LANDTAG
NORDRHEIN-WESTFALEN
16. WAHLPERIODE

STELLUNGNAHME
16/1069

A23

20. September 2013, Expertenanhörung Enquete-Kommission „Rohstoffsituation – Schwerpunkt Rohstoffeffizienz und Rohstoffsubstitution“

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Der Input der **nova-Institut GmbH, Hürth bei Köln**, fokussiert ausgewählte Fragen, die in laufenden Projekten bearbeitet wurden:

1.a. IST-Situation Rohstoffe weltweit und Trends

Der Gesamtrohstoffbedarf der Menschheit lag im Jahr 2005 bei knapp 60 Mrd. t und im Jahr 2008 schon bei knapp 70 Mrd. t und gliedert sich in vier Rohstoffgruppen (der Größe nach) (siehe auch Abbildungen 1 und 2):

- Mineralien für Industrie und Bau
- Biomasse
- Fossile Kohlenstoffträger (Kohle, Erdöl und Gas) („Fossil Fuels“)
- Metalle („Metals“)

Insgesamt gehen mehr als 93 % der fossilen Kohlenstoffträger und etwa 5 % der Biomasse in die energetische Nutzung (der größte Teil geht in Lebens- und Futtermittel) – Mineralien und Metalle werden nur stofflich eingesetzt. Insgesamt werden von allen Rohstoffen etwa 80 % stofflich und nur 20 % energetisch genutzt.

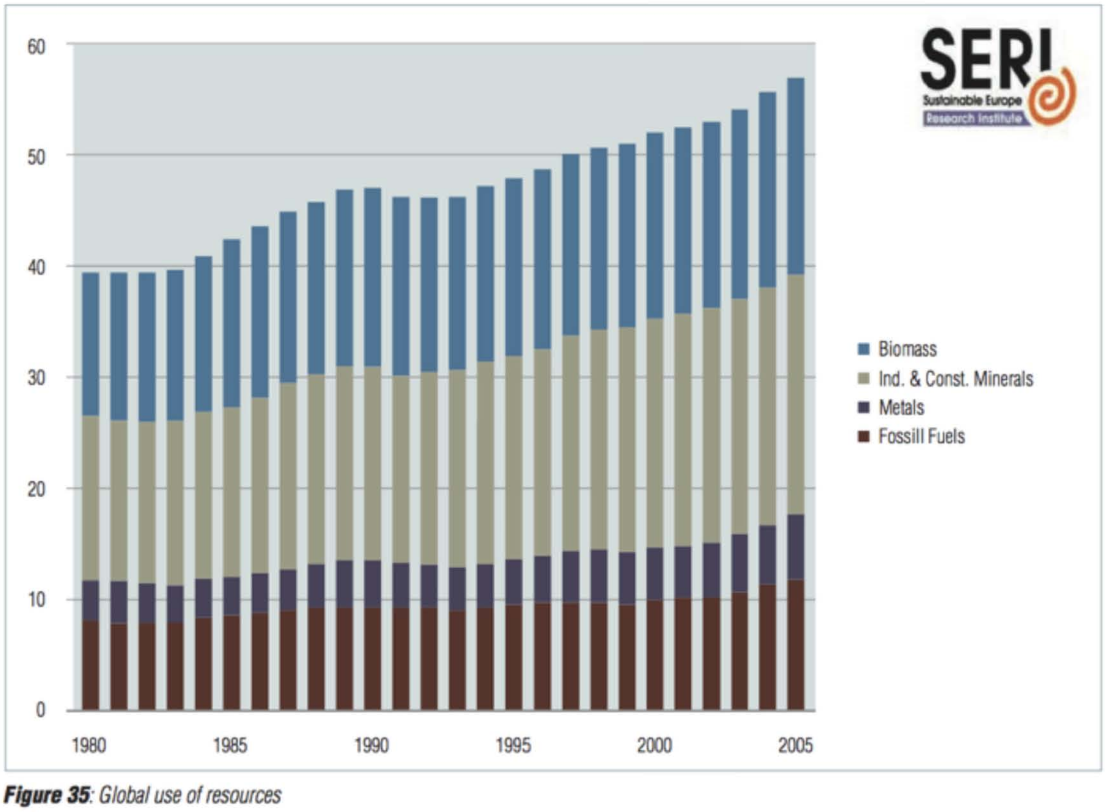


Abbildung 1: Globaler Ressourcenverbrauch nach Sektoren (in Mrd. t), Quelle: UNEP 2008

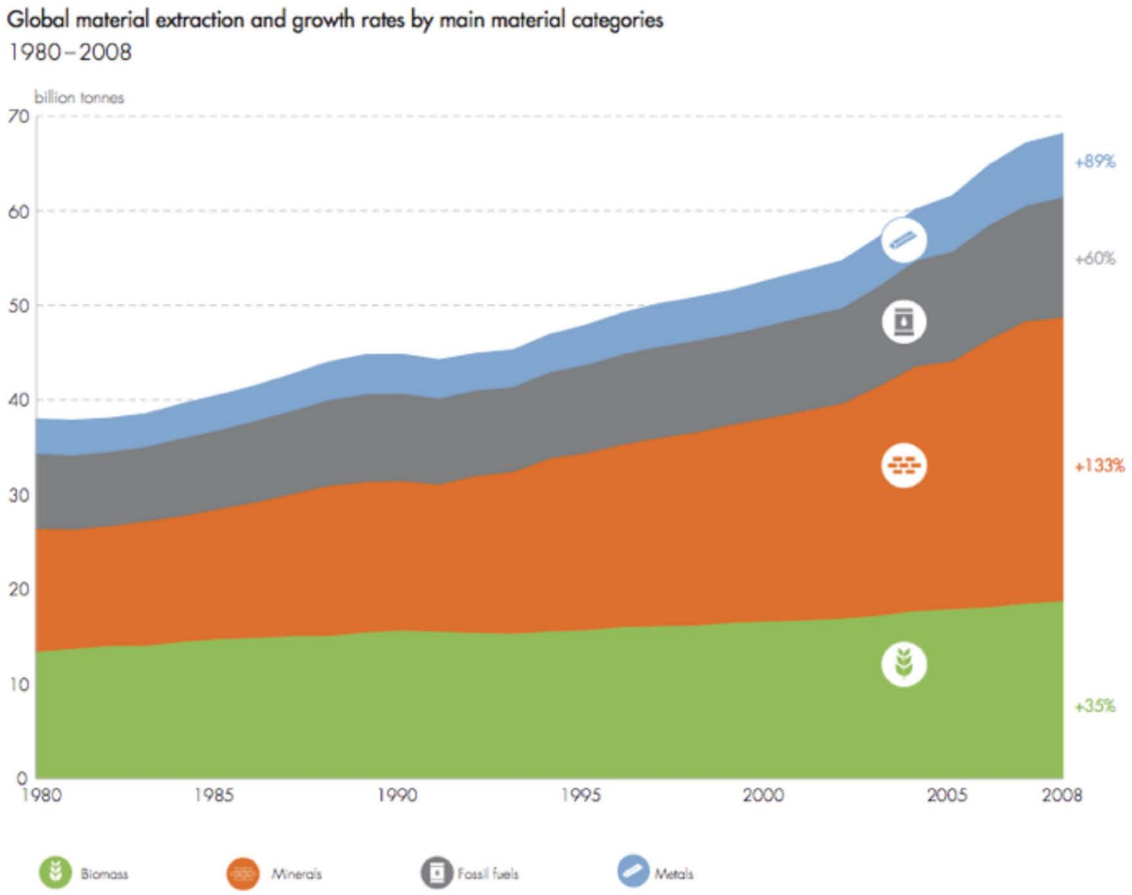


Abbildung 2: Globale Rohstoffentnahme und Wachstumsraten nach Rohstoffkategorien (in Mrd. t), Quelle: Dittrich et al. 2012

Dittrich et al. 2012 entwickeln auch Szenarien für den zukünftigen globalen Rohstoffbe-darf, einmal für den Fall „business-as-usual (BAU)“ (s. Abb. 3) und einmal für den Fall, dass ab 2030 alle Länder auf einem „Best-practice-level“ angekommen sind (s. Abb. 4).
Im „business as usal“-Szenario wird davon ausgegangen, dass der globale durchschnittli-che Rohstoffverbrauch pro Kopf der Entwicklungs- und Schwellenländer ab 2030 auf dem selben Niveau liegt wie in den OECD-Ländern. Eine grobe Schätzung zeigt, dass die Menschheit dann im Jahr 2050 etwa 180 Mrd. t Rohstoffe verbraucht, das sind das 2,7-fache im Vergleich zum Ausgangsjahr 2008.
Im „best-practice“-Szenario gehen die Autoren von einem nur mittleren Bevölkerungs-wachstum aus, von einem hohen technischen und logistischem Entwicklungsstand, einem reduzierten Rohstoffeinsatz und einer effizienteren Nutzung der Rohstoffe. Das würde durchschnittlich nur Rohstoffverbrauch von 10 t pro Kopf und Jahr bzw. 93 Mrd. t im Jahr 2050 (das wären nur etwa 35 % mehr als 2008). Der Verbrauch wird sind dann bis 2100 auf einem Niveau von 100 Mrd. t stabilisieren, der sich auf etwa 22 Mrd. t Biomasse, 23 Mrd. t Fossile Kohlenstoffträger, 8 Mrd. t Metalle und 45 Mrd. t Mineralien aufteilt.

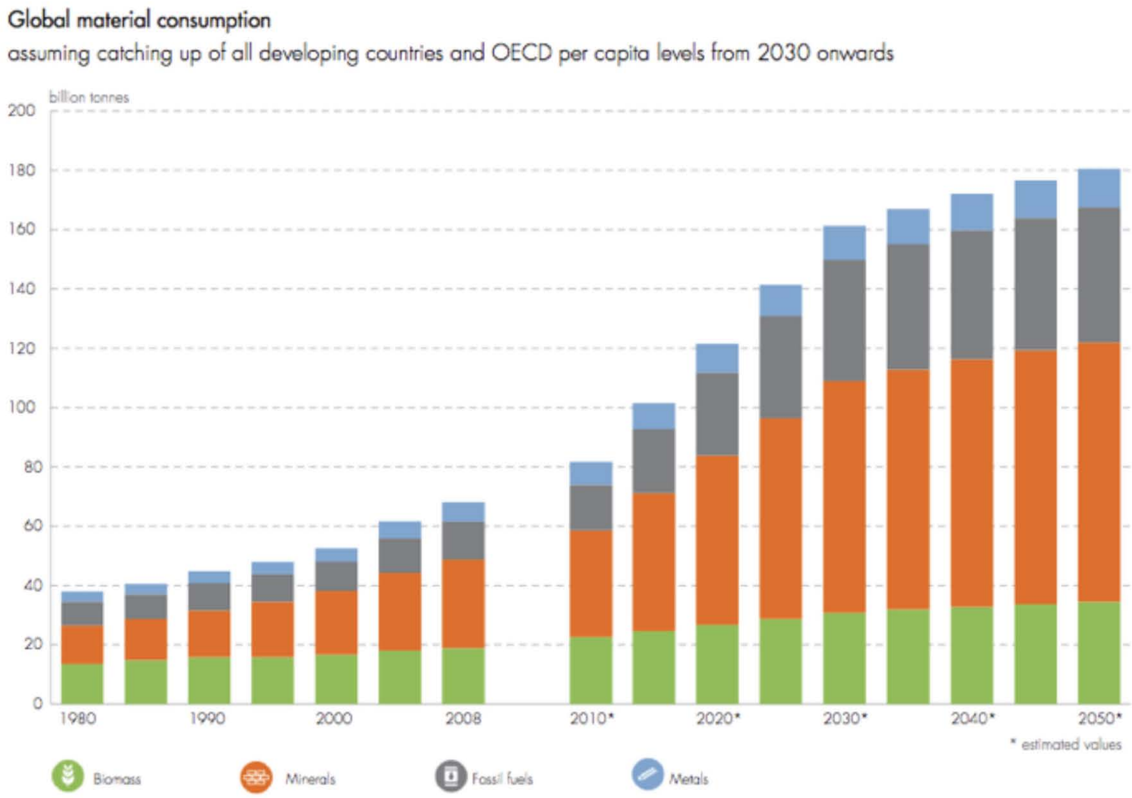


Abbildung 3: Globaler Rohstoffverbrauch bis 2050 im BAU-Szenario (in Mrd. t), Quelle: Dittrich et al. 2012

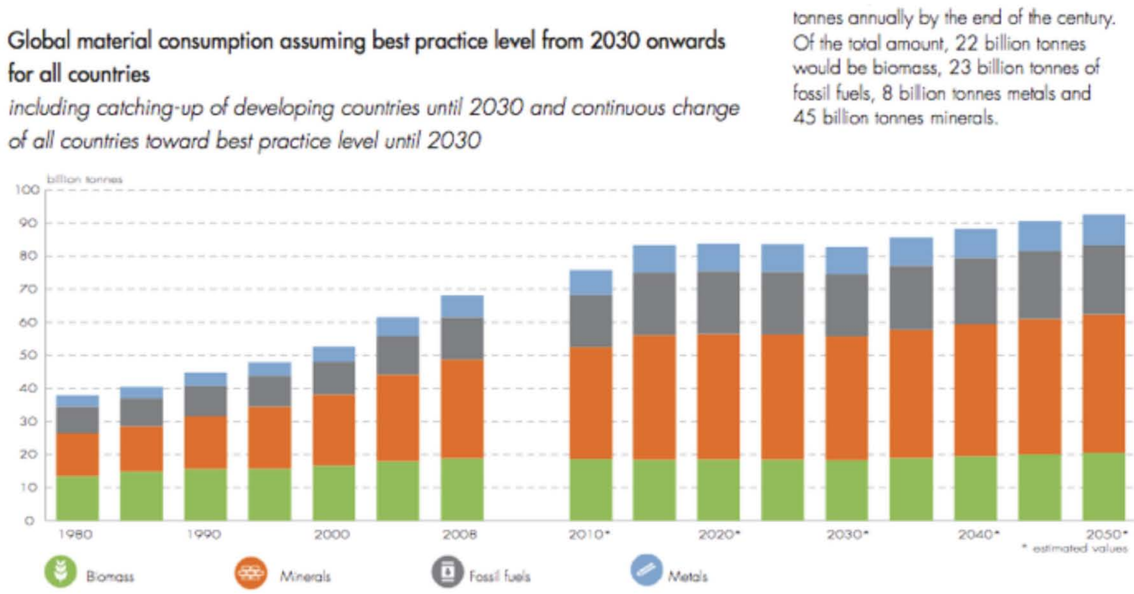


Abbildung 4: Globaler Rohstoffverbrauch bis 2050 im „best-practice"-Szenario (in Mrd. t), Quelle: Dittrich et al. 2012

Wie die nächste Abbildung zeigt, unterscheidet sich der Rohstoffverbrauch pro Kopf und Jahr in verschiedenen Ländern ganz erheblich. Der Anstieg dieses Pro-Kopf-Verbrauchs bei gleichzeitig wachsender Weltbevölkerung führt zu einem erheblich steigenden Rohstoffbedarf, der je nach technologischem Fortschritt und Effizienzsteigerungen verschieden stark begrenzt werden kann.

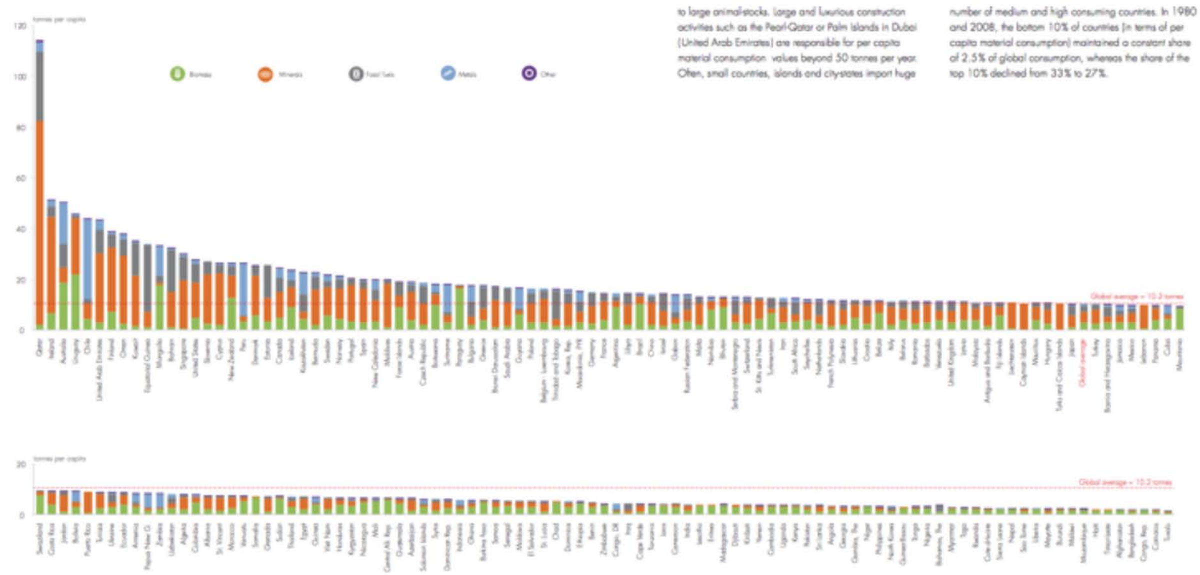


Abbildung 5: Tonnen Rohstoffverbrauch pro Kopf in verschiedenen Ländern (in t pro Jahr und Kopf), Quelle: Dittrich et al. 2012

7.a. Ist damit zu rechnen, dass die landwirtschaftlich genutzte Fläche wesentlich ansteigen wird?

Weltweit ist eine Ausdehnung der landwirtschaftlichen Flächen um einige 100 Mio. Hektar möglich (siehe Abbildung 6), ohne dabei auf Schutzgebiete oder Wälder zurückgreifen zu müssen. Selbst in Europa gehen Experten von 10 bis 30 Mio. Hektar zusätzlicher Agrarflächen aus.
Wichtiger als die Ausdehnung der Agrarflächen ist aber die Steigerung der Erträge, die in vielen Entwicklungs- und Schwellenländern noch ganz erheblich ist (teilweise um den Faktor 5 bis 10). Selbst mit moderner ökologischer Landwirtschaft sind z.B. in Afrika Ertragssteigerung um das 2- bis 3-fache (oder sogar mehr) möglich. Auch in Europa sind in einigen Ländern erhebliche Steigerungen möglich. So liegen die Weizenerträge in Rumänien heute auf demselben Niveau wie zu römischen Zeiten!

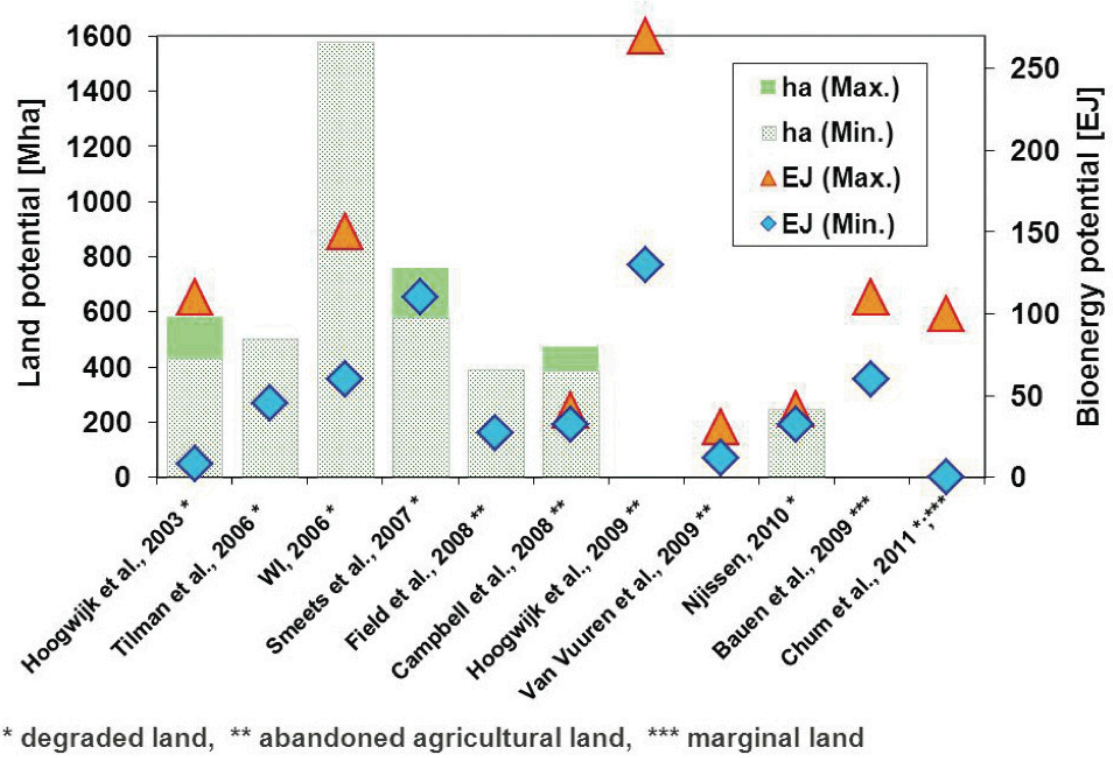


Abbildung 5: Flächen- und Bioenergiepotenzial weltweit nach verschiedenen Studien (12-10-30 BioRisk)

In Deutschland und NRW spielen Ausweitungen der Agrarflächen keine relevante Rolle und auch die Ertragssteigerungen werden nur noch moderat ausfallen. Hier geht es vor allem um die optimale Allokation von Flächen und Biomasse unter Gesichtspunkten wie Klimaschutz, Ressourceneffizienz, Kaskadennutzung und Kreislaufwirtschaft – aber auch Investitionen, Wertschöpfung und Arbeitsplätzen.

Unter diesen Gesichtspunkten ist dringend ein Politikwechsel notwendig, da die Flächenallokation zu Gunsten von Bioenergie und Biokraftstoffen zu Lasten der stofflichen Nutzung den genannten Kriterien in keiner Weise gerecht wird.

8.a. Welche Bedeutung kommt nachwachsenden Rohstoffen in der chemischen Industrie, heute und zukünftig zu?

Es gibt keine verlässlichen Zahlen zum Einsatz nachwachsender Rohstoffe in der Chemie. Schätzungen gehen für Deutschland von einem Anteil von 10 bis 15% aus, bezogen auf den Kohlenstoffinput. Zählt man den mineralischen Rohstoffeinsatz mit hinzu, sinkt der Anteil auf 5 bis 7%.
Grundsätzlich ist ein erheblich höherer Anteil möglich, technisch betrachtet kann der fossile Kohlenstoff vollständig durch Biomasse substituiert werden. Welcher Anteil ökonomisch und ökologisch sinnvoll ist, muss detailliert untersucht werden.

Bei geeigneten Rahmenbedingungen, wie z.B. einer Gleichbehandlung der energetischen und stofflichen Nutzung in allen Regularien, ist sicherlich eine Verdopplung des Einsatzes bis 2030 möglich.

8.c. Welche Zielkonflikte (Nahrung – Energie – Chemie-Rohstoffe) existieren bei Agrarprodukten und wie lassen sie diese vermeiden?

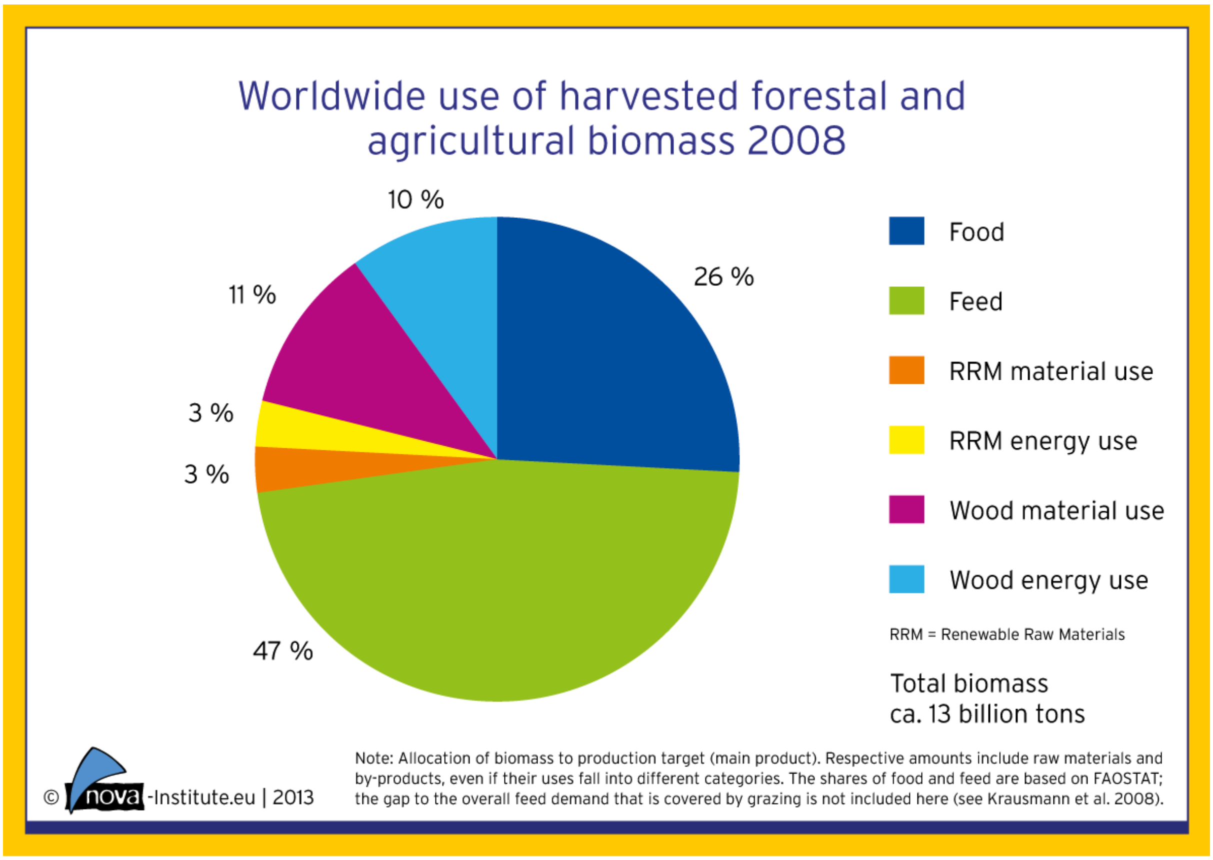


Abbildung 6: Weltweit geerntete Biomasse von Agrar- und Forstflächen und ihre Anwendungen

Abbildung 6 zeigt, welchen großen Anteil Futtermittel für die Fleisch-, Milch- und Eierproduktion ausmachen. Knapp 50% der gesamten Biomasse geht in Futtermittel. Nimmt man die extensiv genutzten Weideflächen noch hinzu, steigt der Anteil sogar auf knapp 70%. Eine Reduzierung des Fleischkonsums würde demnach die Konkurrenz um Biomasse am stärksten entlasten.

Die Abbildung zeigt ferner, dass die stoffliche und energetische Nutzung in etwa dieselbe Menge an Biomasse verbrauchen. Vor der massiven Förderung der Bioenergie/Biokraftstoffe lag die stoffliche Nutzung deutlich vorne.

Eine Reduzierung der Flächenkonkurrenz lässt sich vor allem mit folgenden Maßnahmen erreichen:

- Substitution von Biokraftstoffen durch Solar- und Wind-betriebene Elektrofahrzeuge. Diese ernten von derselben Fläche die 40 bis 100-fache Energie verglichen mit Biokraftstoffen.
- Ausbau der stofflichen Nutzung und dabei vor allem der bio-basierten Chemie und Werkstoffe (Kunststoffe und Verbundwerkstoffe) mit konsequentem Recycling (Kreislaufwirtschaft) und Kaskadennutzung, an deren Ende eine energetische Nutzung stehen kann.
- Hierdurch könnte die geerntete und industriell genutzte Biomasse in erheblich stärkerem Maß zu Ressourceneffizienz, Klimaschutz, Wertschöpfung und Arbeitsplätzen beitragen.

Zur Problematik der industriellen Nutzung von „Food-Crops“ bitte das beigefügte Papier „nova paper #2 on bio-based economy 2013-07: Food or non-food – which agricultural feedstocks are best for industrial uses?“ beachten.

8.d. Wie groß ist das weitere Potenzial der stofflichen Nutzung von Holz?

Zunächst ist wahrzunehmen, welche großen Potenziale die Holzwerkstoffindustrie und ihre nachgelagerten Branchen in Deutschland und speziell auch NRW aktuell noch besitzen. Gleichzeitig gefährdet die durch massive Förderung ausdehnende Bioenergienutzung (Holzpellets) durch Verknappung und Preissteigerungen die Zukunft der gesamten Branche, die droht nach Osteuropa auszuwandern.
Dies hätte erhebliche Verluste an Wertschöpfung und Arbeitsplätzen zur Folge, die durch neue Arbeitsplätze im Bioenergiebereich nicht ansatzweise aufgefangen werden können.

Gerade bei Holz können erhebliche Potenziale durch konsequente Kaskadennutzung gehoben werden. Die Herstellung von Pellets sollte möglichst nur als Nachnutzung einer vorangegangenen stofflichen Nutzung erfolgen. Gerade im Nadelholz sind wertvolle Bestandteile wie Terpene, Tallöl oder Kolophonium enthalten, die vor einer energetischen Nutzung extrahiert werden sollten – wie dies auch bei der Zellstoffindustrie heute üblich ist.

Weitere potenzielle Anwendungen stellen Bioraffinerien dar, in denen aus Zellulose, Hemizellulose und Lignin eine Vielzahl an bio-basierte Chemikalien produziert werden können. Aktuelle technische-ökonomische Bewertungen des nova-Instituts haben gezeigt, das solche Bioraffinerien die geringsten Subventionen benötigen, wenn sie keine Biokraftstoffe, sondern nur möglichst hochpreisige Chemikalien herstellen.

9. Wie groß ist das Potenzial zur stofflichen Verwendung von CO_2?

Grundsätzlich können sämtliche kurzkettige Chemikalien aus CO_2, Wasser und Sonnenenergie hergestellt werden.
Abbildung 7 zeigt, welche Moleküle bzw. chemische Bausteine (building blocks) zukünftig besser aus CO_2 bzw. Biomasse produziert werden können. Insbesondere Syngas aus Biomasse hat vor diesem Hintergrund nur geringe Zukunftschancen.
Abbildung 8 vergleicht die Produktion von Ethanol aus Biomasse mit der von Methanol aus CO_2. Die bereits in Island und Deutschland realisierten Power-to-Gas-Anlagen, die Überschuss-Solar- und Wind-Strom in Methan bzw. Methanol umwandeln, stellen eine viel versprechende Technologie dar.
Sowie man große Teile der Chemie ebenso über Methan (Erdgas, Shale Gas) wie über Erdöl realisieren kann, gilt die ebenso für die stoffliche Nutzung von CO2 (CCU = Carbon Capture and Utilization) in Form von Methan bzw. Methanol.

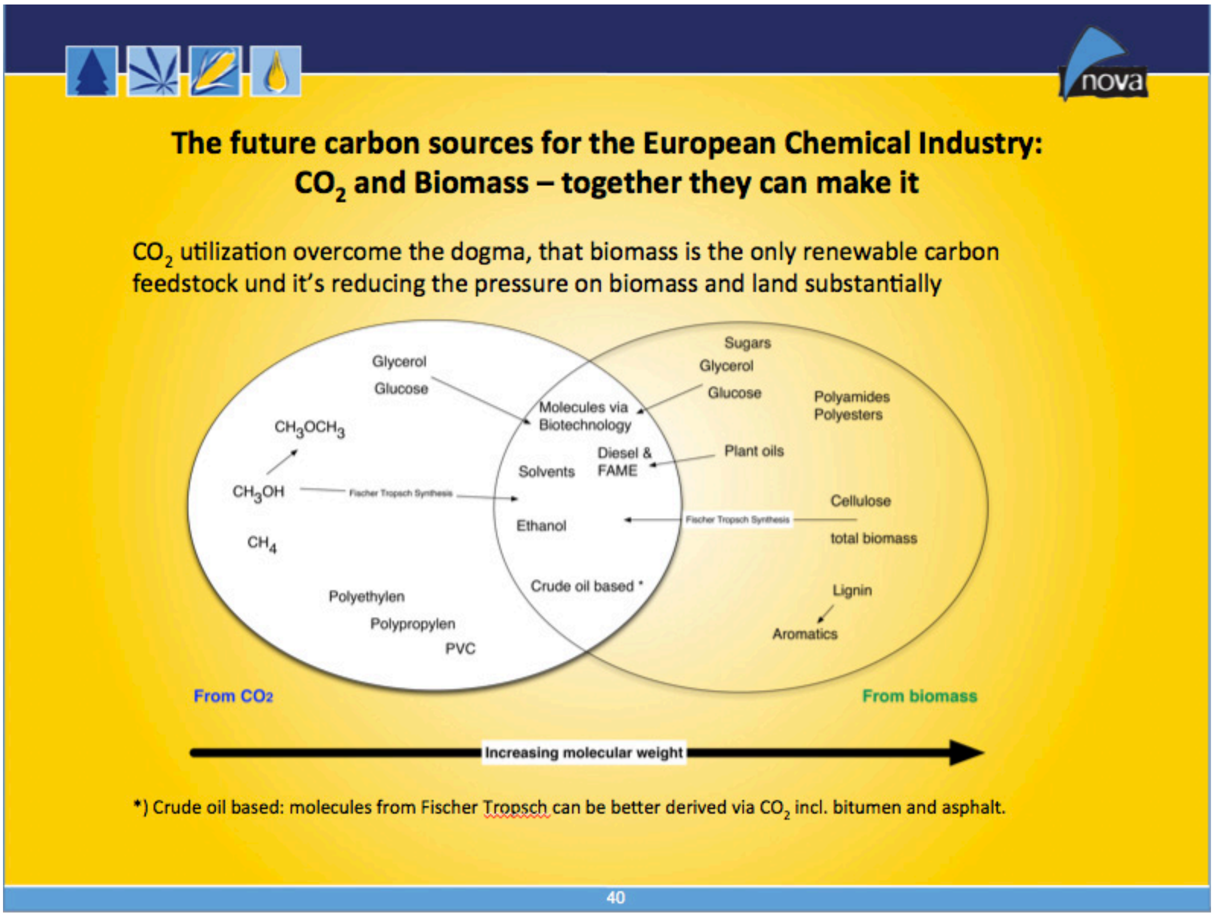


Abbildung 7: Chemie-Bausteine zukünftig aus CO2 bzw. Biomasse

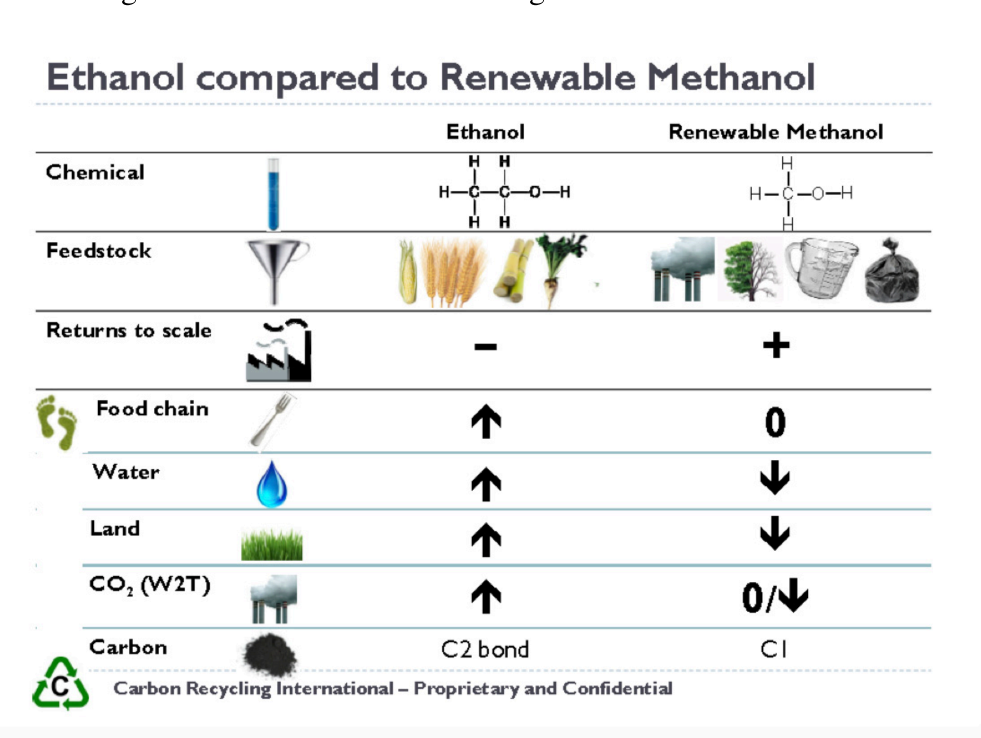


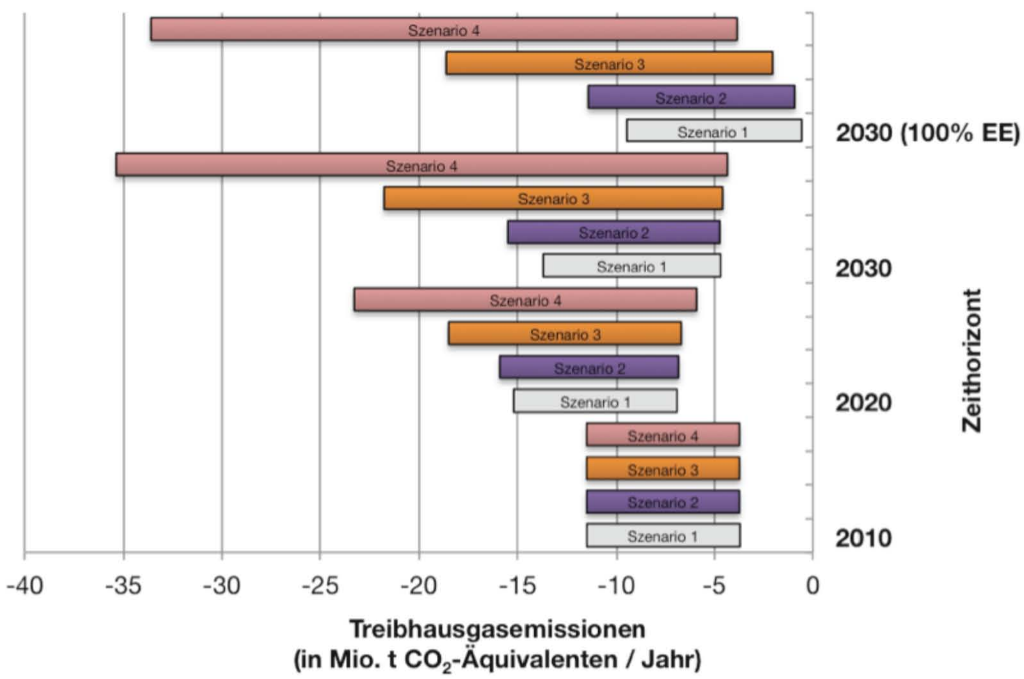
Abbildung 8: Ethanol aus Biomasse versus Methanol aus CO_2

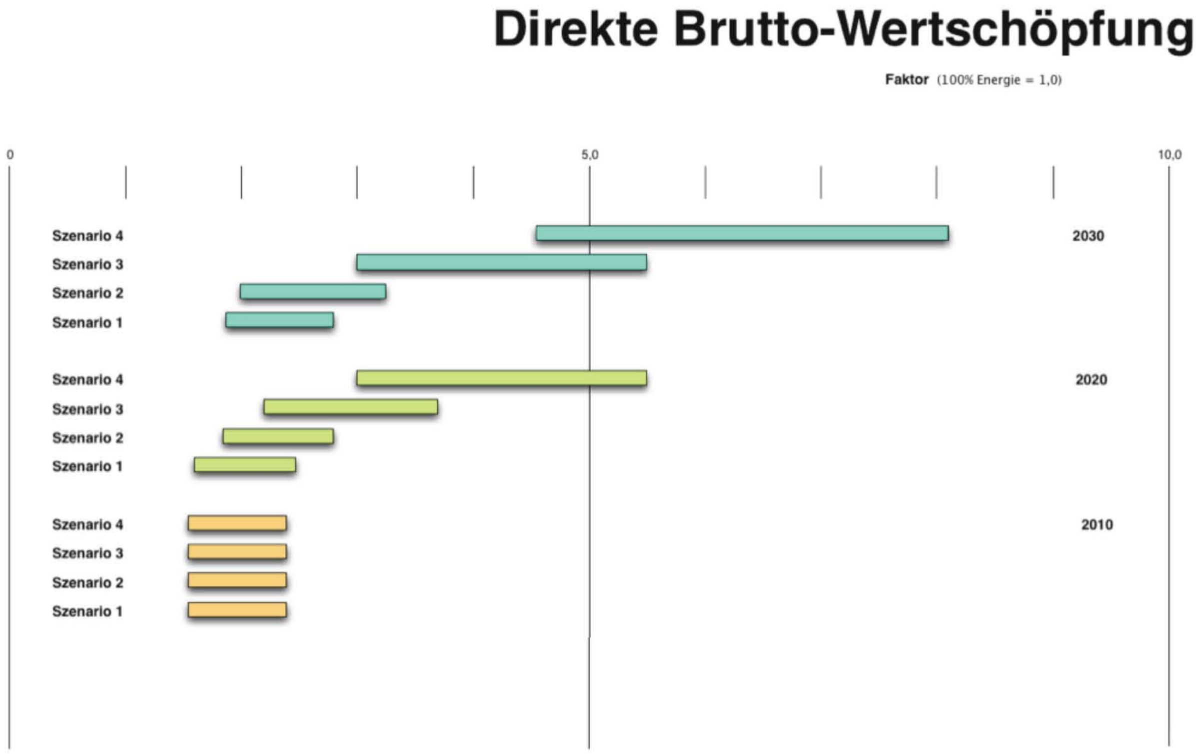
10. Welche Auswirkungen sind bei Substitution im sozialen, ökonomischen und ökologischen Bereichen (Stichwort: Nachhaltigkeit) zu erwarten?

Genau diese Frage wurde in einem Projekt des nova-Instituts für das Umweltbundesamt (UBA) umfassend untersucht. Die Ergebnisse werden im Oktober 2013 publiziert. Die beiden nächsten Abbildungen zeigen vorab die wichtigsten Ergebnisse. Untersucht wurden vier Szenarien

Ausgangsbasis: 2,5 Mio. ha werden in Deutschland für nachwachsende Rohstoffe genutzt, davon 85% für Bioenergie/Biokraftstoffe und 15% für die stoffliche Nutzung. Betrachtet wurden vier Szenarien für das Jahr 2030, die in der Studie detailliert unterfüttert werden:

Szenario 1: Im Jahr 2030 werden 80% energetisch und 20% stofflich genutzt.
Szenario 2: Im Jahr 2030 werden 75% energetisch und 25% stofflich genutzt.
Szenario 3: Im Jahr 2030 werden 50% energetisch und 50% stofflich genutzt.
Szenario 4: Im Jahr 2030 werden 10% energetisch und 90% stofflich genutzt.
Szenario 4b: Im Jahr 2030 werden 10% energetisch und 90% stofflich genutzt und die gesamte Stromproduktion erfolgt auf Basis erneuerbarer Energien, vor allem Sonne und Wind.





Die Ergebnisse zeigen sehr deutlich, welche großen Potenziale für Umwelt und Ökonomie eine stärkere stoffliche Nutzung von Biomasse anstelle einer energetischen Nutzung aufweisen würde.

Michael Carus, Geschäftsführer des nova-Instituts, Hürth (www.nova-institut.eu)

Hürth, den 17. September 2013.

Quellen:

- Dittrich, M., Giljum, S., Lutter, S., Polzin, C. 2012: Green economies around the world? Implications of resource use for development and the environment. Wien, 2012.
- UNEP 2008: Detailed assessment: Material efficiency, Chapter 6.

nova paper #2 on bio-based economy 2013-07

Food or non-food: Which agricultural feedstocks are best for industrial uses?

Authors: Michael Carus (Dipl.-Physicist) and Lara Dammer (M.A. Pol. Sci.), nova-Institut GmbH

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nova paper #2 on bio-based economy 2013-07

Food or non-food – which agricultural feedstocks are best for industrial uses?

*Authors: Michael Carus (Dipl.-Physicist) and
Lara Dammer (M.A. Pol. Sci.), nova-Institut GmbH*

1 Executive Summary

This position paper is a contribution to the recent controversial debate about whether food crops should be used for other applications than food and feed. It is based on scientific evidence and aims to provide a more realistic and appropriate view of the use of food-crops in bio-based industries, taking a step back from the often very emotional discussion.

Our position is that all kinds of biomass should be accepted for industrial uses; the choice should be dependent on how sustainably and efficiently these biomass resources can be produced.

Of course, with a growing world population, the first priority of biomass allocation is food security. The public debate mostly focuses on the obvious direct competition for food crops between different uses: food, feed, industrial materials and energy. However, we argue that the 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, as will be discussed below.

We therefore suggest a differentiated approach to finding the most suitable biomass for industrial uses.

In a first step, we must address the issue of whether the use of biomass for purposes other than food can be justified at all. This means taking the availability of arable land 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.

The second step is then to find out how best to use these available areas. Recent studies have shown that many food crops are more land-efficient than non-food crops. This means that less land is required for the production of a certain amount of fermentable sugar for example – which is especially crucial for biotechnology processes – than would be needed to produce the same amount of sugar with the supposedly "unproblematic", second generation lignocellulosic 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 utilization of food crops in bio-based industries very efficient.

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.

We therefore request that political measures should not differentiate simply between food and non-food crops, but that criteria such as land availability, resource- and land efficiency, valorization of by-products and emergency food reserves are taken into account.

This also means that research into first generation processes should be continued and receive fresh support from European research agendas and that the quota system for producing sugar in the European Union should be revised in order to enable increased production of these feedstocks for industrial uses.

And we ask for a level playing field between industrial material uses of biomass and biofuels/bioenergy in order to reduce market distortions in the allocation of biomass for uses other than food and feed.

2 Introduction & Objectives

This paper aims to make a contribution to the recent discussion about food vs. non-food crops for industrial uses. We want a framework that supports the use of feedstocks that are truly the most advantageous in terms of sustainability and resource efficiency and hence in terms of food security. To do this we need to find out which really are the best biomass feedstocks for industrial uses, and in this paper we will provide answers to this question, based on scientific evidence and detailed logical arguments.

The topic is complex and controversial. Unfortunately, public debate often settles for too many simplified and polemical answers, such as "using food crops is bad per se". This paper will look into the manifold aspects that influence biomass usage and its impact on food security.

Consequently, the paper analyses the latest data for biomass use and biomass availability under the current frameworks, gives definitions for crops, and estimates the huge potential for biomass use (see Sections 3 and 4). On the basis of these findings, we define our position on the use of biomass for industry (see Chapter 5) and derive policy recommendations.

3 Biomass use in the European Union and worldwide

With an increasing world population, ensuring food security is the first priority of biomass usage. At the end of 2011, there were about 7 billion people on our planet. The global population is expected to reach more than 9 billion people by 2050. This alone will lead to a 30% increase in biomass demand. Increasing meat consumption and higher living standards will generate additional demand for biomass. The European Commission came to the 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. […] As global demand for biomass for food and industrial purposes grows over the coming decades, EU agriculture, forestry, fisheries and aquaculture capacity will need to be sustainably increased."

Food and feed clearly are the supply priorities for biomass use, followed by bio-based products, biofuels and bioenergy. Figure 1 shows the use of the 10 billion tonnes of biomass harvested worldwide in 2008. Animal feed predominates with a share of 60%, which will increase even further due to increasing meat consumption. If grazing land is taken into account as well as arable land, the share of biomass used for feed exceeds 70% (see Figure 2).

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 (even in the EU there are between 2.5 and 8 million hectares arable land that are not currently in use), arable land and biomass are limited resources and should be used efficiently and sustainably.

Huge potential for increasing biomass availability

As the numbers above show, 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, as will be discussed below.

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 utilized. (Dauber et al. 2012, Zeddies et al. 2012)

Both aspects mean that political reforms and huge investment in agro-technologies and infrastructure are necessary.

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 (FAO 2011);
- 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 fuelling 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. (Carus 2012)

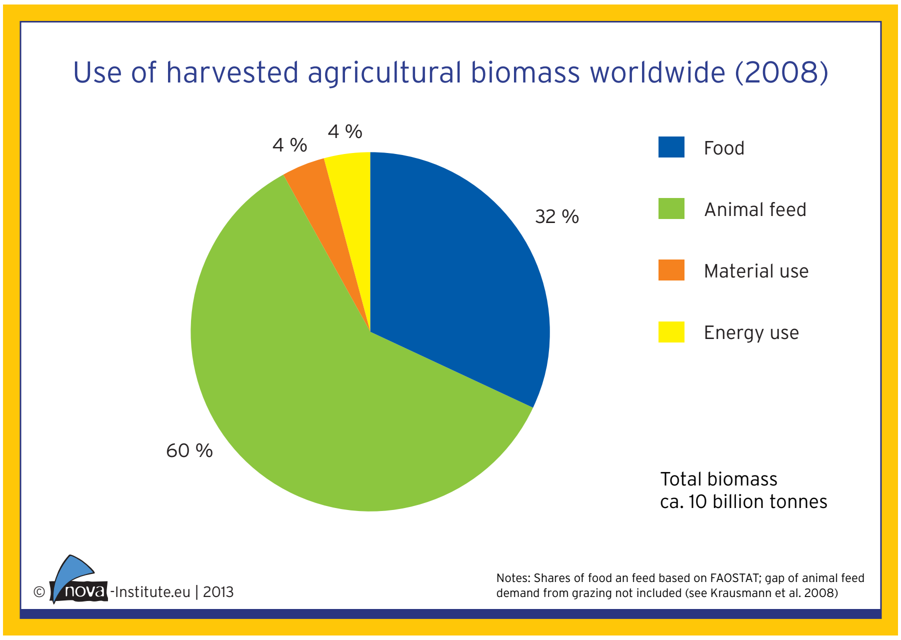

Figure 1: Worldwide allocation of harvested biomass by production target (main product) in 2008. Respective amounts include raw materials and their by-products, even if their uses fall into different categories.

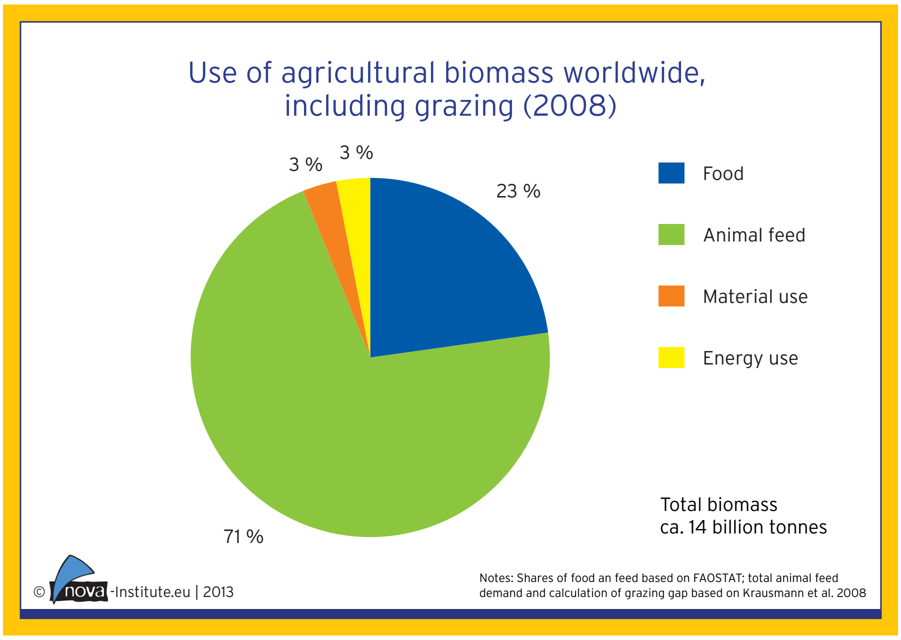

Figure 2: Worldwide allocation of biomass, including grazing, by production target (main product) in 2008. Respective amounts include raw materials and their by-products, even if their uses fall into different categories.

First, second and third generation feedstocks

The use of biomass to obtain different chemicals and materials is virtually as old as mankind (e.g. birch bark pitch use dates back to the late Paleolithic era). It has been conducted on an industrial scale for over 100 years. For example, starch is used on a large scale in the paper industry. 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 their potential direct competition with food and animal feed, politicians and scientists have in the last ten years introduced the idea of using lignocellulosic feedstock as a raw material for fermentable sugars and also for gasification. Lignocellulose means wood, short-rotation coppice such as poplar, willow or Miscanthus, or else lignocellulosic agricultural by-products like straw. These are the so-called second-generation feedstocks. Very recently, more and more research is being carried out into using algae as a feedstock; this is known as a third-generation feedstock.

Whether the use of second-generation feedstocks will have less impact on food security is questionable and will be discussed below.

Public debate only focuses on direct competition between food crops for different uses. Therefore, one of the most common questions raised is: "When will your company switch from food crops[1] to second-generation lignocellulosic feedstock?" From our point of view this is the wrong question. The real question is: "What is the most resource-efficient and sustainable use of land and biomass in your region?" It is not a question of whether the crop can be used for food or feed; 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 (see Chapter 6).

4 Current frameworks for the industrial use of biomass

"The Bioeconomy Strategy and its Action Plan aim to pave the way to a more innovative, resource efficient and competitive society that reconciles food security with the sustainable use of renewable resources for industrial purposes, while ensuring environmental protection." (European Commission 2012)

Under the social challenge "Food Security, sustainable agriculture, marine and maritime research and bio-economy", the Horizon 2020 proposal makes the following statement about biomass use: *"The aim is the promotion of low carbon, resource efficient, sustainable and competitive European bio-based industries."* In this context, a bio-based industry infrastructure based on first-generation technology (mainly starch, sugar and oil) is not seen as an appropriate future choice for Europe. Biorefinery projects that focus on food crops especially tend to be viewed more critically in Europe than elsewhere.

The effect of this is that EU research policy is focused on mobilizing efforts to be the leader in the deployment of biorefineries that rely on second-generation lignocellulosic and third-generation algae feedstock.

Several NGOs (e.g. Greenpeace 2010, Oxfam 2012) want to freeze the use of food crops, especially for biofuels, because they fear direct competition with the food market and a severe impact on food prices and food availability for the poorest. In 2012, the European Commission reacted to these demands with a proposal to decrease the biofuel mandates with regard to food crops and ILUC in order to improve the environmental impact of biofuels (European Commission 2012b). International companies are also seeking to avoid using food crops as part of their biomass strategies and are focussing instead on second- and third-generation feedstocks.

Today, most of the bio-based chemicals and plastics rely on first-generation feedstock, and the technology as well as the economies of the second and third generation have yet to really prove themselves viable beyond subsidized cases. Recently we have seen some promising achievements in terms of enzyme costs and performance. On the other hand, many projects failed and a lot of companies are stopping or delaying activities in second- and third-generation endeavours, in part due to the low cost of conventional carbon sources (e.g. shale gas).

By contrast, the US, Brazil and China are pushing ahead with the development of industrial biorefineries that use food crops as a feedstock with the aim of kick-starting their bio-based industries; yet of course they are at the same time supporting the second and third generations. In the US, for example, an increased mandate has been implemented for the inclusion of corn-based ethanol fuel and chemicals, and it was stated in advance that this would be effective for the next 15 years at least. These factors give the EU's competitors a clear first-mover advantage.

Industry needs more time to develop the right technologies for second- and third-generation feedstock usages and therefore the first-generation feedstock should be considered as an important, long or even everlasting bridge to the second and third generations – if these turn out to be more efficient from a land-use perspective in the future.

5 A differentiated approach to finding the most suitable biomass for industry

There is no black-and-white answer to the question of what constitutes the most suitable biomass for the bio-based economy. Depending on local conditions, it is possible that any one – or indeed several – of food crops, lignocellulosic crops or algae are favourable in terms of sustainability, food security, environmental impacts and economy.

One important factor influencing these impacts is the use of by-products. If food crop or agricultural waste by-products are available and not already used in other processes[2], 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 (FNR 2013) and the processes for utilizing them are not yet established.

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.

When politicians and industry reacted to public debate during the 2008 food crisis, they gave too simplistic an answer to the potential food versus industry conflict, concluding that industry should switch to non-food crops as soon as possible.

From our point of view, the question of food versus non-food crops for industry is in itself oversimplified, as well as misleading. The real questions and conflicts are different, since both uses compete for land. Which crops use the land most efficiently and sustainably?

This means that any appropriate answer would include asking whether there are 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 to potentially produce 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?"

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 misallocation or underutilization of agricultural resources, i.e. land and biomass. We provide some background information on food crops below.

1 Note: This paper does not distinguish between food and feed crops, since animal feed is simply a precursor to food uses.

2 Availability depends on market demand and is influenced by incentive schemes. As a general rule, by-products currently used as feed or as feedstock for industry are not available for other purposes in the foreseeable future – see also Chapter 6.

6 Facts about food and non-food crops

This section provides some basic facts about the different uses of food and non-food crops that are often overlooked in public debate. It will look at the utilization of by-products, resource efficiency and the flexibility of potential uses.

How are food crops utilized for industrial material use today?

Typically, all parts of a food crop such as sugar, starch, oil, proteins and fibres are used in a wide range of applications. Biorefineries for food crops have existed for many years. Biorefineries convert all parts of a harvested crop into food, feed, materials and energy/fuel, maximizing the total value. If this maximum output value were not attained, the prices of the food and feed parts would go up.

For example, using sugar, starch or oil for bio-based chemicals, plastics or fuel leaves plant-based proteins, which are an important feedstock for the food and animal feed industry. At present, the world is mainly short of protein[3] and not of carbohydrates such as sugar and starch. This means that there is no real competition with food uses, since the valuable part of the food crops still flows into food and feed uses.

Table 1 and Figure 2 below give an overview of the valorization of processed fractions of crops, if the main use is material use, dry matter only. The percentage is related to grain or fruit only; additional (lignocellulosic) fibres from straw, leaves, etc. are not taken into account.

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 where the carbohydrates are used completely for chemicals.**

Hence, an increase in the use of food crops for industrial applications increases local protein production for animal feed, replacing imported soy proteins. Also, from an animal nutrition perspective, it is better for growth to feed the protein and fibre fraction separately and not the whole grain.

Crop	Carbohydrates		Oils		Proteins		Fibres (lignoce llulosic)	
	%	Use	%	Use	%	Use	%	Use
Sugar beet	65–70 %	Industrial			5–7 %	Feed	5–7 %	Feed
Sugar cane	30 %	Industrial					60 %	Industrial – 2nd Generation
Wheat	60 %	Industrial			10 %	Feed, Food	30 %	Feed, Food
Corn	75 %	Industrial	5 %	Food	15 %	Feed	5 %	Feed
Soy			20 %	Industrial	Proteins and Fibres 80 %			Feed, Food (soy milk and tofu from extracted proteins)
Rapeseed/ Canola			40 %	Industrial	Proteins and Fibres 60 %			Feed

Table 1: Valorization of components of food crops used in industry. This considers only the special case of when all carbohydrates (sugar beet, sugar cane, wheat and corn) or oils (soy and canola) are used for industrial material use only, their by-products being subsequently used for food and feed.[4]
Sources: Kamm et al. 2006; IEA Bioenergy, Task 42 Biorefinery 2012: Country Reports.

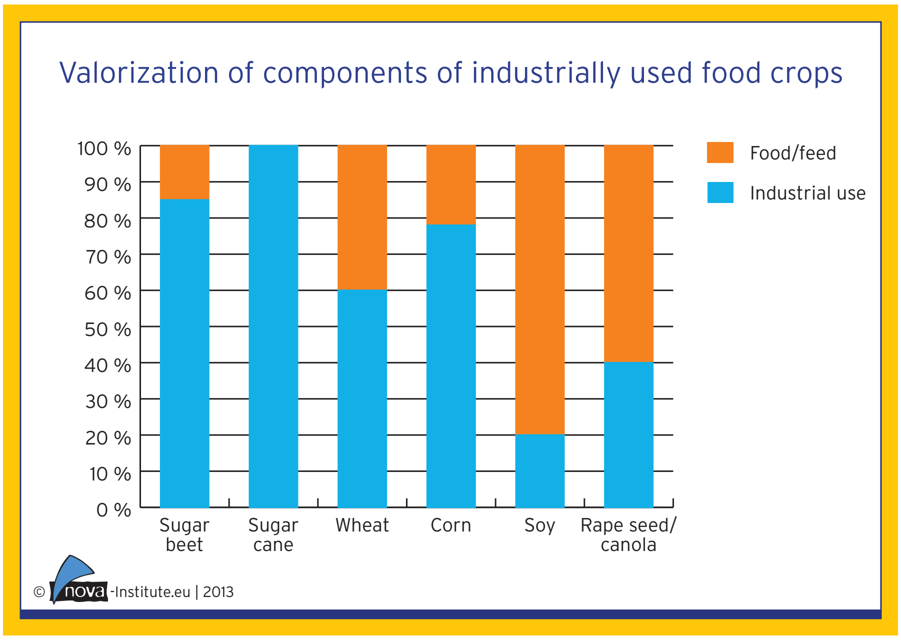

Figure 3: Valorization of components of food crops used in industry. This considers only the special case of when all carbohydrates (sugar beet, sugar cane, wheat and corn) or oils (soy and canola) are used for industrial material use only, their by-products being subsequently used for food and feed.[4]

Resource efficiency

Food crops have been cultivated for a couple of thousand years. They were the first cultivated plants and there have been large improvements in yield per area. Furthermore, the use of sugar, starch and oil is well established in the food, feed and chemical industries. The processes have been optimized and commercialized for decades – but advanced bio-technology can nevertheless lead to further efficiency gains.

In terms of fermentable sugar yields per hectare, sugar cane and sugar beet in particular can be more resource-efficient than second-generation lignocellulosic crops. A recent publication by Bos et al. 2012 shows that the land use per tonne of bio-based PLA, bio-based PE and bioethanol is lower for sugar beet and sugar cane than for the lignocellulosic perennial crop *Miscanthus*, see Figure 4. Also, avoidance of non-renewable energy use (NREU) for the various bio-based products compared to their fossil-fuel-based counterparts is greatest for sugar cane, sugar beet, followed by maize, *Miscanthus* and wheat. Therefore sugar cane and sugar beet have the highest land-use

3 Even Europe is a net importer of plant proteins from North and South America. Local production of industrial crops, generating protein by-products, would decrease these protein imports (and correlated land).

4 Table 1 and Figure 3 do not give an overview of actual current use of food crops, but only the special case when carbohydrates or oil are used exclusively for industrial material use. The reality is somewhat different: (1) Most of Brazil's mills can produce both ethanol and sugar, but the amount of each product varies according to market conditions. The regular mix is 55 % ethanol and 45 % sugar. (2) With one raw material, the European starch industry serves different application sectors – confectionary and drinks, processed foods, feed, paper and corrugating, pharmaceuticals, chemicals/ polymers and biofuels – in an integrated, continuous and balanced manner.

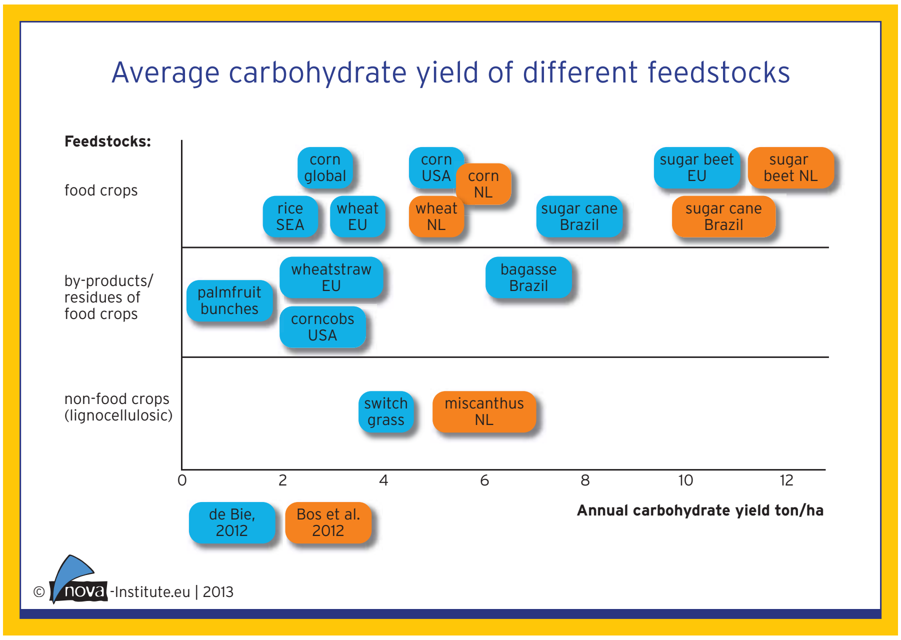

Figure 4: Annual carbohydrate yield per hectare for different feedstocks. (nova 2013, based on de Bie 2013 & Bos et al. 2012)

efficiency in terms of the amount of product per area, as well as the smallest CO_2 footprint.

Similar results were presented by de Bie 2012, see Figure 4. The annual carbohydrate yield in tonnes/ha is highest for sugar beet in the EU (> 10), followed by sugar cane in Brazil (8), bagasse in Brazil (7), corn (US, 5–6), switch grass (US, 4) and wheat (EU, 3–4).

These results are not very surprising. Starch, sugar and plant oils are used by the crops as energy storage for solar energy, and easy to utilize again. In contrast, lignocellulose gives the crop a functional structure, but is not built to store energy. This functional structure is built to last and protect the plants from microorganisms. Only specific enzymes (plus energy) are able to saccharify the lignocellulosic structure and transform it into fermentable sugars. Although terrific improvements have been achieved in this field over the last two decades, the price of the enzymatic cocktail and its efficiency are, alongside capital requirements, still the biggest obstacle to this strategy.

As a result, lignocellulosic biomass is definitely not the best option for fermentation processes, because the conversion of lignocellulose into fermentable sugars is energy-intensive and the technology for using lignin is still in its infancy.

Impacts of short-rotation coppice (SRC) on greenhouse-gas balances

A recent study on the impact of increased SRC cultivation on ground-level ozone shows once again that the choice of the most suitable biomass for industrial uses is complex and influenced by many different factors.

According to the researchers, fast-growing trees such as eucalyptus, poplar and willow evaporate more isoprene than traditional food crops. In combination with nitric oxide, this gas produces ground-level ozone. Extensive SRC cultivation would therefore lead to an increase in ground-level ozone concentrations, which would have negative impacts on human mortality and crop yields.

The study highlights the need to consider more than simple carbon budgets or food vs. non-food arguments when deciding which feedstocks to cultivate. (Ashworth et al. 2013)

Flexible application of food crops – emergency food reserve

One aspect that is rarely mentioned for some reason is that food crops for industry can also serve as an emergency reserve of food and feed supply, whereas second-generation lignocellulose cannot be used in the same way. **This means that food security can be assured through the extended use of food crops.** In a food crisis, sugar cane (Brazil) and corn (US), for example, can be immediately redirected to the food and feed market. This is especially possible with crop varieties certified for food and feed.

This already occurred in Brazil in 2011 via a flexible bioethanol quota, whereby the quota is reduced if there is demand for food or feed. This kind of flexible quota can be used to stabilize market prices for food and feed. In contrast, a fixed quota like the one operating in the EU and the US tends to destabilize market prices.

By contrast, lignocellulosic crops such as short-rotation coppice (SRC) only provide industrial supply security. SRC cultivation takes up land that cannot then be used for food and feed production. In a food crisis, the biomass yield from SRC fields cannot be used for food and feed, thereby maintaining the pressure on the food and feed markets. **The SRC-based lignocellulosic biomass can only feed the industry, even during a food crisis. Land is often blocked for a relatively long period of time.**

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 only use 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 however 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 utilizing 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 valorized in other applications is severely limited and cannot form the basis for an entire industry.

Therefore, growing more food crops for industry creates a quintuple win situation:

- **The farmer wins, since he has more options for selling his 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 also 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.**

SWOT ANALYSIS: Food Crops for Industry

	Helpful to achieving the objective	**Harmful** to achieving the objective
Internal origin attributes of the biomass	▶ Established logistic and processes (varieties, cultivation, harvest, storage, quality control) ▶ Sugar cane and beet: Highest yields of fermentable sugar per ha (high land efficiency) ▶ Positive GHG balance and low non-renewable resource depletion, high resource efficiency ▶ Protein rich by-product press cake or DDGS (Dried Distillers Grains with Solubles) for feed ▶ Lower production costs than sugars from lignocellulose **STRENGTHS**	▶ Direct competition to food and feed market ▶ Price level directly linked to food and feed prices; high prices during food crisis ▶ High volatility of the raw material prices ▶ Decreasing production would cause shortages on animal feed markets ▶ Sensitive to drought and dry winter freeze **WEAKNESSES**
External origin attributes of the environment	▶ Easy to use for biotech processes ▶ Fast implementation and growth of the Bio-based Economy; required technology is state of the art ▶ Food security only possible with a globally growing volume of food crops: Emergency reserves & market stabilization; (partial substitution with non-food crops would lead to artificial shortage) ▶ Economic security for the farmer due to more choices of selling his stock **OPPORTUNITIES**	▶ Under high pressure from public, NGOs and politicians: Claimed impact on food prices and food shortages ▶ Simple strong and populistic messages like "No Food Crops for Industry" ▶ During food crisis: High prices and no secure supply for the industry ▶ Insecure political framework; very complex EU legislation concerning specific food crops (e.g. sugar) **THREATS**

Figure 5: SWOT Analysis of food crop use for industry (nova 2013)

7 Level playing field for industrial material use and bioenergy/biofuels

As shown in Chapter 3, there are several factors influencing overall biomass availability. However, allocation of biomass to the different sectors also plays an important role. The first priority should always be food security, but after that the allocation of feedstocks between energy and material uses should be based on criteria such as the availability of possible substitutes, environmental friendliness, climate protection, added value, employment and innovation.

Bioenergy and biofuels receive strong on-going support for commercial production (quotas, tax incentives, green electricity regulations and more). By contrast, however, there is currently no similar, comprehensive European policy framework in place to support bio-based materials and products. Without comparable support, bio-based materials and products will further suffer from underinvestment from the private sector. Current policy leads to market distortion regarding feedstock availability and allocation, which increases the price for land and biomass.

There are several good reasons for differentiating between industrial material use of biomass as opposed to bioenergy and biofuels and for preferring the use of the limited biomass for materials over the use of biomass for bioenergy and biofuels:

- The industrial material use of biomass leads to a much higher turnover, added value and employment per tonne (and also per hectare) along the long added value chain. Estimations show that this can be 5 to 10 times higher than for bioenergy and biofuels;
- Bio-based materials and products show greater land and resource efficiency than bioenergy and biofuels, especially if recycling and cascading utilization are realized, with energy recovery as an end-of-life option;
- Bio-based materials and products serve as a carbon sink during their lifespan in contrast to biomass for energy and fuel, which rerelease the carbon immediately during their use phase and/or end of life. More bio-based durable goods from industrial use in particular will allow carbon to be captured and stored during the critical period of climate change over the coming decades;

- Bio-based materials and products cannot be as easily replaced by other renewables as bioenergy/biofuels can be by solar and wind power;
- Due to their higher added value, bio-based materials and products need less financial support than bioenergy/biofuels – or even no specific support at all, if market distortion from unbalanced support for bioenergy and biofuels is reduced;
- In total, industrial material use of biomass makes less demand on resources than energy and fuels, so the potential pressure on land and biomass is lower. Furthermore, much higher bio-based shares can be reached in the specific material application sectors than in the energy and fuel sectors.

A new political-economic framework is needed to rebalance the financial support for energy and industrial material use of biomass. Whatever the application, this new framework should be linked to climate protection, resource efficiency, employment and innovation.

8 Impacts on policy – what are we asking for?

All kinds of biomass should be accepted as feedstock for the bio-based economy. This should be mirrored in public debate and perception, as well as in specific political measures. **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.** First, second or third generation biomass itself should not be taken as the sole acceptance criterion, but nor should it be ignored.

The acceptable biomass must of course also meet established international sustainability standards (as it must to be eligible for the RED quotas) covering sustainable land use, natural biosphere protection and social sustainability. The criteria discussed in this paper such as resource and land efficiency, a lower environmental footprint and the lowest possible competition with food should be integrated into updated sustainability certification schemes.

The following Figure 5 sums up the advantages and disadvantages of increased industrial use of food crops discussed above. It shows that food security is higher with a global increase of food crop production, since resource efficiency is higher, land use is reduced and the flexibility of crop allocation in times of crises is greater.

European research agendas should again support first-generation processing lines for bio-based 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. This improvement should not be limited to second- and third-generation feedstocks.

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. Sugar beet in particular can be a very attractive feedstock for the European chemical industry – without any negative impact on the food and feed sector. Increasing yields are currently leading to decreasing areas under cultivation with sugar beet in some member states.

Implement a level playing field between industrial material use and biofuels/bioenergy. Today, European policy only provides significant support for biofuels and bioenergy, even though criteria such as environmental friendliness, climate protection, the availability of possible substitutes, added value, employment and innovation speak in favour of supporting the industrial material use of biomass.

> The region in the world which will optimize and balance the support of the use of biomass for energy and material first, will profit from a considerable growth, investments, green jobs, innovation, increased resource efficiency and additional climate protection. … Limited biomass should be used most efficiently: **Do more** value added and create more employment – **with less** biomass: **Bio-based Products**. (Carus et al. 2011)

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nova papers on bio-based economy

nova paper #1: Level Playing Field for Bio-based Chemistry and Materials. 2011-07.

nova paper #2: Food or non-food: Which agricultural feedstocks are best for industrial uses? 2013-07.

Download at: *www.bio-based.eu/policy/en*

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