

**DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INDUSTRY
COMMITTEE FOR SCIENTIFIC AND TECHNOLOGICAL POLICY**

Working Party on Biotechnology

ISSUES PAPER FOR THE OECD WORKSHOP ON "SUSTAINABLE BIOMASS DRIVES THE NEXT BIOECONOMY"

10-11 June 2014

This document is a background report for discussion at the Workshop on "Sustainable Biomass Drives the Next Bioeconomy", to be held on 10-11 June 2014.

It is based on short papers from speakers at the workshop. They were asked to provide information related to the topic of their presentation with the following structure:

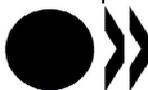
- *The current situation;*
- *How their work might advance the situation; and*
- *Public policy options to act as enablers and/or to remove barriers.*

For further information, please contact: Kathleen D'Hondt; Email: kathleen.dhondt@oecd.org or Jim Philp; Email: james.philp@oecd.org; Jacqueline Allan; Email: jacqueline.allan@oecd.org

JT03358600

Complete document available on OLIS in its original format

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.



**ISSUES PAPER FOR THE OECD WORKSHOP ON “SUSTAINABLE BIOMASS DRIVES
THE NEXT BIOECONOMY”**

10-11 JUNE 2014

OECD Headquarters, Paris

ABSTRACT

This report is organised as follows:

- An introduction, extracted from a short policy paper published by OECD and Dutch government officials (Pavanan et al., 2013);
- Objectives of the workshop;
- Speakers’ papers; and
- Annex 1 containing the agenda.

An official report will be made available after the Workshop.

TABLE OF CONTENTS

ABSTRACT.....	2
INTRODUCTION	5
Biomass sustainability and certification: many issues for the policy maker	5
Drivers for biomass sustainability	5
Measuring biomass sustainability	6
How much biomass can actually be grown sustainably?	7
Other societal challenges.....	7
REFERENCES	8
OBJECTIVES OF THE WORKSHOP.....	9
SPEAKERS’ PAPERS.....	10
METHODS AND APPROACHES TO ESTIMATE GLOBAL BIOMASS POTENTIALS.....	10
Abstract	10
Introduction	10
More efficient use of biomass	10
Sustainability of biomass production	11
More biomass cultivation	12
Global biomass potential in 2050.....	12
THE “BILLION TON UPDATE”: METHODOLOGIES AND IMPLICATIONS	14
Abstract	14
Current Status	14
Future Efforts	14
Implications	15
REFERENCES	16
LCA, ENVIRONMENTAL FOOTPRINT AND ALTERNATIVE APPROACHES.....	17
Abstract	17
The current status	17
How will it or should it evolve?	18
Required policy measures	19
A NOVEL INDEX APPROACH FOR MEASURING BIOMASS SUSTAINABILITY	20
Introduction	20
Current benchmarking tools	20
An index approach.....	21
Policy decisions	21
Conclusions	22
REFERENCES	23
MEASURING ILUC: PROBLEMS AND PROGRESS	25
Abstract	25
What is ILUC?	25
Why do we have ILUC?	25

Current issues with ILUC	26
Future potential of ILUC	27
Future Policy Options.....	27
SUSTAINABLE PRODUCTION OF BIOFUELS FROM FEEDSTOCK GROWN ON MARGINAL LANDS	28
Abstract	28
Current status.....	28
Two challenges.....	28
Future directions.....	29
Policy options.....	30
REFERENCES	32
HOW DOES SIGNIFICANTLY INCREASING BIOMASS PRODUCTION IMPACT LAND USE – CASE STUDY FROM BRAZIL	33
Abstract	33
Sugarcane cultivation today	33
Combining future growth with land use planning.....	34
What’s next ?.....	34
INDUSTRIAL MATERIAL USE OF BIOMASS: VALUE ADDED AND SUSTAINABLE FEEDSTOCK, FOOD OR NON-FOOD: WHICH AGRICULTURAL FEEDSTOCKS ARE BEST FOR INDUSTRIAL USES?	36
Abstract	36
Current status.....	36
Future directions.....	37
Policy options.....	39
REFERENCES	40
ANNEX 1	41

INTRODUCTION

1. There was a time when we lived off the land, in what we could have called a bioeconomy. The large crude oil discoveries in the mid-20th century changed the way we live. Now, however, the grand challenges being posed to our society are causing us to rethink the future. These challenges include climate change, energy security, rural regeneration and the need for economic growth without environmental damage. This calls for a new bioeconomy in which sustainably grown and harvested biomass becomes an industrial raw material.

2. The grand challenges for humanity include energy security, food security, climate change and a growing world population. They are all linked together by an instinctive, and yet increasingly complex and evolving concept, that of sustainability. Industrial biotechnology is seen as part of the overall solution, principally to combat climate change and strengthen energy security. At its beating heart is a huge policy challenge – the sustainability of biomass.

Biomass sustainability and certification: many issues for the policy maker

3. The concept of sustainable development has been defined rather simply as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.¹ Such a simple definition, however, lends itself to almost infinite malleability. Biomass sustainability alone is a tangled web of interlinking research, business, logistics, environmental and social issues.

Drivers for biomass sustainability

4. Biomass is the fourth largest energy source after coal, oil and natural gas. Bioenergy is the most important renewable energy option, at present and in the medium-term (Ladanai and Vinterbäck, 2009), although at present the amount of modern bioenergy produced is still outweighed by traditional forms like simple wood ovens (Chum et al., 2011). But the use of biomass for biobased production in ambitious bioeconomy plans is fraught with the risk of unsustainable, over-exploitation of natural resources.

5. We have come to rely so heavily on crude oil for fuels, chemicals and materials that we practically cannot live without it. It is clear that crude oil reserves, no matter how many more are discovered, are ultimately finite. Many publications support the contention held by many independent institutions that conventional oil production may soon go into decline (Owen et al., 2010).

6. Anthropogenic greenhouse gas (GHG) emissions are now considered to be inextricably linked to climate change and global warming. The most important of these is CO₂ (Pachauri and Reisinger, 2007). Over 100 countries have signed up to trying to limit the average temperature rise to 2°C or below (relative to pre-industrial levels) (Meinshausen et al., 2009). Drastic reductions in GHG emissions are required:

¹ Our Common Future (1987), www.un-documents.net/our-common-future.pdf

developed countries as a group would need to reduce their emissions by 40% to 95% compared to 1990 levels by 2050, even if developing countries also make significant contributions (Gupta et al., 2007).

Measuring biomass sustainability

7. Generating a quantitative (numerical) or semi-quantitative scale of sustainability is beguiling, as it implies uniform comparability that would lend itself to certification and international harmonisation. Certification is the process whereby an independent third party assesses the quality of data in relation to a set of predetermined standards. These are mostly formulated as criteria that have to be fulfilled for the certification of a product or process.

8. Critical to generating the criteria are the quality and quantity of indicators that are used in their derivation. The Global Reporting Initiative² (GRI) cites 36 indicators that seem to be related to sustainability. For efforts in international harmonisation, however, a small number of critical indicators is necessary, or the task becomes unwieldy.

9. International harmonisation requires not only robust analysis, but consensus, and the latter is often more difficult to achieve. The experience of van Dam and Junginger (2011) is illustrative. Based on responses to a questionnaire sent to international stakeholders from 25 European and 9 non-European countries, the respondents rated the following three sustainability criteria with the highest scores in terms of relevance to include in a biomass and bioenergy certification system:

1. Minimization of GHG emissions (87% of respondents);
2. Optimization of energy balance (81%);
3. Protection of water quality and quantity (76%).

10. However, there was much disagreement e.g. optimisation of energy balance was not a high priority in some European and non-European countries. Instead, minimisation of deforestation was given very high priority in these countries. There was only agreement amongst the respondents that a criterion on the minimisation of GHG emissions should be included, and that the other two above were considered “highly relevant”. Moreover, social criteria are sometimes regarded as low in reliability and practicability, and tend therefore to be assigned a low ranking.

11. The most common tool for such measurements is Life Cycle Analysis (LCA). LCA is not relevant to financial and social criteria, however, and is therefore sub-optimal for measuring biomass sustainability. Conversely, when other tools such as Living Planet Index (LPI), City Development Index (CDI), Human Development Index (HDI), and Environmental Performance Index (EPI) are applied, they often fail to meet scientific criteria.

12. An alternative, more efficient approach may be to apply a market solution. Total Factor Productivity (TFP) has been used routinely in assessing agricultural economic productivity, and it may be possible, by incorporating environmental (Glendining, 2009) and social criteria, to make a single index of sustainability of commodities based on price-related productivity measures.

² www.globalreporting.org/

How much biomass can actually be grown sustainably?

13. Several studies have tried to estimate the available amount of biomass in Europe and worldwide, now and into the future. All these studies show large uncertainties. Europe is an interesting case as it has limited land availability for growing biomass, and ambitious bioeconomy plans. The total supply of sustainable biomass in 2030 may be enough to fulfill the demand of a 10% biobased economy (PBL Netherlands Environmental Assessment Agency, 2012).

14. The United States position is more favourable. A US Department of Energy report (US Department of Energy, 2011) demonstrates the feasibility of scenario assumptions for a US billion ton biomass resource, capable of displacing 30% of the nation's petroleum consumption. Several important assumptions are required, however, and they require strong policy support.

15. Therefore bioeconomies will either grow unevenly across the globe, or biomass will be traded internationally. The European Union is one region which will probably depend on the world market to supply its bioeconomy with biomass in the future.

Other societal challenges

Financial. Energy infrastructure investment decisions are expected to total over USD 20 trillion (Pachauri and Reisinger, 2007) between 2005 and 2030, and these will have a long-term impacts on GHG emissions, because of the long lifetimes of energy plants and other infrastructure capital stock. Biofuels are attractive in that the changes to the global energy infrastructure would be less than for other new forms of energy. However, the strain on biomass availability in a bioeconomy would be greatest by using biofuels as road transport fuels.

Land use changes. The Intergovernmental Panel on Climate Change (IPCC) reported that current agricultural land use and land conversion contributions to GHG emissions (CO₂, CH₄ and N₂O) are globally estimated to be at least 2.5 times greater than the total emissions from global transport (Smith et al., 2007). Quantifying these emissions, especially from indirect land use change (ILUC) remains a great challenge and it is therefore difficult to include them into sustainable criteria.

Biomass disputes and their settlement. Biomass sustainability disputes have already begun appearing, and are predicted to increase in the future as pressure on fertile land increases. The situation is serious enough to have warranted exploration of the feasibility of setting up an international biomass dispute settlement facility (The Hague Institute for Global Justice, 2012). Biomass disputes relate to human rights issues (land rights, worker's rights, local economies), environmental issues (effects on soil, land, air, biodiversity and climate) and economic issues (international trade, market distortions, property rights and business-to-business conflicts). The global sustainable biomass governance system is a patchwork of a large number of voluntary standards and regulations, and it is thought that a dispute settlement facility would lend it credibility and legitimacy.

REFERENCES

- Chum, H. et al (2011) Bioenergy. In Intergovernmental Panel on Climate Change Special Report on Renewable Energy Sources and Climate Change Mitigation, Cambridge University Press, Cambridge, UK
- van Dam, J. and M. Junginger (2011) Striving to further harmonization of sustainability criteria for bioenergy in Europe: Recommendations from a stakeholder questionnaire. *Energy Policy* 39, 4051–4066
- Glendining, M.J. (2009) Is it possible to increase the sustainability of arable and ruminant agriculture by reducing inputs? *Agric. Systems* 99, 117-125
- Gupta, S. et al. (2007) Policies, Instruments and Co-operative Arrangements. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. B. Metz *et al.* (eds), Cambridge University Press, Cambridge, UK
- Ladanai, S. and J.Vinterbäck (2009) Global potential of sustainable biomass for energy. SLU, Swedish University of Agricultural Sciences Department of Energy and Technology. Report 2009:013, ISSN 1654-9406
- Meinshausen, M. et al. (2009) Greenhouse-gas emission targets for limiting global warming to 2°C. *Nature* 458, 1158-1163
- Owen, N.A. et al. (2010) The status of conventional world oil reserves—Hype or cause for concern? *Energy Policy* 38, 4743–4749
- Pachauri, R. K. and A. Reisinger (eds) (2007) In Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK
- Pavanan, K.C., R.A. Bosch, R. Cornelissen and J.C. Philp (2013). Biomass sustainability and certification. *Trends in Biotechnology* 31, 385-387
- PBL Netherlands Environmental Assessment Agency (2012) PBL Note. Sustainability of biomass in a bio-based economy. A quick-scan analysis of the biomass demand of a bio-based economy in 2030 compared to the sustainable supply. PBL Publication number 500143001, 22 pp
- Smith, P. et al. (2007) Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. B. Metz *et al.* (eds), Cambridge University Press, Cambridge, UK
- The Hague Institute for Global Justice (2012) Exploring the opportunity for a biomass dispute settlement facility. M. Taanman and G. Enthoven (authors), 43 pp
- US Department of Energy (2011) US Billion-ton update: biomass supply for a bioenergy and bioproducts. R.D. Perlack and B.J. Stokes (Leads) ORNL/TM- 2011/224, Oak Ridge National Laboratory, Oak Ridge, TN, 227 pp

OBJECTIVES OF THE WORKSHOP

The objectives of the workshop are to exchange information on the role, availability and limitations of biomass as a driver of the bioeconomy and how all these are related to food-feed production. How can policies help to overcome barriers and contribute to stimulate the bioeconomy? The workshop should draw the bigger picture, stimulate discussion and lead, hopefully, to more cooperation between participants on this important topic.

SPEAKERS' PAPERS

METHODS AND APPROACHES TO ESTIMATE GLOBAL BIOMASS POTENTIALS

Jan ROS
PBL Netherlands Environmental Assessment Agency
The Netherlands

Abstract

The availability of sustainable biomass as a future substitute for fossil resources is dependent on the available land for biomass cultivation and options to use the biomass produced in agriculture and forestry more efficiently. Based on current flow schemes of biomass over the world the potential to use more biomass for new applications without disturbing current applications can be assessed. An analysis of the current biomass flows and scenario studies including sustainability criteria provide more insight in the possibilities to support a larger bio-based economy in 2050.

1. In case of very strict sustainability criteria and many practical barriers to use more of the residues and wastes, probably 50 EJ of biomass would be the future potential. In a more optimistic view about 400 EJ could be produced. However, the realisation of a future supply of about 150 EJ in a sustainable way is already quite challenging. In the development of strategies to realise a global reduction of greenhouse gases in line with a maximum increase of temperature of 2°C it would be sensible to assume a limited future potential for bioenergy and develop enough clean alternatives to avoid disappointments.

Introduction

2. Bioenergy is becoming increasingly a prerequisite to achieve emission reduction targets of greenhouse gases and improve the security of energy supply. The biomass availability for applications can be increased by producing more biomass and using the biomass more efficiently. However, in both cases there are important restrictions. Firstly, bioenergy should not be promoted at the expense of current applications of biomass, with the highest priority for food security. Secondly, biomass must be produced in a sustainable way, meaning in a way the net releases of greenhouse gases into the atmosphere are reduced and biodiversity is spared.

3. In this short paper, the current biomass flows and the potential to use it more efficiently are discussed as well as scenarios to produce more biomass in future.

More efficient use of biomass

4. In the current situation (2010) about 400 EJ of biomass are produced and harvested all over the world. Most of the bioenergy is coming from wood (about 50 EJ) with an important share for direct use in households in developing countries. It is not clear to what extent this biomass is harvested in a sustainable way. Only a small part of the energy in agricultural crops is actually used for bioenergy (about 11 EJ).

5. The energy content of agricultural crops including their residues produced across the world is estimated at 200 EJ, grass- and rangelands produce about 115 EJ. Both mainly deliver the inputs to the human food system. Most of the energy is not available for the energy system, because it is vital in the livestock system and also for people i.e. energy to live. If the unused and sometimes burned crop residues would be used for energy, the extraction could increase with about 24 EJ. In this assumption sustainable soil carbon management is considered (roughly half of the above-ground carbon should remain in the soil). Other potential energy sources are better use of waste flows from industrial processing and consumption. This could produce an additional 21 EJ.

6. In the current situation, there is considerably more wood fuel than wood for other purposes like timber products and paper and for forest residues (together 17 EJ). Part of the primary forest residues and dead wood that is currently left in the forest (globally also about 17 EJ per year) can be harvested for bioenergy. Furthermore, a lot of wood products end up in landfills. The amount of wood waste for energy can considerably increase over the coming decades, also because the stock of wood in our society is still increasing (at this moment 15 EJ is produced, 7 EJ comes out as waste). So, on the long term, more wood waste can be expected.

7. The step from potential to (large scale) energy production requires an balanced and efficient chain of biomass producers, the agro- sector and the forestry sector, and a proper transport infrastructure (road, rail and water). All these conditions need to be fulfilled in order to keep the costs as low as possible and make the investments profitable. In developed regions such conditions are common and further up-scaling of biomass use seems feasible. In developing regions in many cases the basic structures are lacking: road and transport infrastructure is limited and the agricultural production is often small scale farming, characterised by low inputs and traditional organic soil management, and less organised. These are serious obstacles in the development of bioenergy especially in less developed regions.

8. The given numbers for a larger potential supply of biomass for energy are related to primary biomass production in 2010. In a world with a growing population and expected economic growth in many countries the demand for biomass products such as food will further increase. Therefore, also more residues and wastes will be produced. However, in not all cases can a linear relationship be assumed, especially not in agricultural production. Crop productivity may increase, but it is foreseen that the development in plant genetics will focus on the most valuable part of the crops and not its residue. The consequence is that the residues will not increase as much as the crops.

Sustainability of biomass production

9. The sustainability of biomass is often associated with issues such as indirect land use change (ILUC) for the production of more agricultural crops for energy or the carbon debt for expansion of wood felling. In Europe, getting an agreement on sustainability criteria has been an ongoing process for many years already.

10. The problem with indirect land use change is that it cannot be measured directly, because the indirect effects may appear anywhere. The interaction between the bioenergysub-system and the larger global system is very complex. Many model calculations have made clear greenhouse gas emissions related to indirect land use change may be considerable, but the results are sensitive to a lot of model parameters. Although indirect emissions cannot be predicted very precisely, it can be concluded that there is a big risk of negative impacts, also on global biodiversity.

11. Wood growth and natural decay both take time, and this is an important aspect of sustainability assessments of wood used for energy. Wood taken from forests can be regarded as a carbon-neutral energy source, but it takes time, sometimes many decades, to close the carbon cycle. In practice, it is not only

about the regrowth time. Additional felling reduces average growth rates in many forests and thus the sequestration of carbon. The main reason is that old trees take up much more CO₂ than young trees, the substitutes for the harvested old trees. Therefore, the use of wood from felling as a substitute for fossil fuels may lead to an increase instead of a reduction of greenhouse gas emissions for many decades.

12. Short rotation plantations, perennial crops or fast-growing trees, on agricultural land may be an option, but in these cases there are similarities with the direct and indirect land-use change effects related to energy crops. Further analysis is required to enable a clear judgment on the impact of this option.

More biomass cultivation

13. The results of the many studies assessing the future biomass potential for energy vary from zero to more than a 1000 EJ per year. This range is mainly caused by different assumptions on the future area of agricultural land for the cultivation for energy crops without introducing competition with food production. They are based on scenarios for the expansion of the world population, their consumption and the development of agricultural productivities, the yields per hectare. Many studies also consider specific circumstances such as the availability of degraded land (with lower yields), dry land (with water scarcity) and specific sustainability criteria. If the most extreme scenarios are disregarded, in 2050 an extra production of biomass for energy of 40-150 EJ would be possible.

14. However, the risk of indirect emissions due to policy targets creating bioenergy markets cannot be excluded beforehand. If sustainability criteria are assumed to be very strict to avoid any risk of indirect effects, no agricultural land will be available for energy crops at all.

15. Another option is the production of aquatic biomass (like algae). Based on the current situation, the costs are much too high for bioenergy. However, if future development of aquatic biomass would be successful, this type of biomass production could offer new possibilities. It should be realised that any number for its future potential is just a first guess.

Global biomass potential in 2050

16. Based on the presented considerations global biomass potential can be assessed based on three sets of expectations:

High:

- Very productive agriculture, leaving land for energy crops
- Almost all of the sustainably available residues and waste is used
- New developments are quite successful

Mid:

- Agriculture will be more productive, but land for energy is quite limited
- About half of the sustainably available residues and waste is used
- Only a few new developments for niche markets

Low

- Land use for the energy crops is not considered sustainable
- Only a small part of residues and wastes is used
- No new developments

Table 1. Assessment of the global biomass potential for energy in 2050

		Future expectations (EJ)		
		High	Mid	Low
Forests (wood)	Production*	110	45	10
	Production residues	25	15	5
	Waste	20	15	5
Agriculture	Production*	80	25	5
	Production residues	30	15	5
	Waste	45	30	20
Aquatic	All	90	5	0
Total		400	150	50

* The available land is divided between production of woody biomass or energy crops.

17. To bring this potential into the perspective of Europe: if an equal distribution per capita in 2050 is assumed, the potential for Europe (including trade) would be about 10 EJ based on 'mid' expectations. In case of a distribution based on income, it might be twice that potential. However, these are of course just indicative numbers, because future trade is quite uncertain.

THE “BILLION TON UPDATE”: METHODOLOGIES AND IMPLICATIONS³

Bryce STOKES
Senior Advisor
CNJV, U.S. Department of Energy
United States

Abstract

According to a recent Billion Ton Update report, the United States, depending on assumptions made, may be able to produce one billion tons of dry biomass per annum, thus substituting 30% of gasoline requirement with renewable biofuels. This paper discusses that report. Published methodologies for measuring biomass potential are variable and understanding underlying methodologies, assumptions, and analyses is critical. The “Billion-Ton Update” may give leads on how to harmonise the approaches. It is very important to effectively estimate the sustainable capacities for biomass production for both domestic use and international biomass trade.

Current Status

1. The original Billion Ton Report was completed in 2005 to assess the sustainable biomass potential in the U.S. (Perlack et al. 2005). An important conclusion from this earlier work is that the conterminous United States had the potential to sustainably produce a billion tons of biomass annually. The publication initiated much dialogue and debate as to the credibility and significance of this finding. It is considered by some to be a masterful quantification of an otherwise ambiguous and contentious topic. Others took the opportunity to point out the shortcomings of the study. The criticisms of, and the comments on, the 2005 report provide a starting point for the re-evaluation of the underlying data and methodologies.

2. A concentrated effort was made to be responsive to the criticisms and to improve the overall analyses. Over the 5 years after the first publication, updated and additional data and information was secured, and a more rigorous and refined analytical approach was taken to improve the assessment and develop a new report. The “Billion-Ton Update” was published in 2011 (US Department of Energy 2011). Like the original, the study is a “supply” analysis and not a “demand” analysis.

3. Instead of periodic updates, there is an ongoing effort to add improvements and to update as necessary. The report and access to data and results from the report are available on the Bioenergy Knowledge Development Framework (KDF) website.⁴ There are tools on the site to download data, do numerical summaries, and to create maps.

Future Efforts

4. The discussion on improvements between the 2005 and 2011 versions is included to provide insights into completing a national assessment. Many of the changes were made to increase the resolution

³ This paper does not constitute or imply policy of the U.S. Department of Energy or CNJV, LLC. The paper is the sole responsibility of the author.

⁴ www.bioenergykdf.net/content/billiontonupdate

from a national-scale snapshot to a more spatially relevant scale. Other changes (Table 1) are based on reviews and comments received from users of the original report.

Table 1. A summary of the changes.

2005 Original	2011 Update	Comments
Limited number of authors	50 experts contributed	Include government and non-government to enhance expertise and perspectives
No distinction between currently used feedstock and future potential	Accounted for currently used feedstock and estimated potential annually	Clarify future potential under assumptions as compared to current uses
National estimates with no spatial information	All primary feedstocks at a county level and others were at state level	Make data and results available at the finest spatial resolution possible
No economics	Availability based on supply curves	Use supply curves to estimate biomass availability
Sustainability only moderately addressed	Detailed and modeled analysis used to address sustainability	Include and explain sustainability approaches
No land use change	Modeled land use change for energy crops	Ensure that requirements for food, feed, and fiber are met before biomass
Snapshot at the time of report	Annual estimates up to 2030	Make future projections using scenarios

5. With this in mind, in the future biomass assessments should include:

- Adequate and verifiable data and information - Biomass should be considered a commodity just like other agricultural and forest products. Investments need to be made to provide such information;
- Yield – a significant variable in biomass supply is yield, either from residues and wastes or from energy crops. The literature, empirical studies, and expert opinion are used to develop yield estimates. Scenarios incorporated a range of annual yield increases;
- Supply curves – the underlying premise is that of estimating the biomass availability at different prices. Farm gate/roadside costs are developed for each feedstock and modeled to determine biomass availability at a given price;
- Sustainability – this is another important, underlying premise that had to be incorporated into the analysis. Different feedstocks require different approaches. These include using multipliers and coefficients to model certain parameters such as soil carbon retention;
- Land availability and land-use change – land availability is important in estimating biomass production and land-use change is an important sustainability issue. Land competition between conventional crops and energy crops, and among energy crops are modeled.

Implications

- Identify the goal of the assessment – biomass assessments can be very strategic or used in tactical decision-making. Decide upfront as to the primary purpose and use of the tool.

- Decide the level of detail and analysis to reach the goal of the assessment – very detailed assessments are very expensive, but provide the greatest value in knowing and understanding biomass resources. Broad, general assessments have little practical value and utility other than estimating national capacities.
 - Show and explain assumptions – changing assumptions can change the answers; so ensure transparency and careful explanation and supporting documentation.
 - Verify and validate the data and the underlying assumptions and methods – provide all references and explain data transformations and calculations. Use the most current data as possible and show the data if not accessible publicly.
 - Use standard and understandable terminology – explain any colloquial terms or use more standardised terminology and methodology.
 - Be transparent – provide references and explain methods, calculations, and models as discussed above. Transparency provides credibility.
 - Provide all sources of data – reference the timeframe as some data sets are updated periodically.
 - Include all biomass sources – assess terrestrial and aquatic if algae are a potential source.
 - Incorporate sustainability - use international sustainability protocols and model impacts as much as possible with actions for mitigation.
6. Resource sustainability is determined through various analytical methods and modeling.
- Discuss the roles of indicators and options of oversight: Best Management Practices (BMPs), certification, use of protocols, regulatory compliance, etc.
 - Understand and model water impacts – both quality and quantity.
 - Understand landscape effects such as habitat and diversity and quantify the impacts as well as land-use change.
 - Assess the impacts on conventional crops, i.e., the food, feed, and fibre demands into the future.
 - Complete life cycle analyses as appropriate or other assessment so GHG emissions can be estimated.
 - Include all aspects of sustainability – environmental, economics, and social while assessing potential positive and negative impacts.

REFERENCES

- Perlack, R.D., L.L. Wright, A.F. Turhollow, R.L. Graham, B.J. Stokes and D.C. Erbach (2005), Biomass as feedstock for a bioenergy and bioproducts industry: the technical feasibility of a billion-ton annual supply. DOE/GO-102995-2135 or ORNL/TM- 2005/66. Oak Ridge National Laboratory, Oak Ridge, TN. 60 pp.
- US Department of Energy (2011), U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 227p.

LCA, ENVIRONMENTAL FOOTPRINT AND ALTERNATIVE APPROACHES

Franz FIALA, European Association of Consumer Representation in Standardisation (ANEC)
Belgium

Abstract

There is a generally held view that LCA is inappropriate to the assessment of biomass sustainability, for various reasons, including the fact that it does not take social or economic indicators into account. ANEC, the European Association for the Co-ordination of Consumer Representation in Standardisation, argued in a recent document to the EU that LCA indicator results are not even a solid base for environmental communication and decision making.

The current status

1. LCA methodology has unique advantages when analysing the environmental performance of products as it allows in theory – based on an accounting of all relevant material flows throughout the entire life cycle – to obtain a complete picture of certain environmental burdens associated with a product. This enables comparisons across technological boundaries and to identify relevant stages in the life cycle, as well as improvement options.

2. By contrast, LCA methodology features fundamental shortcomings including dependency on numerous subjective choices, need for simplifications, lack of adequate data and limited precision. The history of LCA has shown clearly these constraints with heated debates following publications of comparative studies and accusations of manipulation. In some cases European policy was completely misguided based on flawed LCA results (see e.g. biofuels). These limitations cannot be overcome by another layer of rules in addition to existing standards – they are inherent in the system of life cycle assessment.

3. In addition, LCA is definitely not the definitive tool which can suitably characterise all environmental impacts. Many impacts cannot be reasonably related to reference flows referring to a functional unit and aggregated throughout the life cycle, because the effects are space-, time- and threshold-dependent. Many of the LCA impact categories and models are of questionable scientific validity, are outdated or lack broad support. Sound environmental assessments require a mix of different tools (environmental impact assessment, human health and environmental risk assessment, technology assessment, etc.) taking due account of their strengths and weaknesses.

4. Life cycle assessment is a suitable tool for orientation regarding certain aspects at the onset of indicator development or regulatory requirement setting. It delivers rough estimates rather than precise figures. However, suitable production, consumption or disposal indicators are typically more robust, in many ways more meaningful or relevant, cheaper, they can be measured and are easier to verify (or to enforce).

5. Consumer/purchaser information based on a choice of LCA indicators is a step in the wrong direction – even if linked to rating scales which will often not be possible. The reason is that the poor precision of the method will not allow comparisons of similar products and the establishment of bands comparable to the European Union energy labelling scheme (where, despite well-defined test protocols, tolerances can be as big as the width of one band). Irrespective of this, consumers/purchasers need a clear indication of a superior product – such as the one provided by a traditional type I label. The significance of

(several) life cycle indicator results is difficult to assess even for experts, let alone the average consumer/purchaser. Apart from that, such indicators will be of little interest as they are not related to consumer/purchaser needs. Bombarding consumers/purchasers with such information may meet some advertising needs to give a corporation the glow of sustainability – as in case of questionable carbon footprint labels – but has little to do with provision of sound environmental information to assist purchasing decision making including public procurement.

6. Obviously LCA is an environmental tool which does not address economic and social impacts at all. However, these are crucial for policy decisions, particularly where such impacts are crucial.

How will it or should it evolve?

7. The EU Commission develops a harmonised methodology for the calculation of the environmental footprint of products, services (PEF) and organisations (OEF) with a view to assess, display and benchmark their environmental performance based on a Life Cycle Assessment (LCA) approach. The proposed method is based on existing normative documents on LCA such as the International Reference Life Cycle Data System (ILCD) or ISO 14040/44. In fact, the EF methodologies are by no means new; rather they constitute a remix of existing tools and related guidance. It aims to harmonise existing approaches and provide further guidance to ensure "more consistent, robust and reproducible PEF studies". For instance, 14 impact categories have been defined.

8. A key concept for improving comparability is the development of "Product Environmental Footprint Category Rules" (PEFCRs) for specific products. These will be developed with the cooperation of volunteering stakeholders and industry during a 3-year testing period which started at the beginning of 2014. The objectives of the EF pilot phase are:

- To set up and validate the process of the development of product group-specific rules (Product Environmental Footprint Category Rules – PEFCRs), including the development of performance benchmarks;
- To test different compliance and verification systems, in order to set up and validate proportionate, effective and efficient compliance and verification systems;
- To test different business-to-business and business-to-consumer communication vehicles for Product Environmental Footprint information in collaboration with stakeholders.

9. However, the EF initiative of DG Environment was unfortunately not preceded by an in-depth investigation about fundamental benefits, limitations, usability and cost efficiency of existing approaches including Life Cycle Assessment on the one hand, and a broad discussion about stakeholder perceptions and expectations regarding environmental assessment and related indicators on the other hand. This was a serious omission most likely resulting in a questionable outcome with a potential to constrain future environmental assessment and mislead environmental policy.

10. A reasonable approach must identify the relevant indicators for the relevant products and organisations using a broad range of assessment methods (also including economic and social impacts), and must not follow a one-size-fits-all methodology and collect data for the sake of collecting data. This task cannot be shifted to LCA (or other) service providers but must be taken first at the political level. Hence, it is important to develop a framework for indicator development embedded in the system of political decision making, translating priority environmental concerns and broad target setting into specific quantified environmental demands at the macro level (European Union, member states), as well as organisational and product level.

11. It would have been useful to start the debate about a harmonised methodology from a broader perspective including a discussion about pros and cons of current practices and – based on that – to identify needs for improvement covering all dimensions of the subject in question. Instead, the European Commission embarked on a detailed methodological development in a rather confined way. This may lead to questionable outcomes – the promotion of a rather one-dimensional tool at the expense of well-established approaches and, last but not least, too big and questionable financial burdens for little (if any) benefit. It is time to pause for a rethink. This view is also supported by several business organisations.

Required policy measures

12. From the above the following conclusions can be drawn with respect to policy measures:

- A fundamental review of current LCA rules and practices needs to be conducted, including:
 1. The claimed ability of LCA methodology to comprehensively cover all relevant aspects of natural environment, human health and resources throughout its life cycle;
 2. The limitations of the LCA approach regarding value-choices, subjective scenarios, simplifications, exclusion of spatial and temporal, threshold and dose-response information;
 3. The limitations regarding the precision of LCA results due to constraints of data availability and quality;
 4. The scientific validity of impact assessment categories and models;
 5. The coverage of environmental aspects which cannot be quantified (biodiversity) or are difficult to predict (persistent chemicals);
 6. The limitations of using LCA indicator results for communicating environmental performance such as declarations or labelling;
 7. The cost efficiency of the approach;
 8. Evidence for its usability in practice (product comparisons and benchmarking) and its usefulness regarding policy making;
 9. The need for democratic and balanced stakeholder involvement in conducting life cycle studies, most notably where the results are used in a public policy context.
- Possible complementing and/or alternative environmental assessment and communication approaches using indicators which are tailored to specific product groups, more relevant, more robust, better verifiable and more cost effective should be discussed;
- Qualitative indicators (e.g. compliance with organic farming standards) are also to be seen as an essential element of environmental assessment and information;
- Indicators should focus on aspects of considerable concern (KPIs) with significant improvement potentials;
- Economic and social impacts need to be taken into consideration, such as effects on food supplies and prices as a result of biomass/biofuel production and appropriate methodologies for this need to be developed;
- An adequate forum involving a broad range of stakeholders for the critical review of LCA methodology and possible alternative approaches for the assessment of product systems independent of commercial interests and of LCA practitioners should be identified or established and the work should be sufficiently funded.

A NOVEL INDEX APPROACH FOR MEASURING BIOMASS SUSTAINABILITY

*Daniel Gaitán-Cremaschi¹, Miranda P.M. Meuwissen¹, Alfons G.J.M. Oude Lansink¹, Don. M. Jansen², Frits K. van Evert², Roeland Bosch³, Mattheüs van de Pol³

Introduction

1. The demand for biomass is projected to increase in the coming years as a result of the fast-growing global population and the transition towards a bio-based economy. This will have direct and indirect effects on human well-being (climate change, over-exploitation of natural resources, competition for land use, changing land-use patterns, loss of biodiversity, energy and food insecurity). [1,2,3,4] There is serious concern about whether biomass demand is met in a way that respects the three pillars of sustainability, i.e. the integrity of the natural system, social equity and the economy. [5,6]

2. It is expected that governments and/or companies will want to treat imported biomass differently on the basis of how sustainably it was produced. When this leads to barriers to exports or imports of biomass, it is likely that conflicts will arise. A commonly accepted measure of sustainability is a first condition to negotiate a settlement of such conflicts [7], but current labels and standards (e.g. UTZ Certified, Fair Trade) are not commonly accepted. Policy makers and business stakeholders have expressed the need for an internationally accepted tool to discriminate sustainable biomass production. Thus, the objective of this research is to develop a tool that can be used to compare the sustainability of various sources of the same type of biomass product: a tool for benchmarking of biomass in terms of its sustainability.

Current benchmarking tools

3. The environmental impact of producing a commodity is typically determined by performing a Life Cycle Assessment (LCA). LCA gives a detailed description of the environmental impact resulting from delivering a good or a service. LCA is widely accepted as the best available method of assessing environmental impact, but other commonly used methods include the ecological footprint? [8] food miles, [9] eco-efficiency [10] and the Overall Business Impact Assessment (OBIA). [11]

¹Business Economics Group, Wageningen University and Research Centre, The Netherlands

²Plant Research International, Wageningen University and Research Centre, The Netherlands

³Ministry of Economic Affairs, The Netherlands

4. However, the major limitation of all above methods is their inability to aggregate the different sustainability issues in an objective way. Aggregation requires making complicated trade-offs between sustainability aspects with different dimensions such as kilograms of CO₂ emissions and hours of child labour; such trade-offs are normally not in the mind set of people. At this point, practitioners can only generate an overall sustainability number by using their own weighting factors when aggregating the different impact categories and this introduces an undesirable subjectivity. A second important limitation of the methods is that they have failed to incorporate the social implications of biomass production. [12,13,14,15] Thus, the above methods have limited usefulness for the purpose of measuring sustainability of biomass in international trade flows.

An index approach

5. We propose an index approach for sustainable benchmarking of biomass production chains based on the concept of Total Factor Productivity (TFP). [16,17,18,19,20] The general idea of TFP is that it reflects the rate of transformation of inputs (capital, labour, materials, energy and services) into outputs (biomass stock), where negative social and ecological externalities associated to different sustainability issues are included in terms of “bad” outputs. For example, the outputs of a soy production system may include soy oil and soy meal and the inputs of the same soy system may consist of land, seed, labour, pesticides and fossil fuel. The use of fossil fuel emits greenhouse gases to the atmosphere contributing to climate change (this last output is a “bad” output of soy production). The quantification of outputs and inputs needed for the index may partly be obtained from an LCA analysis. The TFP index takes the analysis one step further in that it incorporates the several *sustainability issues into a single measure of sustainability*. Hence, the index facilitates the integration and comparison of sustainability issues affecting human well-being at different temporal and spatial scales. Thus, a biomass chain with the best sustainability performance, i.e. the highest TFP score, is the one that produces the highest ratio of output to input where the “bads” are output penalties that lower the sustainability performance. Multiple chains with different sets of outputs and inputs can be compared using the TFP index.

6. In order to use the TFP index, the multiple input-output variables must be expressed using a common denominator. One solution is to use prices that reflect the relative importance of input and output variables towards sustainability. In this solution, observed prices can be used for the marketable inputs and outputs and shadow prices need to be estimated for externalities that are non-tradable in conventional markets, and therefore, related price information does not exist. TFP indexes using (shadow) prices reveal the relative performance of a biomass production chain reflected in the form of price signals. A second solution for aggregating multiple inputs and outputs into a single index is the use of distance functions. This solution is based on input and output quantity information (including “bads”) as the way to identify a sustainable frontier of the production possibilities set. [21]

Policy decisions

7. The tool we are proposing could be used by the OECD and others, e.g. retailers, to compare the sustainability level of various biomass stocks that are produced at different locations and in a variety of socio-economic contexts. The tool is sufficiently flexible to allow aggregation of different sustainability issues. We aim to secure acceptance of the tool by consulting with all stakeholders (policy makers, business stakeholders, NGOs) on:

1. The selection of sustainability issues (i.e. the inputs and outputs); and
2. The method for aggregating multiple input and output variables in the TFP index.

Selection of sustainability issues: even though the definitions and perceptions of sustainability vary, the selection of inputs and outputs should be based on the issues of sustainability that are of established concern for expert scientist communities, policy makers and to society's well-being, such as global warming, energy, innovation, human rights, equity, land use, etc. Hence, application of the TFP index requires a common base level of sustainability, which could be defined from regional, national and/or international biomass sustainability debates [22]. It should consist of a limited number of input and output variables, enough to convey information regarding the level of sustainability of biomass production chains. Nevertheless, it might be flexible in such a way that additional context specific requirements that are in line with policies at different institutional levels could be incorporated.

Selection of aggregation method: there may be debate among stakeholders about which aggregation method to use (i.e. through prices or distance functions). While each of the two methods has merits, the main advantage of aggregating sustainability issues using price information is that it can be applied to benchmark biomass production chains as long as data for two or more units is available. This is in fact a benefit with respect to the policy decision-making process in data-poor situations, where information about different sustainability issues is still lacking. Nevertheless, it requires making decisions about the importance of different sustainability issues expressed in the "true" shadow price. These decisions imply incorporating social, political, and ethical values in monetary terms, which are often conflicting with each other due to spatial and temporal scales, i.e. from the short-term, site level to the long term, global level, upon which the stakeholders are affected by the externalities arising from biomass production [15]. Economic valuation tools can be used to facilitate and support the estimation of shadow prices for decision making.

8. In contrast, the use of distance function based methods allows easily integrating multiple environmental and social externalities without requiring (shadow) prices. Nevertheless, it requires a large set of observations for the multiple inputs and outputs to be included in the sustainability assessment.

Conclusions

9. Regarding sustainability, the OECD may be able to play a similar important role in mitigating conflicts in biomass trade as the organisation has done in the past thirty years on the issues of producer and consumer support through the system of Producers Support Estimate (PSE). The proposed new tool is promising to make such mitigation feasible as it allows an integrated assessment of the sustainability of imported biomass and bio-industrial products. Hence, we recommend the OECD to adopt this research and to actively participate in further development, as it is uniquely placed to facilitate the required interaction of research and policy making. Members of the OECD could play an important role in consensus building on the inclusion of which various components of sustainability and on the desired aggregation method.

REFERENCES

- [1] Yakovleva, N. 2007. Measuring the sustainability of the food supply chain: a case study of the UK. *Journal of Environmental Policy & Planning* 9, 75-100.
- [2] Butchart, S.H.M., M. Walpole, B. Collen, A. Van Strien, J.P.W. Scharlemann, R.E.A. Almond, J.E.M. Baillie, B. Bomhard, C. Brown, J. Bruno, K.E. Carpenter, G.M. Carr, J. Chanson, A.M. Chenery, J. Csirke, N.C. Davidson, F. Dentener, M. Foster, A. Galli, J.N. Galloway, P. Genovesi, R.D. Gregory, M. Hockings, V. Kapos, J-F. Lamarque, F. Leverington, J. Loh, M.A. McGeoch, L. McRae, A. Minasyan, M.H. Morcillo, T.E.E. Oldfield, D. Pauly, S. Quader, C. Revenga, J.R. Sauer, B. Skolnik, D. Spear, D. Stanwell-Smith, S.N. Stuart, A. Symes, M. Tierney, T.D. Tyrrell, J-C. Vié and R. Watson (2010). Global biodiversity: indicators of recent declines. *Science*, 328, 1164-1168.
- [3] Dirzo, R. and P.H. Raven (2003), Global state of biodiversity and loss. *Annual Review of Environment and Resources* 28, 137-167.
- [4] Jackson, L.E., U. Pascual and T. Hodgkin (2007), Utilizing and conserving agrobiodiversity in agricultural landscapes. *Agriculture, Ecosystems & Environment* 121, 196-210.
- [5] Färe, R., S., S. Grosskopf, T. Lundgren, P.O. Marklund and W. Zhou 2012. Productivity: should we include bads? *CERE Working Paper, 2012:13*. Umeå, Sweden: CERE, Centre for Environmental and Resource Economics, SLU and Umeå University, Umeå, Sweden.
- [6] Junginger, M., C. S Goh, A. Faaij, L. Pelkmans, L. Goovaerts, C. Goh, M. Junginger, J. Dam, I. Stupak, C.T. Smith, H. Chum, O. Englund, G. Berndes, A. Cowie, E. Thiffault, U. Fritsche and D. Thrän (2014). The role of sustainability requirements in international bioenergy markets. *International Bioenergy Trade*. Springer Netherlands.
- [7] Pavanan, K.C., R.A. Bosch, R. Cornelissen and J.C. Philp (2013), Biomass sustainability and certification. *Trends in Biotechnology* 31, 385-387
- [8] Wackernagel, M. and W. Rees (1995). *Our Ecological Footprint: Reducing Human Impact on the Earth*. New Society Publishers, Philadelphia, PA.
- [9] Paxton, A. (1994), *The Food Miles Report: the Dangers of Long Distance Food Transport*; Safe Alliance: London.
- [10] de Simone, Livio and Popoff, F., 1997, *Eco-efficiency: The Business Link to Sustainable Development* (MIT, Cambridge, MA). A.P. Taylor, D. Postlethwaite. Overall Business Impact Assessment (OBIA). Proc of the 4th LCA Case Studies Symposium, SETAC, Brussels (1996), pp. 181–187.
- [11] Yakovleva, N., J. Sarkis and T. Sloan, T. (2011), Sustainable benchmarking of supply chains: the case of the food industry. *International Journal of Production Research* 50, 1297-1317.
- [12] Böhringer, C. and P.E.P. Jochem. (2007), Measuring the immeasurable - A survey of sustainability indices. *Ecological Economics* 63, 1-8.

- [13] Azapagic, A. and S. Perdan (2000). Indicators of sustainable development for industry: a general framework. *Process Safety and Environmental Protection* 78, 243-261.
- [14] Singh, R.K., H.R. Murty, S.K. Gupta and A.K. Dikshit (2009). An overview of sustainability assessment methodologies. *Ecological Indicators* 9, 189-212.
- [15] Barnett, V. *et al.* (1995), Agricultural sustainability: Economic, environmental and statistical considerations. John Wiley and Sons, Chichester etc.
- [16] Ehui, S.K., *et al.* (1992), A general approach for evaluating the economic viability and sustainability of tropical cropping systems., in: M. Bellamy and B. Greenshields (Eds.), *Issues in Agricultural Development: Sustainability and Cooperation*. IAAE Occasional Paper No. 6, Aldershot, UK, Dartmouth Publishing Co. pp. 110-119.
- [17] Glendining M.J. (2009), Is it possible to increase the sustainability of arable and ruminant agriculture by reducing inputs? *Agricultural Systems* 99, 117-125.
- [18] Lynam J.K., *et al.* (1989), Sense and sustainability: Sustainability as an objective in international agricultural research. *Agricultural Economics* 3, 381-398.
- [19] Gaitán-Cremaschi, D., M.P.M. Meuwissen and A.G.J.M. Oude Lansink (2014), Measuring biomass production performance towards sustainability. Working paper. Business Economics Group, Wageningen University.
- [20] Chung, Y. H., R. Färe and S. Grosskopf (1997), Productivity and undesirable outputs: a directional distance function approach. *Journal of Environmental Management* 51, 229-240
- [21] Hein, L., K. Van Koppen, R.S. De Groot and E.C. Van Ierland, E.C. (2006), Spatial scales, stakeholders and the valuation of ecosystem services. *Ecological Economics* 57, 209-228.

MEASURING ILUC: PROBLEMS AND PROGRESS

*Harley STODDART,¹ Clare WENNER² and Michael GOLDSWORTHY³

Abstract

Sustainability of agricultural systems and how to assess the sustainability, with considerations of Indirect Land Use Change (ILUC) is probably the greatest impediment to accurately determining the greenhouse gas emission (GHG) savings from any land-based activity.

Definition:

Biomass for industrial use includes the production of (bio-) fuels for transport, (bio-) energy for heat and power, materials and chemicals.

What is ILUC?

1. Where previously uncultivated land is used to grow crops for industrial use, there is a direct land use change (LUC) and there are protocols in the Renewable Energy Directive (RED) to calculate the GHG impact of LUC. When the produce of existing cropland is diverted away from traditional markets towards industrial uses there is likely to be an increase in demand for land and the crop and this could potentially lead to uncultivated land elsewhere in the world being converted to cropland; this is indirect land use change (ILUC) and could have a significant impact on global GHG emissions e.g. by encouraging deforestation. Since a primary purpose of biomass for industrial use is to reduce GHG emissions, it is important that the impacts of ILUC are considered.

Why do we have ILUC?

2. Since the publication of FAPRI modelling by Searchinger et al. (2008) and the UK Government's Gallagher Review (RFA, 2008), ILUC has been an important issue, especially for European biofuel policy. Searchinger cautioned that ILUC could negate any GHG savings from biomass for industrial use; Gallagher suggested that the issue must be addressed for biofuel policy to have clear climate benefits. Various options were considered by the European Commission and the adoption of ILUC factors was considered to be the most appropriate way forward. ILUC models develop specific ILUC factors, for different types of biomass (sugar/starch/oil.), that are applied universally to all biofuels, regardless of the specific circumstances under which the biomass is produced.

3. While the European Union is still debating whether it is prudent to introduce ILUC into current policy, the methodology of choice has already been decided upon in the event that ILUC is implemented; the Commission selected IFPRI-MIRAGE-BioF as it was considered to be the most suitable model to estimate the ILUC emissions 'in the European Union context'.

*¹Research and Policy Manager, Agriculture and Horticulture Development Board (AHDB), United Kingdom; ²Renewable Energy Agency (REA), United Kingdom; ³National Non-Food Crops Centre (NNFCC), United Kingdom

Current issues with ILUC

4. Understanding, measuring and managing ILUC is inherently very complicated. Policies are designed to support the uptake of biomass for industrial use (biofuels in particular) in order to maximise GHG savings, as well as to ensure that any public funds are spent appropriately.

5. Models built to calculate GHG emissions have been adapted to accommodate ILUC. These models not only rely on the magnitude of specific mandates within a policy environment but also require a large number of inputs including commodity pricings, projected crop yields, price elasticities, transformation elasticities (the ease with which land is converted from one to another use) and substitution elasticities (the ease in which comparable products, or co-products are substituted), amongst numerous other variables. Many of these inputs require use of broad assumptions, which vary between studies, and the means in which elasticities are calculated is dependent upon the model used. It is not surprising that the estimated ILUC for biomass varies greatly in accordance with which model is used, and in which study it was used.

6. Co-product allocation represents a further controversial issue of ILUC modelling. Many crop-based biofuels are delivering significant GHG savings as well as a valuable food source in the form of high protein animal feed. This provides a stimulus to improved and sustainable agricultural productivity. Where biofuel production gives co-products that displace other animal feed crops, this will reduce the demand for these animal feed crops. This leads to a reduction in land use change that offsets the ILUC of the biofuel crop. The net ILUC impact may therefore be either a penalty or a credit in GHG emissions.

7. Whilst it is almost consensually agreed across the science community that biofuels can result in indirect emissions, despite a lack of agreement regarding the magnitude, there are many reservations about introducing ILUC into policy as it essentially represents a 'best guess' rather than an accurate measurement based upon empirical data.

8. For instance the IPCC has voiced concern that the continued lack of sensitivity analysis and evaluation of uncertainty in ILUC modelling prevents the determination of a range of plausible and reliable estimates of emissions due to land use change: "*...estimates of global LUC are highly uncertain, unobservable, unverifiable, and dependent on assumed policy, economic contexts, and inputs used in the modelling.*" (IPCC Working Group 3 Contribution to AR5 synthesis Report).

9. A separate study analysing the effect of biofuel expansion on land use in major producing countries, provides evidence to suggest that development of the biofuel industry has neither contributed to land extensification, nor resulted in a reduction in supply of crops to food, feed and fibre markets (Hans Langeveld, 2013). Instead it suggests that biofuel production has been paralleled with improvements in cropping intensity. It can only be speculated as to whether there has been a causal relationship between increased biofuel production and improvements in land use efficiency. However, as biofuels are subject to strict sustainability criteria, it is reasonable to assume that biofuel production has made a greater contribution to improving land use efficiency than have the food, feed and fibre markets. The conclusions provides evidence against the argument that biofuels are causing ILUC and that the currently estimated ILUC emission factors for biofuels are unlikely to be a true representation of actual values and should therefore not be considered to be adopted in policy until models can better account for co-product allocations and multiple cropping.

10. ILUC modelling, as it currently exists, is in no state to provide an accurate assessment of indirect emissions of biofuel production, especially for use in policy making, nor is it likely to be in the near future. However, it is also clear that ILUC will not be dismissed any time soon as there remains too much pressure from NGOs and environmental political groups. It is therefore imperative that the biomass industries begin to adopt a position on ILUC (outside of denial of existence) that will provide the most stable platform for growth of the bioeconomy.

Future potential of ILUC

11. An alternative solution to the complexities of modelling ILUC emissions is to promote the uses of biomass that are unlikely to have a large impact on ILUC. This would provide a means of mitigating ILUC whilst avoiding the need for relying on controversial modelling results. In essence, for biomass to demonstrate that it has a low ILUC impact, it needs to prove that the feedstock has not come from land in competition with food production, or from carbon rich lands (forests, peat lands). These measures provide a means to prevent, or minimise the impact of extensification.

12. The development of mitigation options using supply chain certification schemes could provide a workable solution for addressing ILUC. Such a process could allow developers to provide evidence that their biomass for industrial uses has minimal ILUC impact (by e.g. using abandoned or degraded land, improving crop yields) and therefore should be exempt from application of any ILUC penalty, such as an ILUC factor. This concept has already gained traction in the last round of voting in the European Council and could be built upon to provide a more satisfactory outcome to addressing ILUC in European Union policy.

13. What is certain is that as long as there is policy uncertainty (real or perceived), there will be a lack of investor confidence. Without the requisite investment there will not be the industry infrastructure necessary to deliver the desired alternatives to current fossil fuel uses, with reduced GHG emissions and protection of the environment. Which after all else is said and done, is the very purpose of the policies in the first place.

Future Policy Options

14. All forms of biomass should be accepted as feedstock for the bioeconomy; this should be mirrored in public debate and perception, as well as in specific policies. Biomass must meet established international sustainability standards covering GHG savings, sustainable land use and environmental protection. These criteria should be integrated into supply chain certification schemes.

15. Financial incentives (public funds) should only be based on higher resource and land use efficiencies, sustainability and GHG savings and the lowest possible level of competition with food. Food or non-food biomass should not be taken as the sole acceptance criterion.

16. Reform the existing quota systems and increase (European) production of sugar for industry use. Sugar beet is a very attractive feedstock for the European chemical industry, with very low impact on the food and feed sector as increasing yields are leading to decreasing areas under cultivation.

17. Implement a level playing field between industrial use of biomass for materials and chemicals and biofuels/bioenergy. Currently, European policy only provides support for biofuels and bioenergy, even though criteria such as GHG savings, sustainable land use, environmental protection, fossil substitution, added value, employment and innovation speak in favour of supporting industrial use of biomass for materials and chemicals.

SUSTAINABLE PRODUCTION OF BIOFUELS FROM FEEDSTOCK GROWN ON MARGINAL LANDS

Ilya GELFAND
Senior Research Associate
W.K. Kellogg Biological Station of Michigan State University
United States

Abstract

Marginal land represents an untapped resource to produce cellulosic biomass for fuel production. Using marginal land may provide significant greenhouse gas emissions savings benefits as well as being a resource for production of significant amounts of biomass. In this way a contribution to transportation energy needs would be made, while providing substantial climate and – if managed properly – conservation benefits.

Current status

1. Policies that promote the production of biofuels in the USA, Europe, and other regions have the potential to benefit society if both the ecological and economic impacts of their adoption are considered appropriately when developing policy measures. There are currently two major themes in biofuel research:

1. Development of new methods to utilise biomass; and
2. Evaluation of where and how this biomass can be produced sustainably.

2. Large quantities of food and/or feed crops such as corn and soybean are directed toward the production of grain-based ethanol and biodiesel. While the cultivation of highly productive crops on prime agricultural land could produce large quantities of biofuels, this practice can have detrimental environmental consequences such as lower carbon sequestration in soils, higher greenhouse gas (GHG) emissions from soils, nitrate pollution, and changes to biodiversity and human health. It also has economic impacts on food prices, causing them to rise due to end-use competition among the crops (i.e., ethanol *versus* food).

3. An alternative approach is to grow lignocellulosic (or cellulosic) crops on “marginal lands”. These are defined as lands poorly suited to growing field crops, due to inherent climatic and edaphic limitations, or due to a vulnerability to erosion under cultivation.[1] Growing cellulosic feedstocks on such lands is advantageous due to the low management intensity required, increase in soil carbon stocks, and reduced soil erosion and GHG emissions.

Two challenges

4. Two major challenges are encountered in the use of marginal lands to grow feedstock for biofuel production:

1. *Choosing the right crops to ensure sufficient productivity with environmental benefits:* Achieving sufficient yields on inherently unproductive lands can be achieved by choosing plants with characteristics that facilitate growth on marginal soils. These would include perennial roots, low nitrogen requirements, and little need for intensive management. Two major types of cellulosic crops meet these criteria: perennial grasses and purpose-grown trees (short-rotation forestry).

Perennial grasses and short-rotation trees can provide environmental benefits, yet with specific tradeoffs[2-7]— both require time investments, in the form of multi-year cropping and the commitment of farmers.

2. *Understanding the landscape dynamics that influence the supply and distribution of feedstocks:* Growing biofuel feedstocks on marginal lands may further amplify the complexity of feedstock supplies. Parcels of marginal lands can potentially be spread across landscapes. They may or may not be connected by a suitable road network, or be of suitable size for successful harvesting and handling of biomass. Therefore, in advance, it is important to estimate the potential for developing an infrastructure for the supply of biorefinery feedstocks, and to understand the connectivity of land parcels identified as suitable for planting biofuel feedstocks. The development of local biomass processing facilities,[8] capable of storing small quantities (relative to the amounts required by a biorefinery) of feedstocks that have preferably been pretreated to homogenise and deconstruct the biomass, can help to decentralise the flow of biomass and increase stability of the supply.
5. Current research in this field aims to address these challenges by optimising the right feedstock crop with the right management practices at the right location.

Future directions

6. Based on our current understanding of the trade-offs involved in the production of cellulosic biofuel feedstocks, there are three major questions that require in-depth scientific research before a sustainable biofuel economy can be established:

1. *What are direct and indirect effects of land conversion on GHG emissions?*

- a) Only limited information is currently available on the effects of land use change on GHG emissions. Direct measurements of GHG emissions during conversion of established grassland to produce biofuel crops showed that such conversion results in a large carbon debt, on the order of ~10 Mg CO₂ equivalents ha.[1] This debt is estimated to require between 30 and 120 years of biofuel processing before any positive climate benefits could be achieved from the use of biofuels, depending on whether no-till versus tilling practices are used in the conversion process.[9] The carbon debt can be reduced if the grassland is harvested before establishment of the biofuel crops, and could potentially be prevented if the biofuel crop can be inter-seeded into existing vegetation.
- b) Modelling studies suggest that if prime cropland is used to support biofuel production, GHG emissions will be doubled over at least 30 years¹⁰. On the other hand, a recent assessment of actual change in land-use after the latest rise in corn prices showed that US Midwest farmers extended their crop area by only 2% while facing a 64% leap in expected profitability.[11]

2. *What is the availability of marginal lands?*

In terms of understanding the availability of marginal lands for biofuel crop production, what is their potential productivity, and where are they located relative to potential biorefineries? In addition, we need to know if landowners are willing to grow biofuel crops in the first place. For example, a recent survey[12] of marginal landowners in Michigan, US showed that only 15-30% of the available land would be leased for biofuel production. Farmers also indicated a preference for growing prairie vegetation, switchgrass, or corn, over short-rotation poplar trees.

3. *What is the ideal biofuel feedstock?*

We need to evaluate which plants are ideal for use as biofuel feedstocks, what are the advantages and disadvantages of annual and perennial biofuel crops? Inherent tradeoffs that need to be assessed include:

- a) Annual feedstocks, such as corn, can have very high productivity owing to many years of selection and breeding, and high agrochemical inputs;
- b) Perennial feedstocks provide various ecosystem services[13] (such as soil C sequestration and stabilisation) in addition to the biomass produced, require a low input of agrochemicals, and have a high ratio of energy return on investment, high climate mitigation benefits, and the potential to produce greater yields than annual plants on marginal lands;
- c) Annual plants can be replaced by other crops if the demand changes, while perennial crops need to be grown for several years before harvesting is possible, and they cannot be rotated as often as annual feedstocks; and
- d) Mature forest once harvested will not regenerate for many decades.[7]

7. In summary, future research must assess not only the biophysical aspects of biofuel production, but also the socio-economic impacts. An interdisciplinary approach will enable better understanding of public and landowner perspectives, in relation to the use of existing landscapes for renewable energy production as part of the more general ecosystem services such as clean water and biodiversity.

Policy options

8. The following policy measures should be considered to support full development of a sustainable biofuel feedstock economy:

- Develop best management practices for biofuel feedstock production. Maximum environmental benefits are achieved by combining the right crop with the right location and the right cultivation practices.
 - Guidelines for sustainable feedstock production need to be developed and will require monitoring tools for assessment.
- Include the time dimension into assessment of the environmental impacts of biofuel feedstocks.
 - Harvesting of existing mature forests is not providing expected climate mitigation since forest will require decades to re-growth and to uptake CO₂ which will be released due to harvest and use of forest biomass as a biofuel feedstock.
- Implement the growth of cellulosic feedstocks on marginal lands.
 - Although they are potentially less productive than high-input/high-yield crops, such feedstocks can provide more environmental benefits.
- Develop breeding and selection programmes for new feedstock crops.
 - In the assessment of potential crops, ecosystem services need to be included and considered, in addition to crop yields.
- Give high priority to the implementation of low-input cropping systems, such as grasses.

- Establish land-use guidelines. A spatial inventory of lands in areas suitable for biofuel production is needed to inform the development of such guidelines.
 - Need to include land connectivity and assessments of potential yields. This must identify the existing land-use patterns at a small spatial scale, to be relevant for the growth of feedstocks, as an alternative land use (i.e. sub-kilometre).
 - Include consideration of the fact that impacts of agricultural intensification are experienced domestically (i.e, direct land-use change) and globally (i.e. indirect land-use change).
- Establish a rewards system to encourage landowners to incorporate the production of biofuel feedstocks.
 - Policies such as long-term contracts for biomass production or specific subsidies related to biofuel feedstocks can provide farmers with more economic security.

REFERENCES

- [1] Kang, S., W.M. Post, J.A. Nichols, D. Wang, T.O. West, V. Bandaru and R.C. Izaurralde (2013), Marginal lands: concept, assessment and management. *Journal of Agricultural Science*; Vol. 5, No. 5; 2013 5:129-139.
- [2] Ruan, L., A.K. Bhardwaj, S.K. Hamilton and G.P. Robertson (unpublished) Nitrogen fertilization challenges the climate benefits of cellulosic biofuels.
- [3] Somerville, C., H. Youngs, C. Taylor, S.C. Davis and S. P. Long (2010), Feedstocks for lignocellulosic biofuels. *Science* 329: 790-792
- [4] Heaton, E., S. Long, T. Voigt, M. Jones and J. Clifton-Brown (2004), *Miscanthus* for renewable energy generation: european union experience and projections for Illinois. *Mitigation and Adaptation Strategies for Global Change* 9: 433-451
- [5] Raghu, S., R.C. Anderson, C.C. Daehler, A.S. Davis, R. N. Wiedenmann, D. Simberloff and R.N. Mack (2006), Adding Biofuels to the Invasive Species Fire? *Science* 313: 1742
- [6] Gelfand, I., R. Sahajpal, X. Zhang, R.C. Izaurralde, K.L. Gross and G.P. Robertson (2013) Sustainable bioenergy production from marginal lands in the US Midwest. *Nature* 493:514-517.
- [7] Searchinger, T.D., S.P. Hamburg, J. Melillo et al., (2009) Fixing a critical climate accounting error. *Science* 326: 527-528
- [8] Eranki, P.L., B.D. Bals and B.E. Dale (2011) Advanced Regional Biomass Processing Depots: a key to the logistical challenges of the cellulosic biofuel industry. *Biofuels, Bioproducts and Biorefining* 5:621-630.
- [9] Gelfand, I., T. Zenone, P. Jasrotia, J. Chen, S.K. Hamilton and G.P. Robertson (2011) Carbon debt of Conservation Reserve Program (CRP) grasslands converted to bioenergy production. *PNAS* 108:13864-13869
- [10] Searchinger, T., R. Heimlich, R.A. Houghton, F. Dong and A. Elobeid (2008), Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land-use change. *Science* 319:1238.
- [11] Swinton, S.M., B.A. Babcock, L.K. James and V. Bandaru (2011), Higher US crop prices trigger little area expansion so marginal land for biofuel crops is limited. *Energy Policy* 39:5254- 5258.
- [12] Hayden, N.J. (2014), Landowner willingness to supply marginal land for bioenergy production in Michigan. Agricultural, Food, and Resource Economics. East Lansing, MI: Michigan State University. M.Sc. thesis.
- [13] Werling, B.P., T.L. Dickson, R. Isaacs et al., (2014) Perennial grasslands enhance biodiversity and multiple ecosystem services in bioenergy landscapes. *PNAS* in press.

HOW DOES SIGNIFICANTLY INCREASING BIOMASS PRODUCTION IMPACT LAND USE – CASE STUDY FROM BRAZIL

Géraldine KUTAS
Head of International Affairs
Brazilian Sugarcane Industry Association (UNICA)

Abstract

Most countries around the world are searching for clean, renewable options to increase energy supplies and reduce dependence on fossil fuels. Brazil has started this journey some forty years ago and the country has successfully transitioned from importing almost 80% of its total oil consumption to becoming virtually energy independent and a world leader in renewable energy. Brazil has one of the cleanest energy matrices, with more than 40% of energy coming from renewables, when the rest of the world averages only 13%.

The primary source of renewable energy is sugarcane (15.4%). While this plant was first dedicated to sugar production, tremendous advances in technology have allowed it to go beyond food, ensuring that all parts of the sugarcane plant are converted into energy. Sugarcane ethanol is used in the transport sector as a renewable fuel that cuts greenhouse gas emissions by an average 90 percent compared to gasoline. Increasing the uptake of sugarcane ethanol can help improve global energy security by diversifying both fuel supply and suppliers. Sugarcane ethanol also serves as a substitute for oil to produce bioplastics. In addition, bioenergy is another innovative area for sugarcane, where leftover sugarcane biomass - known as bagasse – is burned and converted into clean electricity. Today the installed capacity is 4 160 average MW, but our potential is more than 15 200 average MW by 2020 (almost 9% of Brazil's electricity matrix, second to hydroelectricity).

Sugarcane cultivation today

1. In 2012/13, Brazil produced 588 million tons of sugarcane, which yielded 38 million tons of sugar and 23.2 billion litres of ethanol. That makes Brazil the world's largest sugar producer and second largest ethanol producer, behind the United States.

2. Sugarcane is grown on a small amount of Brazil's farmland occupying 9.5 million hectares. Of that amount, 4.6 million is used to grow cane to be processed into ethanol. Using just 1.4% of country's arable land, Brazil has managed to replace almost 40% of its gasoline consumption with clean and renewable ethanol. Brazil is indeed the only country in the world where consumers have the option at the pump to choose the fuel they want to use (gasoline or ethanol) because the vehicles are Flex Fuel Vehicles. The largest reservoir of arable land available in Brazil are pastures, mostly degraded, that currently covers 198 million hectares. With the progressive intensification of cattle ranching activities, substantial areas of pastures are released every year for the expansion of crop production such as sugarcane, but also grains and oilseeds. A 2008 report by the University of Wageningen revealed that 5.4 million hectares of pastureland were made available for other uses between 2002 and 2006, while the cattle herd increased by 18 383 heads. According to the Brazilian National Institute for Space Research (INPE), more than 65% of new sugarcane production took place on pastures while the remaining 35 percent expands on cropland, and this trend is forecast to continue.

Combining future growth with land use planning

3. Sugarcane production needs to expand to accommodate the booming demand for sugarcane-derived products, and especially for clean and renewable first and second-generation ethanol. Higher volumes of cane can be obtained in the future thanks to productivity gains, but additional land dedicated to sugarcane will also be required. Proper land use planning is essential to manage this growth while simultaneously preserving and protecting precious natural resources.

4. Almost 90% of Brazilian sugarcane production takes place in South-Central Brazil, with the remainder grown in North Eastern Brazil. Both producing regions are located some 2 000 to 2 500 km away from the Amazon. The Amazon region simply does not offer appropriate growing conditions for sugarcane and would never be a target for expanded production, regardless of government regulation.

5. In 2009, the Brazilian government launched the Agro-ecological Zoning for Sugarcane initiative to induce the expansion of sugarcane production in areas that are agronomically, climatically and environmentally suitable. This pioneer initiative – with the stated goal “to expand production, preserve life and ensure a future” – is essential to guarantee the sustainable growth of sugarcane production.

6. The rules established by the Agro-ecological Zoning include:

- No sugarcane expansion or new ethanol production facilities in sensitive ecosystems like the Amazon, the Pantanal wetlands and Upper Paraguay river basin;
- No clearance of native plants to expand sugarcane cultivation anywhere in the country, including the native Cerrado;
- Identification of suitable areas where sugarcane should be prioritised. These areas include land with proper conditions for the use of mechanical harvesting, cattle breeding areas that are underused or degraded (more than 34 million hectares), and also regions with lower need for water usage in production.

7. But ethanol production will increase faster than land expansion as huge investments in R&D are done in the sector to boost productivity. Productivity is forecasted to increase from 7 100 litres/ha to 21 500 litres/ha in 2025 due to processes optimisation, and technology availability to produce cellulosic ethanol and advanced bio-hydrocarbons. Although the country was a latecomer to these new technologies, investments have started to flow. At least three commercial cellulosic ethanol plants, which will use the bagasse as raw material, are under construction in the country. In the near future, they will also use the tops and the leaves of the cane that are increasingly available thanks to the mechanisation of the harvest, but are today left in the fields. This new source of biomass encompasses one third of the sugarcane energy and would contribute to producing more energy with less resources.

8. Advanced bio-hydrocarbons are also developing rapidly, using the same raw materials. They are substantially similar to conventional hydrocarbon fuels such as gasoline, diesel or jet-fuels but are produced from biomass feedstocks. They are clean, low-carbon and renewable like ethanol, but do not require engine changes or additional infrastructure. Because they have the same energy content as fossil fuels, bio-hydrocarbons can reduce dependency on gasoline and increase environmental benefits. American companies such as Amyris and Solazyme have partnered with Brazilian traditional sugarcane mills to develop these new products.

What's next ?

9. The success of renewable energies strongly depends on supportive and stable policy framework. Over the last four years, the Brazilian government and the Congress have legislated a lot on land use

planning. The agro-ecological zonings, but also the revised forest code are part of these new pieces of legislation. It is now time for implementation and producers must adapt.

10. At the same time, there are more questions about indirect land use change (ILUC), mainly from Europe. Not even three years after the entry into force of the Renewable Energy Directive (RED) adopted in 2009, the Commission has launched a legislative proposal to deal with the ILUC issue by capping the use of all conventional biofuels (biofuels produced from food-based raw materials) no matter their estimated ILUC factor. This black and white vision is not only unfair for biofuels such as sugarcane ethanol that significantly reduce greenhouse gas emission even when ILUC is accounted for, but it is also a disincentive for the most promising technologies to produce cellulosic ethanol and advanced biohydrocarbons. First, because it is the traditional business and know-how that support the R&D costs of these technologies and second because this new business only makes sense if co-located at existing sugarcane plants that are becoming biorefineries.

11. The legislator should not lose the final objective. The problem we try to address is increasing CO₂ emissions in general. The main source of greenhouse gas emissions is deforestation/land use change provoked by many factors, not only by the displacement of agricultural activities due to biofuels production increase. The objective of the legislation should therefore be to reduce deforestation, not to only tackle biofuels that only occupies 1% of the world's arable land, according to the IEA. If the goal is to limit the sources of emissions, efforts made to address deforestation and emissions resulting from land use change in general should be taken into account.

12. Not all biofuels are created equal and they do not all deliver on their promises. It is therefore essential to develop robust science in order to evaluate accurately the magnitude of ILUC emissions from specific biofuels. Until we get to this point, mitigation measures, such as policies to reduce deforestation and land use planning, taken by countries must be recognised and promoted. This is the way forward to produce food, feed and fuels at the same time and in the same place, making a more efficient and sustainable use of natural resources.

INDUSTRIAL MATERIAL USE OF BIOMASS: VALUE ADDED AND SUSTAINABLE FEEDSTOCK, FOOD OR NON-FOOD: WHICH AGRICULTURAL FEEDSTOCKS ARE BEST FOR INDUSTRIAL USES?

Michael CARUS
Managing Director
Nova-Institut
Germany

Abstract

New opportunities are being created by and for biobased investments such that more value-added can be generated from industrial material use of biomass. There has been a long standing debate on food or non-food crops as feedstocks for industrial uses, and on sustainability certification for biomass. This presentation will examine some of the critical issues.

Current status

1. The choice of biomass – food and non-food crops – should be dependent on how sustainably and efficiently these biomass resources can be produced. The only crucial issue is land availability, since the cultivation of non-food crops on arable land would reduce the potential availability of food just as much or even more. A differentiated approach to finding the most suitable biomass for industrial uses is needed. The issue of whether using biomass for purposes other than food can be justified at all must be addressed. This means that the availability of arable land should be taken into account. Several studies show that some areas will remain free for other purposes than food production even after worldwide food demand has been satisfied. These studies also show potential for further growth in yields and arable land areas worldwide. Recent studies have also shown that many food crops are more land-efficient than non-food crops. Also, the long-time improvement of first generation process chains as well as the food and feed uses of by-products make the utilisation of food crops in biobased industries very efficient.

Biomass use in the European Union and worldwide

2. With an increasing world population, ensuring food security is the first priority of biomass usage. Increasing meat consumption accompanying higher living standards will generate additional demand for biomass. The European Commission came to the following conclusion in 2012: “*Global population growth by 2050 is estimated to lead to a 70% increase in food demand, which includes a projected twofold increase in world meat consumption.*” [1]

3. In 2008, the 10 billion tonnes of biomass harvested worldwide were used as follows: 60% animal feed; 32% food; 4% material use; 4% energy use. Although agricultural yields can be significantly increased in many developing countries, and arable land can still be expanded by a few hundreds of millions of hectares worldwide without touching rainforest or protected areas, arable land and biomass are limited resources and should be used efficiently and sustainably.

How are food crops utilised for industrial material use today?

4. Biorefineries for food crops have existed for many years. Biorefineries convert all parts of a harvested crop into food, feed, materials and energy/fuel, maximising the total value. If this maximum output value were not attained, the prices of the food and feed parts would go up.

5. For oil crops, the protein-rich press cake often constitutes a much larger share of the harvested biomass than the plant oil used for oleochemistry. Starch crops have protein-rich by-products such as vital wheat gluten or corn gluten, which play an important role in human nutrition or in the animal feed industry. The protein fraction and the fibre-rich fraction are always used in the food and feed industries due to their high value in these markets, even in cases in which the carbohydrates are used completely for chemicals.

Future directions

Huge potential for increasing biomass availability

6. The industrial material use of biomass makes up for only a very small share of biomass competition. Other factors have a much greater impact on food availability. Due to increasing demand for food and feed as well as bioenergy and industrial material use, the crucial question is how to increase the biomass production in a sustainable way:

1. *Increasing yields*: Tremendous potential for increasing yields in developing countries is hampered by a lack of investment in well-known technologies and infrastructure, unfavourable agricultural policies such as no access to credits, insufficient transmission of price incentives, and poorly enforced land rights.
2. *Expansion of arable land*: Some 100 million hectares could be added to the current 1.4 billion hectares without touching rainforest or protected areas. Most estimates calculate up to 500 million hectares. These areas will require a lot of infrastructure investment before they can be utilised.[2,3]

First-, second- and third- generation feedstocks

7. Today, a wide range of chemicals, plastics, detergents, lubricants, and fuels are produced from agricultural biomass, mainly from sugar, starch, plant oil, and natural rubber, the so-called first-generation feedstocks. Because of the potential for direct competition with food and animal feed, politicians and scientists have in the last 10 years introduced the idea of using lignocellulosic feedstock as a raw material for fermentable sugars and also for gasification. These are the so-called second generation feedstocks. Increasingly research is being carried out into using algae as a feedstock; this is known as a third-generation feedstock.

8. Whether the use of second-generation feedstocks will have less impact on food security is questionable. “*What is the most resource-efficient and sustainable use of land and biomass in your region?*” It is a question of resource and land efficiency and sustainability. The competition is for land. Land used for cultivating lignocellulosic feedstock is not available for food or feed production.

Resource efficiency

9. Food crops have been cultivated for at least 2 000 years and yields per area have increased hugely through selective breeding. Furthermore, the use of sugar, starch, and oil is well established in the food, feed, and chemical industries and have been optimised and commercialised for decades – but advanced biotechnology can nevertheless lead to further efficiency gains.

10. One important factor influencing sustainability, food security, environmental impacts and economy is the use of by-products. If food crop or agricultural waste by-products are available and not already used in other processes, these second generation feedstocks are expected to have the lowest impact and to be the most favourable. But there is limited availability of by-products that are not already in use,

and the processes for utilising them are not yet established.[4] It is important to recognize that availability depends on market demand and is influenced by incentive schemes. In general, by-products currently used as feed or feedstock for industry are not available for other purposes in the foreseeable future. So if arable land is planted with short-rotation coppice such as poplar or willow, *Miscanthus* or other high-yield grasses instead, we are not much closer to answering the question about the differing adverse impact of either food or lignocellulosic crops. Land-use and resource efficiency – over the whole process chain of biomass use – need to be taken into consideration.

Flexible application of food crops—emergency food reserve

11. Another very important aspect that argues in favour of industrial use of food crops is the flexibility of crop allocation in times of crises. If a food crisis occurs, it would be possible to reallocate food crops that were originally cultivated for industry to food uses. This is not possible with non-food crops—they can only ensure supply security for industrial applications.

12. First-generation crops also have the potential to give the farmer more flexibility in terms of his crop's end use. If the market is already saturated with food exports of a crop, this allows the crop to be diverted towards industrial use. The reverse is also true when there is a food shortage. The same cannot be said of non-food crops with single, industrial use. If the industry is forced to use only non-food crops, this will lead to more land use for non-food crops, which would in fact induce an artificial scarcity of land for food crops. Growing food crops – on land that is currently either not at all or not properly in use, will increase the global availability of these crops, increase the market volume and thus reduce the risk of speculation peaks as well as shortages in certain parts of the world. It is often argued that utilising lignocellulose will not take up any land, as long as only by-products are used and no specified cultivation for industrial purposes takes place. However, the potential availability of lignocellulosic by-products that are not already valorised in other applications is severely limited and cannot form the basis for an entire industry.

13. In summary, growing more food crops for industry creates a quintuple-win situation:

- The farmer wins, with more options for selling stock and, therefore, more economic security;
- The environment wins, due to greater resource efficiency of food crops and the smaller area of land used;
- Food security wins, due to flexible allocation of food crops in times of crisis;
- Feed security wins, due to the high value of the protein-rich by-products of food crops;
- Market stability wins due to increased global availability of food crops, which will reduce the risk of shortages and speculation peaks.

14. Growing food *versus* non-food crops both compete for land. The crops that use the land most efficiently and sustainably should be identified as well as free agricultural areas left in the country or region that are not necessary for food and animal feed production, domestic use or export. In most countries and regions, arable land remains available for the potential production of biomass for industrial uses, whether material, energy, or both. In this case, the real question is: “*How can we use these free areas as a sustainable feedstock for industry with the highest resource- and land efficiency, the highest possible level of climate and environmental protection, and the lowest competition with food?*” Land-use and resource efficiency – over the whole process chain of biomass use – need to be taken into consideration.

15. Depending on local conditions, food crops can fulfil these criteria just as well as non-food crops, and this will remain the case in the future. In some cases, they may even score higher in these categories.

So the dogma of ‘no food crops for industry’ can lead to a mis-allocation or under-utilisation of agricultural resources i.e. land and biomass.

Policy options

16. We propose the following:

- All kinds of biomass should be accepted as feedstock for the biobased economy;
- Potential political and financial measures should only be based on higher resource and land efficiency, sustainability, and a lower environmental footprint of the biomass, and the lowest possible level of competition with food. The acceptable biomass must of course also meet established international sustainability standards;
- European research agendas should again support first generation processing lines for biobased chemistry and materials to improve resource efficiency and sustainability and especially to find the best applications for all parts of the crop in the food, feed, materials, and energy sectors;
- Research should also identify the most resource- and land efficient crops and production pathways for specific regional conditions and applications;
- Increase the European production of sugar for industry via a reform of the existing quota systems;
- Implement a level playing field between industrial material use and biofuels/bioenergy.

17. Political reforms and huge investment in agro-technologies and infrastructure are necessary.

18. There is also huge potential for saving biomass and arable land:

- Reduced meat consumption would free up a huge amount of arable land for other uses. Deriving protein from cattle requires 40 to 50 times the biomass input than protein directly obtained from wheat or soy;
- Reducing food losses will also free up huge areas of arable land. Roughly one-third of food produced for human consumption is lost or wasted globally, amounting to about 1.3 billion tonnes per year;[5]
- Increasing the efficiency of biomass processing for all applications by the use of modern industrial biotechnology;
- Using all agricultural by-products that are not inserted in any value chain today. Lignocellulosic residues in particular can be used in second generation biofuels and biochemicals;
- Finally, the use of solar energy, which also takes up land, for fueling electric cars is about 100 times more land efficient than using the land for biofuels for conventional cars. In addition, solar energy can be produced on non-arable land, too. Increased use of this means of transportation would release huge areas of arable land that are currently used for biofuels. This should be an important part of the strategy beyond 2020.[6]

REFERENCES

1. European Commission. Innovating for Sustainable Growth: A Bioeconomy for Europe. *Ind Biotechnol* 2012;8(2):57–61.
2. Dauber, J. Bioenergy from “surplus” land: Environmental and socio-economic implications. *BioRisk* 2012;7:5–50.
3. Zeddies, J., E. Bahs and N. Schönleber, Gamer W. Report: “Globale Analyse und Abschätzung des Biomasse-Flächennutzungspotentials.” Berlin, Germany: Bundesministerium für Bildung und Forschung, August 2012. Available at: www.bdbe.de/files/8313/4815/4630/Globale_Biomassepotenziale_Universitt_Hohenheim_Zwischenbericht_2012.pdf (Last accessed June 2013).
4. Fachagentur Nachwachsende Rohstoffe e.V. Bestandsaufnahme zum biogenen Reststoffpotenzial der deutschen Lebensmittelund Biotechnikindustrie. Gülzow, 2013.
5. Food and Agriculture Organization of the United Nations. “Global Food Losses and Food Waste.” Rome, 2011.
6. Carus, M. From the field to the wheel: Photovoltaic is 40 times more efficient than the best biofuel. *Bioplastics Magazine* 2012;7:(1):58–59.

ANNEX 1

OECD WORKSHOP ON “SUSTAINABLE BIOMASS DRIVES THE NEXT BIOECONOMY: A NEW INDUSTRIAL REVOLUTION?” – BACKGROUND, OBJECTIVES AND DRAFT AGENDA

10-11 JUNE 2014

OECD Headquarters, Paris

Background

There was a time when we lived off the land, in what we could have called a bioeconomy. The large crude oil discoveries in the mid-20th century changed the way we live. Now, however, the grand challenges being posed to our society are causing us to rethink the future. These challenges include climate change, energy security, rural regeneration and the need for economic growth without environmental damage. This calls for a new bioeconomy in which sustainably grown and harvested biomass becomes an industrial raw material.

Objectives of the Workshop

The objectives of this workshop are to exchange information on the requirement, versus availability and limitations of biomass to drive the bioeconomy and how this is interrelated to food-feed production. How can policies help to overcome barriers and contribute to stimulate the bioeconomy? The workshop should draw the bigger picture, stimulate discussion and may lead to more cooperation between participants on this important topic.

DRAFT AGENDA

Conference Chair: Peter SCHINTLMEISTER, Chair of the Task Force on Industrial Biotechnology

DAY 1 – 09.30-17.00	
WELCOME AND INTRODUCTION	
09.00-09.30	Registration and Coffee
09.30-09.45	Opening of the Meeting and Introductory Remarks <i>Speakers:</i> OECD Secretariat and Dutch delegation
<i>Chair:</i> Pierre-Alain SCHIEB, OECD Consultant and Industrial Bioeconomy Chair, NEOMA Business School, France	
SESSION 1: MEASURING BIOMASS POTENTIALS – 09.45-11.15	
Methods and approaches to estimate global biomass potentials	
<i>Speaker:</i> Jan ROS, PBL, Environmental Assessment Agency, Netherlands	
<p>The availability of sustainable biomass as a future substitute for fossil resources is dependent on the availability of land and options for using biomass produced in agriculture and forestry more efficiently. Based on current flow schemes of biomass over the world the potential to use more biomass for new applications without disturbing current applications can be assessed. Scenario studies including sustainability criteria provide more insight into the available land for biomass production to support a larger bioeconomy in 2050.</p>	
<i>Q&A – 10 minutes</i>	
The “billion ton update”: methodologies and implications	
<i>Speaker:</i> Bryce STOKES, U.S. Department of Energy, United States	
<p>According to a recent report, the US may be able, with some assumptions, to produce one billion tons of dry biomass per annum, thus substituting 30% of gasoline requirement with renewable biofuels. This document will be introduced and discussed. Published methodologies for measuring biomass potential are variable and understanding underlying methodologies, assumptions and analysis is critical. This presentation will aim to propose ways to harmonise the approaches. It is very important to know the capacities for sustainable production of biomass for domestic use and for international biomass trade.</p>	
<i>Q&A – 10 minutes</i>	
Discussions to be led by Session Chair	
11.15-11.45 – Coffee Break	

SESSION 2: QUANTIFYING SUSTAINABILITY LEVEL OF BIOMASS – 11.45-13.15

Measurement Tools: LCA, certifications and beyond

Speaker: Franz FIALA, ANEC, Austria

There is a generally held view that life cycle assessment (LCA) is inappropriate for the assessment of biomass sustainability, for various reasons, including the fact that it does not take social or economic indicators into account. ANEC, the European Association for the Co-ordination of Consumer Representation in Standardisation, argued in a recent document to the EU that LCA indicator results are not even a solid base for environmental communication and decision making.

Q&A – 10 minutes

Total factor productivity (TFP) to measure sustainability of biomass production

Speaker: Daniel Gaitán CREMASCHI, Wageningen University, Netherlands

Total factor productivity (TFP) may be a key technique for the measurement of the performance of agricultural chains. It represents how efficiently the agriculture industry uses the resources that are available to turn inputs into outputs. The methodology can be extended to include social and environmental issues that arise from biomass production. Methods and approaches to apply TFP to measure sustainability of biomass production will be discussed.

Q&A – 10 minutes

Discussion to be led by Session Chair

13.15 -14.30 – Lunch

Chair: Monika SORMANN, Flanders Ministry of Economy, Science and Innovation, Belgium

**SESSION 3: SUSTAINABILITY AS A PRECONDITION OF THE BIOECONOMY –
14.30-16.00**

Measuring ILUC: Problems and progress

Speaker: Harley STODDART, Agriculture and Horticulture Development Board (AHDB), United Kingdom

Sustainability of agricultural systems and how to assess the sustainability are key issues for accurately determining, the greenhouse gas emission savings from any activity based on land use. Indirect Land Use Change (ILUC) is probably the greatest impediment to that accurate determination. Is it possible to accurately measure sustainability and ILUC, what are the problems and what progress has been made?

Q&A – 10 minutes

Sustainable biomass and marginal land

Speaker: Ilya GELFAND, Michigan State University, United States

Marginal land represents an untapped resource to produce cellulosic biomass for fuel production. Using marginal land may provide significant savings in and benefits from reduced greenhouse gas emissions as well as being a resource for production of significant amounts of biomass. In this way a contribution to transportation energy needs would be made, while providing substantial climate and – if managed properly – conservation benefits.

Q&A – 10 minutes

Discussion to be led by Session Chair

16.00-16.30 – Coffee Break

SESSION 4: INTERACTIVE EXCHANGE OF VIEWS – 16.30-17.00

Moderators: Roeland BOSCH, Chief Economist, formerly of Ministry of Economic Affairs, Netherlands and Jim PHILP, OECD Secretariat

Conclusions from the first day's sessions and discussions will be summarised and validated by a concluding discussion with the audience/participants.

Cocktail Reception

DAY 2 – 09.30-12.45 (Coffee service at 09.00)
Chair: Dirk CARREZ , CleverConsult, Belgium
SESSION 5: INTERRELATIONSHIPS OF BIOECONOMY AND FEED-FOOD PRODUCTION – 09.30-11.00
<p style="text-align: center;">Industrial material use of biomass - Value added and sustainable feedstock, food or non-food: Which agricultural feedstocks are best for industrial uses?</p> <p>Speaker: Michael CARUS, NOVA Institute, Germany</p> <p>New opportunities are being created by and for biobased investments such that more value-added can be generated from industrial material use of biomass. There has been a long standing debate on food or non-food crops as feedstocks for industrial uses, and on sustainability certification for biomass. This presentation will examine some of the critical issues.</p> <p>Q&A – 10 minutes</p>
<p style="text-align: center;">How does significantly increasing biomass production impact land use? Case study from Brazil</p> <p>Speaker: Géraldine KUTAS, UNICA, Brazil</p> <p>UNICA, the Brazilian sugarcane industry organisation, is arguably the most important trade association in the debate on biomass sustainability. Brazil is having to double sugar cane production this decade. This could have an impact on land use and ILUC. This may have significant political and business consequences for biomass (sugarcane) production in Brazil.</p> <p>Q&A – 10 minutes</p>
<p>Discussion to be led by Session Chair</p>
11.00-11.30 – Coffee Break

SESSION 6: WHAT LESSONS HAVE WE LEARNT? – 11.30-12.30

Mediating global conflicts concerning biomass

Speaker: **Roeland BOSCH**, Chief Economist, formerly of Ministry of Economic Affairs, Netherlands

In the eighties a trade war about agricultural products was avoided because a measuring standard was developed by the OECD: the Producer Subsidy Equivalent. This presentation will reflect on this experience and look at possible concerns around flows of biomass needed for the global bioeconomy.

Q&A – 10 minutes

Discussion to be led by session Chair

CLOSING REMARKS – 12.30-12.45

Speaker: **Peter SCHINTLMEISTER**, Chair of the Task Force on Industrial Biotechnology

Inventory of discussion points and forming preliminary conclusions.