IUS – Institut für Umweltstudien

ifeu – Institute for Energy and Environmental Research

BIOLYFE Workshop on

Challenges and opportunities for lignocellulosic ethanol biorefineries:

A SWOT analysis

Walter Kretschmer, Uwe Weibel, Monika Langer (IUS)
Maria Müller-Lindenlauf, Guido Reinhardt (IFEU)

Madrid, 3 April 2013

Agenda

- **Introduction**
  Guido Reinhardt
- **What's the SWOT workshop about?**
  Walter Kretschmer
- **Interactive discussion of key issues**
  Guido Reinhardt and Maria Müller-Lindenlauf
  - **Feedstock provision**
  - **Processing to bioethanol and use of the final product**
- **Concluding remarks**

The workshop team

Dipl-Biol Walter Kretschmer

- Master in biological science
- 30 years of experience in consultancy on environmental and sustainability issues : EIA, LCA, SWOT
- Contribution to BIOLYFE
  - task leader for technological assessment, environmental assessment, SWOT analysis and integrated assessment

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What's the SWOT workshop about?

The BIOLYFE project and sustainability assessment

SWOT analysis in general

The SWOT approach in BIOLYFE

Objectives and structure of this workshop

The BIOLYFE project

BIOLYFE: Second generation BIOethanol process: demonstration for the step of Lignocellulosic hYdrolysis and Fermentation

The BIOLYFE project aims at

- **improving critical steps of the 2nd generation bioethanol production process**
- **demonstrating the whole supply chain, from feedstock sourcing via fuel production to product utilisation.**
- **investigating technological alternatives that are most promising**
- **providing a multi-criteria evaluation of the 2nd generation bioethanol technological, environmental, economic and social aspects.**

The BIOLYFE project

- **A key point for the success of the technology is the construction and operation of a 40.000 ton/y 2nd generation ethanol industrial demonstration unit:**
  - **To prove the technology tested on a pilot plant scale on larger scale**
  - **To define the best operating conditions**
  - **To prove the crop-to-ethanol value chain on larger scale**
  - **To generate all the data needed for the design of industrial plants**

The BIOLYFE project

The BIOLYFE project

Second generation BIOethanol process: demonstration for the step of Lignocellulosic hYdrolysis and FErmentation

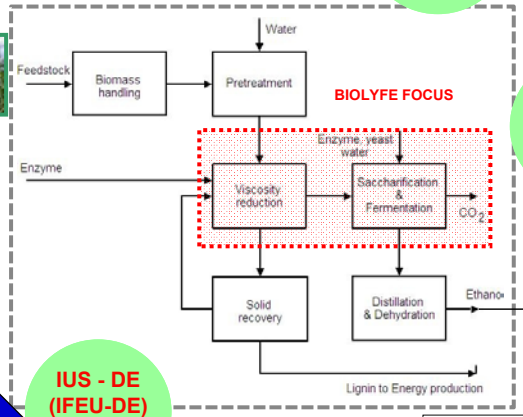
ENEA - IT (Pretreatment)

Univ. Lund SE (TAURUS-SE) (Microorganism Fermentation)

Agricon-sulting IT (Biomass production)

WIP - DE (ETA - IT) (Dissemination)

Novo-zymes DK (Enzymes)

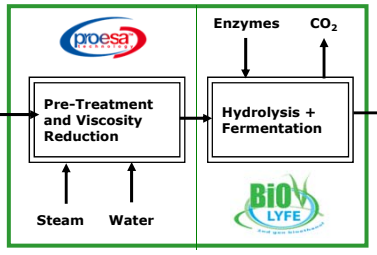


Chemtex – IT (***Coordinator***, 2nd gen. Bioethanol demo unit)

IUS - DE (IFEU-DE) (Integrated assessment)

EC-FP7

The BIOLYFE project

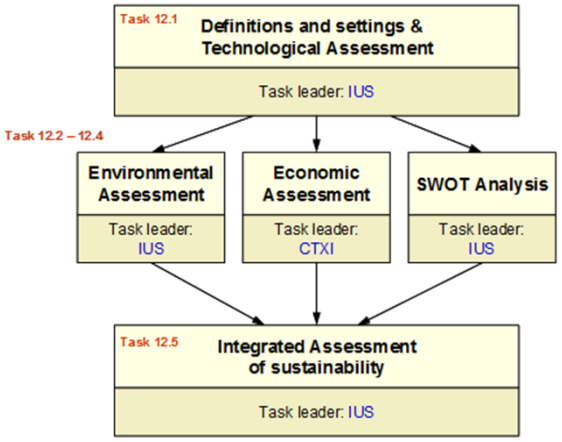


The main sections developed in R&D are:

1. **Agronomy:** Field experimentation and best energy crops identified and characterised.
2. **Biomass Pre-Treatment and Viscosity Reduction:** Continuous process developed and piloted to produce cost-effective and clean fermentable sugars.
3. **Hydrolysis and Fermentation:** Unique hybrid SSCF process scheme yielding high ethanol concentrations.

WP 12: Sustainability assessment

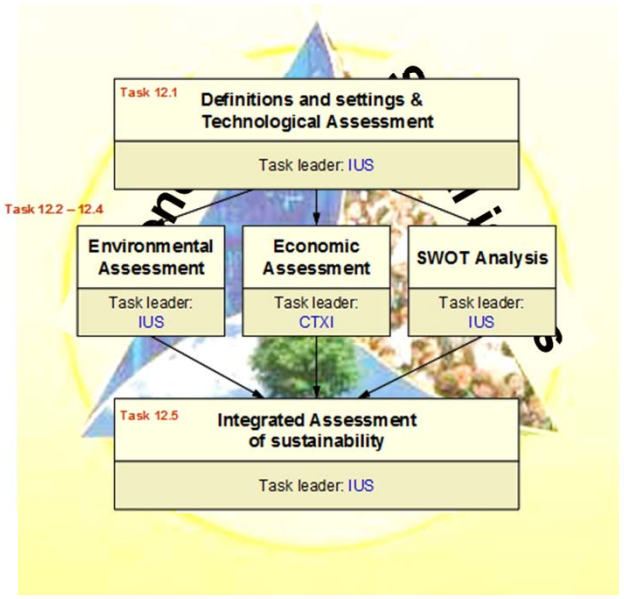
Goal: To provide a multi-criteria evaluation of the sustainability of the BIOLYFE concept taking into account techno-logical, environmental, economic and social aspects. It will generate an optimisation of bioethanol systems.



Brundtland Commission of the United Nations (1987):

"sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

Sustainability assessment in BIOLYFE



What's the SWOT workshop about?

The BIOLYFE project and sustainability assessment

➡ **SWOT analysis in general**

The SWOT approach in BIOLYFE

Objectives and structure of this workshop

SWOT analysis

- **SWOT analysis originates from business management**
- **A SWOT analysis is a strategic plannig tool used to assess the performance of a project, a product or a company.**
- **SWOT analysis evaluates Strengths, Weaknesses, Opportunities, and Threats (involved in a business venture).**
- **Factors which are internal to the system investigated are classified as strengths (S) or weaknesses (W).**
- **Factors which are external to the system investigated are classified as opportunities (O) or threats (T).**

	Positive	Negative
Internal	Strength	Weakness
External	Opportunity	Threat

SWOT analysis

SWOT analysis as basis for actions:

- **Strengths:**
  Need to be maintained, built upon or leveraged
- **Weaknesses:**
  Need to be remedied, changed or stopped
- **Opportunities:**
  Need to be prioritised, captured, built on and optimised
- **Threats:**
  Need to be countered or minimised and managed

SWOT analysis for biorefineries

Strengths	Weaknesses
• Adding value to the use of biomass • Maximising biomass conversion efficiency minimising raw material requirements • Production of a spectrum of bio-based products (food, feed, materials, chemicals) and bioenergy (fuels, power and/or heat) feeding entire bioeconomy • Strong knowledge infrastructure available to tackle technical and non-technical issues • Biorefinery is not new, it builds on agriculture, food and forestry industries • Stronger focus on drop-in chemicals facilitating market penetration	• Broad undefined and unclassified area • Involvement of stakeholders for different market sectors (agriculture, forestry, energy, chemical) over full biomass value chain necessary • Most promising biorefinery processes/concepts not clear • Most promising biomass value chains, including current/future market volumes/prices, not clear • Studying and concept development instead of real market implementation • Variability of quality and energy density of biomass
Opportunities	**Threats**
• Biorefineries can make a significant contribution to sustainable development • Challenging national and global policy goals, international focus on sustainable use of biomass for the production of bioenergy • International consensus on the fact that biomass availability is limited meaning that raw materials should be used as efficiently as possible – i.e. development of multi-purpose biorefineries in a framework of scarce raw materials and energy • International development of a portfolio of biorefinery concepts, including technical processes • Strengthening of the economic position of various market sectors (e.g. agriculture, forestry, chemical and energy) • Strong demand from brand owners for biobased chemicals	• Economic change and volatility in fossil fuel prices • Fast implementation of other renewable energy technologies feeding the market requests • Bio-based products and bioenergy are assessed to a higher standard than traditional products (no level playing field) • Availability and contractibility of raw materials (e.g. climate change, policies, logistics) • (High) investment capital for pilot and demo initiatives difficult to find, and undepreciated existing industrial infrastructure • Changing governmental policies • Questioning of food/feed/fuels (indirect land use competition) and sustainability of biomass production • Goals of end users often focused on single product

Source: IEA Bioenergy, Task 42 Biorefinery

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➡ **The SWOT approach in BIOLYFE**

Objectives and structure of this workshop

Internal and external factors

Internal (strengths and weaknesses):

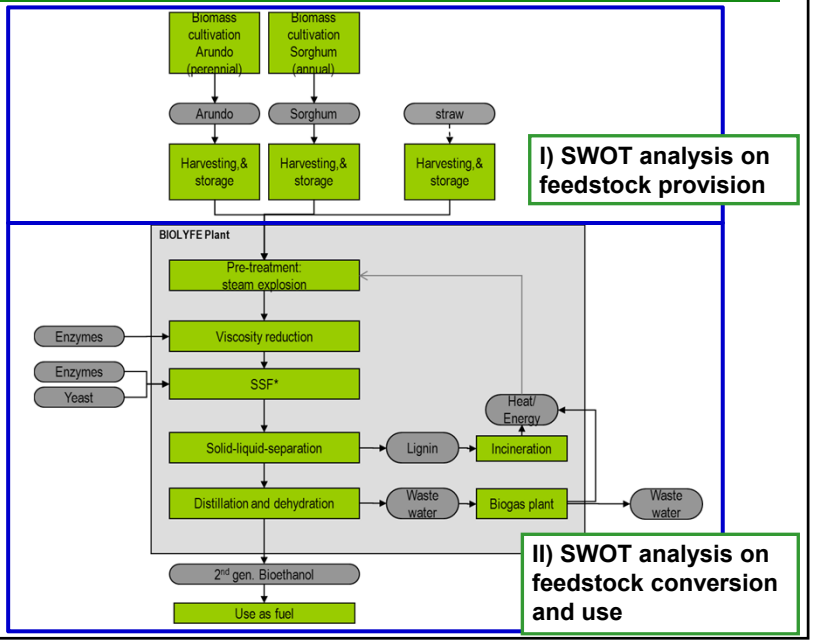
Intrinsic properties of BIOLYFE 2nd generation Bioethanol plants under approved or most likely environmental, economic, political and legal circumstances in 2015

External (opportunities and threats):

All aspects, which relate to

- **Success / failure in development of technologies**
- **Impacts of possibly other environmental, economic, political and legal circumstances**

The BIOLYFE value chain



SWOT analysis approach in BIOLYFE

Collection of SWOT arguments:

1. **Screening SWOT analysis:**
   Literature, BIOLYFE reports
2. **Feedback from consortium members**
3. **SWOT workshop**
   Feedback from external stakeholders and scientists
4. **Finalisation**
   Updated results are published as part of integrated assessment report

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➡ **Objectives and structure of this workshop**

Objectives of SWOT workshops

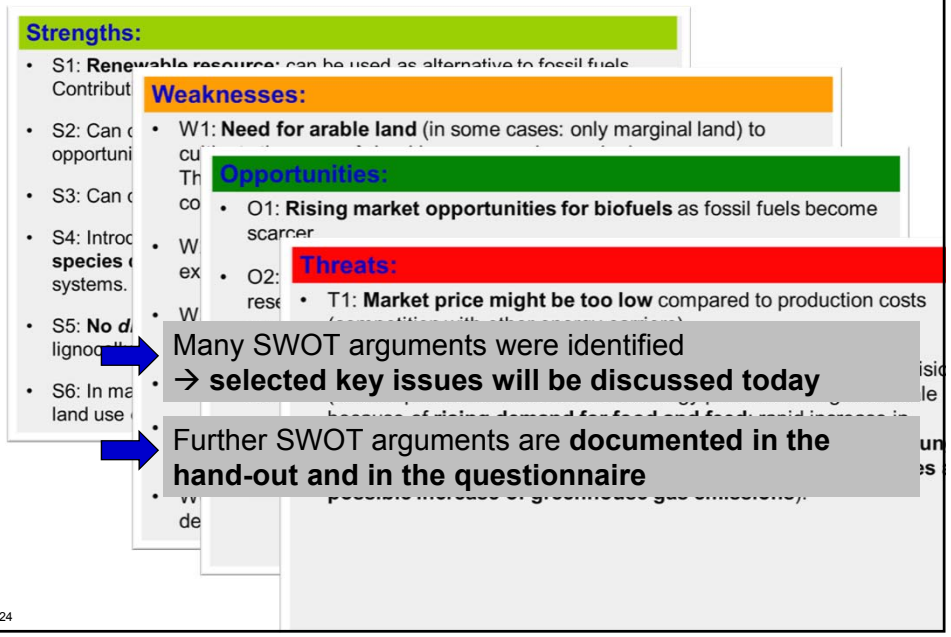
The general objectives of SWOT workshops

- **To check and validate the preliminary SWOT arguments**
- **To identify missing arguments**
- **To weight the SWOT arguments**
- **To discuss strategies and recommendations to overcome weaknesses and threats and to leverage strength and opportunities**

Strategies had to be found to achieve these objectives in the best possible way

Today: Big and experienced group!
Challenge: No split-up in sub-groups

BIOLYFE SWOT tables



Many SWOT arguments were identified
→ **selected key issues will be discussed today**

Further SWOT arguments are **documented in the hand-out and in the questionnaire**

Elements of participation

During the workshop

- **Interactive workshop discussion**
- **Use of concept cards**
- **Use the hand-out for further information**

Workshop format

Workshop is not a conference session …

… in which one person speaks and all others just listen and maybe ask some short questions.

Our workshop session should be …

… an interactive discussion!

Concept cards

…the speakers list for a particular topic is closed?
But you still have something to say?

→ Write it to one of the concept cards and give it to us!

→ Your contribution will be included into the minutes and will be considered for the final SWOT analysis

Hand-out document

Challenges and opportunities for lignocellulosic ethanol biorefineries

A SWOT analysis based on the BIOLYFE concept

Workshop preparation document

3rd ICLE, 3rd April 2013, 17:15-19:00,
Casino de Madrid, Madrid, Spain

→ Was put on your places during coffee break

→ contains additional information (complete SWOT matrices)

Elements of participation

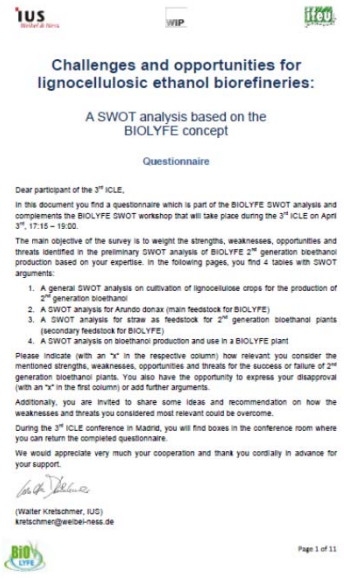
During the workshop

- **Interactive workshop discussion**
- **Use of concept cards**
- **Use the hand-out for further information**

During the conference

- **Return the questionnaire**

Questionnaire



Challenges and opportunities for lignocellulosic ethanol biorefineries:

A SWOT analysis based on the BIOLYFE concept

Questionnaire

Dear participant of the 3rd ICLE,

In this document you find a questionnaire which is part of the BIOLYFE SWOT analysis and complements the BIOLYFE SWOT workshop that will take place during the 3rd ICLE on April 3rd, 17:15 – 19:00.

The main objective of the survey is to weight the strengths, weaknesses, opportunities and threats identified in the preliminary SWOT analysis of BIOLYFE 2nd generation bioethanol production based on your expertise. In the following pages, you find 4 tables with SWOT arguments:

1. A general SWOT analysis on cultivation of lignocellulose crops for the production of 2nd generation bioethanol
2. A SWOT analysis for Arundo donax (main feedstock for BIOLYFE)
3. A SWOT analysis for straw as feedstock for 2nd generation bioethanol plants (secondary feedstock for BIOLYFE)
4. A SWOT analysis on bioethanol production and use in a BIOLYFE plant

Please indicate (with an "x" in the respective column) how relevant you consider the mentioned strengths, weaknesses, opportunities and threats for the success or failure of 2nd generation bioethanol plants. You also have the opportunity to express your disapproval (with an "x" in the first column) or add further arguments.

Additionaly, you are invited to share some ideas and recommendation on how the weaknesses and threats you considered most relevant could be overcome.

During the 3rd ICLE conference in Madrid, you will find boxes in the conference room where you can return the completed questionnaire.

We would appreciate very much your cooperation and thank you cordially in advance for your support.

(Walter Kretschmer, IUG)
kretschmer@weibel-ness.de

Page 1 of 11

→ in your conference folder

→ Objective: To check, validate and weight SWOT arguments

→ **Please return the completed questionnaire to us during the conference** (put it on the table at the back of the conference room!)

Questionnaire

→ Continuation of table 1: General SWOT analysis on cultivation of herbaceous lignocellulose crops for the production of 2nd generation bioethanol

		I disagree to this argument	Low relevance	Medium relevance	High relevance	Very high relevance (possible show stopper)
Opportunities	O1: **Rising market opportunities for biofuels** as fossil fuels become scarcer.					
	O2: New crops, that have shortly entered into the focus of agricultural research → **still high potential for enhancement of the currently available genetics and management practices.**					
	O3: Robust plants could be **cultivated on marginal land** not suitable for other purposes.					
	O4: Global sustainability **certification schemes** for biofuels are established or under development (GBEP, RSB) facilitating a proof of sustainability to positively influence public perception.					
	Any opportunity missing? Please add!					
Threats	T1: **Market price might be too low** compared to production costs (competition with other energy carriers).					
	T2: Rising **land scarcity** can lead to unsustainable biomass provision (less surplus land available for bioenergy production at global scale because **of rising demand for food and feed**; rapid increase in demand for bioenergy **can bring food prices up and increase hunger**; increased risk of **harvest failures**; **risks for endangered species and possible increase of greenhouse gas emissions**).					
	Any threat missing? Please add!					

Do you have any recommendation to overcome the weaknesses and threats you considered most relevant for successful cultivation of lignocellulosic herbaceous bioenergy crops?

Weighting of SWOT arguments

Option to add further arguments

Option to add comments, in particular on strategies to overcome weaknesses

Elements of participation

During the workshop

- **Interactive workshop discussion**
- **Use of concept cards**
- **Use the hand-out for further information**

During the conference

- **Return the questionnaire**

After the conference

- **If you have further comments: contact me! (kretschmer@weibl-ness.de)**

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- **Concluding remarks**

Dr Maria Müller-Lindenlauf

- PhD in agricultural science
- About 7 years of experience in LCA and sustainability assessment for agricultural products
- Stages of her carrier: Bonn University, FAO, IFEU
- Fields of work in IFEU:
  - Environmental impacts and sustainability issues for agriculture and biomass production
  - LCA of food and biobased products
- Contribution to BIOLYFE
  - SWOT analysis

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Key issues - Overview

Biomass provision

1. **Avoidance of negative impacts of too high straw extraction rates**
2. **Land availability and land allocation for dedicated bioenergy crops**
3. **Cooperation with farmers**
4. **Logistics and storage**

Biomass conversion and use

5. **Acceptance and public support**
6. **Economic performance**

Any other issues?

7. **Further issues**

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Topic I

Use of straw for bioethanol production:

Avoidance of negative sustainability impacts of too high straw extraction rates

Further arguments:
table 7, p. 12 of the hand-out

Straw extraction and use for biorefining

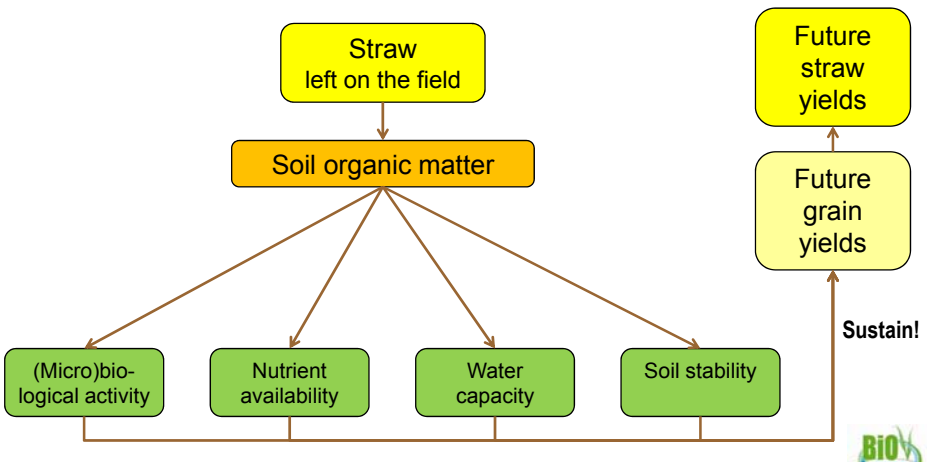
Strengths and opportunities:

- Straw is a residue: No additional land use
- Income opportunity for farmers

Weaknesses and threats:

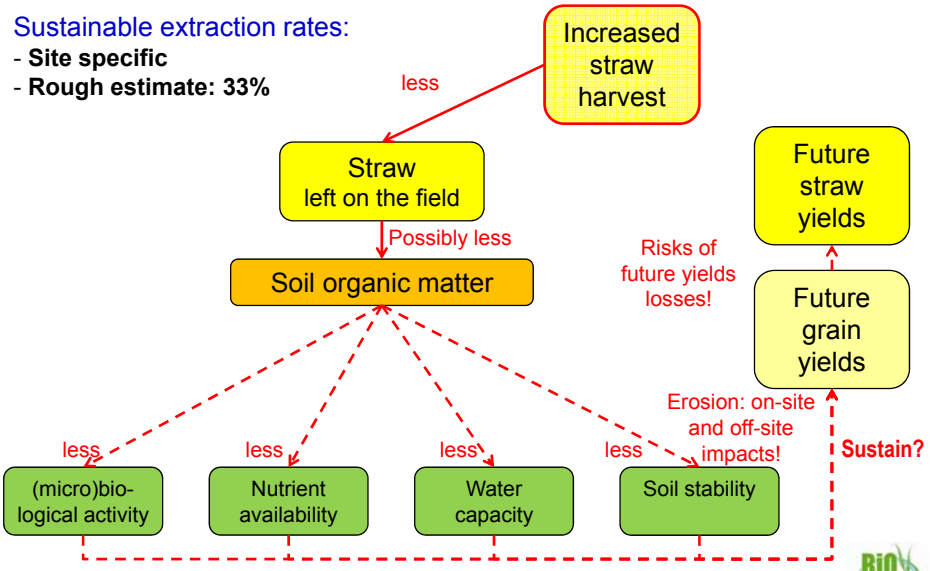
- Competition with other uses
- Risk for soil fertility in case of too high extraction rates

Soil organic matter and soil fertility



Soil organic matter and soil fertility

Sustainable extraction rates:
- **Site specific**
- **Rough estimate: 33%**



Competition for sustainably extractable straw

Traditional uses
- **Animal bedding**

Other innovative uses
- **Use for energy in CHP plants**

	Mio t (EU 27) +Ukraine+Balkan
Harvestable straw	**215**
Removable straw	71
Use for CHP (currently)	2
Use for bedding not returned to field	22
Available straw	**47**

Preliminary

Source: BIOCORE project

High total straw availability in EU. **BUT: regional** straw availability is limiting factor

Regional straw scarcity may increase „temptation“ to extract too much straw!

Discussion I

Use of straw for bioethanol production

What do you think…

- **How can unsustainable extraction rates be avoided and soil fertility maintained?**
- Which further issues do you consider relevant for sustainable straw provision for bioethanol production?

Topic II

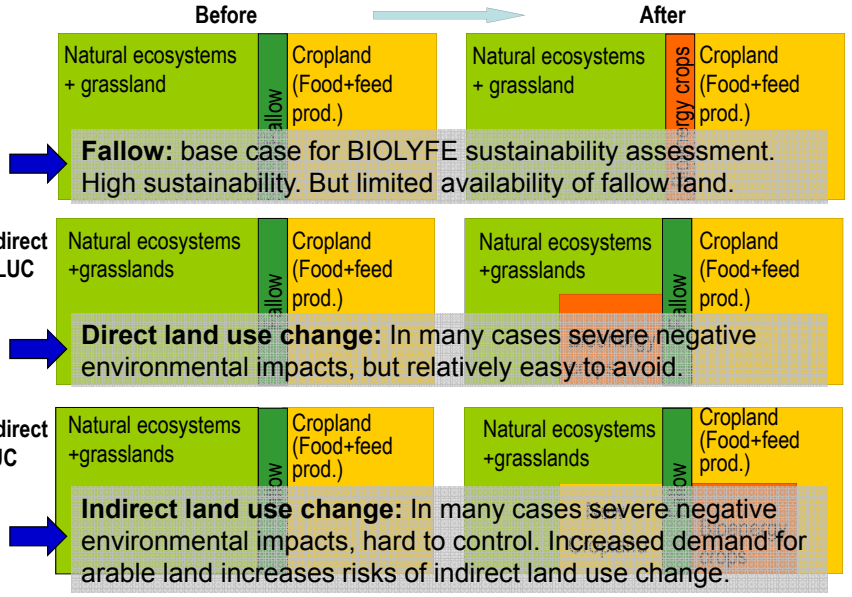
Cultivation of bioenergy crops: The issue of land availability and land allocation

Why is this important?

- **Dedicated bioenergy crops (example: Arundo!) → land needed for cultivation**
- **Type of land used for cultivation and the previous use of this land highly affects sustainability**

Further SWOT arguments for cultivation of herbaceous bioenergy crops: table 3-6, p. 3-11 of the hand-out

The issue of land use change (LUC)



Arundo cultivation **on fallow land**

Strengths and opportunities:

- Contribution to rural development, income opportunity for farmers
- Contribution to climate change mitigation
- Fallow land is cheap land → good economic performance

Weaknesses and threats:

- Invasiveness
- Alteration of hydrological regimes

Arundo cultivation **on crop land**

Strengths and opportunities:

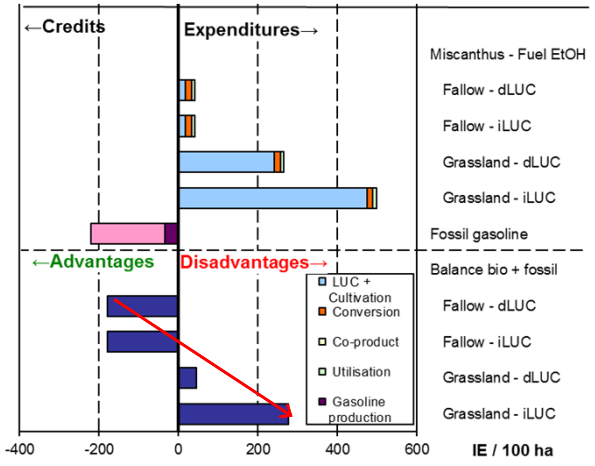
- Lower erosion risks compared to most other crops (in particular compared to annual crops)
- Reduced fertiliser and pesticide application on the arundo plantation

Weaknesses and threats:

- Invasiveness, alteration of hydrological regimes
- **No additional jobs in agriculture**
- **Displacement of food crops** → risk of rising food prices, severe risk for social sustainability
- **Risk of displacement of natural ecosystems** in other parts of the world (indirect land use change) → risks of **increased GHG emissions**, **biodiversity losses, negative social impacts for local populations**

Land use change effects on GHG balances

Example: dLUC und iLUC effects on GHG balances of Miscanthus (used for production of 2nd generation bioethanol as a fuel)



Source: Rettenmaier et al. 2010: N. Rettenmaier, S. Köppen, S.O. Gärtner, G.A. Reinhardt: Life cycle assessment of selected future energy crops for Europe. Biofuels, Bioproducts and Biorefining, 11/2010; 4(6), pp. 620-636 ;

Arundo cultivation **on marginal land**

Arundo has some properties making it suitable for cultivation on marginal fallow lands:

- **resistant to stagnant moisture**
- **tolerant to salinity, even marshlands**
- **established plant is drought resistant**
- **can survive low temperatures when dormant (i. e. in winter).**
- **tolerant to the presence of toxic metals (such as cadmium, nickel, arsenic and lead) in the rhizosphere**

But: On marginal land

- **the yields are often lower!**
- **harvest and transport costs might be higher**
- **biomass properties might be less suitable (contamination!)**

→ may negatively affect economics

Discussion II

Land availability and land allocation

What do you think…

- **What favours (and what hinders) cultivation of Arundo donax (or other perennials) on marginal and fallow land?**
- **What is needed to avoid a crowding-out of food crops?**
- Which further issues do you consider relevant for the sustainable cultivation of perennial bioenergy crops?

BIO LYFE

Topic III

Cooperation with farmers

Why is this important?

- **No supply of agricultural biomass without cooperation of farmers**
- **Cooperation between bioenergy plants and farmers not yet fully established**

Further SWOT arguments:
table 3-7, p. 3-12 of the hand-out

Strengths and opportunities:

- Arundo: cultivation can be an income opportunity for farmers
- Arundo: is easy to cultivate (not very pest sensitive, low fertiliser demand, low quality requirements)
- Straw: Straw selling is income opportunity for farmers

Weaknesses and threats:

- Arundo: Farmers lack knowledge and experience
- Arundo: Farmers bind themselves for many years to Arundo cultivation
- Arundo: Other crops may provide higher earnings per hectare
- Arundo on marg. land: Farmers might not have access to marginal land
- Straw: Farmers will not sign long term contracts → risks for feedstock security for bioethanol plant

Discussion III

Cooperation with farmers

What do you think…

What hinders farmers (and what motivates them)

… to cultivate herbaceous perennial crops (e.g.: Arundo) for bioethanol production?

… to cultivate Arundo and other robust perennials on marginal land?

… to sell straw for bioethanol production?

Topic IV

Infrastructure and logistics

Why is this important?

- **Large amounts of biomass have to be transported and stored**
- **Infrastructure for large-scale 2nd generation bioethanol plants not yet established**

Further SWOT arguments:
table 3-7, p. 3-12 of the hand-out

Strengths and opportunities:

- Arundo: flexible harvesting time → less storage capacities needed
- Straw: low moisture content at harvest, in most cases no technical drying needed

Weaknesses and threats:

- Arundo: partly too high moisture content at harvest → drying needed for storage
- Straw: Only one harvesting time per year (in most regions) → has to be stored year round. Harvest time is in a period with high agricultural work load
- Arundo on marginal land: Marginal land is often located in remote areas → infrastructure not fully developed even in Europe

Discussion IV

Infrastructure and logistics

What do you think…

What are bottlenecks and challenges for infrastructure and logistics?

…for straw?

…for arundo?

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Topic V

Acceptance issues and public support

Why is this important?

- **2nd gen. BioEtOH still depends on public support**
- **Public support depends on public acceptance**
- **Note: Sustainable value chains increase acceptance**

Further SWOT arguments:
table 9, p. 15-16 of the hand-out

Strengths and opportunities:

- Politics: Funding available for research and development → because of contribution to energy security, climate change mitigation and rural development
- Population: Higher acceptance compared to 1st generation biofuels (food vs. fuel debate!)

Weaknesses and threats:

- Low acceptance for biofuels because of food vs. fuel debate in many regions
- Low acceptance because of expected negative environmental impacts
- Low acceptance amongst some car drivers, flexfuel cars for E85 rare in Europe

Discussion V

Acceptance and public support

What do you think…

What hinders and what favours public acceptance and market access?

What kind of public support is needed? And what are the advantages and pitfalls of each measure?

Topic VI

Economics of 2nd gen. BioEtOH

Why is this important?

- **There will be no 2nd gen. BioEtOH on the long run if it turns out to be not economically competitive**

Further SWOT arguments:
table 9, p. 15-16 of the hand-out

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Economic performance

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Strengths and opportunities:

- Rising oil prices
- Runs on low price biomass
- Technological developments may further increase efficiency and lower costs

Weaknesses and threats:

- Still immature technology → relative performance compared to other biofuel technologies not yet clear
- High costs for enzymes
- High energy demand for pre-treatment and product separation
- High investments needed
- Economic only at large scale (risks for feedstock scarcity or high biomass provision costs)

Discussion VI

Economics

What do you think…

What are the main economic risks for 2nd generation bioethanol plants (and biomass providers)? And how can these risks be overcome?

Discussion VII

What do you think…

Which further issues are relevant and should be mentioned in this discussion?

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How to continue

- **Please return your concepts cards to the table at the back of the conference room**
- **Please return the completed questionnaires to table at the back of the conference room (until closure of conference on Friday)**
- **If you have further comments: We would appreciate to receive your email! You can find our email addresses on in the hand-out document (first page)**

A summary of the workshop results will be available at the conference web page

Acknowledgement

David Chiaramonti
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