... (Oger R. & Debord. M. 2006)

... allowing to address geographical context knowledge and problematic ... (Debord M. 2006)



(Oger R., 2005)

... when considering the history, use, and location of a primary production and its related practices... (Ometto A. et al. 2007)

Use of whole farm geo-traceability

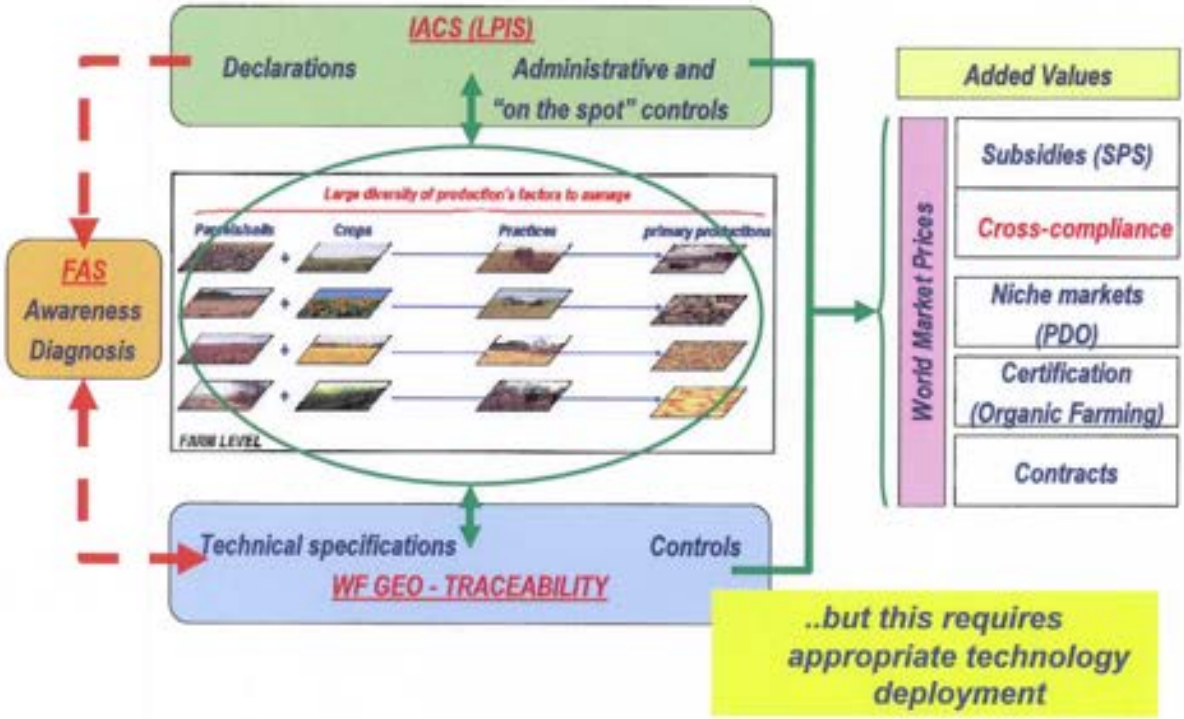
Multi-purpose tool

–to achieve

- Farming systems optimization
- Eco-environmental sustainability
- Access to new markets (e.g. quality, contracts)

–to facilitate

- Access to public subsidies
- Public administration controls
- Public administration advice
- Certification bodies work



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ICT tools deployment in agriculture

Average or smaller farms:

– PC for data storage

Big/high income farms:

Above +

– Expert systems for management
– On –line access to public and private DB (e.g. LPIS, trade & prices data etc.)

Advanced /pioneering farms:

Above +

– GPS devices for precision farming
– GIS tecnology
– Automatic data registration devices as RFID
– PDA
– GPRS

Farm ICT assets upgrade

Pre-conditions

- Financial incentives
- Market perspectives
- Supporting legal framework and (in general) legal simplification
- ICT local infrastructure (broad band etc.)
- Benefit-cost analysis

Farm ICT assets upgrade: *pros*

Appropriate and reliable information collected and stored for

- quality productions (incl. organic & niche productions: production schemes fulfillment)
- contract productions (production protocols fulfillment)
- ordinary subsidized productions (cross compliance standards)

At benefit of

- farmers (production factors optimization, no cc penalties, increased self-esteem etc.)
- retailers/ traders/ importers/ exporters
- certification bodies
- consumers
- public control bodies (agriculture & environment)
- public & private advisory bodies

All stakeholders in the production chain!

Farm ICT assets upgrade: *cons*

- SW and HW purchase costs
- Requiring training and support
- Lack of (some) farmers' confidence
- Extra work!

Agriculture: new 'tasks'

- Food Safety
- Food security and worldwide stabilised markets
- Environment care (about e.g. pollution, illegal dumping, biodiversity)
- Liability (e.g. conventional & GM crops coexistence)
- Animal welfare
- Workers safety
- Consumers awareness (>more information but problem of label complexity)
- Red tape (subsidies request, certifications etc.)

This imply more

- –Formation
- –Information
- –Data collection
- –Data analysis
- –Data delivery

Agriculture: new business perspectives

Non-food area as

- green chemicals
- biofuels (1°, 2°, 3° or 4° generation)

[Requiring sustainability certification]

Not biomass delivery-linked (services) as

- Agro & Eco-tourism
- Carbon credits market

[Requiring spatial data up-to-date (and measurement certification?)]

Agriculture: future technological challenges

- Simplification farming practices to
  - minimize inputs
  - achieve a lower ecological footprint
  - increase flexibility
- Diversification farm productions to
  - optimise manpower/machinery exploitation
  - stabilise income
- Product pre-processing *in situ* to increase the output value at farm gate
- Rationalization of national/regional markets to
  - shorten food chains
  - reduce food miles
  - promote farmers markets and
  - GAS (Gruppi d'acquisto solidale)
- Internet sales

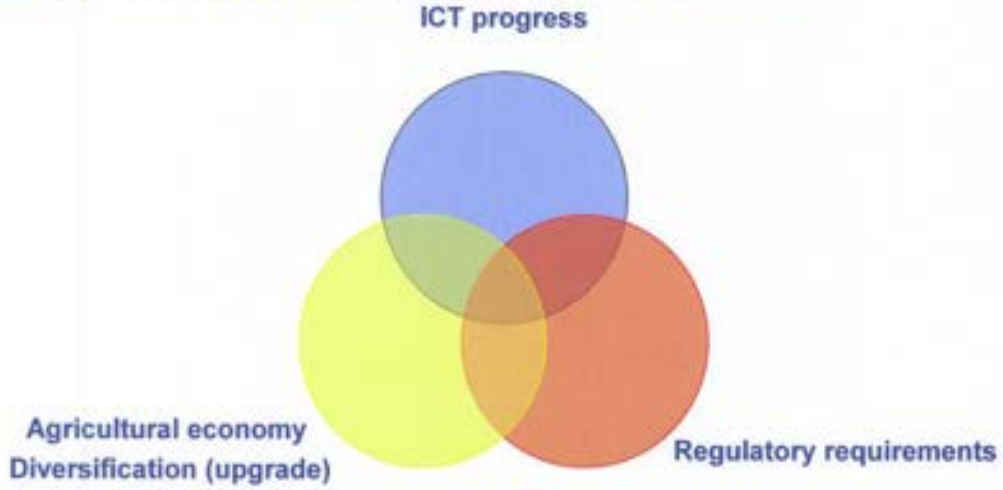
ICT: future technological developments

- HW (portable devices):
  - PDA with more operational capacity (incl. batteries duration!)
  - GPS for geo-referencing farming practices
  - GPRS for data transmission
  - RFID: more information capacity and more user-friendly data capture
- SW: more user-friendly and automatic/pre-defined data analysis

To be supported by policy/administrative developments like:

More transparent data access and exchange (from public to private and vice versa) also to prevent frauds about farm practices, abuses and illegal behavior

W F geo-traceability at cross-road



Focus: green chemicals opportunity….

For human society:

-To tackle oil shortage expected in 25(?) years

For Earth:

-To get rid of oil as feedstock for plastics etc. asap

–To reduce fossil fuels direct pollution (e.g. tank sinking and pipeline burst) and indirect pollution

For world-wide agriculture

–To increase GHG neutral balance agriculture

–To provide new appeal for agriculture business

–To promote an higher consideration of agriculture in the society

–To achieve a diversified and rentable agriculture

But taking care of

– Assuring environmental sustainability criteria compliance through detailed and **geo-referenced practices records** (incl. the purpose of preventing cross contaminations etc.)

– Implement appropriate public control & monitoring systems to avoid frauds and illegal markets

….can further justify geo-traceability implementation !

And we can conclude that…..

Whole Farm Geo-Traceability could be the baseline (or the common basis) for various certification schemes including sustainability certification for biofuels and green chemicals

In particular, we think that green chemistry could be WFGT 'sponsor' and viceversa.

However, we still need to know more about green chemicals, in particular ….

We would like to know:

1. Which crops will be in the coming years more concerned as green chemicals producers ?
2. Is there any market priority in bio-based products demand? (e.g. pharmaceuticals, plastics)
3. State of play of main research projects at EU level.
4. Can green chemicals production present specific eco-sustainability problems?
5. Are sustainability criteria eventually identified for bio-fuels suitable for green chemicals production chains? Can certification issue be tackled with the same approach?
6. Which will be the research areas to focus in the coming years?
7. What policy makers do to push this sector?
8. Why green chemicals have not yet got (so far) same political attention as biofuels?
9. Which role can play geo-traceability in green chemicals agriculture diffusion?
10. Which role can play JRC in this context? E.g. create a network? Promote specific research projects.

Green Chemistry: Today and Tomorrow

Prof.James CLARK
University of York

Abstract

Green Chemistry is concerned with developing new low environmental impact and sustainable technologies for the creation of genuinely and verifiably green and sustainable chemicals. There are multiple drivers for change including the increasing costs and limited availability of traditional resources; legislative pressure on manufacturing and waste disposal; and customer pressure for greener products. By combining these drivers with the opportunities provided by biomass as a potential source of carbon and industrial and domestic wastes as sources of other elements and compounds for making chemicals we have an irresistible opportunity to move towards green and sustainable chemicals. Green Chemistry shows the ways to achieving this thorough more efficient biomass conversion technologies, clean chemical extraction and synthesis, and green product design. It is vital that we engage all actors across all relevant supply chains in this process of change – from furniture to clothing and from electronics to pharmaceuticals.

Green Chemistry
Centre of Excellence

THE UNIVERSITY of York

Research
Industry
Networking
Education

Green Chemistry
Today and Tomorrow

James Clark

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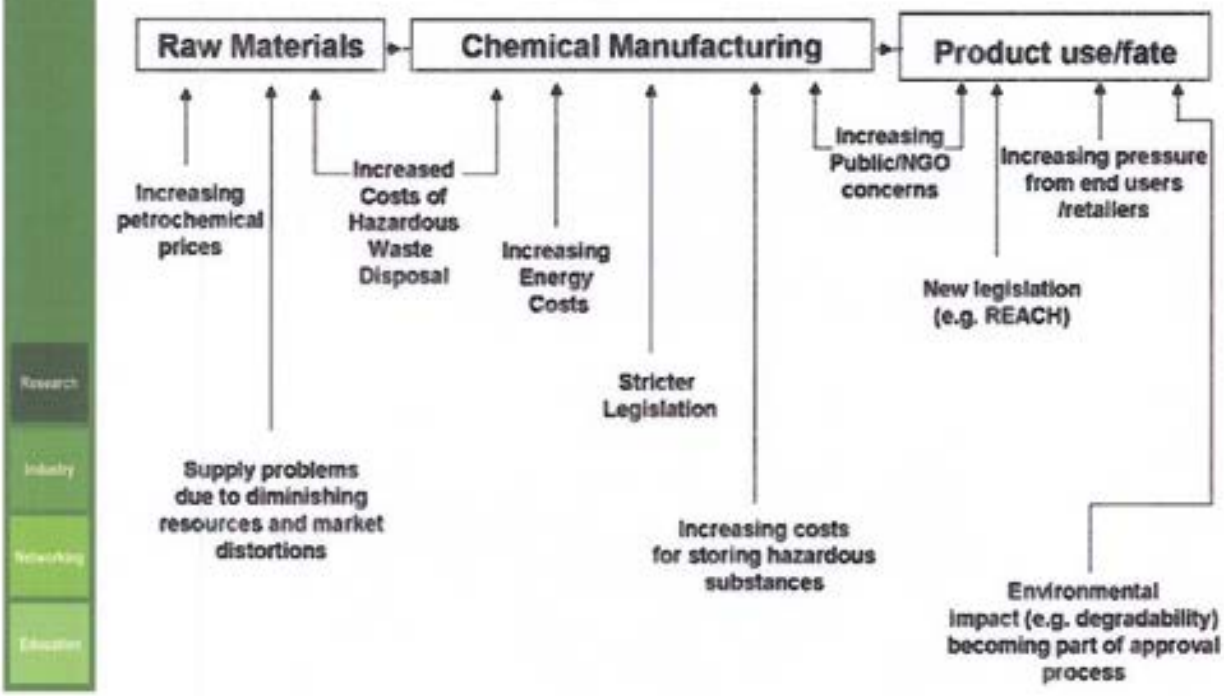
www.greenchemistry.net

Benefits of the Chemical Industry

Pressures on the Chemical Industry Across the Lifecycle



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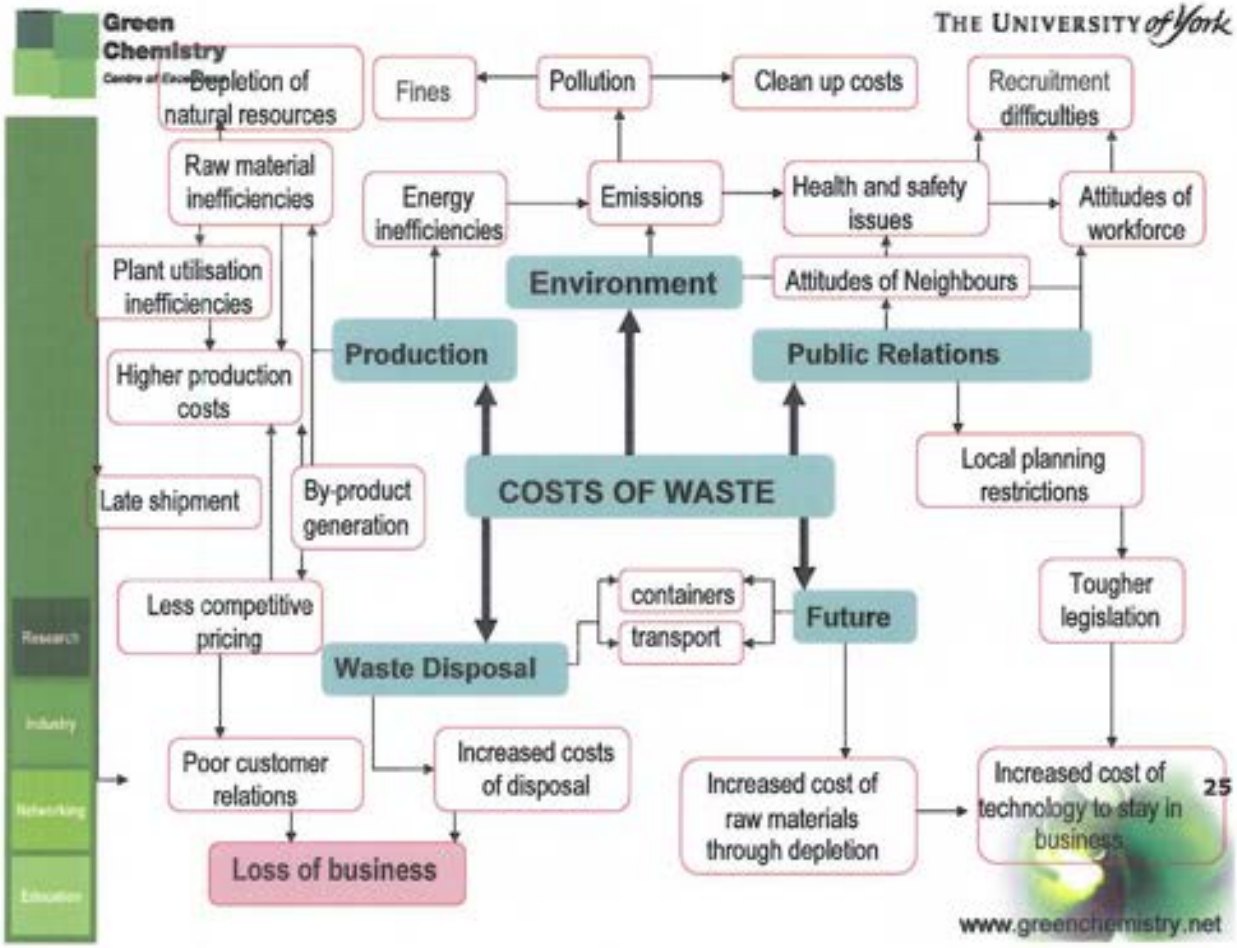

Green Chemistry Centre of Excellence

THE UNIVERSITY of York

Green Chemistry and the Consumer

"Research shows that 80% of the 16 Million people visiting our stores each week want sustainable products"

"A clear majority (of our customers) want this process to be simplified"

"Green Chemistry is not only a solution, it is the solution"

[Mike Barry, Mark & Spencer Head of CSR]

"Chemicals are featuring more prominently in stakeholder resolution .... The resolutions are a sign of pressure to come, driven by more organised NGO actions, increased consumer concern and an availability of safer alternative products"

"(Major companies) ... are being asked to lay out a strategy for becoming a leader in safe chemical use"

[Ends report]

"Green chemistry offers corporate managers and investors on opportunity to reap the benefits of 21st century thinking and avoids the risk of 20th century chemistry"

[Rich Liroff, WWF-US]

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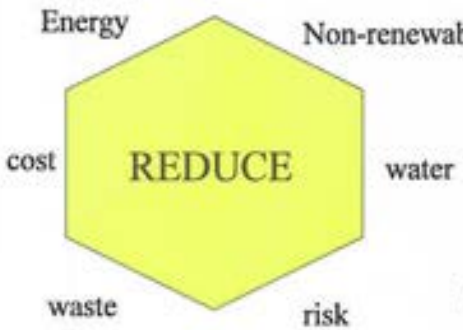
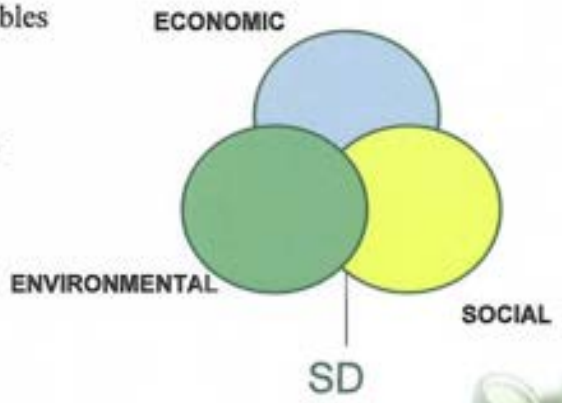
What is Green Chemistry?

Sustainable Development and Business





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Networking
Education

www.greenchemistry.net

Green Chemistry Themes

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Making your raw material *more sustainable*

The chemical industry is too dependent on traditional virgin sources of raw materials - sources that are becoming scarce, expensive and unreliable, and often from regions with uncertain social and political conditions

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Resource demands of chemical manufacturing

10% of oil for chemical manufacturing

Long global supply chains add to chemical environmental footprints

10% of oil used as raw material for making chemicals

Chemical Manufacturing produces 4% of global CO2

Disposal of chemicals can use resources and cause environmental harm

Pre-manufacturing | **Manufacturing** | **Product Delivery** | **Product Use** | **End of Life**

Chemical industry needs numerous raw materials (P, S, Sb,In, As..) which are becoming rare

High resource demands for disposal

Chemical use may have high energy costs

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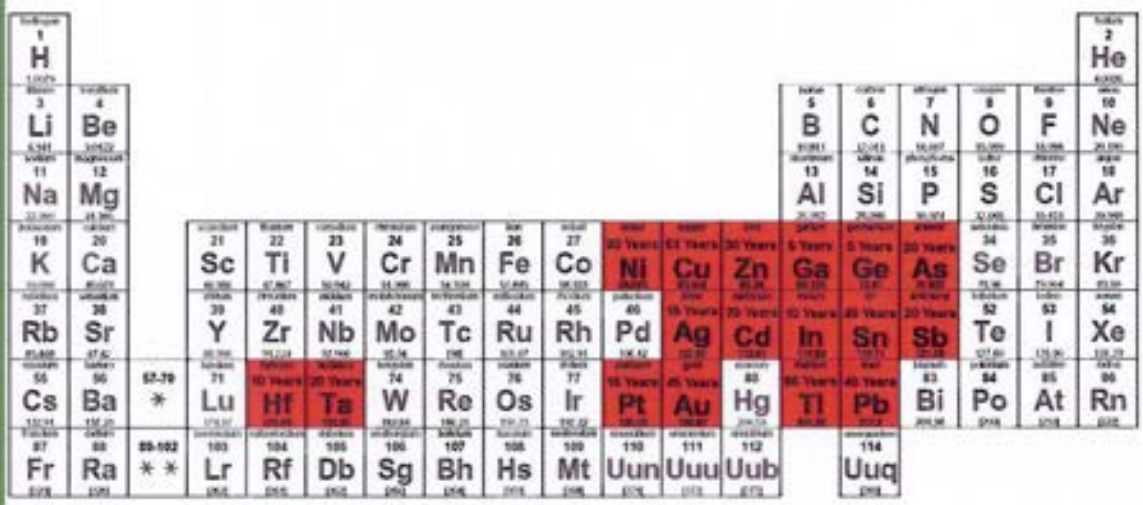
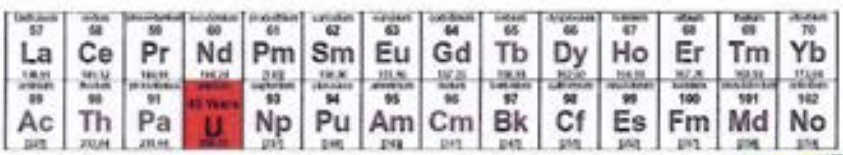
Key elements are running out!





*Lanthanide series

**Actinide series

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Waste is tomorrows resource

We need to encourage the greater use of chemically rich waste as a resource

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Sustainable sources of Carbon

Over 90% of organic chemicals are based on petroleum feedstocks this is not sustainable

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CHEMICAL POTENTIAL

ADDING VALUE

Extractables
(secondary metabolites from straw)

Benign Extraction Methods
Separation/Purification
Green Chemical Transformation

Materials
(primary metabolites – starch, cellulose)

Expansion Methods
Green Chemical Modification
Composites

Bulk Chemicals
((Bio)chemical processing of bulk materials/residues)

Selective Fermentation
Controlled Pyrolysis
Extraction Technology
(Bio)platform molecules
Green Chemistry/technology

TECHNOLOGIES

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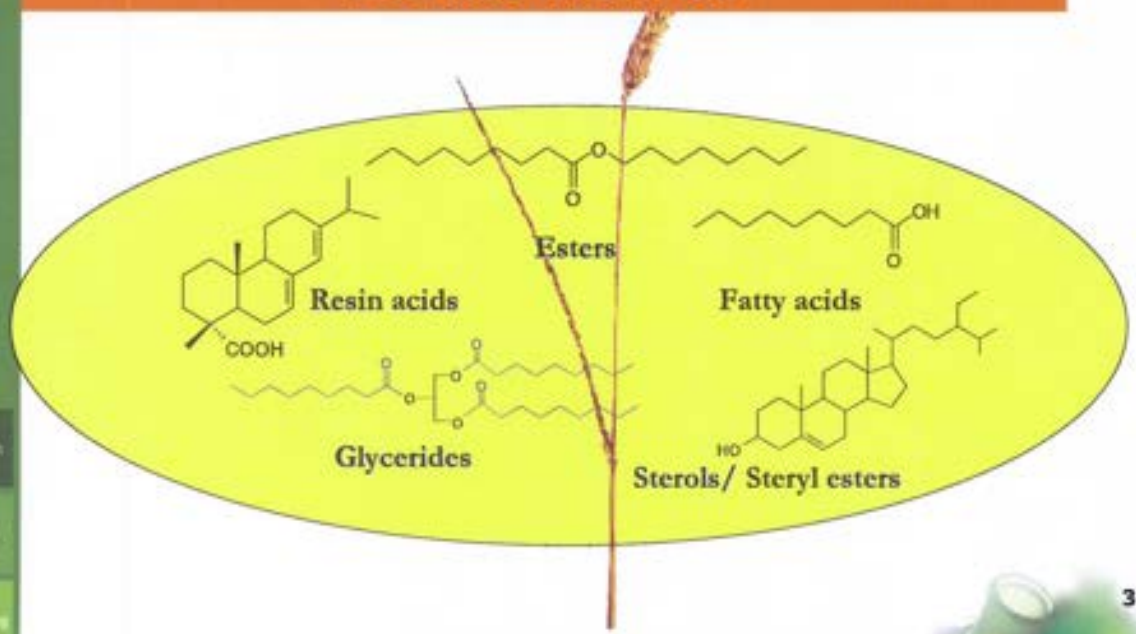
Plant waxes



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Biodiesel Glycerol -fuel and chemical value

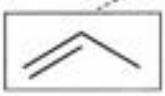
especially when based on wastes as feedstocks

Glycerine co-product

= old route to glycerol

New Solvay Process

Epichlorohydrin



propene

Surfaces, plastic etc

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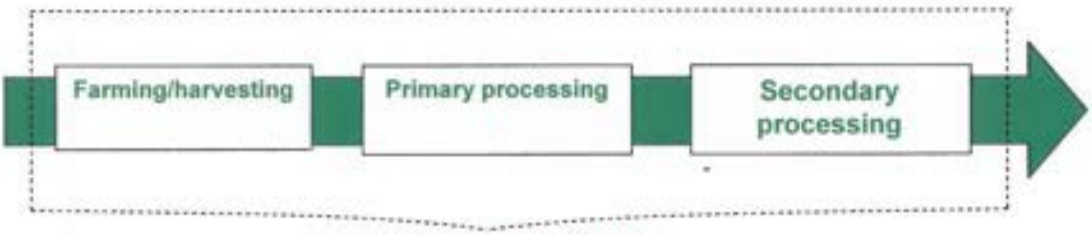
www.sustoil.org

SUSTOIL: a new Network for the sustainable use of plant oils

- 23 partners from 10 EU countries
- Collaborators from outside EU
- Coordinated by the Green Chemistry Centre



INTEGRATED BIOREFINERY SCHEMES

We need to more rapidly move towards the use of non-competitive biomass as a feedstock for chemical manufacturing

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Making your process *greener*

Chemical manufacturing is largely based on chemistry that is complex, energy- , solvent-, and water-intensive and produces considerably more (often hazardous) waste than product

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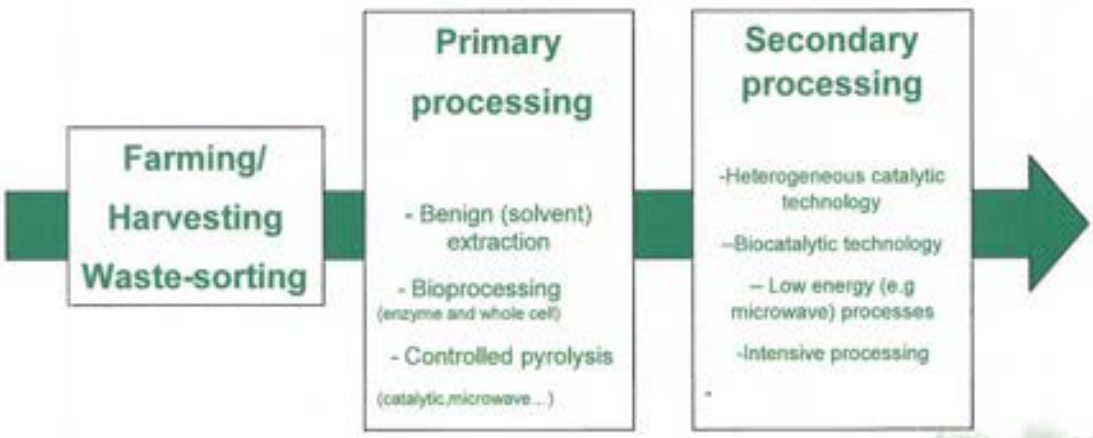
Green Chemical Processing



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For example……for the preparation of widely used intermediates

Making Amides: Development of a Cleaner Process

Starting Material

Traditional Chemistry	Green Chemistry
Expensive and dangerous auxiliaries	Single step catalytic process
Low atom utilisation	Cheap reusable catalyst
Large amount of dangerous waste	Very high atom utilisation
	Simple work-up/separation
	No hazardous waste

Amide product

We can be too clever to be green: we need to encourage simpler, cleaner chemical manufacturing

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Making your product *greener*

Social, environmental, legislative, supply chain and worldwide political pressures make the introduction of greener products imperative

Routes to Substitution

PROBLEMS

Identify generic substance types of concern

Examples

Solvents (*replacing VOCs*)

Adhesives (*replacing formaldehyde*)

Flame retardants (*replacing polybrominated cmpds*)

Primers (*replacing chromate*)

SOLUTIONS

Study currently available alternatives

Supercritical fluids, biosolvents (*solvents*)

Modified polysaccharides (*adhesives*)

Clay nanocomposites (*flame retardants*)

Citrates (*primers*)

OPPORTUNITIES

Green and sustainable products

Chemicals derived from renewable resources & with green lifecycle

Platform molecules from biomass

Natural extracts

Biomaterials

Green Chemistry modified natural products

We need to promote practical routes to and incentivise substitution and not simply legislate for avoidance

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Solvents from Renewables

Research

Industry

Networking

Education

Biomass

Fermentation

Green Chemical Transformations

Glucose + H_2 → sorbitol

Glucose → succinic acid

Dextrose --> lactic acid

Levulinic acid

Isosorbide
sosorbide esters
Roquette

Succinate
Esters
(*Bioamber, DSM, Roquette*)

Lactate esters
Ashland

Ethyl lactate
Vertec Biosolvents

Methyl-THF
Loba-Chemie

Examples of Companies showing leadership in Green Chemistry

InterfaceFlor - take-back schemes and research on use of renewable resources and green product design for carpets
Armstrong World - use of renewable resources in floor coverings
GSK- green chemistry process metrics, awards scheme
Cognis, Ecover, Henkel - green surfactants
Pfizer, Rhodia, Enichem, Merck - greener manufacturing processes
Roquette, DSM, Dow, Bioamber, DNP - chemicals based on renewables
Solvay, Dow - chemicals based on biofuel co-products
Nature Works, DuPont - bioplastics
Hua Yi group - corporate green chemistry policy

Companies showing good practice need to be rewarded

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How Green is my Chemical?

Carbon Footprint

Environmental Footprint

Green Chemistry metrics

PBT and related product classifications

There is no standard for measuring greeness but we need to establish a mechanism of approval for methods used and the reporting made

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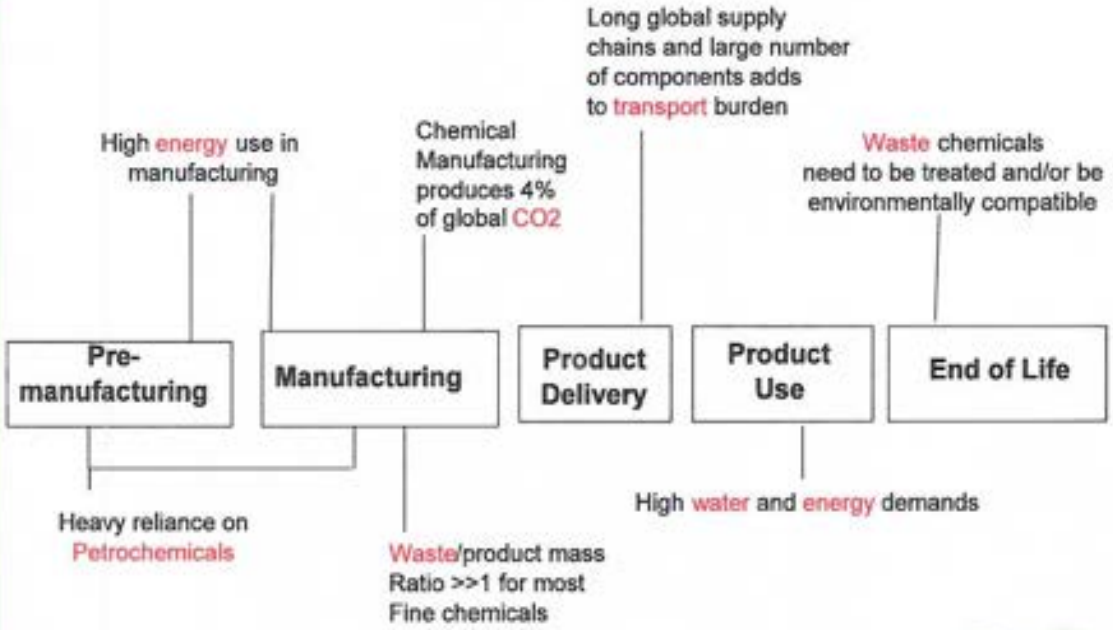
Environmental impacts from a shower gel



We need to encourage full life-cycle thinking across the supply chain for determining environmental impact

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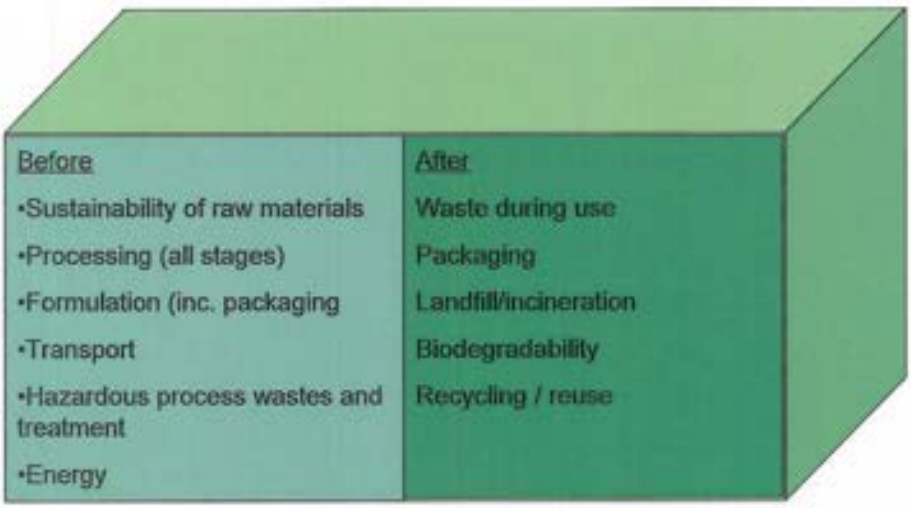
Two – box lifecycle measure of greeness



The consumer is a vital part of the "greening" process

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Supply chain partnerships

Supply chains for current chemicals are inadequate for green and sustainable chemicals

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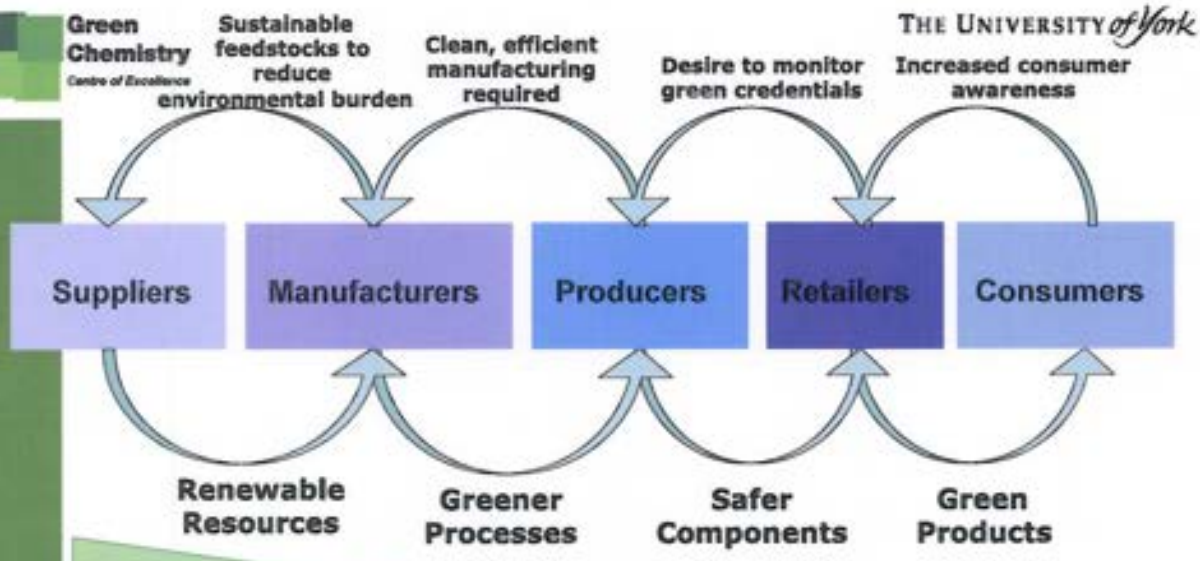

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Eco-waxes

York - Charles Jackson Farms - Botanix - Croda - Compak

"Natural" products are very desirable…they need to be:

- *derived from natural resources*
- *extracted using "natural" solvents (H_2O, EtOH, CO_2)*
- *modified only be "natural" methods (biocatalysis)*

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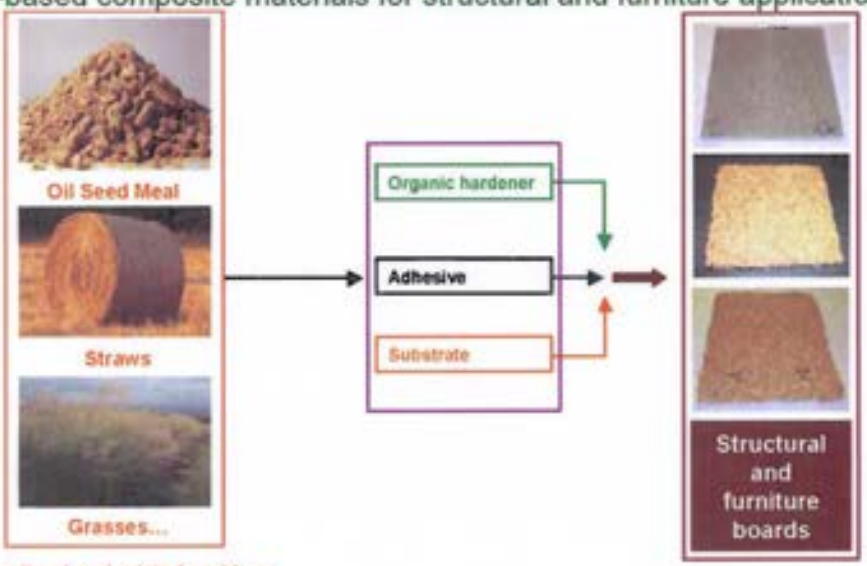
and for the residues……

Green Office

York-Velcourt-Bical-BCC-PQ-B&Q-BioFlame-Compak (LINK)

Bio-based composite materials for structural and furniture applications



Research
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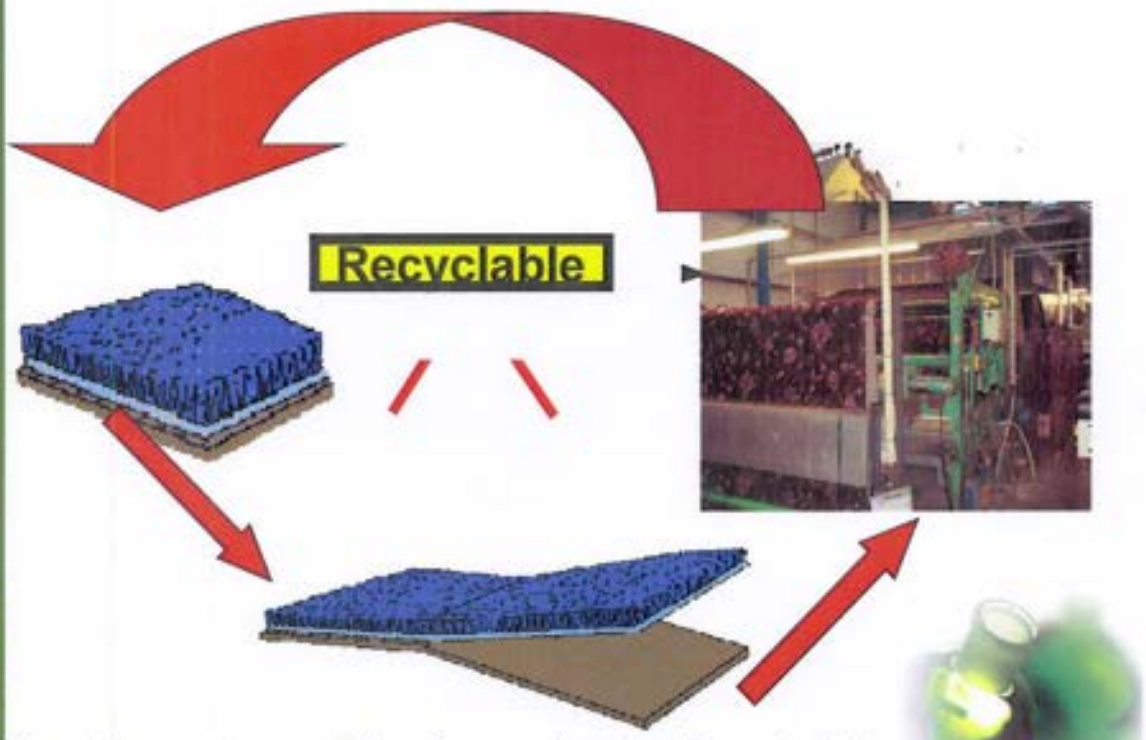
Overall good metrics for sustainability, greener products, waste avoidance and low environmental impact manufacturing

York-Interface-Itac-Contract Chemicals -(TSB)

Switchable adhesives for carpet tiles



We need to promote case studies of green and sustainable supply chains

Activity Areas

The Centre's Activities can be groups into 4 areas:

- **Research**
- **Industry collaboration**
- **Education, including development of teaching and promotional materials**
- **Networking with all chemical stakeholders**

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MSc in Green Chemistry & Sustainable Industrial Technology

Principles & Technologies
Principles, Environmental Impact, Chemical Engineering, Catalysis for Green Chemistry, Alternative Reaction Media, Energy, Clean Synthesis, Renewable Resources, Greener Products

Supporting Courses
IP, Business Opportunities, Green Chemistry Presentations, Legislation Presentations and Literature Research

Research Project & Oral Presentation
In collaboration with Industry

Transferable Skills

Research
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Networking
Education

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Education and Training

Contact-based
Supported e -learning
CPD
(including Masterclasses and on-site delivery)
Full or Part-time
Certificate, Diplomas and Degree options

We need to better prepare the next generation and retrain the existing workforce in the principles and practices of green chemistry

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Networking Projects:
Green Chemistry Network

- Est. 1998 with funding from the Royal Society of Chemistry
- One of the larges international networks of this type in the world
- International membership
- Excellent forum for information exchanges and collaboration

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Education

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GC&C Networking Projects
Green Chemistry & the Consumer

Engaging the retailers through low technical awareness of greener chemistry

- **"Research shows that 80% of the 16 Million people visiting our stores each week want sustainable products"**
- **"A clear majority (of our customers) want this process to be simplified"**
- **"Green Chemistry is not only a solution, it is the solution"**

[Mike Barry, Mark & Spencer Head of CSR]

Biodegradable Surfactants

Environmentally friendly bitter-taste blockers for drugs

Halogen-free flame retardants

http://www.rsc.org/chemsoc/gcn/industry.htm#consumer

We must encourage mechanisms for engaging the (very many) users of the chemical industry

www.greenchemistry.net

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Green consumer products

York-Boots-Bristol and Glasgow Science Centres

Welcome to the green consumer products website.

www.greenconsumerproducts.net

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6th Green Chemistry & the Consumer Symposium

Energy Efficiency of Green Consumer Products

15th & 16th June 2009

The King's Manor, York, UK

Plus pre-symposium Masterclass & evening event

Speakers from retail, industry, academia, NGO and others

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Industry
Education
Green
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Research
Networking

The European Union's Bio-based Products Lead Market

Tomas Jonsson
European Commission, Enterprise and Industry DG

Abstract

The objective of the Lead Market Initiative is to facilitate the market entry of products based on new technologies by addressing possible demand-side problems.The European Commission issued in 2007 the report "Accelerating the development of the market for Bio-based Products in Europe"[1] which was prepared by the inter-service task force in connection with the Communication on the Lead Market Initiative (COM(2007) 860 final). The report contains a concrete action plan for boosting market prospects for bio-based products, which is now being implemented.

Bio-based products can be defined as non-food products made from renewable, biological raw materials, either from cereal crops, oilseed rape, straw, wood, wood waste, hemp, flax, household waste, industrial waste, sludge, etc. The bio-based products lead market has decided to concentrate firstly on the two following product groups: *biochemical products* (bio-polymers, bio-surfactants, bio-solvents, bio-lubricants, plus chemical building blocks such as ethanol, butanol, lactic acid, etc), and *enzymes* (including technical enzymes, food enzymes, and animal feed enzymes).

The Commission has set up an ad-hoc advisory group, including representatives from European Union Member States, academia and industry, to assist in the implementation of the actions, but also to formulate more detailed recommendations for action. These actions will address possible obstacles to introducing new technologies on the market. The main areas where the advisory group is expected to propose changes are: better policy coherence, regulatory changes, standards, product labels, certification schemes, public procurement guidelines, availability of raw material at a competitive price, support to setting up of integrated bio-refineries, improved access to finance, and public awareness of the benefits.

---

1 http://ec.europa.eu/enterprise/leadmarket/biobased_products.htm

The work on developing suitable European Standards for bio-polymers and bio-lubricants has already started in 2008. The availability of such standards is essential if we want consumers, companies and public authorities to make conscious decisions about their purchases. Industry standards and informative product labels can give useful information on the characteristics and environmental benefits of bio-based products, and hence help to open up markets for new technologies.

Bio-Based Products Lead Market

Presenter:
Tomas Jonsson
DG Enterprise and Industry
tomas.jonsson@ec.europa.eu

European Commission
Enterprise and Industry

Why bio-based products?

- ✓ Based on renewable materials
- ✓ Savings in limited fossil resources and reduce greenhouse gas emissions (carbon neutral / low carbon impact)
- ✓ Recovery and recycling possible
- ✓ High bio-degradability or compostability and a lower toxicity
- ✓ Less resource-intensive production (water, energy, waste)
- ✓ Adapting our economies to threatening climate change can be an economic opportunity
- ✓ Agriculture, forestry, industry and households generate significant amounts of waste
- ✓ Rural development
- ✓ Security of resources (less dependence on imports)

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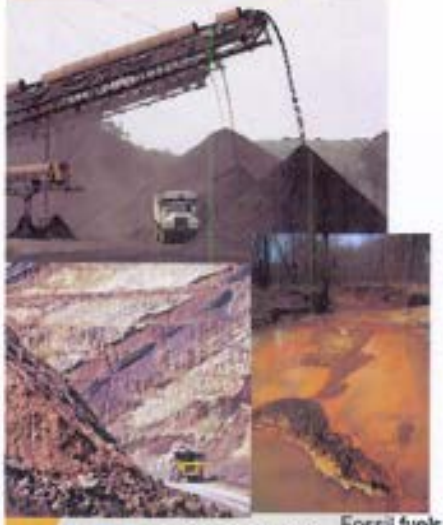
Bio-based products: a definition

Bio-based products refer to non-food products derived from biomass (plants, algae, bacteria, crops, trees, marine organisms and biological waste from households, animals and food production)



60% household waste organic, 20% plastic, glass, cans

Question: biomass + recycled hydrocarbons = bio-based product?

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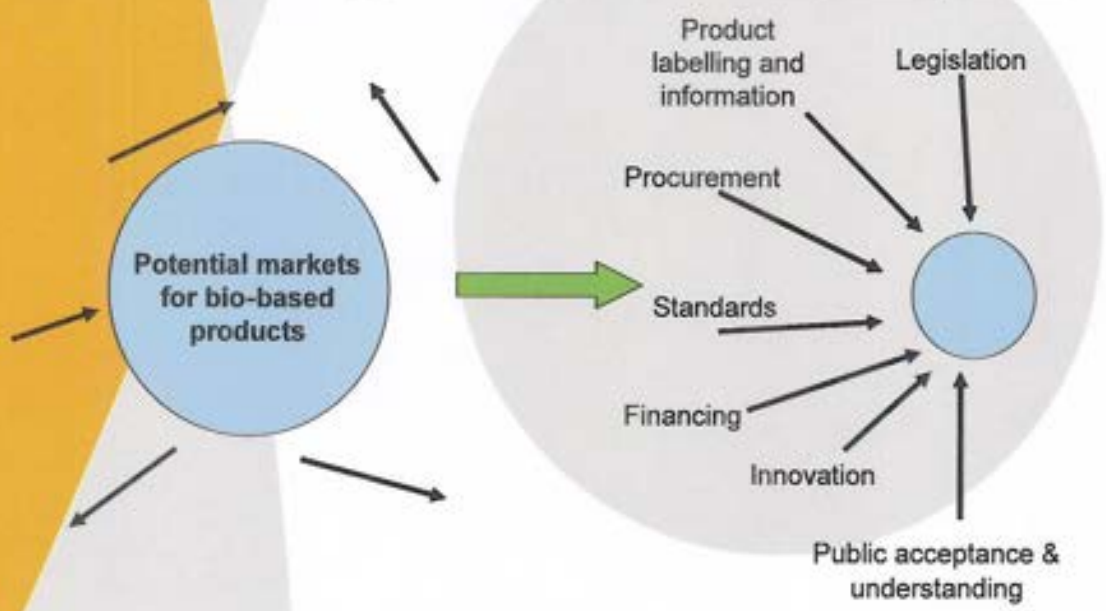
Fossil fuels are hydrocarbons created from fossilized remains of dead plants and animals, that accumulate in the Earth's crust and are exposed to heat and high pressure. Since the process takes hundreds of millions of years they are considered non-renewable resources.

Lead Market approach: Coherent policy mix



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Tasks of the ad-hoc Advisory Group

- ❑ implement the activities of the action plan, in cooperation with the Commission;
- ❑ further develop & define the activities described in the action plan;
- ❑ make recommendations for policy action at the national or European level;
- ❑ ensure that the activities will be coordinated with public authorities, business, civil society & other stakeholders.

Report back during Q4 2009; action to continue until 2011

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Ad-hoc Advisory Group

The advisory group will be composed of members of the Commission's existing networks:

- ➢ ENTR's Contact Network with Member States for Competitiveness in Biotechnology (COMP-BIO-NET)
- ➢ RTD's Knowledge-Based Bio-Economy Network (KBBE-NET)
- ➢ DG AGRI's working group on mobilisation of forest biomass
- ➢ DG TREN's network for the development of national biomass action plans
- ➢ EU Renewable Raw Materials Working Group (EU-RRM)
- ➢ ENTR's Competitiveness in Biotechnology Advisory Group (*industry and academia representatives*)
- ➢ Technology Platforms
- ➢ ETAP (Environmental Technologies Action Plan) WG
- ➢ Several "observers" participate in discussions

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Bio-based product groups: our focus

Biochemical products

- *bio-plastics/bio-polymers*
- *bio-surfactants*
- *bio-solvents*
- *bio-lubricants*
- *chemical building blocks*

Enzymes

- *technical enzymes*
- *food enzymes*
- *animal feed enzymes*

Feedstocks

Cereal crops, oilseed rape, straw, wood, hemp, flax, various waste, sludge, etc

Raw materials

Starch, sugars, cellulose, lignin, proteins, oils/fats, etc

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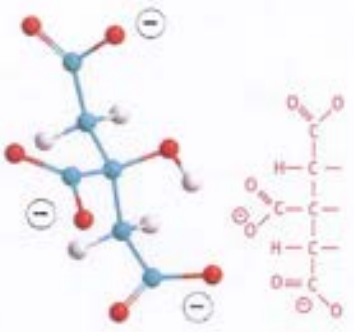
Fig. 6.24 Basic chemical compounds that can be produced from biomass.

Ethanol

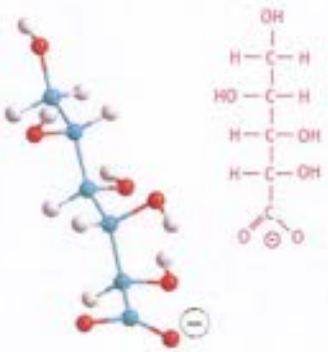
Acetic acid

n-Butanol

Acetone



Citric acid



D-Gluconic acid

Lactic acid

Chemical building blocks

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Biomass sources

- A variety of biomass sources is a benefit to society
- Biomass from crop production should be subject to sustainability criteria, and ideally, traceable
- Biomass from household waste and wastewater is a potential source, but legislation and active policies are needed to build a new processing chain
- Biomass from forestry and industrial waste: underutilized?
- Landfills must be reduced

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Challenges (III)

Municipal waste management in the EU – a very mixed picture

No correlation with income/capita

MUNICIPAL WASTE MANAGEMENT

Country	Recycled (%/total)	Landfill (%/total)	Incineration (%/total)	Waste per person (kg)
Netherlands	65	3	32	624
Austria	59	31	10	627
Germany	58	20	22	600
Belgium	52	13	35	469
Sweden	41	14	45	464
Denmark	41	5	54	696
Luxembourg	36	23	41	668
Spain	35	59	6	662
Ireland	31	69	0	869
Italy	29	62	9	538
Finland	28	63	9	455
France	28	38	34	567
UK	18	74	8	600
Greece	8	92	0	433
Portugal	3	75	22	434

Figures for EU15, 2004.
Source: Institute of Public Policy Research

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Biomass sources

- A variety of biomass sources is a benefit to society
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- Biomass from forestry and industrial waste: underutilized?
- Landfills must be reduced

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Comparison

Biofuels:
- great quantities of biomass,
- low value added,
- emissions of CO_2

Biochemicals, biopolymers:
- small quantities of biomass (5% of petroleum used for chemicals)
- high value added,
- can be recycled, avoid/reduce CO_2

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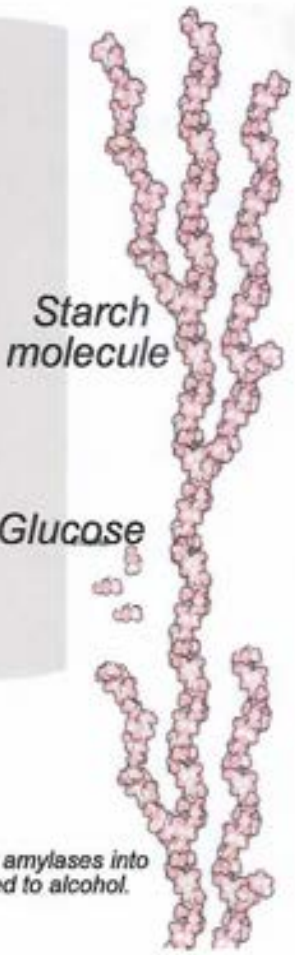
Shift to other biomass sources

Today: Crops and sugar seem to be the predominant sources for the production of biochemicals and biopolymers.

>>Problems: EU sugar price, conflicts between food and non-food uses

Tomorrow: Wood, wood waste, straw, non-food plants, etc.

>> Problems: technological development, misguided policies



Multi-branched starch molecule can be cleaved by amylases into simple sugars (glucose), which are then fermented to alcohol.

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Action Areas: Standardisation

✓ Standardisation:

The Commission proposes to issue two standardisation mandates to the European standards bodies CEN, CENELEC & ETSI:

(a) one **programming mandate**: to explore European Standards (EN) & other deliverables related to measurement, testing, biodegrabability, compostability, product functionality, impact on GHG, amount of Renewable Raw Materials (RRMs) in all bio-based product areas.

(b) one **standardisation mandate** to develop ENs & interim CEN Workshop Agreements (CWAs) for bio-lubricants & bio-polymers – here: biodegradability (for biolubricants only), the application of specific product functionality, the impact on GHG, the amount of RRMs. Descriptive and/or performance ENs.

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Labelling of bio-based products:

- Label for "bio-based" or "renewable raw material"?
- Label for recycling or waste sorting?
- Label for bio-degradability?

- What about mixed raw materials (petrochemicals + bio-based)? Percentage? Label?

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Examples of legal acts or policies to be examined for policy coherence

Biomass action plan (Commission, 2005)

Raw Materials Communication (upcoming)

EU sustainability development strategy

Packaging and packaging waste (Directive 2005/20/EC, 94/62/EC)

Landfill of waste (Directive 1999/31/EC)

Energy labelling (Directive 92/75/EEC)

Eco-labelling, bio-based labelling

Integrated Pollution Prevention and Control legislation (Directive 2008/1/EC)

Communication on Green Public Procurement

Communication on Sustainable Industrial and Consumption Policy

Standardisation

Biotechnology Strategy and Action Plan

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Green chemistry: The KBBE initiative

JENS HOEGEL

European Commission DG RTD

ABSTRACT

The concept of the Knowledge-Based-Bio-Economy (KBBE) comprises several initiatives of the European Commission (DG RTD). An important aim of the concept is to produce materials and products from renewable resources (including waste) in a sustainable manner by converging different technologies, like chemistry, biology, biotechnology and others. Although theoretically, demand for renewables is high, but land availability for their production is limited. Their effects on e.g. GHG emissions, soil degradation and many other factors need to be thoroughly examined, for users to make justified choices. Processing efficiencies and utilisation of by-product streams further add to the complexity of assessing sustainability of end-products. However, utilisation of all outputs (products, by-products, electricity and heat) as foreseen by the biorefinery concept, would allow substantial improvements over current conventional processes, which should be included in the assessment.

Research projects co-funded under the current 7th Research Framework Programme are commonly looking at the sustainability of technologies and activities considered, but no assessment scheme is yet available, generally applicable across all the projects. Various international actors have begun to address this issue, but still considerable time is required to find common agreements on a coherent sustainability assessment approach. Further research is necessary, into which the relevant input provided by European Technology Platforms and ERA-NETs could also feed into.

Green chemistry: The KBBE initiative

Jens Hoegel

Research Programme Officer
Unit Biotechnologies
Directorate Food, Agriculture and Biotechnology
Directorate-General for Research
European Commission

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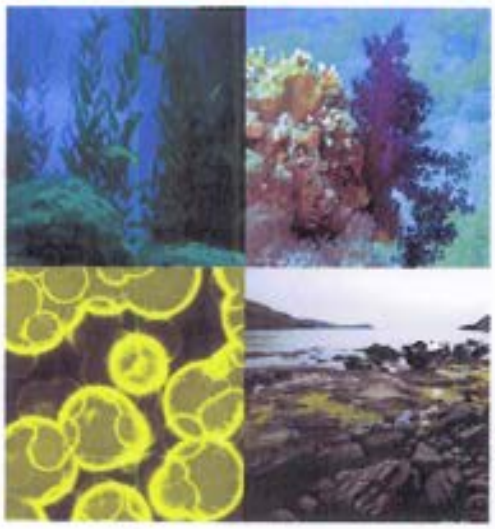
Slide 1

EUROPEAN COMMISSION

Food, Agriculture and Fisheries, and Biotechnology

Knowledge-Based Bio-Economy (KBBE)

KBBE-OBJECTIVES



- **Build a European Knowledge-Based Bio-Economy (KBBE)**
  by bringing together all stakeholders to develop the basis for new eco-efficient and competitive bio-based products
- **Respond to social and economic challenges:**
  - High quality food and sustainable food production
  - Food-related disorders
  - Infectious animal diseases and zoo-noses
  - Sustainable agriculture/fishery and climate change
  - Clean biomaterials from renewable bio-resources
- Support other EU policies
- Respond quickly to **emerging research needs**
- Support the **coordination of National Research Programmes - ERA-NETS**

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Slide 2

What is the Knowledge-Based Bio-Economy?

The knowledge base: Advances in Life Sciences and Biotechnologies in convergence with other technologies such as nanotechnologies, chemistry, information technologies..,

The Bio-Economy: Includes all industries and economic sectors that produce, manage or otherwise make use of biological resources including bio-waste.

The European bio-economy has an approximate market size of over €1.5 trillion, employing more than 22 million people

Sector	Annual turn-over (billion €)	Employment (million)	Data source
Food	800	4.1	CIAA
Agriculture	210	15	COPA-COGECA
Paper/Pulp	400	0.3 direct (4 ind.)	CEPI
Forestry/Wood industry	150	2.7	CEI-BOIS
Industrial Biotech.	50 (est.)		McKinsey*
Total	1610	22.1	

* estimated to be 10 % of sales within the chemical industry accounting for €125 million by 2010

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Slide 3

Major trends affecting the Bio-economy

1. **Changing trade patterns:**
   - globalisation
   - CAP reform
   - consumer-led production
2. **Climate change:**
   - spread of plant diseases (e.g. fungi affecting banana plantations)
   - new varieties/crops
   - water and temperature issues
   - soil degradation
3. **World population trends:**
   - 6.5 bn in 2005 □ 8.3 bn in 2030
   - increasing calorie consumption per capital
   - rising meat demand – up 70% by 2030
4. **Environmental considerations:**
   - land use and reduction of inputs
   - habitat protection
   - maintaining biodiversity
5. **Shifts in energy supply:**
   - higher costs of fossil fuels/scarcity
   - security of supply
   - Reduction of GHG emissions

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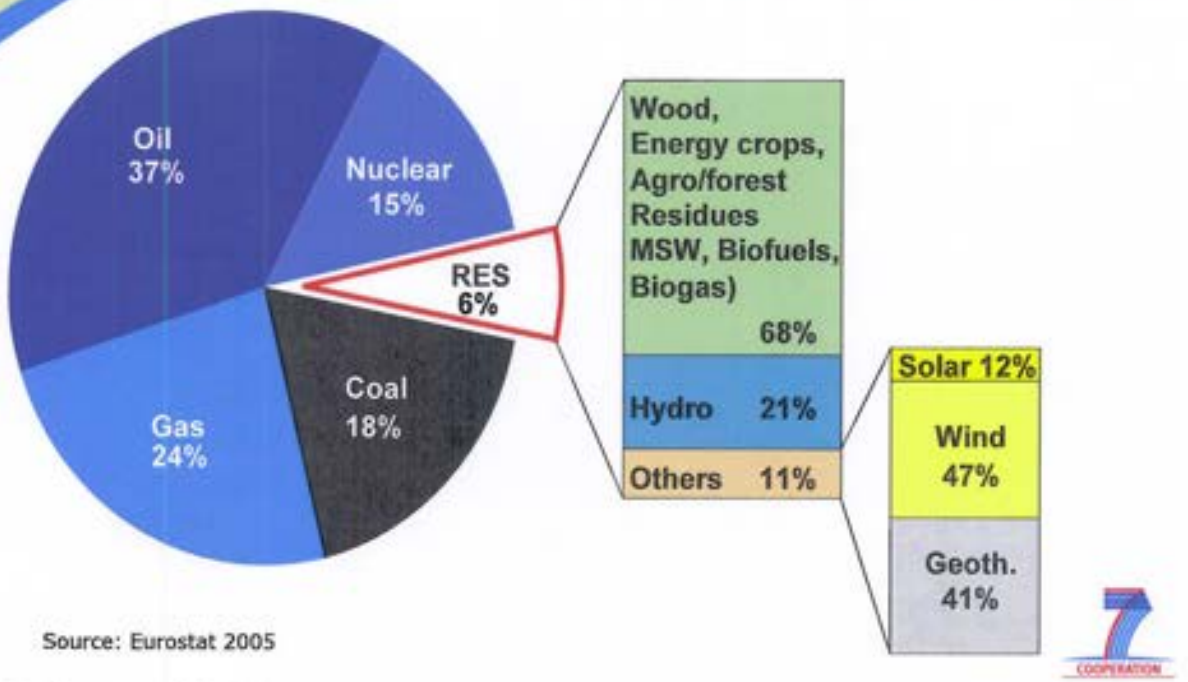
Slide 4

EU Energy Mix: RES share has to increase



Source: Eurostat 2005

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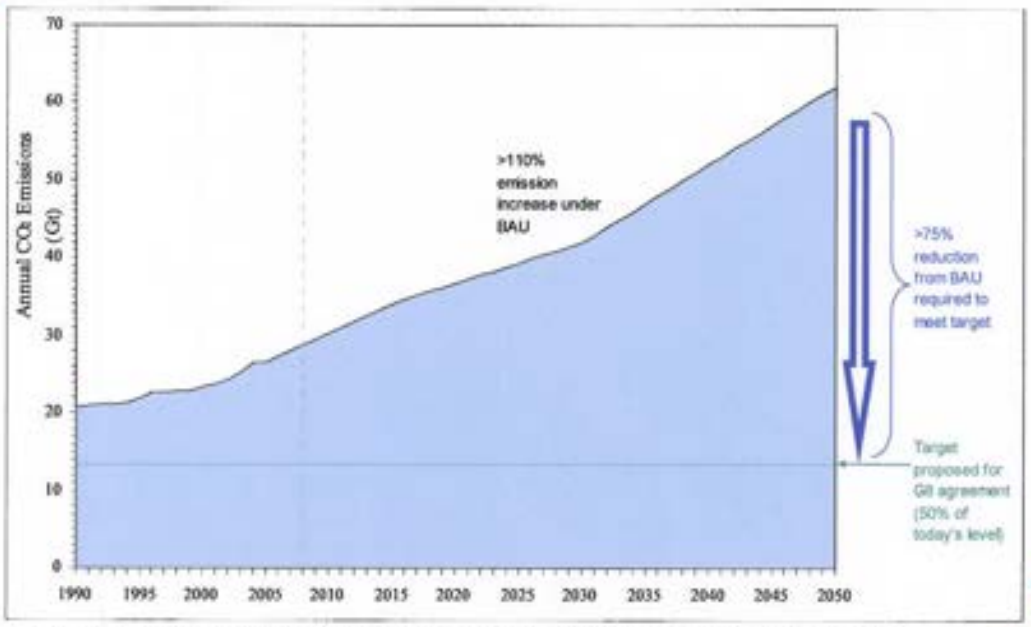
Slide 5

CO_2 Reduction: Required Changes are Massive



*Sources: IEA "Energy Technology Perspectives 2008"; Chair's summary from G8 environment minister's meeting, Kobe, Japan, May 24-26, 2008.

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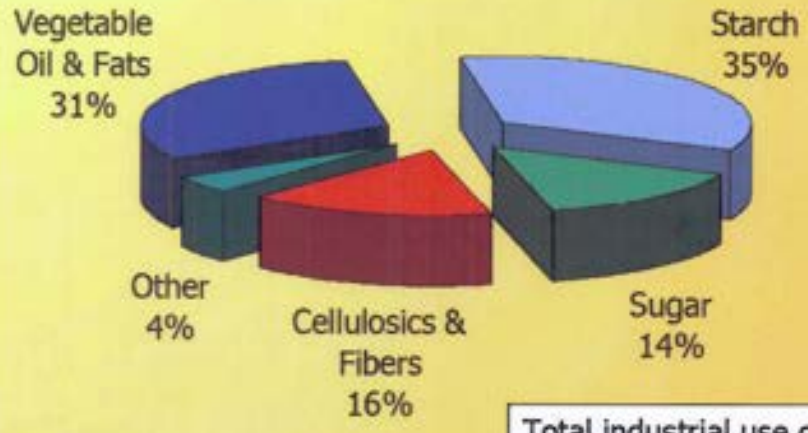
EU-25 Industrial use of biomass (2003)



Total industrial use of RRM: ~ 9 Mio. t

Source: FNR, ERRMA

estimations based on data from:
EU, IENICA, EHGA, CIRFS, EIHA, EuropaBio, AAF, Röper, Kaup, EurObserv'ER, FAO

Note: Document not legally binding

Slide 7

EU-25 Non-food crop land (2005)

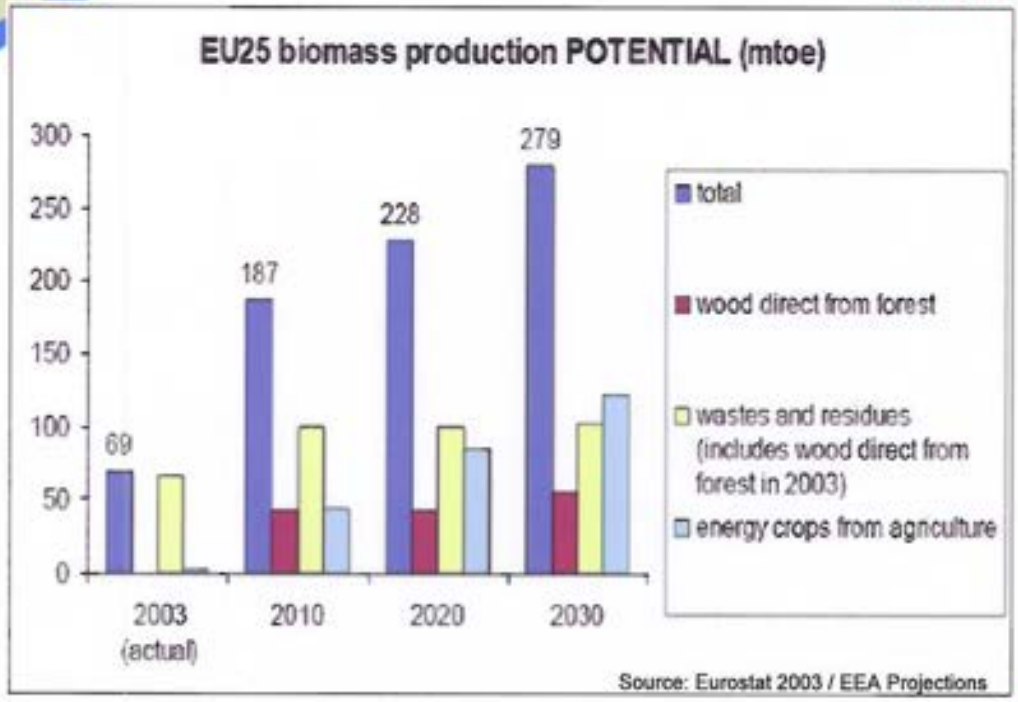
Raw Material	Industrial Use	Bioenergy
Starch Crops	900.000 ha	-
Cotton	460.000 ha	-
Oilseed Crops	425.000 ha	-
Sugar Crops	137.000 ha	-
Medical Plants	113.000 ha	
Fibre Crops	135.000 ha	-
Energy Crops	-	2.800.000 ha
Total	2.270.000 ha	2.800.000 ha
	5.070.000 ha	

Source: FRN, ERRMA

Note: Document not legally binding

Slide 8

Potential availability of biomass



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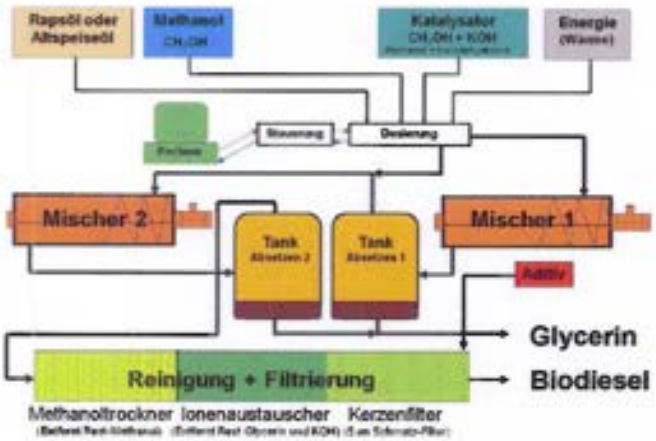
Conventional biodiesel production

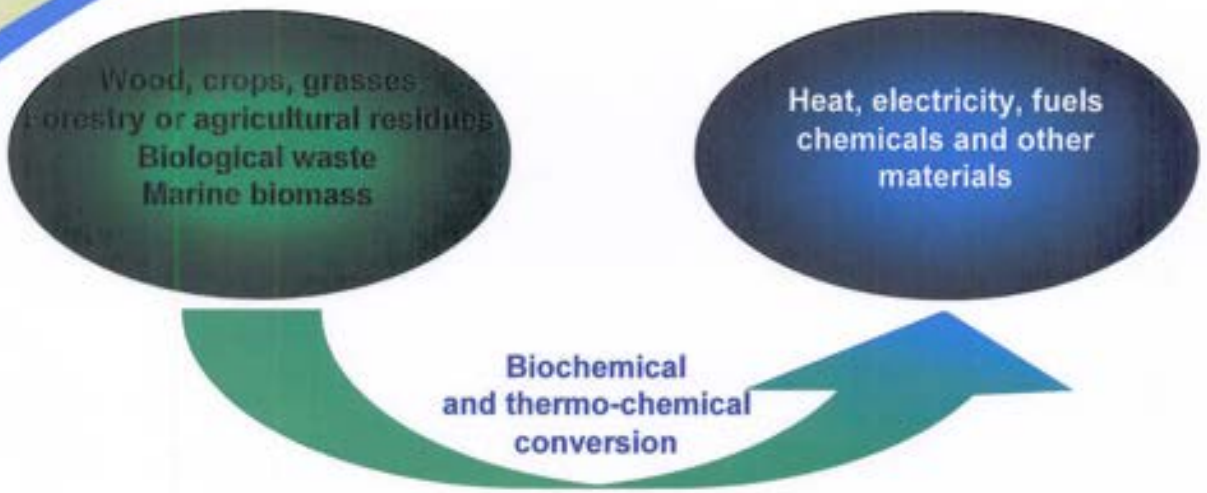


Source: BioD Fuels International GmbH

- Glycerol in many cases „processing residue"
- First generation biofuels with limited level of sustainability

Note: Document not legally binding

The Biorefinery Concept



- Biomass instead of crude oil
- Range of process technologies and raw materials chosen will affect level of sustainability

FP7-KBBE– Current main lines

- Novel sources of biomass and products
- Marine and fresh water biotechnology
- Industrial biotechnology
- Biorefinery
- Environmental biotechnology
- Emerging trends in biotechnologies

- Aim to facilitate development of sustainable non-food products and processes based on biotechnologies

Workprogramme 2009 - Examples

Area 2.3.1: Novel sources of biomass and bioproducts
KBBE-2009-3-1-01: Optimisation of secondary metabolite production in plants
KBBE-2009-3-1-02: Jatropha curcas – breeding strategy – towards a sustainable crop for biomaterials and biofuels
Area 2.3.2: Marine and fresh water biotechnology
KBBE-2009-3-2-02: Sustainable use of seas and oceans – Biomass from micro- and macro-algae for industrial applications
Area 2.3.4: Biorefinery
KBBE-2009-3-4-01: Biomass and bioproducts: sustainability certification and socioeconomic implications
KBBE-2009-3-4-02: Biomass pre-treatment for optimised biomass deconstruction and analytical characterisation
Area 2.3.5: Environmental biotechnology
KBBE-2009-3-5-02: Innovative biotechnology approaches as eco-efficient alternative to industrial processes

Workprogramme 2009 – Examples Call on Biorefineries

- **KBBE-2009-3-7-01 Sustainable Biorefineries**

  Assess environmental, economic and social sustainability along the entire value chain, in particular
  - consequences due to competition of resources for food or biomass utilisation
  - impacts on water use and quality
  - Changes in land-use
  - Soil carbon stock balance and fertility
  - Net balance GHG
  - Biodiversity
  - Potential toxicological risks
  - Energy efficiency

Workprogramme 2009 – Examples
Call on Biorefineries

- **KBBE-2009-3-7-02 Enhancing exchange of information**
  - Promote coordination of on-going research at EU and national level
  - Addressing any relevant aspect along the production chain, incl sustainability issues
  - Aiming to overcome fragmentation in this multidisciplinary field

Note: Document not legally binding

And workprogramme 2010?

Note: Document not legally binding

Sustainability criteria for biomass production

Sustainability assessment until farm gate

- ✓ Huge numbers of plants and environments
- ✓ Consider land use (before and after change under consideration)
- ✓ Consider agricultural practices incl. residue utilisation
- ✓ Consider effects of cultivation on soil, water use, biodiversity
- ✓ Inputs to be considered
- ✓ Logistics to be considered

But what about:

- ✓ European Platform on Life Cycle Assessment (JRC) and of international organisations (UN, OECD, national schemes etc)
- ✓ Production in third countries?

Idea: Unique mechanism to support assessment of sustainability across and beyond the EU

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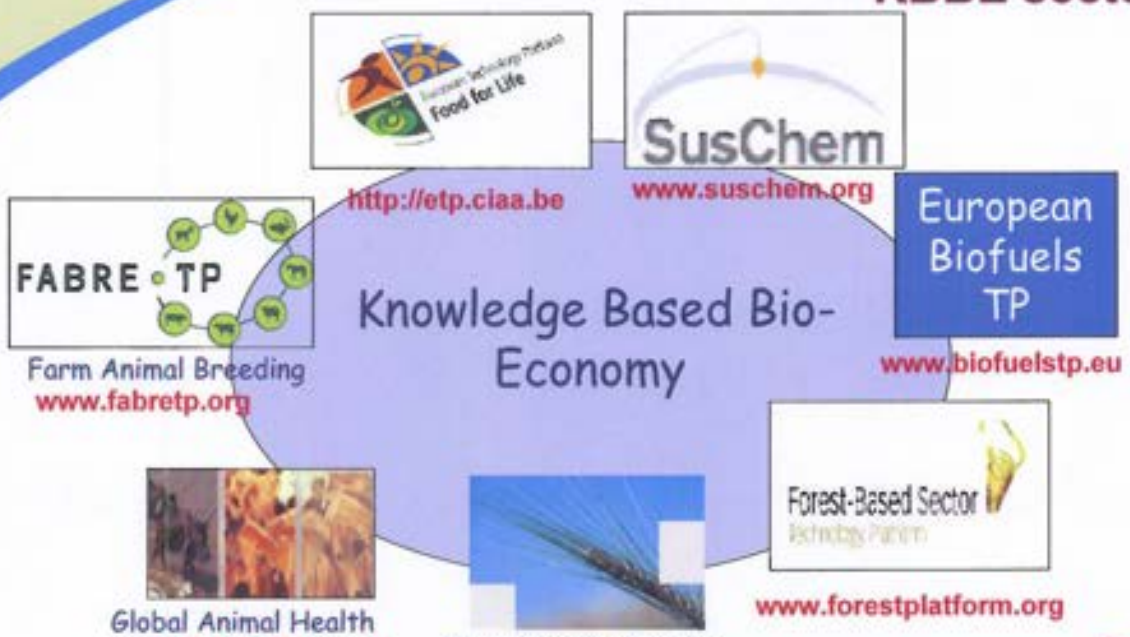
Technology Platforms in the KBBE sector



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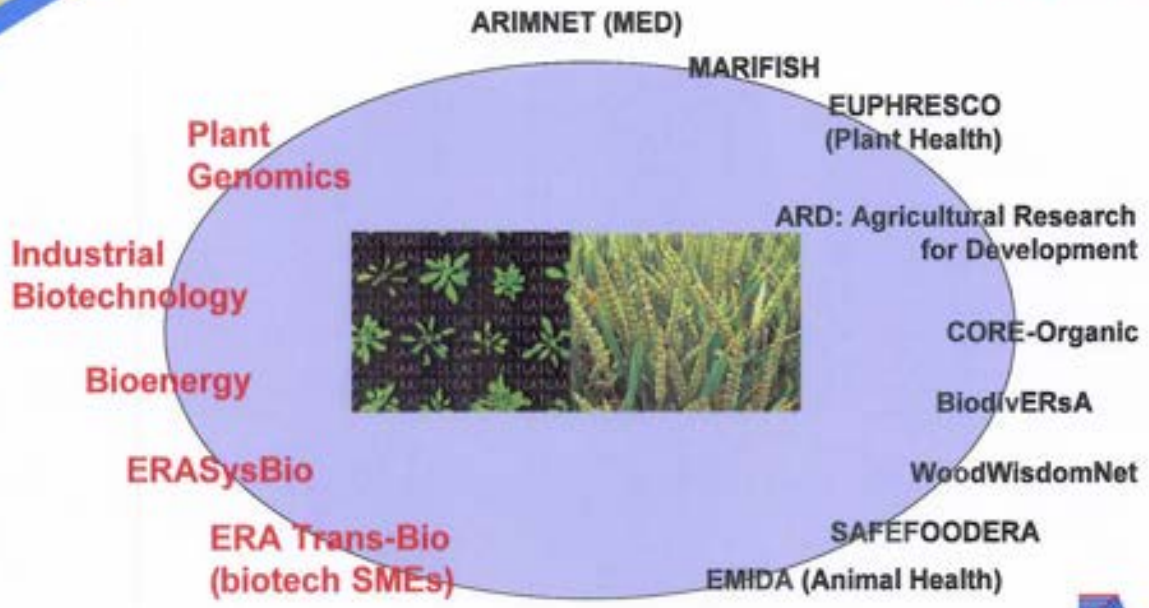
ERA-NETs in the KBBE sector



The End – or?

Sufficient to look at sustainability until farm gate?

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Green chemistry: sustainability certification perspective on the basis of biofuels experience

Dr. Norbert Schmitz
meó Consulting Team

Abstract
Sustainability is a precondition for further bioenergy market development. Major sustainability issues are minimum GHG savings, safeguarding natural land, sustainable cultivation of agricultural land, and ensuring social standards. In agricultural commodity markets, incentives for sustainable production are not set. Sustainability requirements set by politics can help to overcome this market failure. Certification is the appropriate instrument to differentiate between "good" and "bad" biomass and bioenergy. While certification schemes are already in place for niche markets, they do not exist for large scale agricultural commodity markets. A certification scheme that covers the relevant sustainability requirements and information about GHG emissions does not exist. Against this background, a project was launched by the German Federal Ministry of Food, Agriculture and Consumer Protection to develop a international certification system to facilitate trade and use of sustainable biomass and bioenergy. This project is called "International Sustainability and Carbon Certification" (ISCC). ISCC is managed by Meó Corporate Development GmbH, a Cologne based management consultancy focused on renewable energy and sustainability. The overall certification system has been developed with the involvement of more than 100 organisations and is currently tested in field audits in EU27, Brazil,Argentina,andMalaysia.

European Commission Joint Research Centre
Institute for Protection and Security of Citizen (IPSC)

Workshop: Green chemistry future and its possible impact on agriculture: the whole farm traceability approach

Sustainability Certification Perspective on the Basis of Biofuels Experience

Ispra, January 22, 2009

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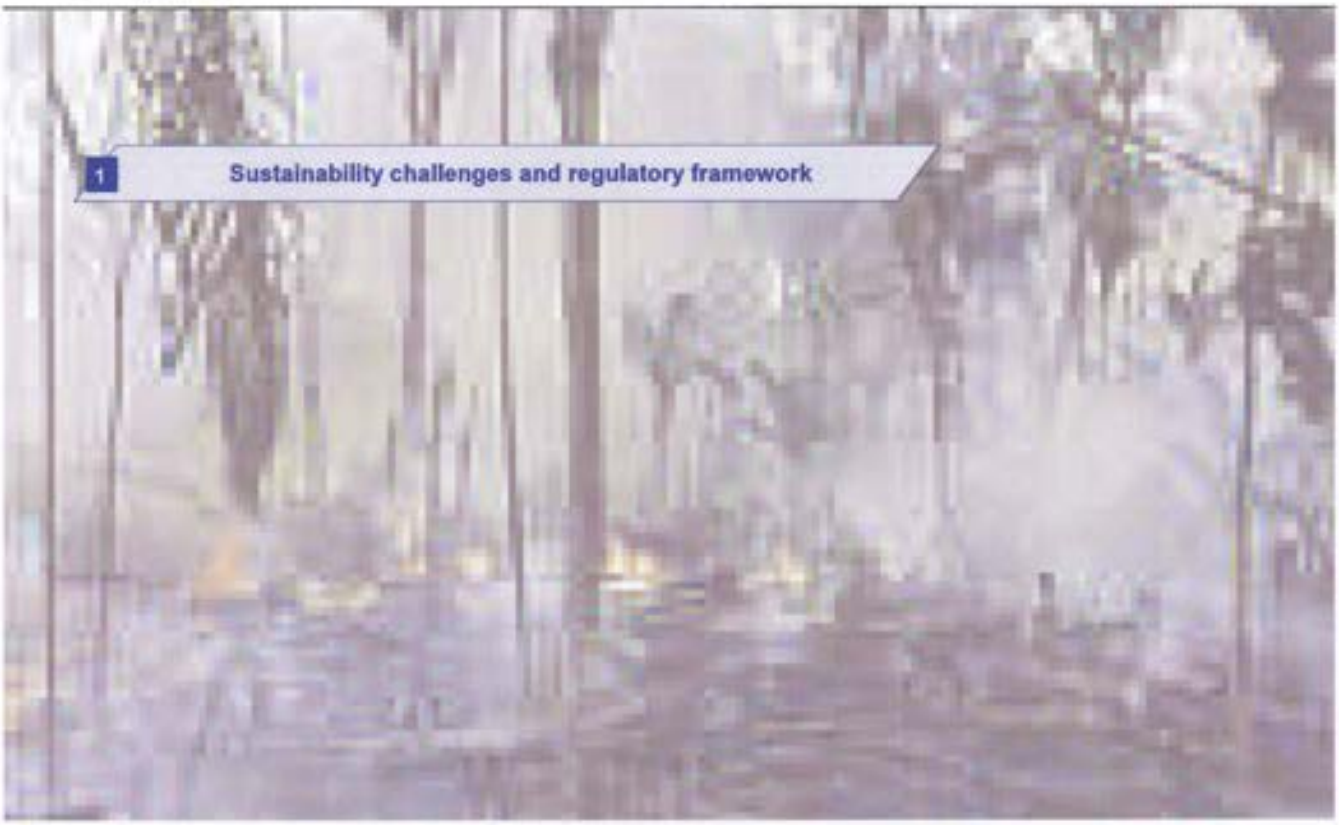
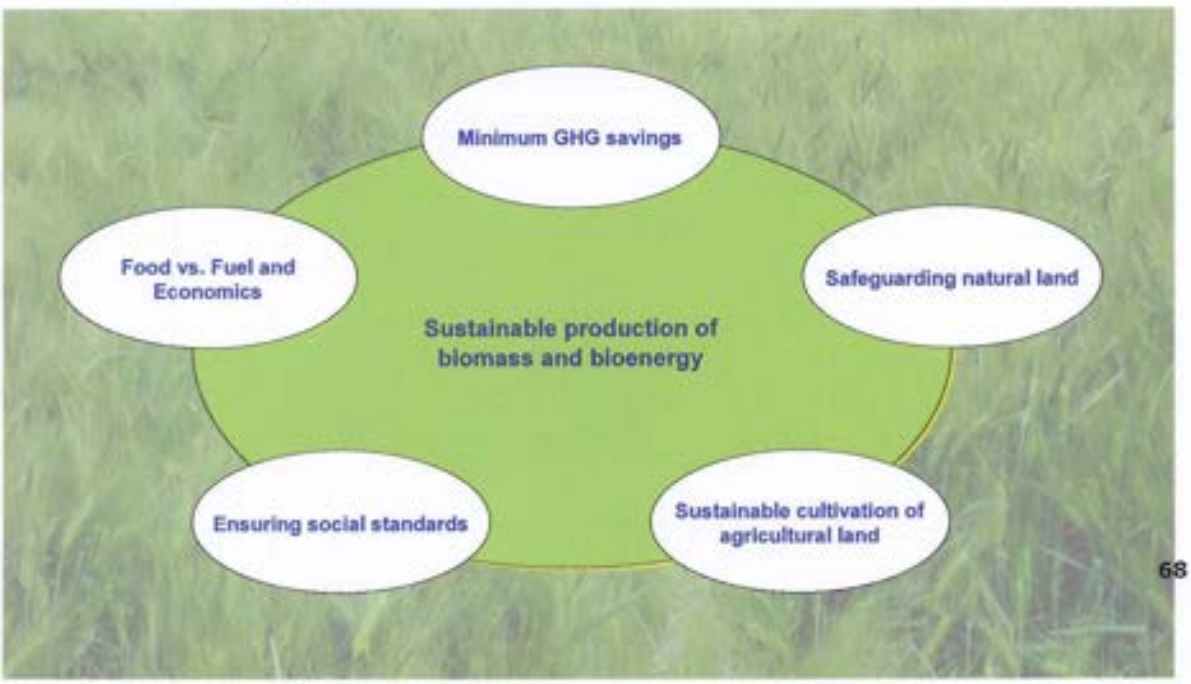
Sustainability Certification of Biofuels – Blueprint for Green Chemistry?

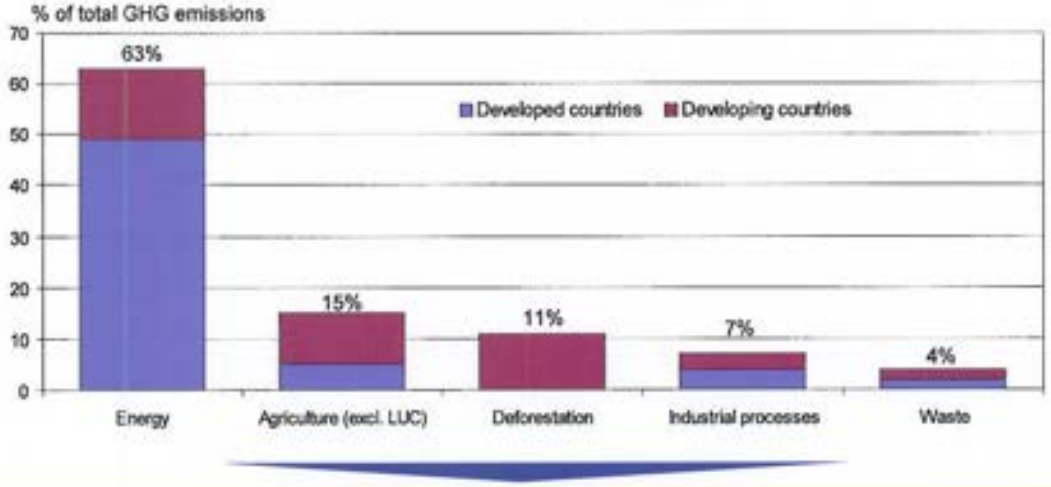
1. Certification schemes for niche markets are already in place (Bio-seal, Fairtrade, Demeter etc.), for international agricultural commodity markets they do not exist
2. Sustainable biofuels production is requested from policy and consumers. Sustainability is a precondition for further market development
3. In commodity markets, incentives for a sustainable production are not set. Sustainability requirements as proposed on European and national levels can help to overcome this market failure
4. Starting with the biofuels market, sustainability requirements will capture other markets as well. Requirements for biomass used in the electricity and heating market exist already
5. Conventional markets will follow. If not all markets are included, leakage effects will result in a situation that sustainability certification will be without any impact
6. Sustainability requirements will split the large international commodity markets. Supply will be limited, price differentiation is likely
7. Credibility of certification schemes is crucial. Bilateral agreements or independent appraisers are not an alternative to allow for a substantiated market differentiation
8. Reliable certification schemes support market differentiation and international trade



Major sustainability issues to be addressed



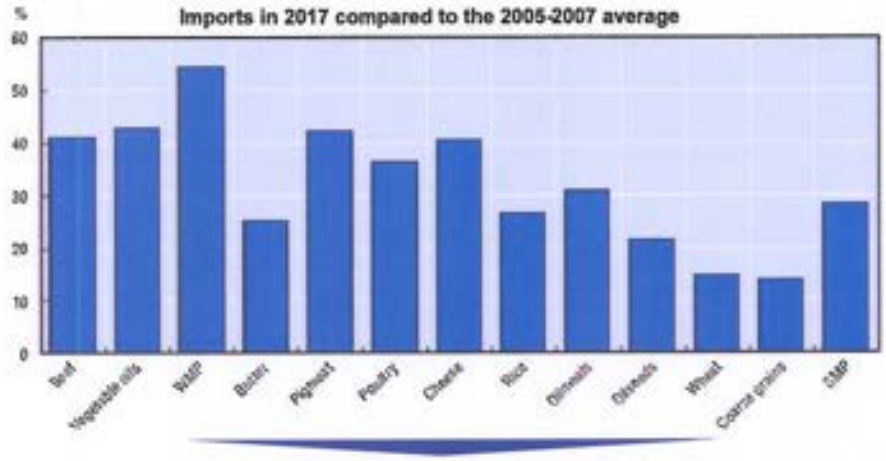
GHG-emissions of the agricultural sector are in the spot light. So far, they are not included in existing certification schemes



- Agricultural sector accounts for up to 35% of GHG emissions (estimates)
- Deforestation accounts for 10 – 30% of global GHG emissions
- 80% of GHG emissions of the agricultural sector derive from developing countries

Source: World Bank (2008): World Development Report

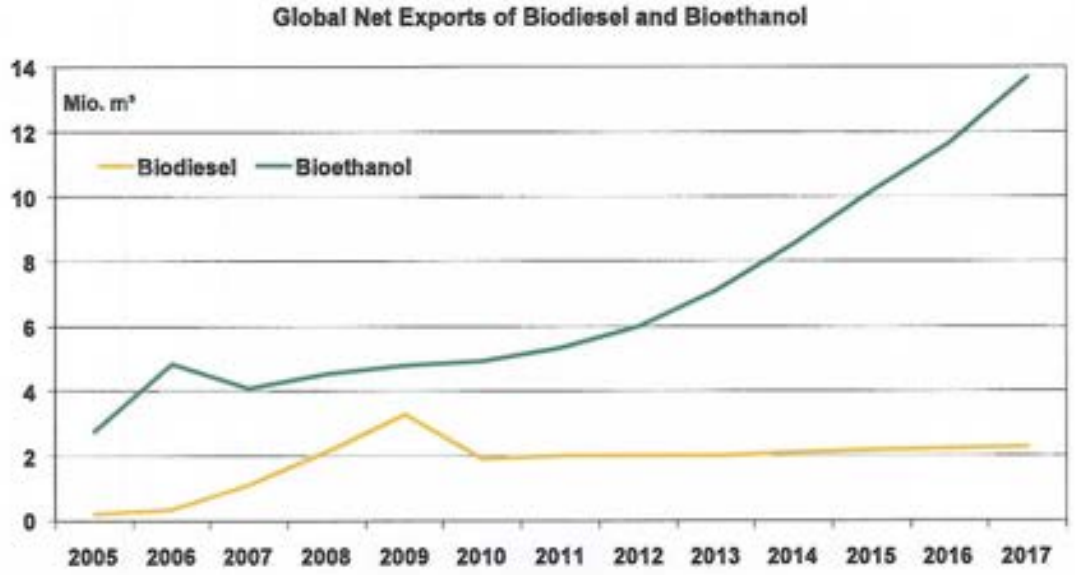
World trade with agricultural products will continue to rise requiring a global approach in sustainability certification



- World trade with agricultural products is expected to grow for all commodities
- Most of the growth in imports takes place in developing countries. However, developing countries are also showing a strong growth in the export of many products
- For livestock products import growth mainly comes from industrialized countries

Source: USDA (2008): Agricultural Projections to 2017, February 2008.; OECD/FAO (2008): Agricultural Outlook 2008-2017

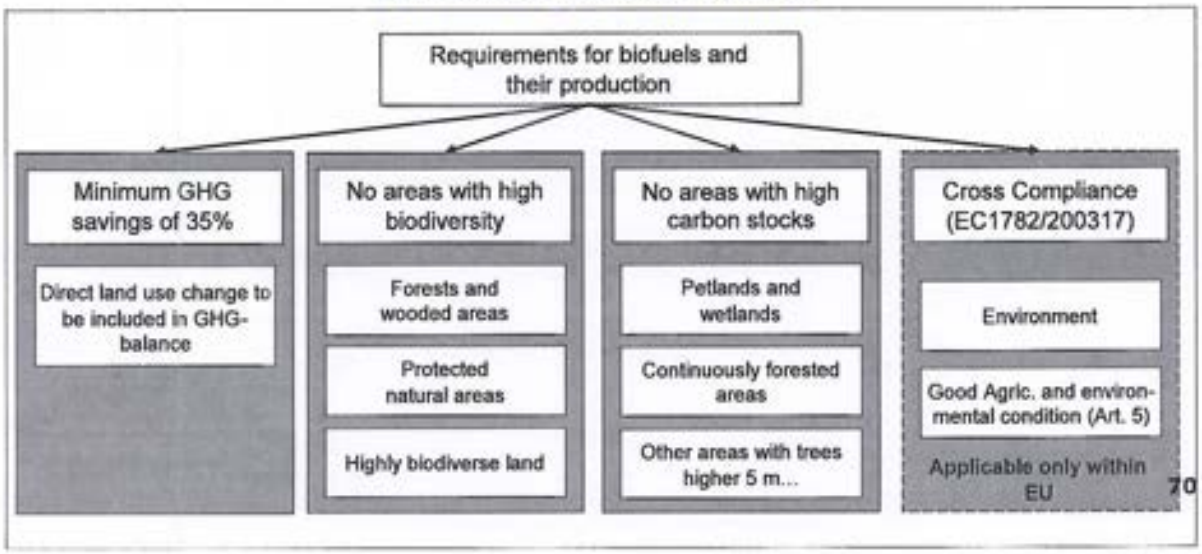
A strong increase in international biofuel trade is expected



Source: FAPRI, 2009.

Components of sustainability

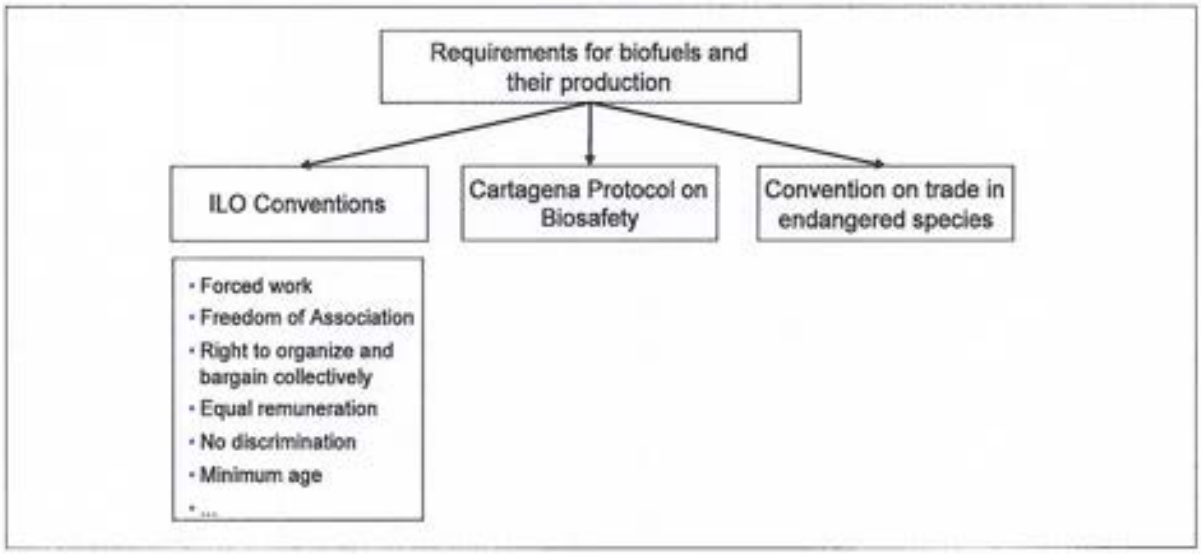
Proof of sustainability is required for biofuels to qualify for the fulfilment of quotas or to be entitled for financial incentives



Source: Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources. 11.12.2008.

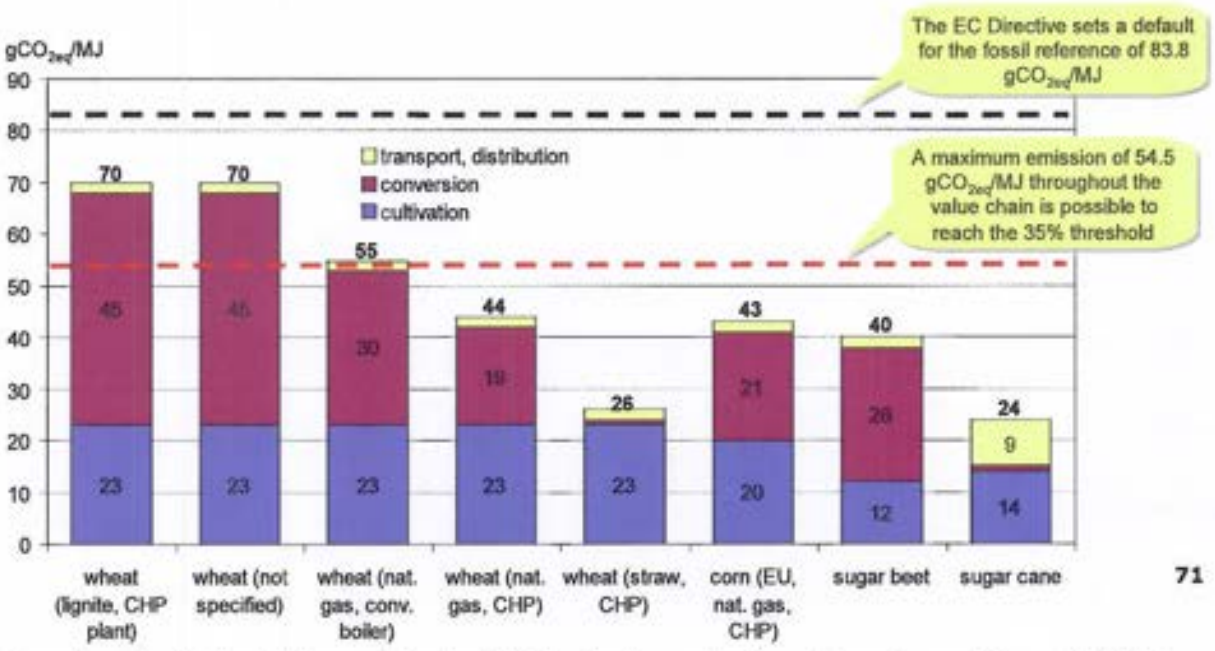
Additional aspects of sustainability

Ratification and implementation of international agreements



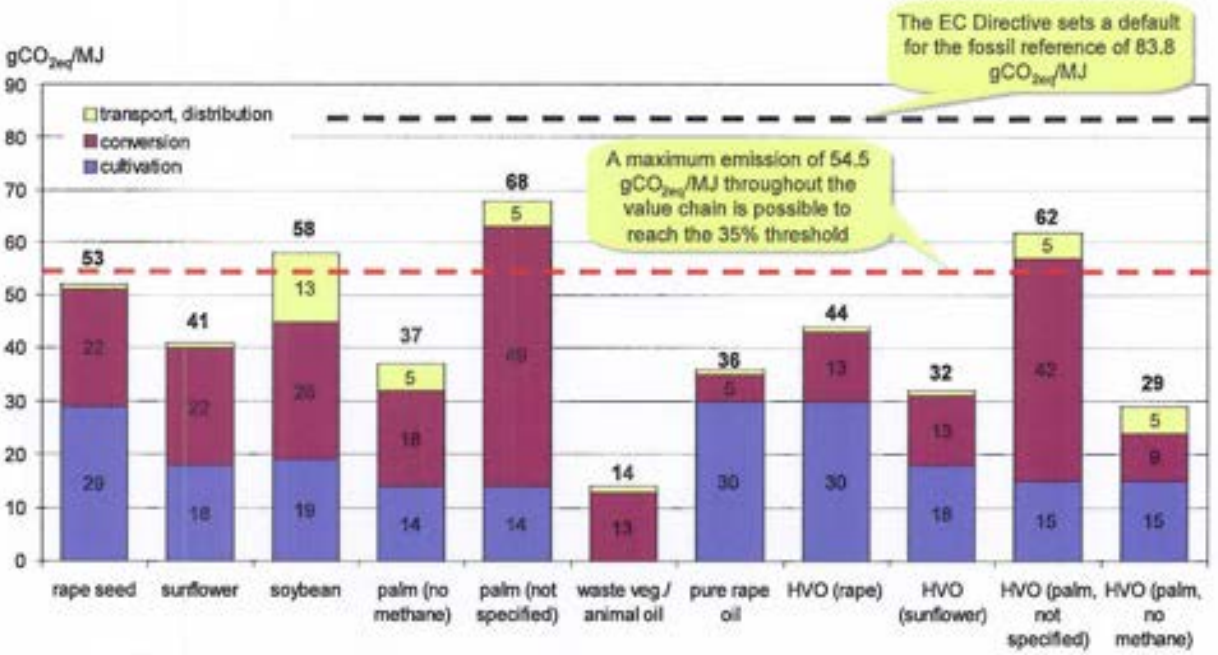
Source: Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources. 11.12.2008.

Default values bioethanol



Source: Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources. 11.12.2008.

Default values biodiesel, plant oil and HVOs



Source: Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources. 11.12.2008.

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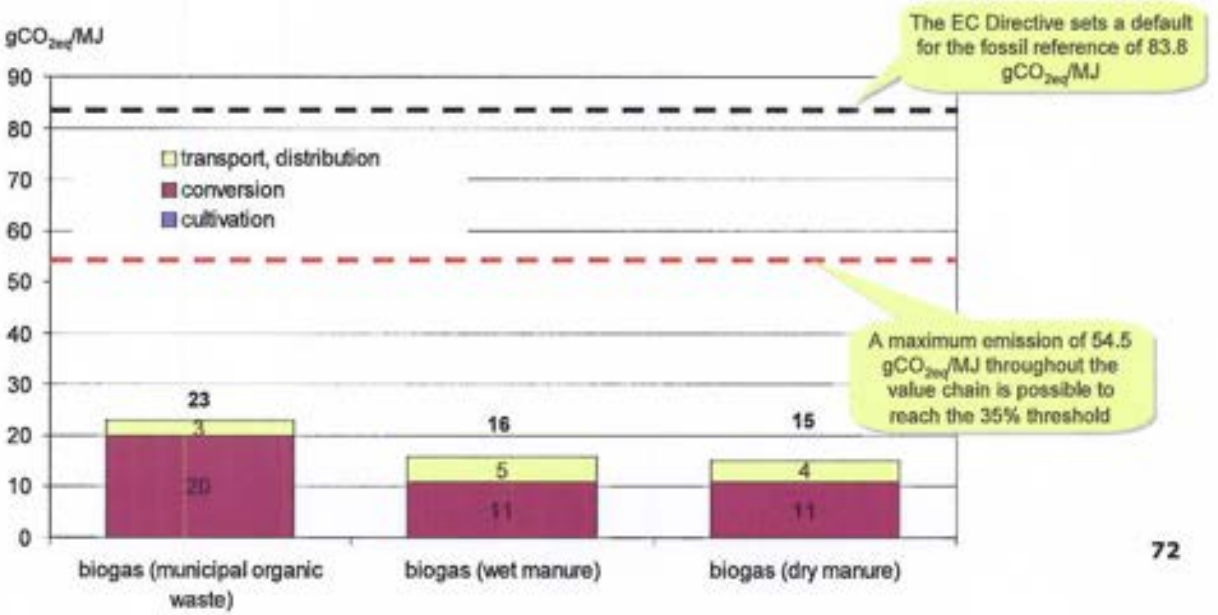
Default values biogas



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Source: Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources. 11.12.2008.

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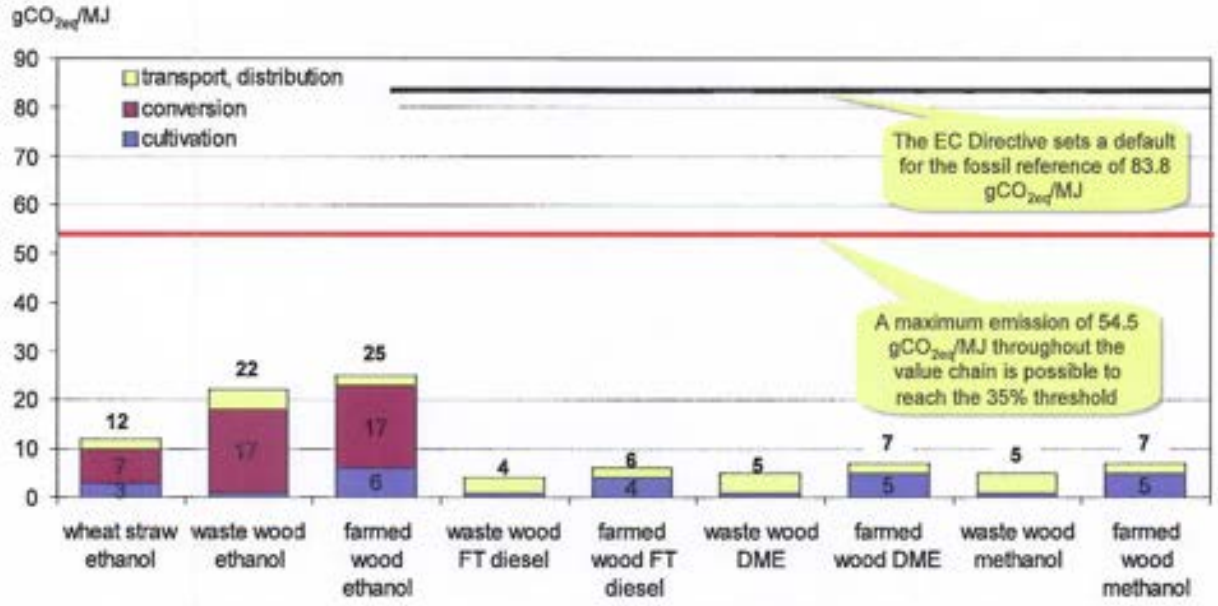
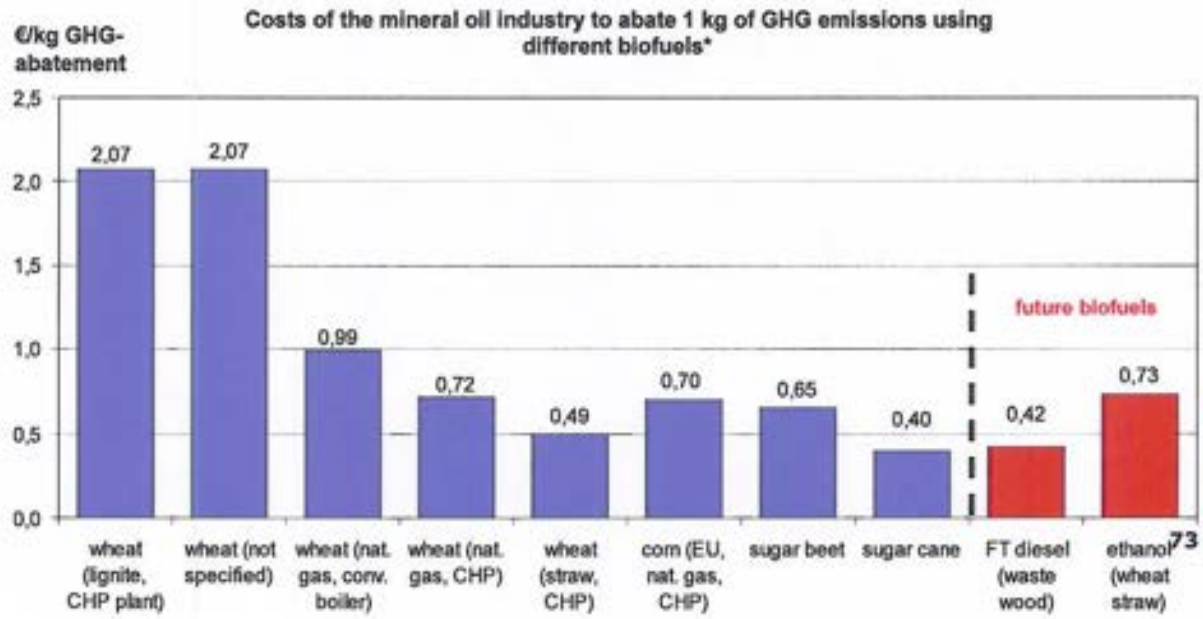
Default values biofuels 2nd generation



Source: Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources. 11.12.2008.

Sustainability and GHG performance will influence international trade, and require credible certification schemes



* calculations by meó, based on production cost assumptions (incl. tariffs and transport) and on the default values from the Renewable Directive

Particular attention is paid to the question on how to cover indirect land use change

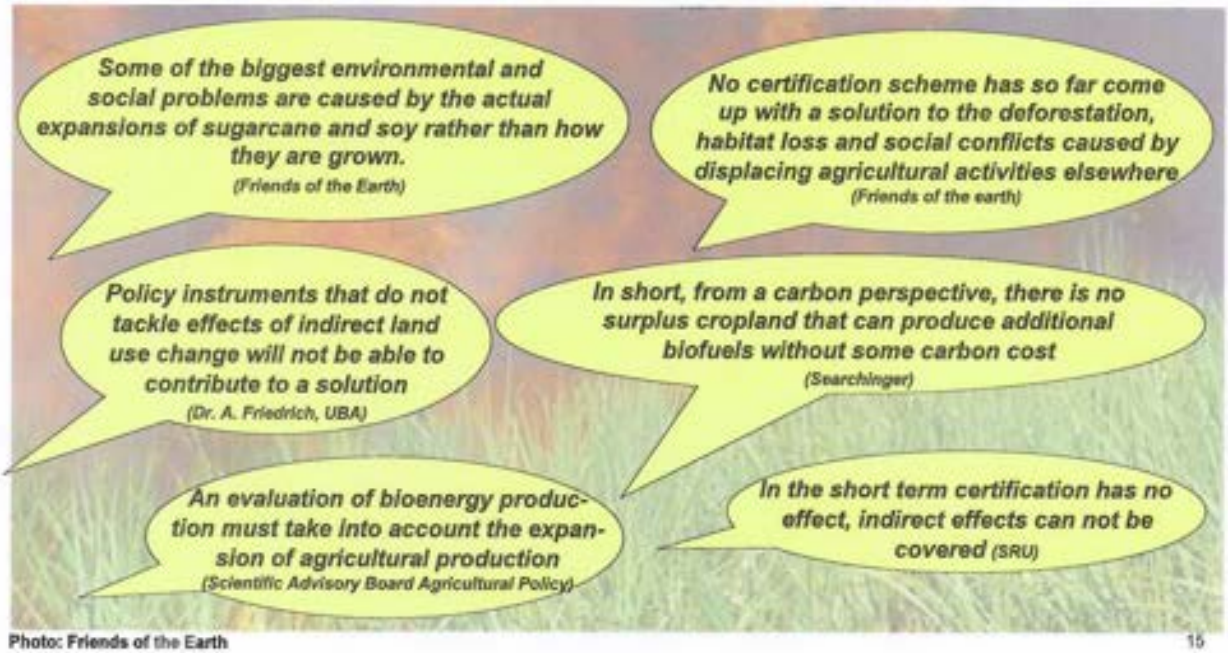
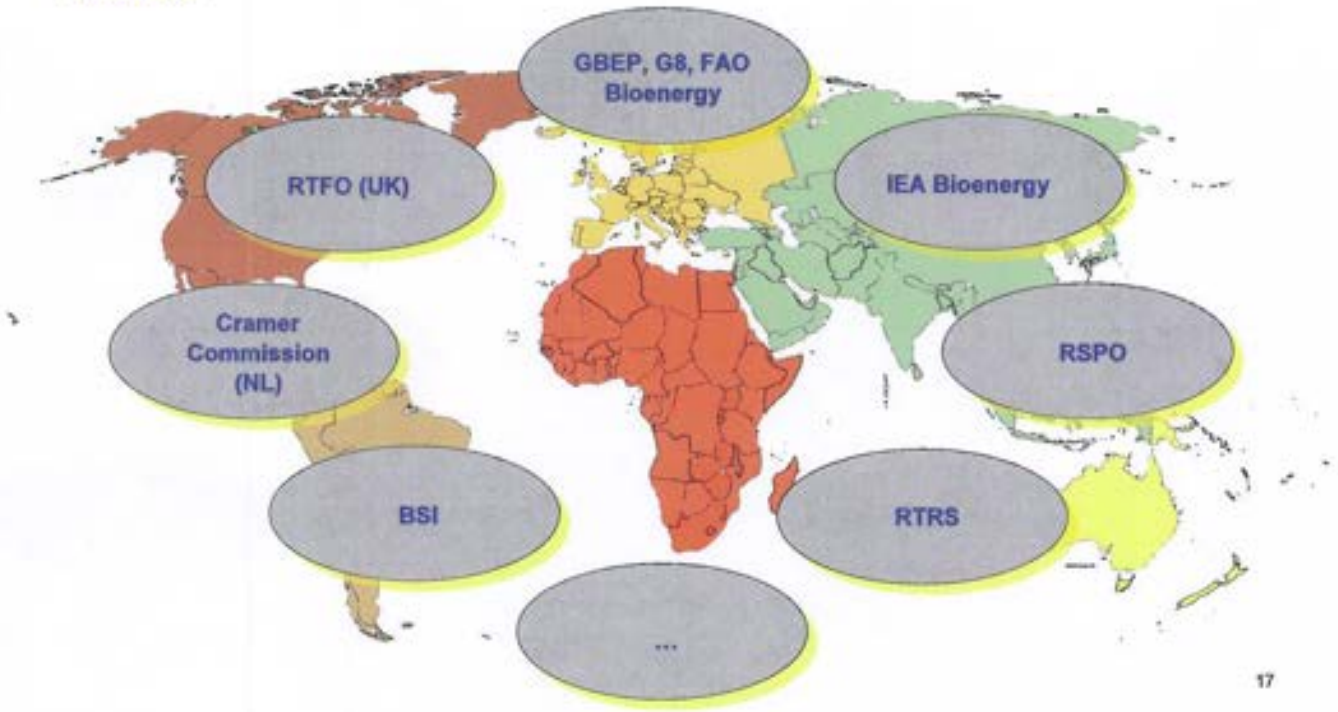


Photo: Friends of the Earth

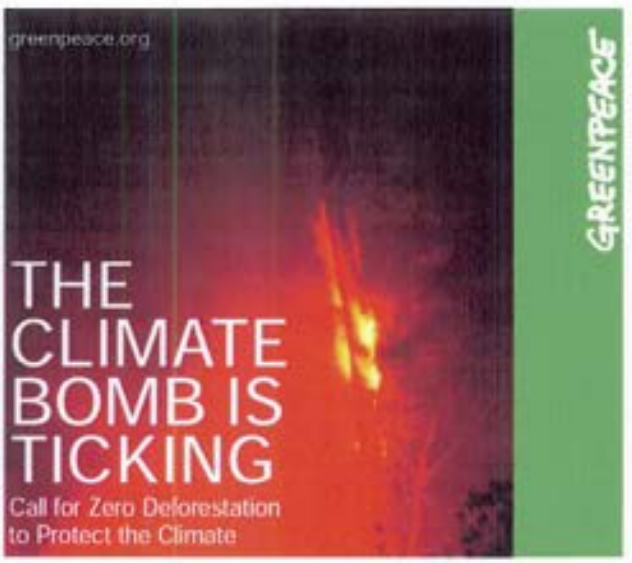
2 Sustainability and GHG Certification

CERTIFICATE OF
CO2 EMISSIONS
REDUCTION

Several initiatives have been started to develop sustainability standards for biofuels



So far, there are no certification systems that cover greenhouse gas emissions from land use change



Example palmoil

- "Current RSPO Principles and Criteria do not address GHG emissions resulting from the establishment of oil palm plantations.
- More broadly, certification is delivered at a plantation level, not a company level; consequently, the initiative risks failing to check the destructive expansion of sector.
- In numerous cases, RSPO producer members are establishing plantations in peatlands or High Conservation Value forest areas."

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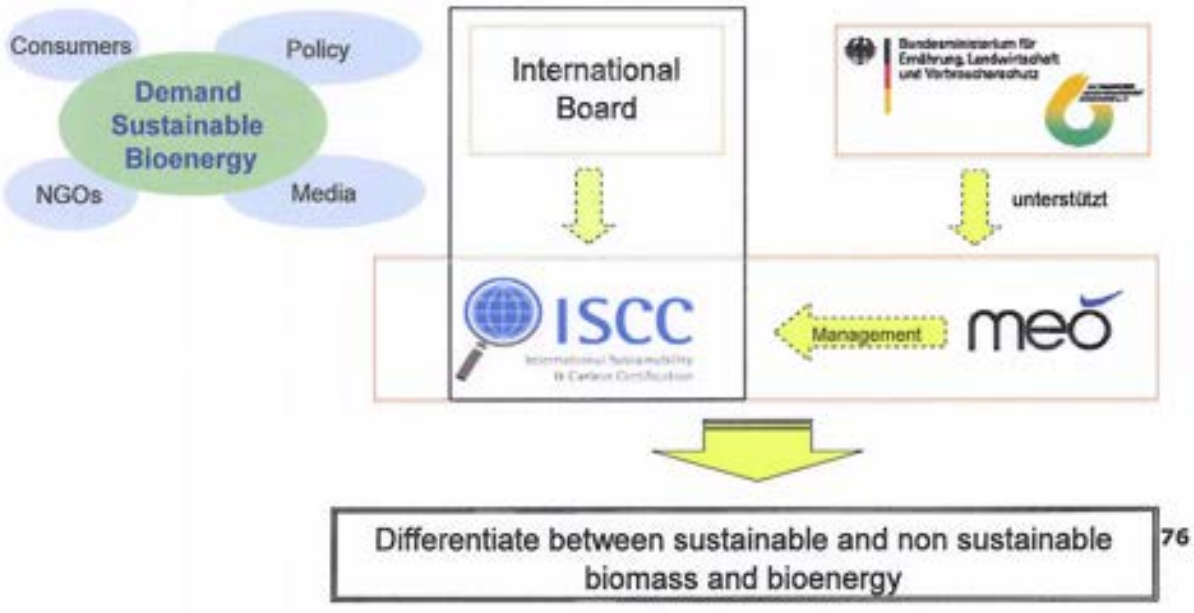
Source: Greenpeace, April 2008

For the enforcement of sustainability requirements the implementation of an international sustainability certification scheme is necessary

- Biomass and biofuel markets do not differentiate between sustainable and unsustainable production
- The necessary market differentiation can take place by certification
- A certification scheme that covers the relevant sustainability requirements and information about the greenhouse gas emissions does not exist
- Today, only some and differently advanced initiatives exist. These are mostly feedstock specific approaches and none of them covers all sustainability requirements
- There is a danger that the co-existence of different systems can lead to multiple uses of individual certificates, double and multiple certification processes, high costs, and a reduction of credibility and effectiveness
- Against this background the pilot project on sustainability certification of biomass and bioenergy, supported by BMELV/ FNR was initiated
- Actually, more than 100 organisations from Europe, the Americas and South East Asia are involved in the project

International Sustainability and Carbon Certification (ISCC) should facilitate trade and use of sustainable biomass and bioenergy



The entire supply chains are represented in the project

Selection

5 components of the ISCC-certifation system

Traceability	Check list	GHG emissions	Registrations	Meta system
• Development of a system to trace back biomass and bioenergy • Mass Balance system	• Development and continuous improvement of check lists to proof sustainability • Consider crop and region specific issues	• Calculation of specific GHG emissions for specific production units, based on requirements set by the EU	• Development central registration for land and certificates • Comparison with no go-areas	• Comparison of ISCC-Systems with other systems • Harmonisation and endorsement of different sytems

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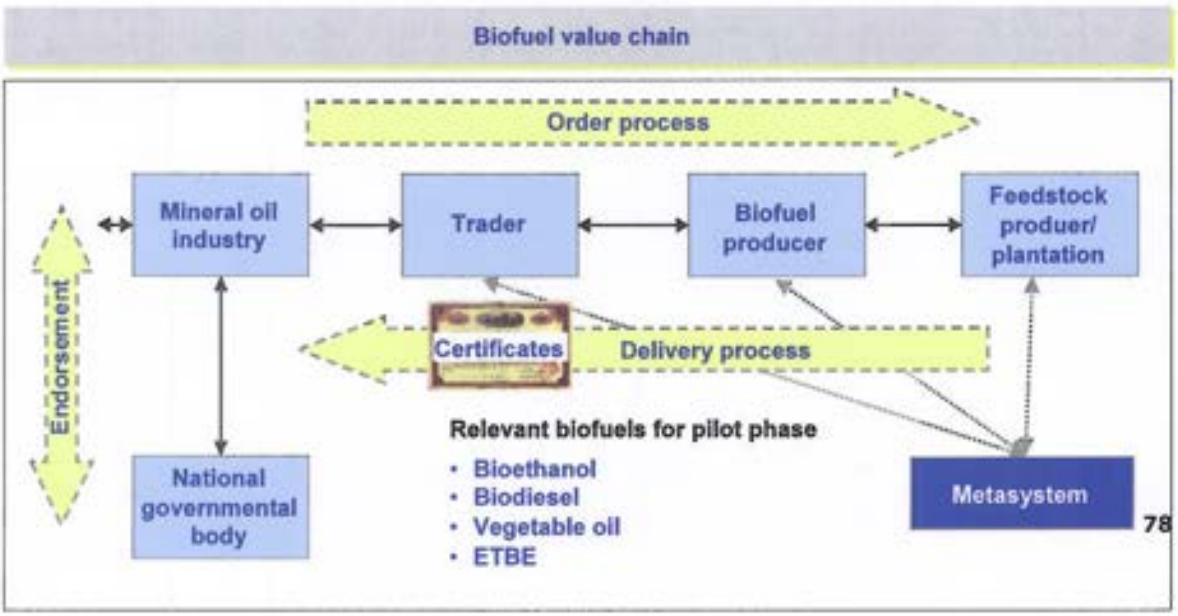
Three basic types of chain of custody systems (CoC) can be distinguished and are analyzed in practice

Track & Trace
- Product is segregated from other products
- Certificate proofs 100% certified and segregated product

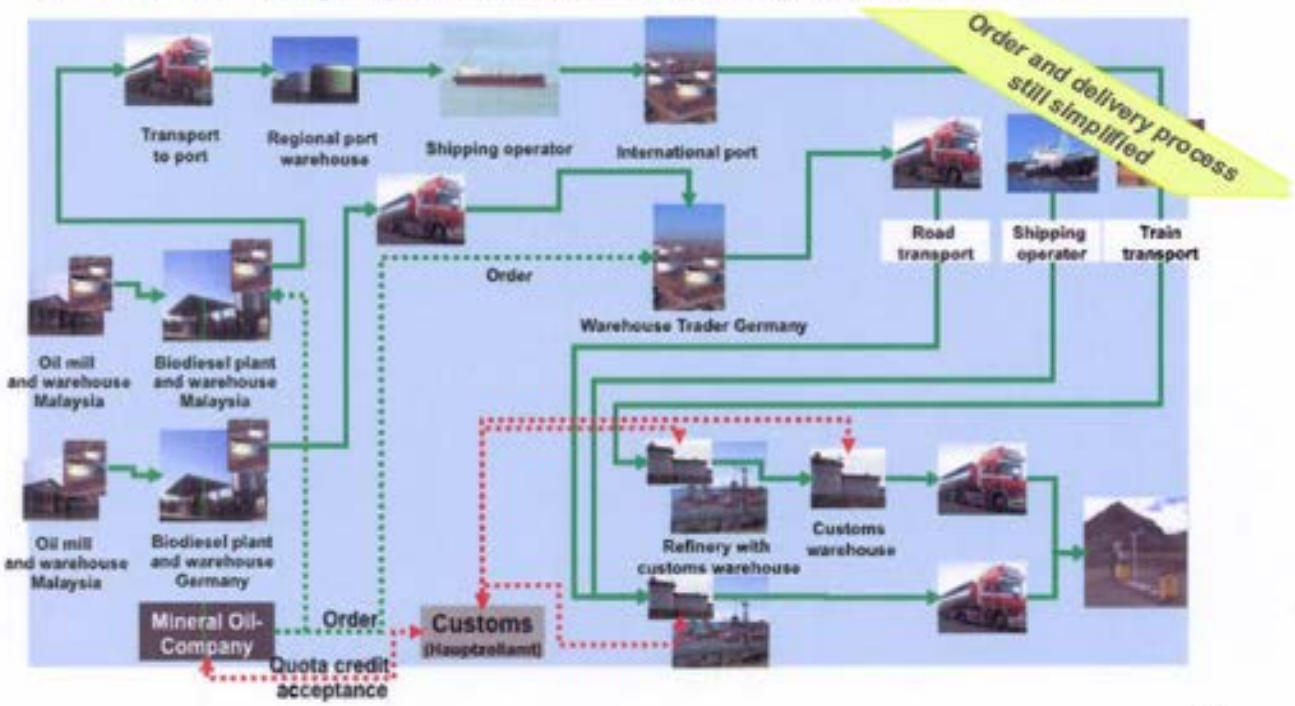
Mass Balance
- Certified product can be mixed with non certified products
- Certificate proofs ratio of certified product

Book & Claim
- Product can be traded independently of certificate
- Certificate proofs that a certified product has been produced

The simulation and analysis of order and delivery processes for different biofuels and chains of custody has been a first pilot task



Real life has hardly any similarities with an idealised value chain



A generic global ISCC-Check list has been developed in a multi stakeholder approach based on forthcoming legal requirements

Analysis of political framework conditions and initiatives:

- Renewable Energy Directive, BioNachV, Cross Compliance, ...
- RSB Version Zero, RSPO, UBA/IFEU, ...

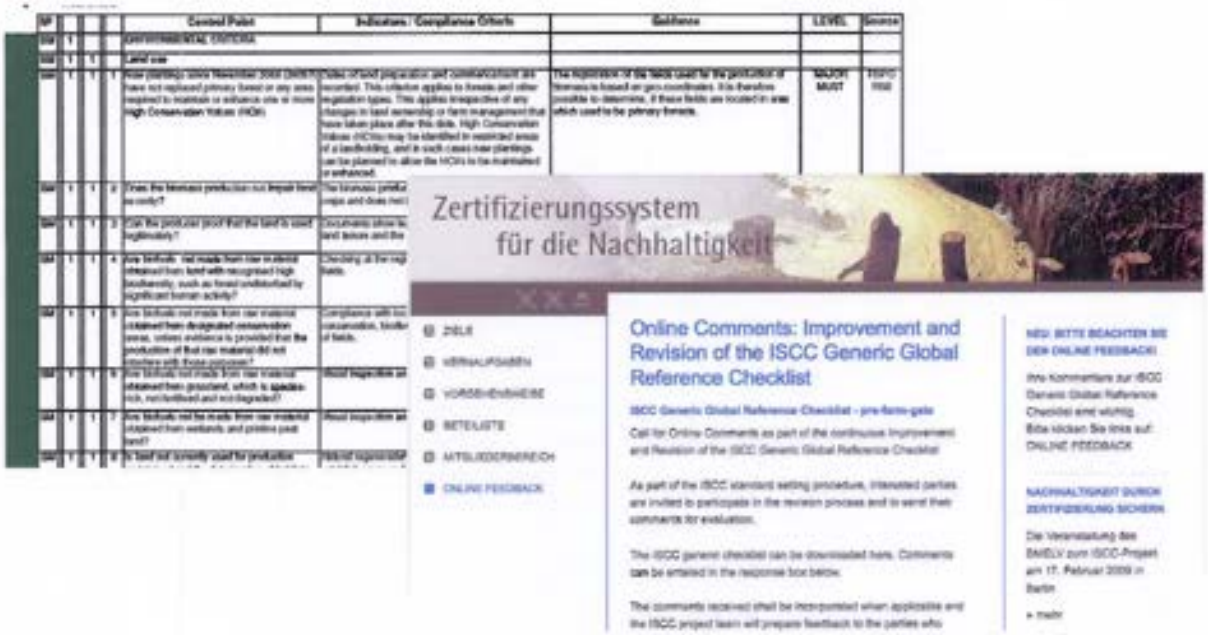
ISCC Generic Checklist

Country Crop Region specific

Control points, indicators, recommendations for auditors

EU **Brazil** **Malaysia** ...

A first public consultation process has been carried out



27

Certified land will be registered within the ISCC system and will be compared with no go-areas

80

28

Land and certificates will be registered in a central data base

(Prototype database)

GHG emission calculation based on the approach defined by the EU

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{CCS} - e_{CCr} - e_{ee}$$

where:

E	-	Total GHG emissions from supply and use of the fuel (in g CO_{2eq}/MJ)
e_{ec}	-	GHG emissions from the extraction or cultivation of raw materials
e_l	-	Annualized (over 20 years) GHG emissions from carbon stock change due to land use change
e_p	-	GHG emissions from processing
e_{td}	-	GHG emissions from transport and distribution
e_u	-	GHG emissions from the fuel in use (shall be taken to be zero)
e_{sca}	-	GHG emissions savings from soil carbon accumulation via improved agricultural management
e_{ccs}	-	GHG emissions savings from carbon capture and geological storage
e_{ccr}	-	GHG emissions savings from carbon capture and replacement
e_{ee}	-	GHG emissions savings from excess electricity from cogeneration

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- Emissions from the manufacture of machinery and equipment shall not be taken into account
- Due to the technically complex and expensive nature of carbon capture, it is virtually impossible to apply this at either of the aforementioned emission points. Hence, both eccs and eccr can be set to zero

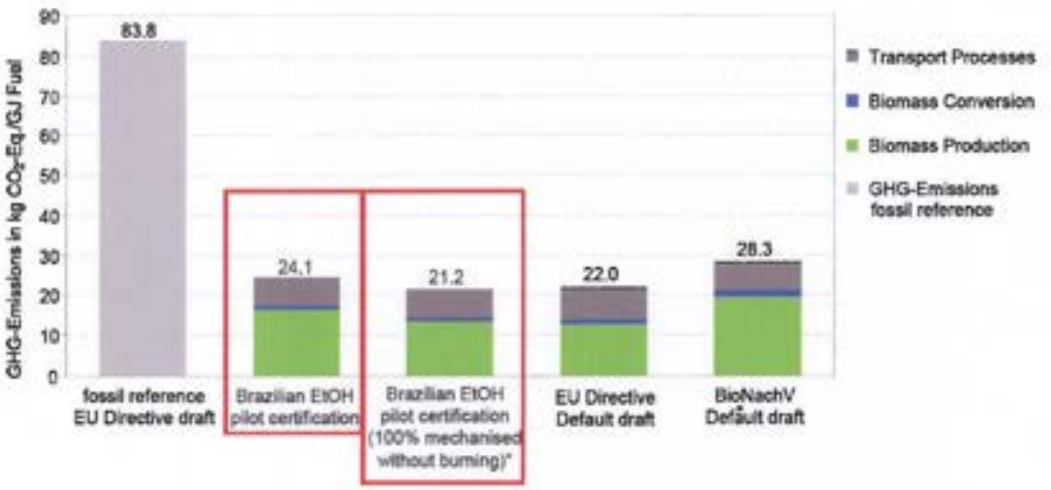
Source: Proposal for a Directive on the Promotion of the Use of Energy from Renewable Sources.

GHG calculation must be focussed and transparent – Example of data template for sugar cane production

Data for the production of sugar cane	Unit	Individual data input
Yield per ha	tc/ha	
Diesel use for cultivation + harvesting	l/tc	
Pesticide	kg/ha	
Herbicide	kg/ha	
N-fertilizer	kg/ha	
P-fertilizer	kg/ha	
K-fertilizer	kg/ha	
Lime	kg/ha	
Others	kg/ha	
Unburned harvesting	%area	
Burned harvesting	%area	

Comparison of company-specific values with defaults possible

Case study Brazil



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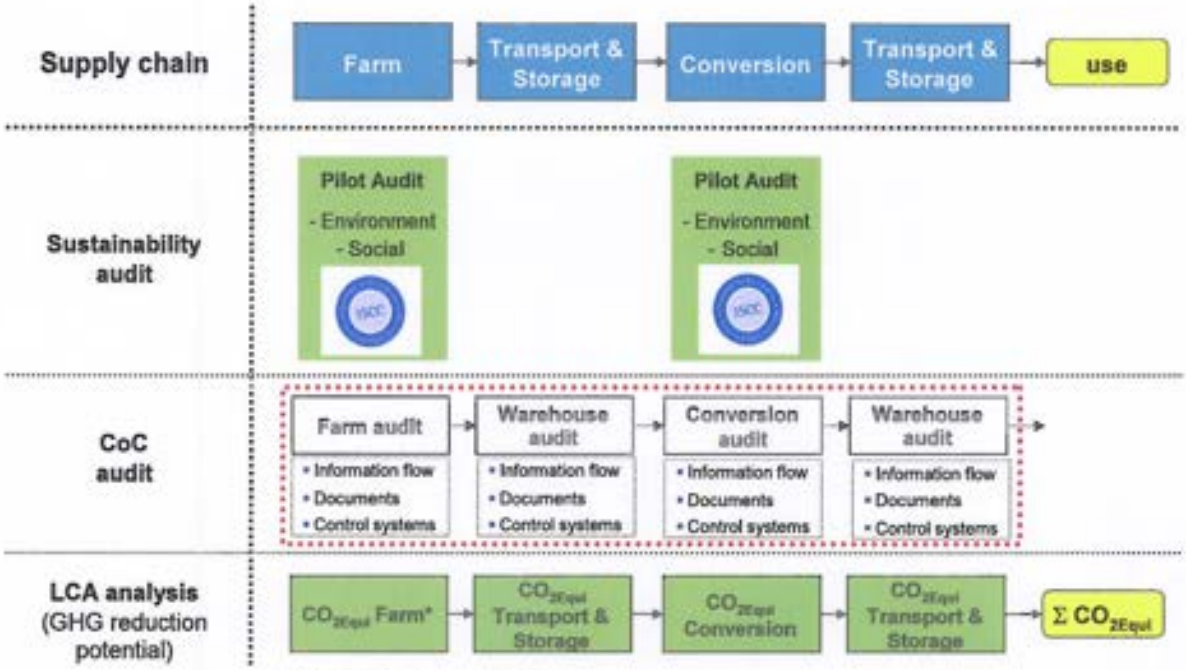
*: Neuer Wert EU Direktive: 24 g/MJ / Version 11.12.2008

Chain of Custody (CoC) audit is part of the certification process



* including land use change calculation

Currently, pilot audits are carried out in different countries with different biomass and biofuels

Supply Chain					
Agriculture	Conversion	Trade	Distribution	Certifyer	LCA
Rape Biodiesel Europe					
Grain Ethanol Europe					
Grain Ethanol Europe					
Palm Biodiesel Malaysia					
Sugarcane Ethanol Brazil					
Sugarcane Brazil					
Soya Argentina					

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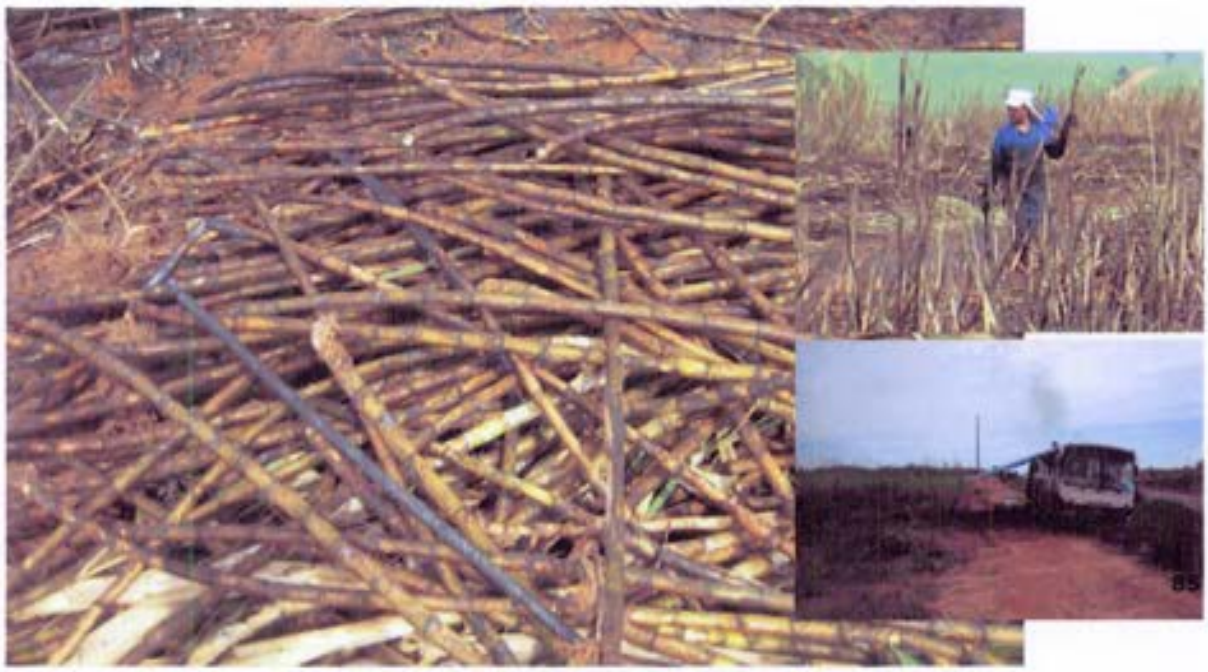
Pilotaudit in Brazil (I)

Pilotaudit in Brazil (II)

Pilotaudit in Brazil (III)

Pilotaudit in Brazil (IV)



Pilotaudit in Brazil (V)

Pilotaudit in Brazil (VI)

Pilotaudit in Brazil (VII)

Certification provides the evidence for differentiating between "good" and "bad" biomass and bioenergy

- Bilateral agreements or global regulations may take very long and may be in conflict with WTO rules
- Certification systems can become operational in the short run, building upon the experience in several markets with certified products
- Certification systems provide the operational framework for verifying whether biomass and biofuels are cultivated and processed in a sustainable manner, according to the legal requirements
- Expectations should be realistic: Certification systems do not solve every problem related to the use of resources, but certification systems can provide incentives for the production of sustainable biomass and biofuels

Green Chemistry: an agricultural production chain for biolubricants

Luca Lazzeri, Lorenzo D'Avino
CRA- Research Centre For Industrial Crops – Bologna (Italy)

Abstract

The potential of biolubricants based on vegetable materials as an environmental friendly alternative to fossil based materials seems to be a very interesting field in green chemistry. The use compounds that are renewable, biodegradable, low toxic and with a potentially positive effect for the environment and against Global Warning in alternative to the deeply pollutant conventional lubricants opens very interesting perspectives in several industrial applications moreover for those utilisations that comprise an end use in which the lubricant is widespread in the environment (textile, tannery, paper tissue, agricultural, drilling, tunnel escavation, saw chains) or remains residual in the final products (tannery, paper tissue, food industry, polymers). As well other applications are interesting as e.g. in metalworking, where in addition to create better work conditions for the operators, could permit, after its use, a recovery and disposal of the oil and it utilisation in the lipochemistry sector. For all these reasons, a niche after niche approach through the activation of different production chains that link agriculture and industry should be encouraged and helped. Some experiences carried out in Tuscany in tannery, textile and tissue-paper lubrication showed how different formulates based on High Oleic Sunflower Oil replaced conventional lubricants without any plant adjustment or process modification. The performances were often similar or, in same cases, higher, opening good perspectives for a differentiation of the final product on the globalised market of the third millennium. The environmental impact evaluation of thirteen Eurostat indicators showed no negative trend and a reduction for example of toxic chemicals consumption or Hazardous waste generation following the substitution of conventional oils. But, even with these very interesting results, the use of biolubricants covered in 2007 only 2.3% of the whole European market. The reasons of this low development is mainly due a) to the production cost of a biolubricant that is around 30% higher than a conventional one, b) to the absence of any

help or incentive from the European Commission for the use of biolubricants, and c) the not sufficient contribution of the new REACH Regulations. For a better valorisation of the biomass a Biorefinery approach by the integral use of the entire production in the non food field should be followed. A production chain with these aims and based entirely on Italian technologies, materials and business led to the cultivation, without any form of European or national subsidies, of around 1000 hectares in Italy in 2007, based on Brassica carinata cultivation. This new chain used the oil in biolubricant (or bioenergy) field because of its erucic acid content and the residual defatted seed meals as the basic product for the patented production of 100% vegetable pellets as fertiliser or amendment for an innovative non-chemical soil fertility and health management in horticultural crops.

Green Chemistry: an agricultural production chain for biolubricants

- Luca Lazzeri, Lorenzo D'Avino –

- Council for the Research in Agriculture –

- Centre of Research on Industrial Crops -

- CRA-CIN Bologne -

Fields of application for lubricant in EU

Biolubricant could become one of the main field of GC application, but it has to be considered as only a partial alternative for the EU market. So, the only sustainable development strategy is a niche after niche approach

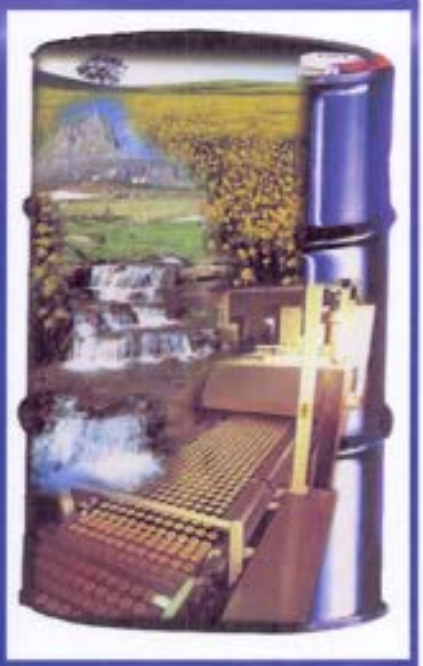
Exclusively the niches that show high environmental benefits should be encouraged and developed

A strong link to the agriculture production chain could provide the best quality and guarantee oil availability in the years.

The chain analysis must not to be limited to economics, but has to consider the energy (MJ) and especially the environmental balances (CO_2-eq) evaluated by a site-specific approach, as fundamental

Workshop on Green chemistry future and its possible impact on agriculture the whole farm traceability approach. Ispra (Italy), 22 January 2009

Vegetable oils main ecological characteristics

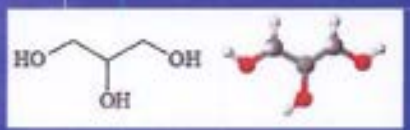


End points of the oils

Widespread in the environment
(textile, tannery, agricultural, drilling, tunnel escavation, saw chains)

Residual in the final products
(Tannery, Paper tissue, Food industry, Polimers)

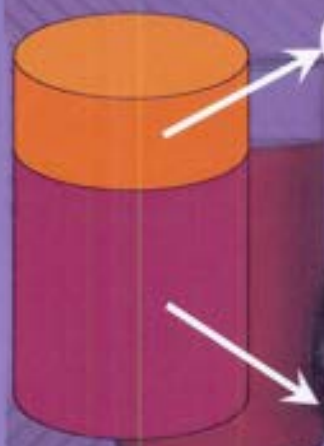
Recovery and disposal
(Hydraulic, mechanical, quencing, sewage treatment)



Glicerol

Lipochemistry

Average composition of a lubricant formulation



From 1 to 30% of "ADDITIVES"
(Pour point depressant, Antifoaming agents, Detergents and dispersants, Antioxidants, Corrosion inhibitors, Biocides, Anti-wear ...)

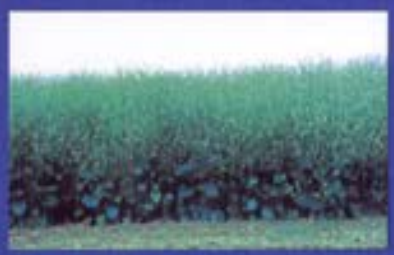
From 70 to 99% from "BASE FLUIDS"

Vegetable oils in Italy as base fluids for biolubricant

High oleic oils
(Sunflower, safflower..)

High oily capability
Good oxidation resistance
High mixing properties

High erucic oils
(Crambe, Carinata..)



High lubricant capability
High smocking point
High mixing properties

Main technological properties

	Viscosity 40 °C ($mm^2 sec^{-1}$)	Fatty acid composition (%)		Iodine number ($g\ J_2/100g$)
		Oleic	Erucic	
	38-42	85	0	80-90
	50-52	19	57	88-92

BIOVIT DULVIT GAT-SPOT

Tuscany Region Programme "Technological Innovation in Tuscany"
Action 1 - Trasferimento tecnologico e diffusione dell'innovazione nella Toscana occidentale
"BIOVIT Project - Biolubrificanti vegetali per l'industria toscana"

Regional Project DoCUP Ob. 2 – Misura 1.7 "Trasferimento dell'innovazione alle PMI" - PRA Azione D21 "Azioni di sistema per la ricerca e l'innovazione"
" DULVIT Project - Diffusione ed Utilizzo dei Lubrificanti Vegetali per l'Industria Toscana"

Interreg IIIC Ecosind n. C3 -03
" GAT SPOT - Gestione Agroterritoriale Sostenibile per gli oleanti Tessili"

DAGA, University of Pisa; CRA-CIN, Bologne; Coldiretti, Confagricoltura, Cia, Tuscany; CON.CER.TEX, Prato; ARPAT, Florence; Houghton Italia – Genoa; Chimont International S. p. A., Pisa; Triumph Italia, Leghorn; Draplane, Prato; Italcol, Florence; Legambiente Toscana, Florence

The Project results

GAT-SPOT

Different formulates based on HOSO have replaced conventional lubricants in tannery, textile and paper production chains without any plant adjustment or process modification.

The performances were similar or, in same cases, higher, opening important environmental perspectives for a differentiation of the final product on the globalised market of the third millennium.

Environmental impact supposing a total substitution of mineral oils with BIOVIT

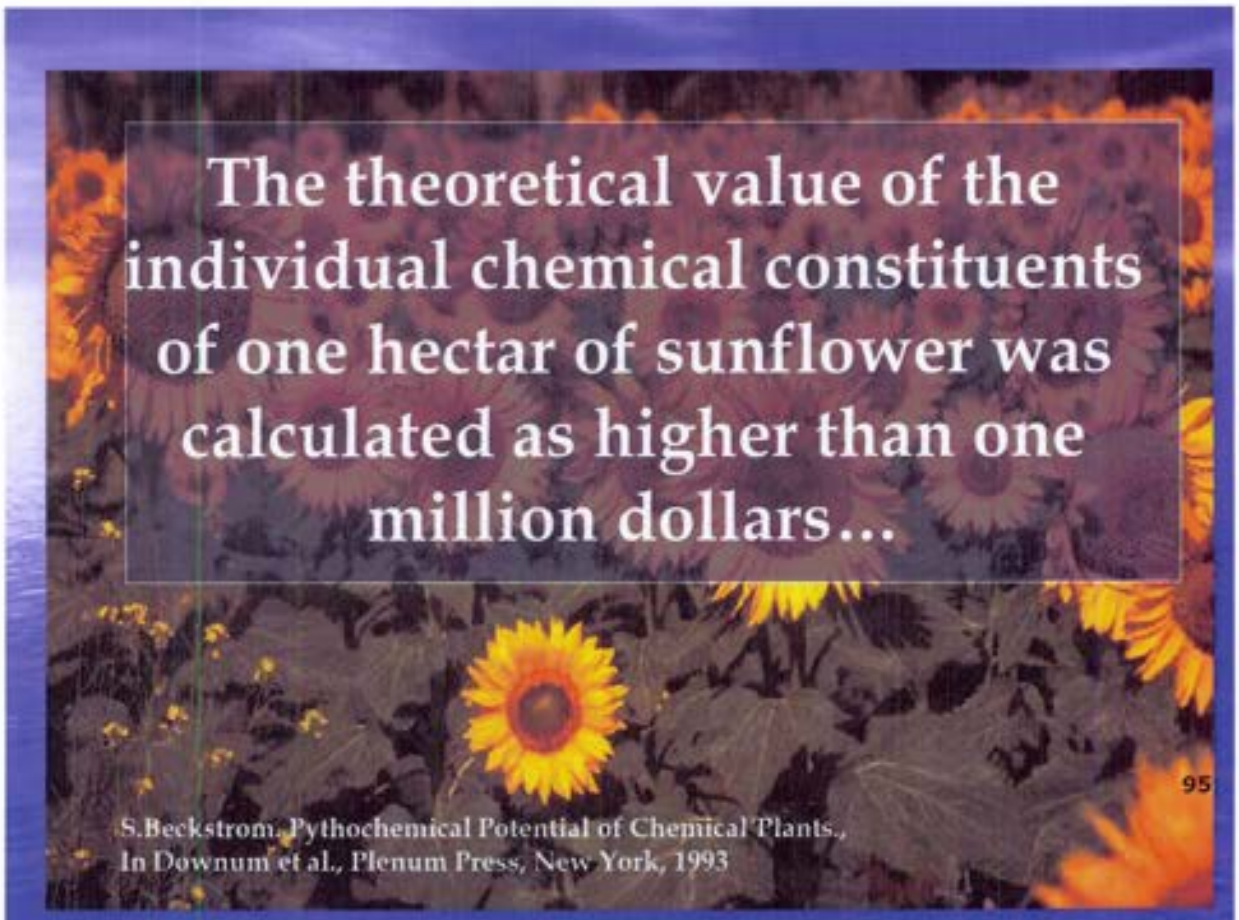
Sector	Trend ☹	Trend 😐	Trend ☺	Eurostat indicators with a positive trend
Agricultural	-	3	10	Eutrophication , Water consumption, Soil nutritional balance, Timber balance, Pesticide use, Toxic chemicals consumption, Hazardous waste generation, Water-bering extraction, Pesticide and Nitrogen amount
Textile	-	6	7	Emission of non-methane volatile organic compounds, CO_2 emission, Water consumption, Toxic chemicals consumption, Hazardous waste generation, Industrial waste generation, Water-bering extraction
Tannery	-	7	6	Emission of non-methane volatile organic compounds, CO_2 emission, Toxic chemicals consumption, Hazardous waste generation, Industrial waste generation, Water-bering extraction

Main reasons of the low development of biolubricant market

The production cost of a Biolubricant is around 30% higher than a conventional biolubricant

There is no help or incentive from the European Commission for the use of biolubricants, and the advantages comprise in REACH Regulament do not seem sufficient

There is no link with local agriculture and consequently no guarantee for oil availability year after year



Workshop on Green chemistry future and its possible impact on agriculture:the whole farm traceability approach. Ispra (Italy), 22 January 2009

The plant is the first biorefinery for the production of lubricants from dedicated agricultural crops…

Brassica carinata as an oleaginous crop for a first generation Biorefinery approach

In Italy starting in 2005, collaboration between a public research group (CRA-CIN, Bologne) and a private SME (Cerealtoscana, Leghorn) activated a Biorefinery production chain based on the integral use of B. carinata seeds in the non food field. The continuous development of this chain, based entirely on Italian technologies, materials and business, led in 2007 to the cultivation, without any form of European or national subsidies, of around 1000 hectares in Italy.

Positive characteristics of *B. carinata*

High rusticity and adaptability

Low chemical input requirement

Strong resistance to diseases and water shortages

Low pod dehiscence even after maturation

Simple mechanization

High amounts of crop residues

Simple insertion in cereal rotation

Negative characteristics of *B. carinata*

Medium yield

Limited knowledge of crop potential

Limited germplasm still to be improved

Absence of regulatory standards

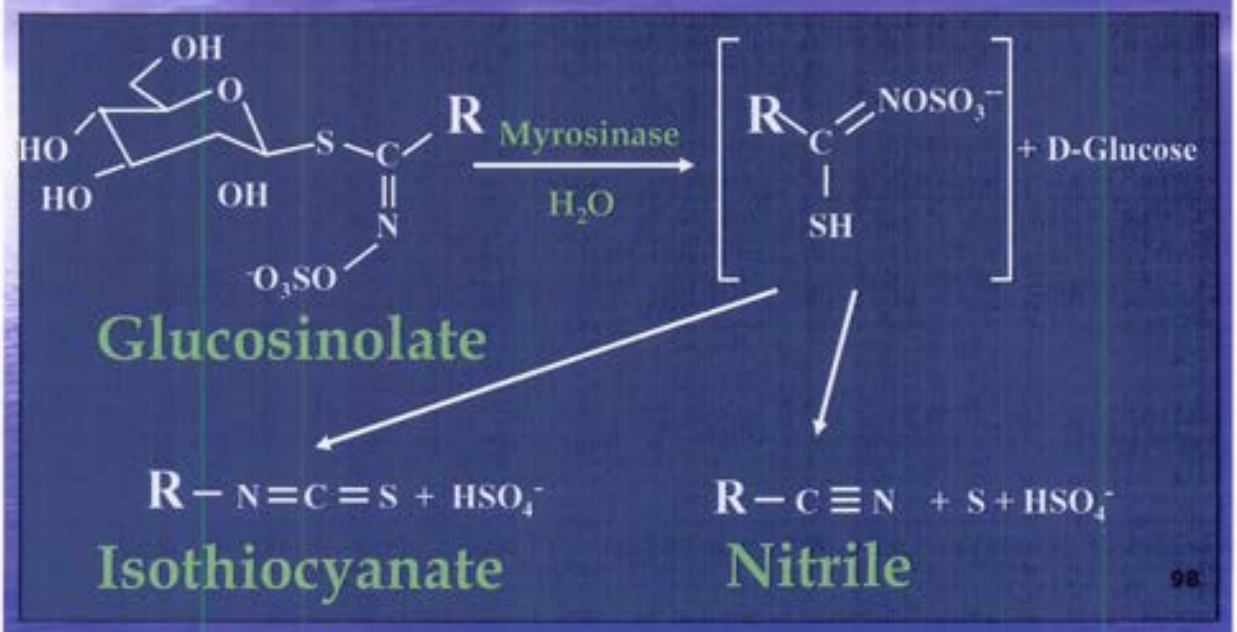
Absence of any form of subsidies

Chemical composition of defatted seed meals
(around 60% of the total yield)

Oil	N	P	K	C	C/N	Org. Matter	GL
	(%)	(%)	(%)	(%)		(%)	mMoles kg^{-1}
9-12	5-6	0,7-1	2-2,5	40-45	7-8	80-85	95-115

Nitrogen OUTPUT/INPUT rate = 2.73

The Glucosinolate-myrosinase system



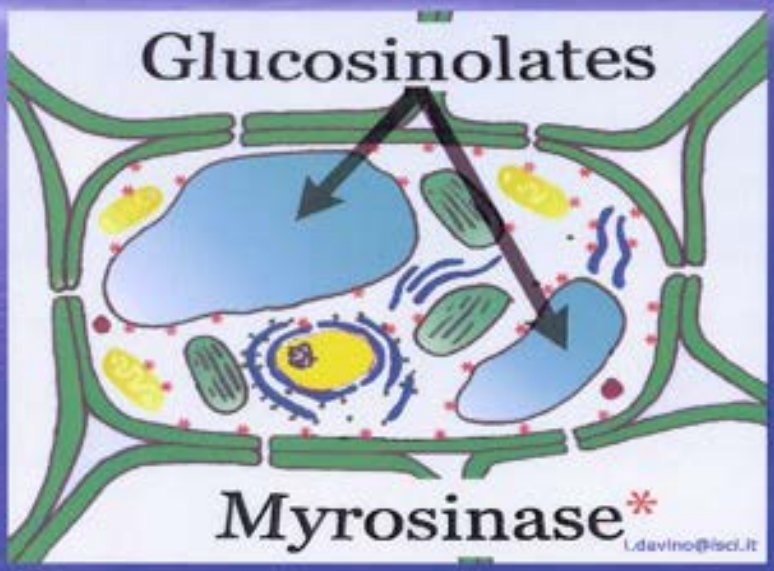
Workshop on Green chemistry future and its possible impact on agriculture:the whole farm traceability approach. Ispra (Italy), 22 January 2009

Biofumigation definition

The weel known suppressive effect of some Brassicas materials on soil borne pests and pathogens through the release of Isothiocyanates and other minor degradation products derived from the hydrolysis of endogenous glucosinolates.

(Kirkegaard & Matthiessen, 2004)

The Glucosinolate-myrosinase system in intact cell



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Amendment pellets based on Carinata defatted seed meals

(Cerealtoscana PCT Nr. IT03/00514 of 22 Agost 2003
CRA-CIN Patent Deposit N°ITA BO2007A 000233)

Infestation level of *Meloidogyne incognita* on zucchini roots after biofumigation

Benefits of an use of co-products as organic fertilisers or amendments

Chemicals in agriculture are widespread in the environment and are the closest to human food chain

If a CO_2 decrease in the atmosphere is an objective of European Community, the carbon sink potential of agricultural soils could offer an important contribute

Soil organic matter incorporation could improve soil fertility and healt, activating a virtous circle year after year that will bring to the decrease of chemicals in agriculture

A new role of agriculture that from a heavy user of chemicals could become the producer of a total or partial organic alternative to fertilisers and pesticides

U.S. Environmental Protection Agency Pesticides: regulating pesticides

Biopesticides are usually inherently less toxic than conventional pesticides

Biopesticides generally affect only the target pest and closely related organisms, in contrast to broad spectrum, conventional pesticides that may affect organisms as different as birds, insects, and mammals

Biopesticides often are effective in very small quantities and often decompose quickly, thereby resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides

When used as a component of Integrated Pest Management (IPM) programs, biopesticides can greatly decrease the use of conventional pesticides, while crop yields remain high

To use biopesticides effectively, however, users need to know a great deal about managing pests

www.epa.gov/pesticides/biopesticides/whatarebiopesticides.htm

First generation Biorefinery on Brassica carinata seed

A process and product innovation in a Biorefinery approach with a biomass utilisation entirely in non-food field of lubricant and amendments

Some potential application fields for vegetable oil as industrial lubricant

Short period		Medium period
Textile	Releases	Tunnel escavation
Tannery		Food industry
Paper	Agricultural	
Paints and inks	Drilling	Hydraulic
		Mechanical

Industrial lubricant uses

	Mton year^{-1}
Hydraulic transmission	700
Metalworking oils	310
Engine, turbine, compressor, electrical oils	230
Greases	80
Others	480

Bilancio dell'azoto organico nella coltivazione di B. carinata

(Media di 22 prove dimostrative in Italia)

INPUT

Fertilizzazione 60 U ha^{-1}

Semina o copertura

Raccolta

OUTPUT

Semi

Produzione 3,2 t ha^{-1}
N organico 92 kg ha^{-1}

Residui colturali

Produzione 9 t ha^{-1}
N organico 72 kg ha^{-1}

Rapporto OUTPUT/INPUT = 2.73

Environmental Assessment: biodegradability

	Mineral based	BIOViT
COD ($mg\ l^{-1}\ O_2$)	14,3 b	20 a
BOD_5 ($mg\ l^{-1}\ O_2$)	4 b	11 a
BOD_5/COD ratio	0.28 b	0.55 a

Site-specific balances: NEB and CO_2eq reduction

Lorenzo D'Avino
RESEARCH CENTRE FOR INDUSTRIAL CROPS – BOLOGNA (ITALY)

Abstract

Our research group is working in software development to calculate Net Energetic Balances (NEB), CO_2equivalent reduction and also production costs (not subject of this communication) in agro-industrial chains.

Our starting point is that in non-food agriculture and green chemistry, more than in food agriculture, chain's evaluation is fundamental and should be related to agro-climatic specificity, should provide analysis in multiple years (rotations), cultivars (intercropping) and co-products (crop residues, glycerol...). In our proposal, the correct approach should contemplate the substitution values as CO_2eq saved in co-product replacement (because utilising for example press cake to produce energy, feed or fine chemical have different environmental implication) and should be flexible to the variability of the coefficients with relation to Best Available Technologies to produce inputs.

Software is already applied to calculate CO_2eq reduction inserting *Brassica juncea* green manure as catch crop in biennial rotation wheat-potato as a sustainable alternative to chemical fumigation in Washington State. Results show how around 2 tons of CO_2eq ha^{-1} was saved at every rotation cycle. Another interesting application is the comparison between balances of same cultivars (*B.carinata* ISCI7) in same year (2007-2008) in different Italian agricultural sites. NEB ratio is always greater than one if we consider energy content in press cake and biodiesel, but differences are huge, above all if we consider energy content in crop residues (NEB ratio up to 32). Furthermore it's very important

which measure unit has to be used for balances: in this application utilising CO_2eq per MJ (of biodiesel produced or of biodiesel and defatted meals produced) or CO_2eq per MJ per year differences among location increase than utilising CO_2eq per ha. Our results show as the non-food chain sustainability is site-specific, mainly because agriculture is the main input factor. To promote green chemistry certification it is necessary to establish which are the strategic objectives: increase renewable energy from agriculture, reduce CO_2eq emissions in atmosphere or raise economic sustainability, because subsidy policies can be very different. In any case *Criteria* of sustainability promoted by the EU should provide clear, precise, transparent and unambiguous methods for sustainability evaluation.

Site-specific balances: NEB and CO_2eq reduction

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In nonfood agriculture and green chemistry chain's evaluation is necessary and should

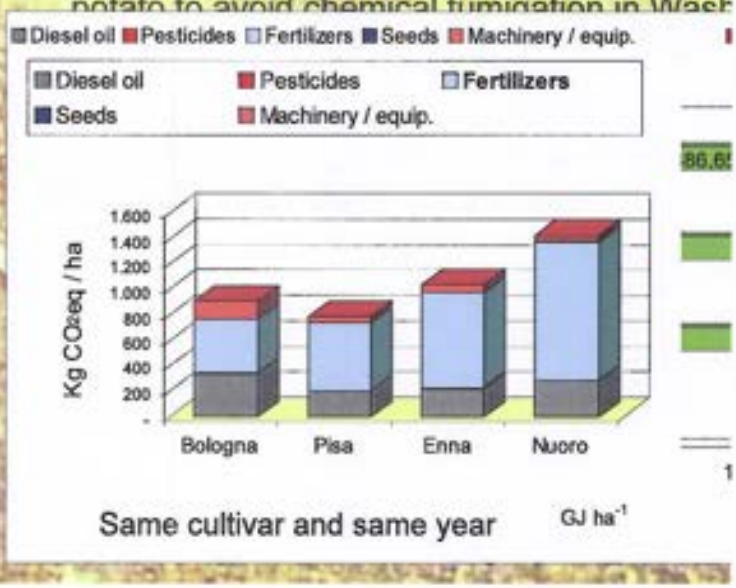
- be related to agro-climatic specificity (*ha* as functional unit)
- provide analysis in multiple years (rotations), cultivars (intercropping) and co-products (crop residues, glycerol…)
- contemplate the substitution values as CO_2eq saved in co-product replacement
- be flexible to the variability of the coefficients with relation to Best Available Technologies to produce inputs

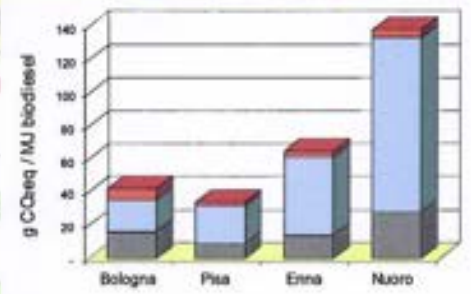
Some applications

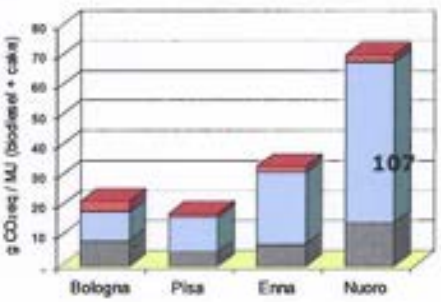
Bioenergie project: oil plant-local chain to produce biodiesel and defatted meals: carinata 2008

Brassica juncea green manure as catch crop

potato to avoid chemical fumigation in Wash







It is necessary to establish which are the strategic objectives:

Increase renewable energy from agriculture
→ contemporary use of oil and plant residues (eg. for biodiesel and biogas)

Reduce CO_2eq emissions in atm
→ quantify the fixation of CO_2 by residues and/or co-products incorporation and improve access through carbon credits (emission trading)

Raise economic sustainability
→ short and brief chains exploiting at the best all residues and co-products (biorefineries)

Criteria of sustainability promoted by the EU should provide for the evaluation o these goals with transparent and unambiguous methods

The agricultural phase request the larger input amounts along the chain, so the optimization of cultivation techniques could influence significantly the environmental sustainability

thank's for your attention

CRA
CRA-CIN
CENTRO DI RICERCA PER LE COLTURE INDUSTRIALI

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European Commission

JRC 51164 – Joint Research Centre – Institute for the Protection and Security of the Citizen
Title: Proceedings of the 1st JRC Workshop on Green Chemistry
Author(s): Editors Paolo Pizziol & Philippe Loudjani
Luxembourg: Office for Official Publications of the European Communities
2009

Abstract

Green chemicals are a great opportunity for agriculture sector. Experts in chemistry, agricultural research, EU policy and chemical industry have been invited to discuss green chemistry future perspectives. Their testimonial is that biomass availability is actually not the limiting factor to cover the need of chemical products. But, there are today insufficient instruments for the promotion of green production processes and to encourage the use of green products as input for fertilizer and phytosanitary controls. In general, together with the existing effective and targeted policies, LEAD and KBBE, more consistency in EU policy is still needed (harmonization of sustainability criteria, set-up of certification schemes relying on GIS technology). An urgent work on standardization of 'green process' assessment methods is requested to pave the way for reliable certification schemes capable of guiding consumers' choice and strengthening consumer level responsibilities.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

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