Green New Deal Series volume 9

GREEN EUROPEAN FOUNDATION

A strategy for a bio-based economy

By Bas Eickhout

GROENLINKS EUROPA

The Greens | European Free Alliance in the European Parliament

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A strategy for a bio-based economy

By Bas Eickhout, Member of the European Parliament Greens/EFA

Based on a study by Jonna Gjaltema and Femke de Jong

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Foreword
By Bas Eickhout

The European Greens have been stating for years that the current Euro crisis cannot be seen as an economic crisis only. Our continent is populated with an ageing society that is dependent on imports of many natural resources to maintain its high level of wealth. This combination is creating a vulnerable society, which is currently shown on a day-by-day basis in countries like Greece, Spain and Portugal. The one-sighted solution that is pushed for by Northern European countries like Germany and the Netherlands is based on the naive believe that this crisis can be solved by cutting expenditures only, further deteriorating our common social welfare system that is already under great pressure.

The European Greens have been pushing for a common European agenda that is also addressing this dependence on natural resources. The creation of a new, Green economy should make us more reliant on sustainable resources that can be produced in our continent. With that we create jobs, we decrease our dependency and we improve our environment at the same time. It is still astonishing that so few politicians are embracing this agenda and only talk about it instead of acting on it.

As part of our Green economic and industrial vision, the bio-based economy plays a pivotal role. It is the bio-based economy that can replace fossil fuels on a broad scale, not only for energy applications, but more importantly also for material, clothing and plastic applications.

However, this transition towards a bio-based economy does not come without risks, as we experience at this moment in the field of bioenergy and biofuels. Here, the market push for the use of biomass for energy leads to increasing land use, land grabbing and volatile food prices. This shows that the bio-based economy can turn into a wrong alternative, both socially as environmentally, if the correct policy framework is not put in place.

This report is written with the promising prospect of a bio-based economy in mind, but certainly also considering our bad experiences on bioenergy and biofuels. How can we ensure that a bio-based economy is really delivering on environmental, social and economic opportunities and will not be misused by large multinationals that are looking for an alternative business model to replace their outdated and finite fossil model?

If the European Greens want to show that they have an alternative Green way out of this ongoing economic crisis, they have to dive into the challenging issues that the bio-based economy is providing us with. Simply discarding options like biofuels will not do. But joining the naive block of believers that alternatives will emerge out of nowhere is for sure not the Green way either. With this report, challenging questions and answers are raised in order to have a proper discussion on a Green vision of the bio-based economy. With that, this report contributes to our Green way out of the current crisis.

Bas Eickhout
Member of the European Parliament,
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and Food Safety

Executive summary

We live in a fossil-based economy. We depend on oil for our energy, transport, materials and chemicals production. At the same time, it is becoming apparent that our economies are unsustainable given that fossil resources are dwindling and set to get ever more expensive. Renewable biological resources (like biomass) will therefore become increasingly important in satisfying our demand. The bio-economy moves away from the fossil economy that runs on petroleum and encompasses the sustainable production of biomass into food, feed and bio-based products such as bioplastics. The bio-based economy makes more widespread use of biomass to replace fossil-based alternatives.

However, the use of biomass is limited due to finite land, water and nutrient (nitrogen, phosphorus) availability. Therefore biomass should not be used for applications where other viable alternatives exist, like for power generation or as biofuels for passenger cars. It is up to policymakers to ensure that the transition to a bio-based economy is sustainable.

A sustainable bio-economy is first and foremost built on the principle of resource efficiency. There is no unlimited amount of biomass, land and, water sustainably available and therefore we need to use it with care. Furthermore, diverting agricultural land from producing food crops to producing biomass for the bio-economy puts additional pressures on food security and food prices. Hence we need to use the biomass for the bio-economy in the most efficient way possible.

By making use of biorefineries, biomass can be utilized in an optimal way. Through biorefinery, biomass is separated into fractions: the valuable complicated molecules are processed into high-value applications such as chemicals and materials, while only the lower quality fractions can be used to make fuels or used for energy recovery. Biorefinery goes hand in hand with cascade utilization. Cascade utilization means that biomass should be used following a hierarchy: it is first directed to the top of the hierarchy (high value application of biomass: biochemicals and biomaterials) and only the remainders can be used for lower value applications (biofuels, bioenergy).

Current EU policies unfortunately do not promote a sustainable bio-economy founded on resource efficiency. EU policies promote the use of lower value applications (biofuels, bioenergy) instead of the higher value applications like biomaterials and biochemicals. The aim of the Renewable Energy Directive is that the EU reaches a 20 percent share of energy from renewable sources by 2020 and a 10 percent share of renewable energy specifically in the transport sector. The latter objective will be mainly achieved through the use of biofuels, while it is projected that more than 50 percent of renewable energy by 2020 will come from biomass. The policies and public subsidies for biofuels are leading to rising food prices, especially the support for the so-called first generation biofuels that are derived from food crops such as maize, soy and sugar. For solid biomass and biogas there are no EU binding sustainability criteria and therefore EU policies could promote burning trees to produce bioenergy with increased greenhouse gas emissions compared to fossil fuels in the short term.

The EU should instead incentivise efficient and high-value use of biomass and therefore the following recommendations are made:

- Sustainability criteria for transport biofuels are implemented, including ILUC factors that sufficiently take the greenhouse gas emissions of indirect land use changes into account.
- EU harmonized and binding sustainability criteria for solid biomass and biogas are put in place, including efficiency of use criteria.
- The zero emission factor for biomass from Annex IV of the ETS directive is removed and instead the biomass feedstocks are given the proper CO_2 factors accounting for the direct and indirect life cycle CO_2 emissions.
- A Biomass Framework Directive is developed covering all applications of biomass (energy, materials, chemicals) in a consistent manner. A biomass hierarchy based on the cascade utilization of biomass is the guiding principle of the Biomass Framework Directive.

- The Ecodesign Directive is extended to cover also non-energy related dimensions, such as recycling content, bio-based content, and the use of primary resources. To ensure effective implementation of the Ecodesign Directive, adequate (financial) resources should be made available.
- Fossil-based chemicals, plastics and additives which can be substituted by less hazardous (biodegradable in case of plastics) bio-based variants are phased-out.

The transition to a sustainable bio-based economy will only be successful in conjunction with other developments. Resource efficiency should be the pillar upon which the green economy is built and therefore biomass is used as little as possible for lower value applications like biofuels and bioenergy. In the year 2050 almost all our energy is supplied from renewable sources, but for many energy purposes, sustainable alternatives to biomass (like solar, wind, geothermal energy; electric vehicles) are available and should be used. Only for certain transport sectors like aviation and shipping are there no such sustainable alternatives to fossil fuels at hand. The bio-economy relies on the sustainable production of biomass, but at the same time the demand for biomass will increase and hence the call for increasing yields will grow louder. To halt biodiversity loss in Europe, this call should not lead to more monocultures through increased use of genetically modified crops and intensive farming.

The transition to the post-petroleum, bio-based economy therefore goes hand in hand with the transition to more sustainable agriculture, renewable energy and sustainable transport.

1. The Bio-based Economy and its Advantages

In the long run our current way of life is unsustainable. Our consumption and waste levels cannot be maintained without decreasing the possibilities for next generations. Our usage of ecosystem services is at such a level that the earth is unable to regenerate at the same pace.

At the base of our unsustainable behaviour lies the use of unprecedented levels of fossil resources. Fossil resources are used for all sorts of everyday applications, such as electricity, cooling and heating, fuels, materials and chemicals. This dependency on fossil resources has led to ever higher levels of greenhouse gasses in the air which in its turn leads to dangerous and irreversible climate change.

Modern economies thus have to overcome their habits of high fossil resource use. The quest for alternative (and lower uses of) resources has already started and hopefully leads us to a more sustainable future. The bio-based economy, which uses biomass as a resource instead of oil, is a promising development in this regard.

In the remainder of this chapter the main characteristics of a bio-based economy will be explained and its advantages will be summarised. While in no way the silver bullet that will solve all the ecological problems we are currently facing, the bio-based economy is a development that the European Union should stimulate. At the same time, it needs to be ensured that the bio-based economy is not simply a "green washing" of our current economy, but entails a structural transformation to a green economy. The challenges relating to the sustainability of the bio-based economy and the possible solutions at the European level will be explained in the subsequent chapters of this report.

1.1 The Bio-based Economy

Our current economy is a fossil-based economy. We are dependent upon oil and gas for our electricity, cooling and heating, fuels for transport, as well as for the production of materials and chemicals. A bio-based economy on the other hand, is not dependent upon fossil resources but is based on biomass. The bio-based economy can be seen as a part of a broader green economy. A green economy uses biomass, but also runs on wind and solar energy and encompasses resource efficient industries that fall outside the sphere of biomass production and usage. In this report however we confine ourselves to only this part of the green economy that uses biomass as its resource. Strictly speaking fossil resources are also made up of biomass, but these came into being over millions of years, while biomass like plants and trees can be used immediately. In this report we focus on this latter group of biological resources.

There are several types of biomass that can have valuable applications in the bio-based economy. Examples of biomass are numerous:

Biomass	Examples
Plants	crops, grass, woody biomass, aquatic biomass
By-products from the field	straw, beet leaves
By-products from the production process	potato peelings, sugar beet pulp
Waste streams	biodegradable municipal waste, sewage sludge, animal fat and manure

At present, biomass is already used in quite a number of industries. Biomass is of course the basis for food and feed, but we also use biomass in industries such as the paper and construction sector. However, biomass could be used in more industries and for many more applications. Biomass could substitute oil in pharmaceutical applications, fine chemicals, chemical building blocks, plastics and it is already used for the production of fuels, heat and electricity.

Unlike fossil resources, biomass is a renewable resource. Plants, trees and all other sorts of biomass will not be depleted, since they can grow over and over again. But although biomass is a renewable resource, it is not, at a given time, an unlimited resource. Its production is dependent on resources such as land, nutrients and water, which are limited in nature. If we would rapidly increase our biomass consumption overnight, land previously used in other ways needs to be diverted to biomass production. This could come at the expense of food production (and hence cause rising food prices) or tropical rainforests (and hence cause biodiversity loss).

Therefore, limits exist to the amount of biomass that can be produced sustainably. (For a detailed account on sustainability concerns see *chapter 3*). It is of utmost importance that we use the sustainably available biomass in the smartest way possible and that we increase the yield on the available land without compromising on sustainability.

1.2 Sustainable Production & Smart Use of Biomass

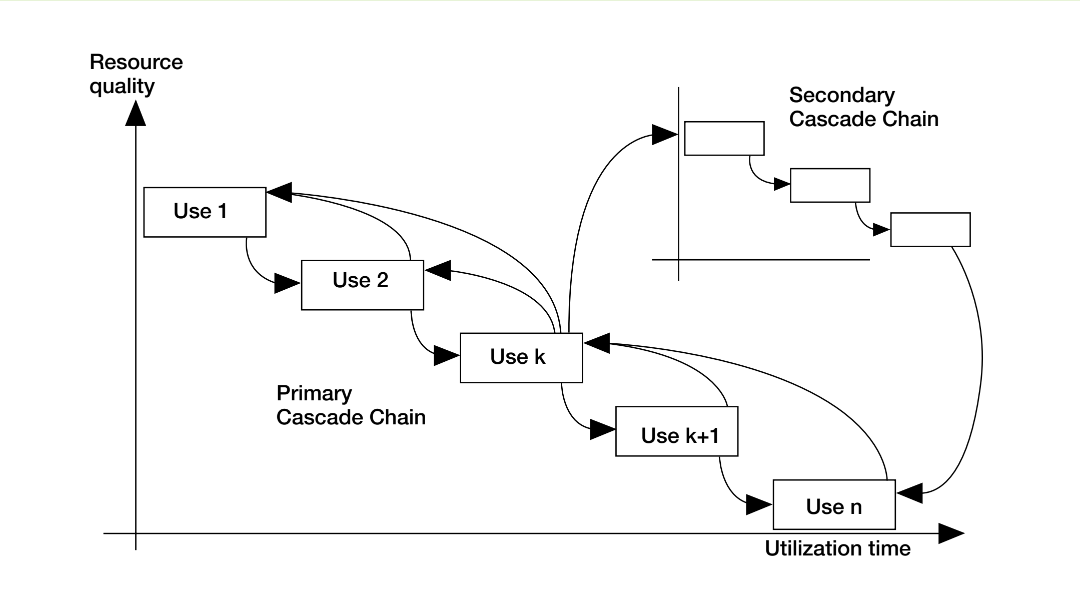
The take-off of the bio-based economy will lead to increased demand for biomass. The biomass that is used should be produced in a sustainable manner, otherwise the bio-based economy is not an improvement compared to the current fossil based economy. In our vision there is a task for politicians to develop a policy framework that ensures, besides **economic viability**, also the **societal** and **ecological sustainability** of biomass production.

Societal concerns that should be taken into account are, for example, the rights of workers and the rights of local communities. Ecological sustainability implies that the bio-based practices and products should have a positive carbon balance compared to their fossil counterparts. Furthermore, biodiversity levels and soil quality should be maintained or improved and the activities should be resource and energy efficient. Only if these factors are met, one can speak of a truly sustainable bio-based economy.

Not only should the **production of biomass** be sustainable, the same applies for the use of biomass. A concept that can steer the use of biomass into a more efficient and effective direction is 'cascading use'. *"In cascade utilization, the biomass is used for high-value materials, which are reused in bulk materials and finally used for production of biofuels and power"*.[1] In *figure 1.1* this process is displayed.

1 Østergård H, Markussen M.V. and Jensen E.S in Langeveld, H., M. Meeusen and Johan Sanders (2010), *The Bio-based Economy. Biofuels, Materials and Chemicals in the Post-Oil Era*, Earthscan, New York, p. 39.

Figure 1.1: The cascade chain operates through the dimension of salvageability – the degree to which a resource quality can be recirculated, regenerated or reprocessed



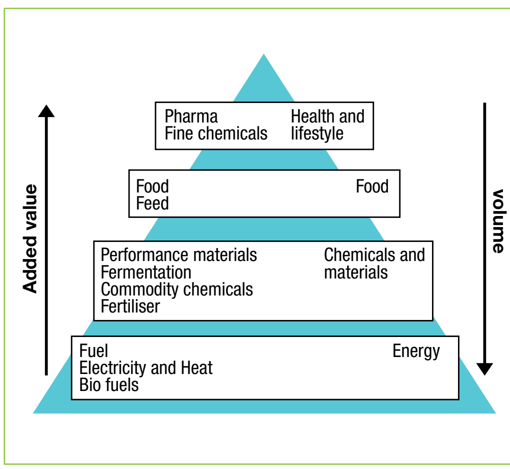
Source: Sirkin and Ten Houten[2]

In an ideal cascade chain, the high-value first use of the biomass uses as much of the quality of the biomass as possible. After this first use, lower quality applications can be manufactured from the biomass. Sometimes resources or products can also be recirculated (*fig. 1.1*). All steps together lead to a longer lifespan of the resource/product used, and thereby increases the efficient and effective use of biomass.

Sirkin and Ten Houten, who developed the above figure, describe resource cascading as a "method for optimizing resource utilization through a sequential re-use of the remaining resource quality from previously used commodities and substances".[3]

The cascade use of biomass should start at the application with the highest quality, but what is this quality? Often it is defined as the added economic value of the product. The Value Pyramid is a schematic overview of the added economic value of biomass uses (*figure 1.2)*. The added value is the highest at the top of the pyramid and the lowest at the bottom. On the contrary, the volume of biomass needed for the applications is the lowest at the top and the highest at the bottom of the pyramid.

Figure 1.2: The Value Pyramid



Source: www.bio-basedeconomy.nl[4]

It is therefore important that, if biomass can be used for these high-value applications, it should not directly go to the lower applications. For example, it is better to first use (parts of) biomass for biochemical plastics and at the end of the material lifecycle burn them for energy recovery.

2 Sirkin, T. and ten, M. Houten (1994), "The cascade chain : a theory and tool for achieving resource sustainability with applications for product design", *in Resource, Conservation and Recycling*, Elsevier, Amsterdam, p. 217.
3 Ibid., p. 215.
4 Bio-basedeconomy.nl, *Bioraffinage en Cascadering*, at http://www.bio-basedeconomy.nl/themas /bioraffinage/, (viewed on 29-06-2012).

Added value is an important parameter of the quality of biomass and should therefore play an important role in the allocation of biomass. However, the market value of the product produced is not the only factor defining resource quality. Resource quality (as depicted on the vertical axis of *Figure 1.1*) should consist of more than only market value because market value "does not account for the kinds of non-monetary value a particular resource may have to the health and welfare of the society at large, nor does it tell us anything about the importance of the resource for the sustenance of generations to come. Nor does it take into account the amount of external expenditures needed to regenerate, or renew, or replace the expended resource quality".[5]

Resource quality is thus "a function of the amount of embodied energy, the degree of structural organisation and the chemical composition of a given resource, substance or material, and also (...) a function of the effort required to produce or reproduce quality. The higher the quality, the greater its potential to carry out more highly demanding tasks".[6] All these factors should hence be considered when developing a framework that promotes the cascading use of biomass.

Looking again at *figure 1.1*, the optimal use of biomass means that the quality of the biomass should be used as much as possible. The first use of the biomass should incorporate the resource qualities as much as possible. In the step from the first to the second use of the biomass, a part of the resource quality will be lost, but also this loss should be minimised. Developing such a cascade chain leads to a smart and optimal use of the quality of the biomass.

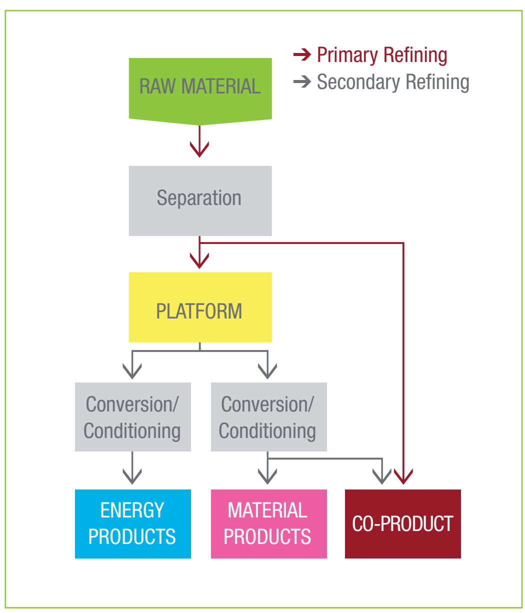
Co-firing biomass in coal plants for energy recovery should thus not be the first use of the biomass because this does not make optimal use of the potential (i.e. quality) of the biomass. Only when the quality of biomass is so low that it cannot be used anymore for other applications, should the biomass be directed to energy recovery.

Another important concept relating to the smart use of biomass is the process of biorefining. *"Biorefining is the sustainable processing of biomass into a spectrum of marketable products and energy"*.[7] Through biorefining, biomass is separated into fractions. The valuable complicated molecules will be processed into high-value applications such as chemicals and materials. Other fractions, with a lower quality, can be used to make fuels or can be used for energy or heat recovery. In this way multiple products are derived from the same biomass. Biorefining leads hence to the optimal utilization of the value of biomass.

Biorefining is an activity that has existed for centuries. It is the process that leads, for example, to our beloved beer and wine. But in the bio-based economy, biorefining will be used for the creation of a lot more products. The techniques and processes used are very advanced. Therefore a lot of sophisticated biorefineries are still in the R&D, pilot and small-scale demonstration phases.

Technologies that are used in these advanced biorefineries are for example separation, biochemical conversion, chemical catalysis, fractionation, enzymatic hydrolysis, fermentation and so on. Biorefining often entails more than one refining process, as is shown in *figure 1.4*.

Figure 1.4: Different components within the Biorefinery



Source: Star-Colibri[8]

5 Ibid., p. 223.
6 Ibid., p. 216.
7 Star-COLIBRI (2011), *Joint European Biorefinery Vision for 2030*, p. 9 at http://www.star-colibri. eu/files/files/vision-web.pdf (viewed on 28-06-2012).

1.3 Advantages of a Bio-based Economy

The bio-based economy has the potential to steer Europe into a greener future. With the right policy framework safeguarding the ecological sustainability, economic viability and societal well-being, the advantages of a bio-based economy, compared to a fossil based economy, are plentiful.

First of all, by transforming our economies to bio-based ones, we will become less dependent upon scarce fossil resources, which will only become more and more expensive in the future. The depletion of fossil resources like oil and gas is hence one of the major reasons to switch to other resource bases. Related to this, the transition to a bio-based economy will make Europe less dependent upon the demands of oil-producing states.

Another argument often given in favour of the bio-based economy is that it will reduce greenhouse gas (GHG) emissions. Our current fossil economy produces a lot of CO_2 emissions by burning fossil resources for electricity, heat and transportation. Proponents of the bio-based economy argue that the emission levels of a bio-based economy will be lower.

The bio-based economy introduces a closed carbon cycle. In our current fossil system we get more and more CO_2 in the atmosphere due to the extraction of carbon (oil or gas) from the earth. This carbon is introduced in the carbon cycle and thereby increases the amount of CO_2 in the system. The result is a stronger greenhouse effect and it thus contributes to climate change. By replacing fossil oil and gas with biomass as a resource, the carbon cycle stays closed: the CO_2 that is released by the combustion of biomass is the CO_2 the biomass retrieved earlier from the air.

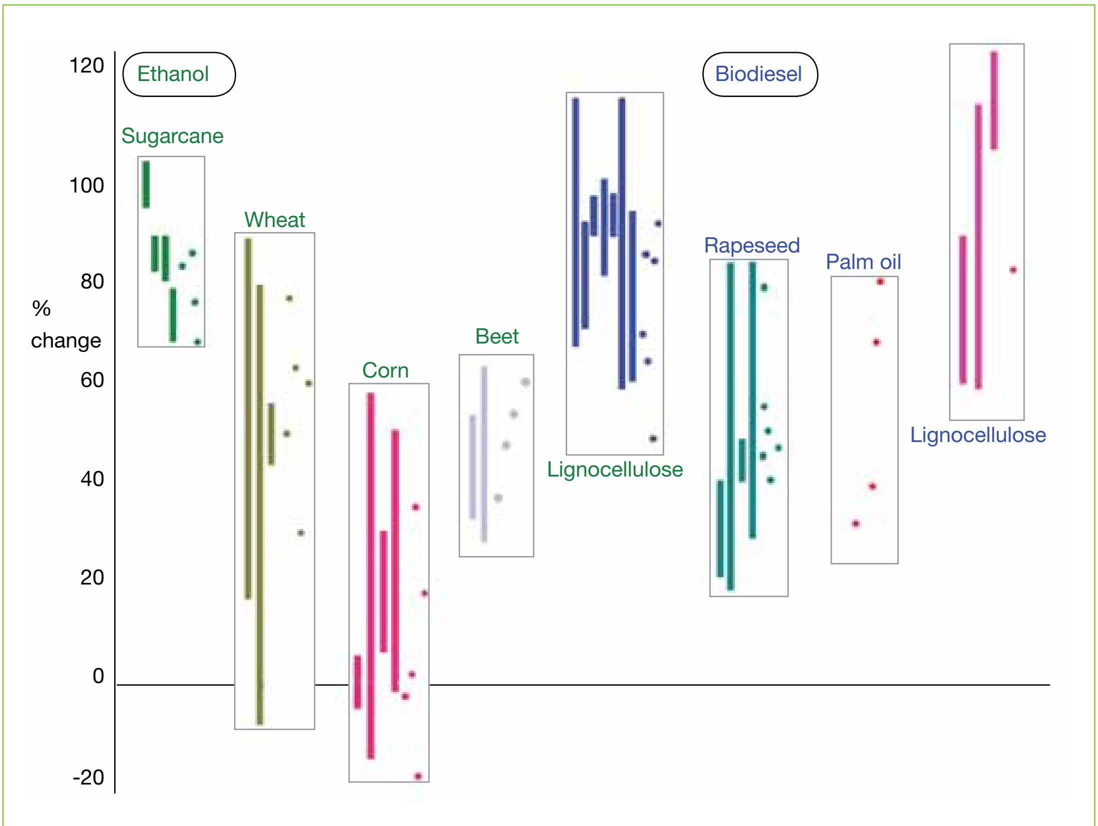
However, this closed carbon cycle does not automatically mean that the bio-based economy and its practices are carbon neutral. The amount of CO_2 in the atmosphere can still increase.

Important issues in this regard are land use change (LUC), indirect land use change (ILUC), the carbon footprint of products, and the carbon debt.[9]

Depending on the usage and sort of biomass, it can be a better or worse option (in terms of CO_2 emissions) than its fossil counterpart. That CO_2 mitigation potential differs greatly between types of biomass used, is graphically displayed in *figure 1.5* which shows the emission changes of different feedstocks for biofuels compared to fossil fuels. Although the bio-based economy entails more than biofuels, the figure illustrates that using biomass instead of oil does not automatically lead to lower greenhouse gas emissions. The figure shows "consolidated results of selected international studies for greenhouse gas emissions per energy content".[10] By using lifecycle analysis the emissions are calculated from well-to-wheel.

8 Ibid. p. 10.
9 For an explanation of these phenomena see chapter 3.1
10 IEA (2010), *Sustainable Production of Second Generation Biofuels. Potential and Perspectives in Major Economies and Developing Countries*, p. 80, at http://www.oecd.org/dataoecd/17/12/ 44567743.pdf (viewed on 28-06-2012).

Figure 1.5: Comparison of well-to-wheel emission changes of different biofuels compared to fossil fuel



Source: IEA[11]

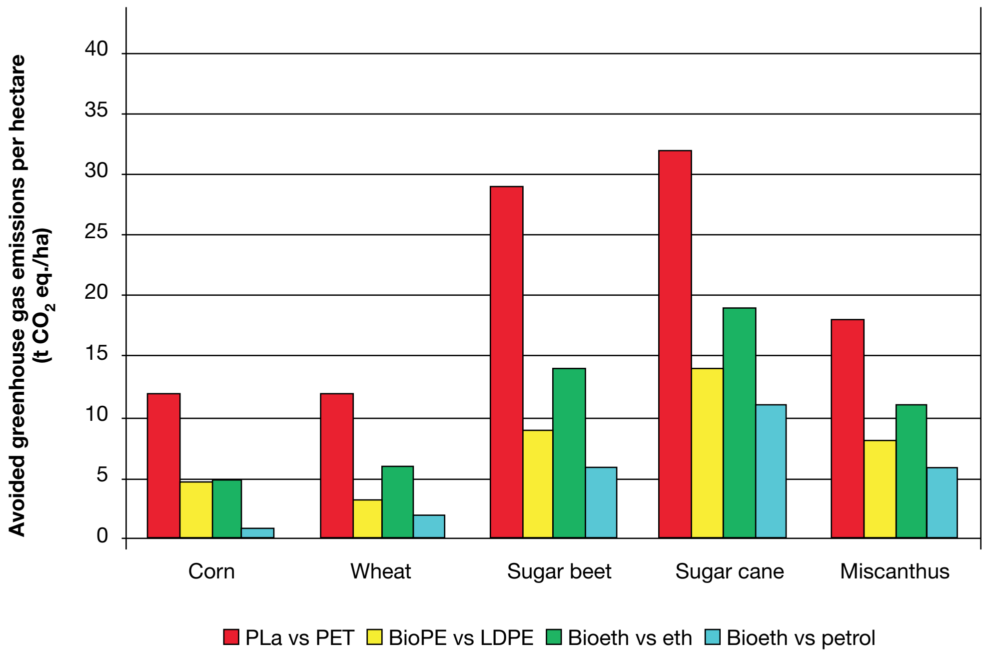
Interpreting *figure 1.5* leads to the conclusion that sugarcane has by far the most promising CO_2 mitigation potential of all first generation biofuels – sugarcane, wheat, corn, beet, rapeseed and palmoil. These other first generation biofuels do not have very great potential: "most current biofuel options do not promise high GHG mitigation, and in some cases they even have higher emissions than do reference fossil fuels".[12]

Second generation biofuels, based on lignocelluloses, have good mitigation prospects, but currently they are still in pilot and demonstration stages and hence not available on a commercial scale. On a side note, the studies on the mitigation potential of these lignocelluloses-based fuels do not take into account nutrient and humus balances of the soil. The "use of primary agriculture and forestry residues for second-generation biofuel production could require additional expenditure to achieve equalised nutrient and humus balance in the soil". All in all, *figure 1.5* shows that CO_2 mitigation potential differs greatly among different biomass feedstocks for biofuels.

As said before, the bio-based economy is more than only biofuels. *Figure 1.6* therefore shows the mitigation potential of different bio-based products, based on a study of Wageningen UR and Utrecht University. The study compares products made from fermentable sugars from different feedstocks: corn, wheat, sugar beet, sugar cane and miscanthus. It is assumed that production is taking place in the Netherlands, except for sugar cane, which comes from Brazil. The production of degradable bioplastic (PLA), non-degradable bioplastic (BioPE) and bioethanol from the above-mentioned feedstocks are compared to their fossil counterparts. PLA is compared with PET, BioPE is compared with LDPE and Bioethanol is compared with petrochemical ethanol and petrol. This leads to the following results:

11 Ibid.
12 Ibid.

Figure 1.6: Sustainability of Bio-based Products from Sugars (Current agricultural practice)



Source: Bos et.al.[13]

There are quite some differences of mitigation potential between the different sorts of feedstocks. Sugar cane has by far the highest mitigation potential for all applications. For the Netherlands, sugar beet has the best mitigation potential.

By comparing the different applications, it becomes visible that degradable bioplastic (PLA), regardless of its feedstock, will have the highest mitigation potential, while bioethanol, if compared to petrol, has the lowest potential.

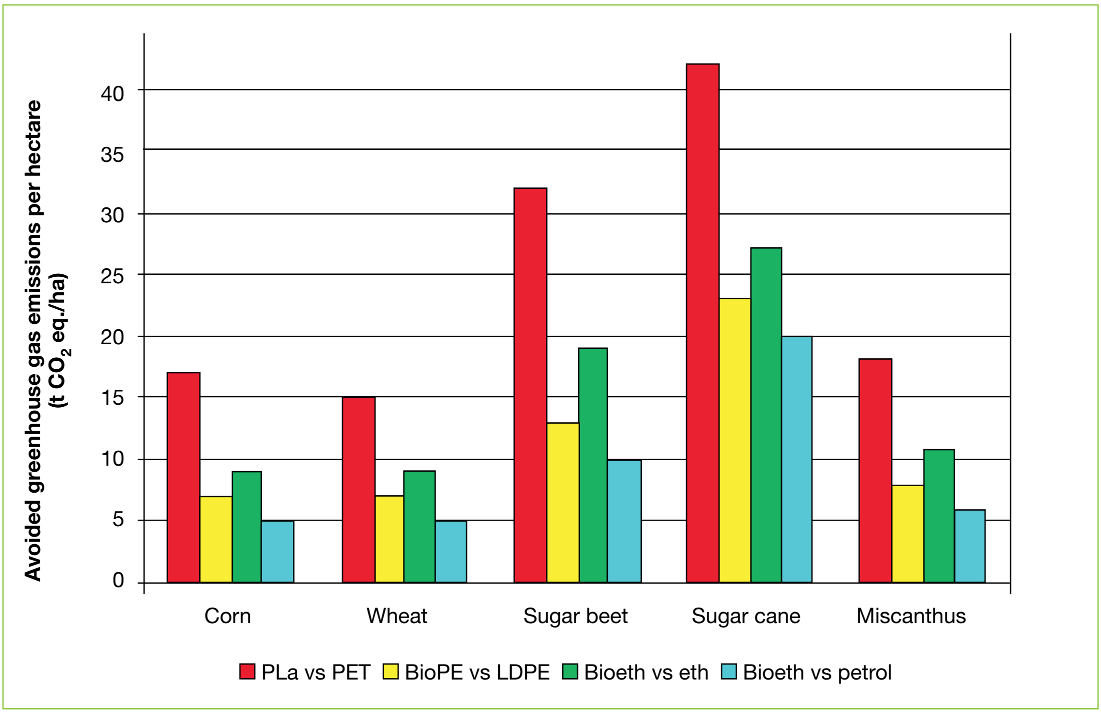
If all co-products of the feedstocks are converted to energy, the mitigation potential of all first generation feedstocks (i.e. all except Miscanthus) will rise, as is displayed in *figure 1.7*.

One should however note again, that the use of all co-products can have negative effects on the soil quality. The amount of soil organic matter is not taken into account in this study. To conclude, the CO_2 mitigation potential of bio-based practices is certainly an advantage of the bio-based economy compared to a fossil economy, but quite substantive differences exist in mitigation potential between different feedstocks and different applications. Not all sorts of biomass, and uses of biomass, should be promoted evenly. Comprehensive studies, relying on life cycle analysis, should indicate the most promising examples of biomass use, which then should be supported by policies.

Chapter 3 will deal with concerns relating to the carbon balance of the bio-based economy in more detail. In *Chapter 4* some policy tools are introduced that can be helpful in safeguarding the net positive carbon result of biomass use. These tools will prevent us from going down the road that seems carbon neutral, but is in fact not. We should strive for a bio-based economy that develops in the right direction. A positive example of greenhouse gas savings in the bio-based economy can be found in the chemical sector. This bio-based chemical sector uses less energy because its processes do not demand high temperatures or high pressure. The result is that the CO_2 emissions from the production processes are lower, as can be

13 Bos, H., S. Conijn, W. Corré, K. Meesters, and M. Patel, *Bio-based Economy Info Sheet. Duurzaamheid van Bio-based Producten gemaakt uit Suikers*, at: http://groenegrondstoffen.nl/ downloads/Infosheets/Duurzaamheid%20bio-based%20producten%20 uit%20suikers.pdf (viewed on 28-06-2012).

Figure 1.7: Sustainability of Bio-based Products from Sugars (All co-products are converted to energy)



Bos et.al.[14]

seen in *figure 1.6* and *1.7* for PLA and BioPE. It is these sorts of developments that should be stimulated, while a halt should be put to developments that increase the levels of CO_2 in the atmosphere.

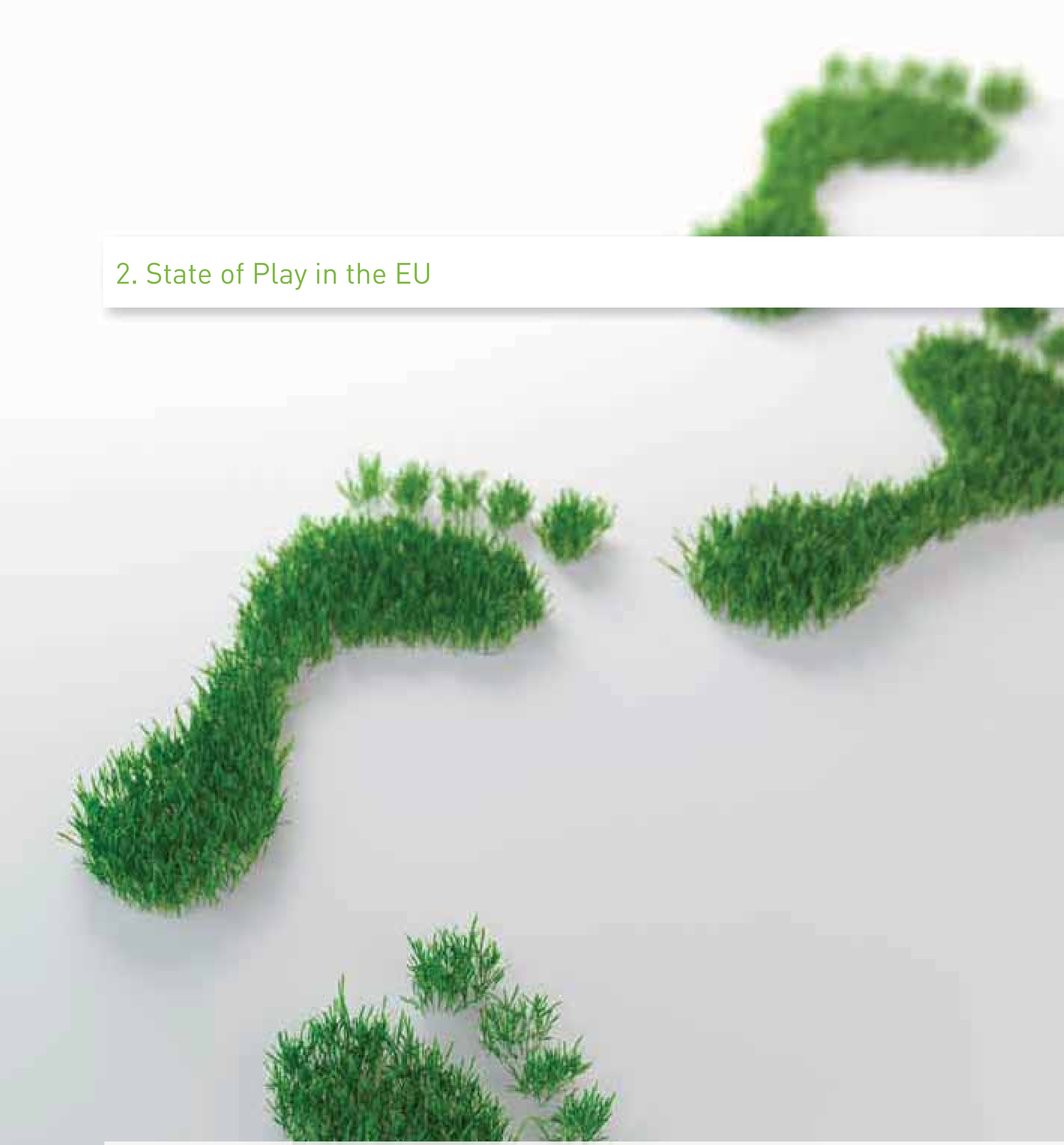
By introducing biorefining and the cascading use of biomass, the bio-based economy also contributes to the aim of the EU to become more efficient in its resource use. Another possible contribution of the bio-based economy is that it can contribute to Europe2020´s aims of smart, sustainable and inclusive growth. The bio-based economy can become a stimulus for economic activity in the European region in areas such as agriculture, manufacturing, the chemical industry, and it can lead to the rise of innovative SMEs. The Commission estimates that "direct research funding associated to the Bio-economy Strategy under Horizon 2020 could generate about 130 000 jobs and € 45 billions in value added in bio-economy sectors by 2025".[15]
And finally, another possible advantage of the bio-based economy is the development of economic activity in rural areas in the EU. To prevent the depopulation of rural areas, it is important to create employment in these regions. This is exactly what the bio-based economy can deliver with its focus on the agro- and forestry sectors and its focus on networks of integrated and diversified biorefineries across the European Union.

1.4 Conclusion

The transition to a bio-based economy has enormous potential for Europe. It can boost green employment and green growth. And above all, a European bio-based economy can lead to lower CO_2 emissions, less use of fossil resources and less dependency on the states producing these resources. To reach these goals, it is important that the transition to a bio-based economy is guided by a sound political framework that takes into account not only economic viability, but also social and ecological sustainability. The political framework should pay attention to the sustainability of biomass production as well as the sustainability of biomass use. For the latter, concepts such as biorefining and cascade utilization of biomass are of utmost importance.

14 Ibid.
15 EU (2012), *Communication (COM(2012) 60 final) Innovating for Sustainable Growth: A Bioeconomy for Europe*, p. 5.

2. State of Play in the EU



The EU 2020 Strategy of the European Commission identifies several Flagship Initiatives, among them the initiatives "Innovation Union" and "A Resource Efficient Europe". As argued by the Commission, the development of a bio-based economy can contribute to the aims of these initiatives.[16] But in order to bring about a bio-based economy, better cooperation between different actors at the European level is necessary. Not the least among the different Directorate Generals (DGs) of the European Commission. The bio-based economy as a topic is not confined to one of the policy areas of the EU, but has links with policies in the areas of agriculture, energy, research and innovation, environment, climate change, maritime affairs, regional affairs, and enterprise and industry. Developing a European framework that will stimulate the development of a bio-based economy and steer its development in a sustainable direction is hence an enormous governance challenge. In this regard, we should welcome the cooperation of the several DGs which has led to the Communication on "Innovating for Sustainable Growth: A Bio-economy for Europe", which was released February 2012.

Below, the state of play of the several policy areas relating to the bio-based economy will be discussed. But first the content of the abovementioned Communication on "A Bio-economy for Europe" (hereafter Communication) will shortly be addressed.

16 EU (2012), *Communication (COM(2012) 60 final) Innovating for Sustainable Growth: A Bioeconomy for Europe*, p. 1.

2.1 Communication on a Bio-economy for Europe

"The idea to consider, in a common context, various sectors of the economy that produce, process and reuse renewable biological resources has been discussed in Europe since the middle of the last decade".[17] Several Presidencies of the EU from 2005 onwards organised, together with the Commission, conferences on the "knowledge-based bio-economy". In 2010 the Belgian Presidency hosted the conference, "The knowledge based bio-economy towards 2020". The conclusions of this conference brought the Commission to believe that a Communication from their side was desirable. This led to the publication of the Communication "A Bio-economy for Europe" in February 2012. Before the communication was created, the Commission held a public consultation on the bio-economy.

The Communication consists of two parts: a Strategy and a Bio-economy Action Plan. The aim of the Strategy and its accompanying Action Plan is "to pave the way to a lower emission, resource efficient and competitive society that reconciles food security with the sustainable use of renewable resources for industrial purposes".[18]

The first part of the strategy identifies five societal challenges that can be addressed by the introduction of a bio-economy. These challenges are: **1)** ensuring food security; **2)** managing natural resources sustainably; **3)** reducing dependence on non-renewable resources; **4)** mitigating and adapting to climate change; **5)** creating jobs and maintaining European competitiveness.

The second part of the Communication, the Action Plan, is divided in three parts: **1)** investments in research, innovation and skills; **2)** reinforced policy interaction and stakeholder engagement; **3)** enhancement of markets and competitiveness in bioeconomy. The Communication identifies points for action on all three topics. Below, a short summary is given:

Investment in Research, Innovation and Skills

Under this banner, action points are included that relate to the promotion of research and innovation. Special emphasis is put on the further development of Joint Programming Initiatives (JPIs) and ERA-Net activities. It is argued that a larger part of the research and innovation should be cross-sectoral and multi-disciplinary in order to address the several societal challenges related to the bio-economy. It is also stated that scientific advice should be provided "for informed policy decisions on benefits and trade-offs of bio-economy solutions".[19]

The recently announced European Innovation Partnership "Agricultural Productivity and Sustainability" will also have a role in fostering the bio-economy and more specifically it will "ensure that innovation is taken into account at the onset of policy development".[20]

The relation between research and innovation on the one hand, and bio-economy sectors on the other should also be improved, for example by feedback mechanisms. Knowledge networks, advisory and business support services are also important in this regard. The Action Plan focuses in particular on bioclusters and European Innovation Partnerships.

Reinforced Policy Interaction and Stakeholder Engagement

Several action points relate to the creation of coherence and interaction between the multiple stakeholders of the bio-economy. First of all the creation of a Bio-economy Panel is advocated. This Panel "will contribute to enhancing synergies and coherence between policies, initiatives and economic sectors related to the bio-economy at EU level, linking with existing mechanisms".[21] Such a panel should also be created at national and regional levels. Another plan is to organise Bio-economy Stakeholder Conferences on a regular basis.

In order to be able to assess progress and impact of the bio-economy, a Bio-economy Observatory should be established. This Observatory will build upon already existing sources and databases and will cooperate with the Joint Research Centre (JRC) and the European Environment Agency (EEA).

Action is not only advocated for the EU level. The Action Plan also urges the development of regional and national bio-economy strategies as well as

17 EU (2012-b), *Commission Staff Working Document Accompanying the document Communication on Innovating for Sustainable Growth:* A Bioeconomy for Europe, p. 7.
18 Ibid., p. 11.
19 EU (2012), *Communication (COM(2012) 60 final) Innovating for Sustainable Growth: A Bioeconomy for Europe*, p. 8.
20 Ibid., p. 6.
21 Ibid., p. 8.

the development of international cooperation on bio-economy research and innovation.

Enhancement of Markets and Competitiveness in Bio-economy

The third part of the Action Plan deals with the development of bio-economy markets. The bio-based economy is in its development phase. Hence the knowledge-base for sustainable intensification of primary production should be improved. This includes improving the "understanding of current, potential and future availability and demand of biomass across sectors".[22]

Other actions proposed are the creation of a research and innovation Public-Private-Partnership (PPP) for bio-based industries that will focus on "the setting up of networks with the required logistics for integrated and diversified biorefineries, demonstration and pilot plants across Europe, including the necessary logistics and supply chains for a cascading use of biomass and waste streams".[23] Negotiations and discussions on such a PPP are ongoing at the moment. Half of the money for this PPP will come from private funds and the other half will come from public funding, most probably from Horizon 2020 funds.

By developing standards and sustainability assessment methodologies the markets for bio-based products and food can be expanded. It is therefore argued in the Communication that green procurement and labelling of bio-based products should also be developed.

Interpreting the Communication

The Communication on the Bio-economy does not entail detailed plans for a policy framework. The communication can be seen as an overview of how several, already existing, policy instruments and funding sources connect to the bio-based economy and how these instruments and funding sources can be used to foster a bio-economy in Europe.

Since the Communication does not mention new funding sources, one can assume that EU financing to spur investments in innovation, research and skills will have to come from the EU Framework Programme for Research and Innovation (Horizon 2020). Other important instruments to foster the bio-based economy are the Common Agricultural Policy (CAP), the Common Fisheries Policy (CFP) and the Integrated Maritime Policy (IMP). In the Communication, it is argued that funding for the development of sustainable supply chains and facilities could possibly come from EU rural development funding, and the Regional Development Funds and Cohesion Policy Funds. Regulations of these funds do however not specifically refer to stimulating the bio-based economy. During the negotiations on the new legislative proposals for the period 2014-2020 this topic should be under close scrutiny.

What is lacking in the Communication is a detailed plan of how the five societal challenges can be met. Without a good policy framework, the bio-economy can exacerbate climate change and worsen food security. In *chapter 3*, some concerns about this will be explained in more detail.

Interviews held with civil servants of the concerned Directorates General (DGs) highlighted the different visions on the bio-economy. In order to make the bio-economy a green success, better cooperation between the DGs related to the bio-economy is needed. The DGs should try to develop a more common view on the bio-economy. The Communication proposes to set up a Bio-economy Panel, so this could help the coordination between the relevant DGs.

Although the Communication is the only EU document directly addressing the bio-based economy, other EU policies and initiatives are having an impact on the bio-based economy as well. Important policies are developed in the areas of Energy and Climate Action, Research and Innovation and Enterprise and Industry.

2.2 Energy, Climate Action and Agriculture

The Europe 2020 Strategy contains targets for sustainable growth. These are **1)** reducing greenhouse gas emissions by 20% compared to 1990 levels by 2020; **2)** increasing the share of renewables in final energy consumption to 20%, and; **3)** moving towards a 20% increase in energy efficiency.

The second target to increase the share of renewables is a legally binding one and part of the Directive on renewable energy (RED). Twenty per cent of Europe's energy has to come from

22 Ibid., p. 9.
23 Ibid.

renewable sources such as solar, wind, hydroelectric and biomass sources by 2020. Here the link with the bio-based economy comes into play. The National Renewable Energy Action Plans (NREAPs) of Member States (MS) show that they expect to meet half of the 20% renewable energy target through bioenergy. Biomass will make up 19% of total renewable electricity, 78% of total renewable heating and cooling and 89% of total renewable energy in transport in 2020 according to the NREAPs.[24] One can hence conclude that with the RED the EU stimulates the development of the bioenergy sector.

Besides this 20% overall target, the RED also sets a sub-target for the use of renewable energy in the transport sector. In 2020, 10% of the energy used in transport should be derived from a renewable source. Besides electricity and hydrogen, biofuels will play an important role in meeting this target. It is estimated that almost 90% of the renewable energy in transport will come from biomass in 2020.

The introduction of the above mentioned targets has led to an increase in the demand for biomass. In order to ensure that biofuels have a positive effect on the climate and the environment, the RED introduces sustainability criteria.[25] "These criteria are related to greenhouse gas savings, land with high biodiversity value, land with high carbon stock and agro-environmental practices".[26] Only when these criteria are met, can the used biofuels count towards the 10% renewable target in the transport sector. Currently, a debate is ongoing concerning which criteria need to be developed for indirect land use change (ILUC).[27]

Unfortunately there are no binding sustainability criteria for the use of solid and gaseous biomass yet. So the biomass that is co-fired in coal power plants does not have to meet any sustainability criteria to be able to count towards the 20% renewable energy target. In 2010 the Commission developed voluntary sustainability criteria for Member States. A study performed for the Commission shows that these criteria are unfortunately hardly implemented in the MS.[28] In order to safeguard positive emission reductions from renewable energy, all uses of biomass should be scrutinized by strict sustainability criteria. In *chapter 3* this concern is thoroughly discussed.

Besides the RED there are some other policy initiatives on energy and climate that stimulate the transition towards a bio-based economy. An older policy initiative is the Biomass Action Plan, which identifies key activities for "boosting the bioenergy market and encourage Member States to establish national Biomass Action Plans."[29] Other examples of important policies are the Low Carbon Economy Roadmap and the initiative on Eco-innovation. The former is a roadmap on emission reductions that looks beyond 2020 and sets post-2020 milestones. The latter initiative, Eco-innovation, was launched in 2008 as part of the Entrepreneurship and Innovation Programme (2007-2013) and was developed to implement the EUs Environmental Technologies Action Plan (ETAP). For the 2008-2013 time span almost 200 million euro is available for eco-innovation projects. "Eco-Innovation is any form of innovation resulting in or aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment, enhancing resilience to environmental pressures, or achieving a more efficient and responsible use of natural resources".[30] A sustainable bio-based economy is also focused on these goals and hence overlaps partly with the projects under the eco-innovation initiative.

DG Agriculture is at the moment working on a EU Forest Strategy, which will probably be published in the beginning of 2013. This Strategy can boost bio-based practices in Europe and could have a positive contribution towards ensuring the sustainability of woody biomass production. The Common Agricultural Policy (CAP) provides the overall EU framework for the supply of biomass and is currently being reformed. Pillar II of the CAP, the Rural Development Policy, includes support for training and information sharing and support could be directed to capacity building for the bio-based economy.

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24 http://www.biomassfutures.eu/public_docs/final_deliverables/WP2/D2.4%20Main%20outcomes%20for%20policy%20makers.pdf
25 For an in-depth discussion of these criteria, see chapter 3.
26 EC (2012), *Renewable Energy. Biofuels –Sustainability Criteria*, at http://ec.europa.eu/energy/ renewables/biofuels/sustainability_criteria_en.htm (viewed on 29-06-2012).
27 More on this in chapter 3.
28 EC (2012-b), *The EC Report on Sustainable Solid Biomass: Status and Key Issues*, at http://www. oeko.de/service/bio/dateien/en/wshag_langue_wscriteria_bioenergy2012.pdf (viewed on 29-06-2012).
29 EC (2012-c), *Renewable Energy. National Biomass Action Plans*, at http://ec.europa.eu/energy/ renewables/bioenergy/national_biomass_action_plans_en.htm (viewed on 29-06-2012).
30 EC (2012-d), *Eco-innovation for a Sustainable Future*, at http://ec.europa.eu/environment /etap/index_en.html (viewed on 29-06-2012).

2.3 Research and Innovation

Besides the abovementioned policies in the areas of energy and climate there are also policies on research and innovation that stimulate the transition towards a bio-based economy.

Through Framework Programmes, the European Union stimulates research and development activities. At the moment, the 7th Framework Programme (7FP), which covers the period 2007-2013, is in operation. The budget of this 7th programme is over 50 billion euro. Two thirds of this budget goes to the Cooperation Programme, which "fosters collaborative research across Europe and other partner countries through projects by transnational consortia of industry and academia".[31] This Cooperation Programme covers several thematic areas. One of these areas is "Food, Agriculture and Fisheries, and Biotechnology". This research theme is particularly interesting for the bio-based economy because its aim is "to build a European Knowledge Based Bio-Economy (KBBE)".[32] The budget for this theme is more than 1,9 billion euro. This theme is focused on three major activities of which two are directly stimulating developments in the bio-based economy: "sustainable production and management of biological resources from land, forest and aquatic environments" and "life sciences, biotechnology and biochemistry for sustainable non-food products and processes". Examples of specific projects relating to the bio-based economy under FP7 are Star-COLIBRI (Strategic Research Targets for 2020 – Collaboration Initiative on Biorefineries) and Global-Bio-Pact. Part of the latter study focused on biomass and bioproduct impacts on socio-economics as well as on sustainability. The Star-COLIBRI project developed, among other things, a European Biorefinery Vision for the year 2030. This vision argues for a network of biorefineries in Europe that can use a wide range of biomass – ranging from crops and residues to wood and algae. The Vision also puts a strong focus on efficient crop systems and improved crops.

Currently the negotiations for the new Framework Programme (Horizon 2020) are on-going.

The programme will cover the period of 2014-2020 and it is proposed to cover a budget of 87 billion euro. The Commission puts forward its proposed priorities under 3 pillars. One of these pillars is called "Societal Challenges", for which the Commission proposes a budget of almost 35 billion euro. Funding will be focused on the following challenges:

Horizon 2020 - Societal Challenges
1. Health, demographic change and wellbeing
2. Food security, sustainable agriculture, marine and maritime research, and the bio-economy
3. Secure, clean and efficient energy
4. Smart, green and integrated transport
5. Inclusive, innovative and secure societies
6. Climate action, resource efficiency and raw materials.

Research that will be funded under societal challenge number 2 can possibly boost the bio-based economy. The proposed budget for research and development under this banner of "food security, sustainable agriculture, marine and maritime research, and the bio-economy" is 4.7 billion euro. But besides funding under challenge number 2, funding under other challenges – such as "secure, clean and efficient energy" and "smart, green and integrated transport" – can also provide the necessary knowledge for the transition towards a sustainable bio-based economy.

Besides "Societal Challenges", Horizon 2020 funds projects under the pillar "Industrial Leadership". "This part aims to speed up development of the technologies and innovations that will underpin tomorrow's businesses and help innovative European SMEs to grow into world-leading companies".[33] Besides stimulating research on, for example, biotechnology and nano technology, this pillar also funnels money to risk finance. By creating a "debt facility" and an "equity facility", money becomes more easily available for innovative projects. These facilities can also mean a stimulus for the development of a bio-based economy.

31 EC (2012-e), *FP7 in Brief. How to get Involved in the EU 7th Framework Programme for Research*, at http:// ec.europa.eu/research/fp7/pdf/fp7-inbrief_en.pdf (viewed on 29-06-2012).
32 EC (2012-f), *Food, Agriculture and Fisheries, and Biotechnology*, at http://cordis.europa.eu/fp7/ kbbe/home_en.html (viewed on 29-06-2012).
33 EU (2012-c), (COM(2011) 809 final), *Proposal for a Regulation of the European Parliament and of the Council establishing Horizon 2020* – The Framework Programme for Research and Innovation (2014-2020), p. 29.

All in all, one can conclude that the proposals of the Commission for Horizon 2020 look promising in regard of promoting the transition to a European bio-based economy. It remains to be seen, however, how many of these ambitions are maintained after approval of Horizon 2020 and, more importantly, the overarching European budget.

2.4 Enterprise and Industry

To promote the uptake of new products and services at the market, the Directorate General Enterprise and Industry has developed a policy called the "Lead Market Initiative" (LMI). This initiative has indicated six sectors as lead markets: eHealth, Protective textiles, Sustainable construction, Recycling, Bio-based products and Renewable energies.

For the LMI "Bio-based Products" the Commission installed an Ad-hoc Advisory Group for Bio-based Products, which consisted of representatives of national governments, academia and industry. The Ad-hoc Advisory Group "prepared a range of documents containing elaborated recommendations to enable the market uptake of bio-based products".[34] Recommendations were made on **1)** access to feedstock; **2)** research, development and innovation; **3)** access to markets; **4)** sector specific market access; **5)** public procurement, and; **6)** on communication strategies, certification and labelling. Recommendations of this Ad-hoc Advisory Group resulted in a mandate of the European Commission for the European Committee for Standardization (CEN) to elaborate a standardisation programme for bio-based products. This work is still on-going. The bio-based products LMI itself ended in 2011, but its work will probably be continued by the Bio-economy Panel that is proposed by the Communication on the Bio-economy (see *paragraph 2.1*).

2.5 Conclusion

The bio-based economy is a topic that gets more and more attention at the European policy level. The presentation of the European Commission's Communication on the bio-economy is an important development in this regard. It proposes to set up a European Bio-economy Panel as well as a Bio-economy Observatory. It also aims at the development of a Public-Private-Partnership for which negotiations are on-going at the moment. These policies and initiatives will stimulate the transition towards a European bio-based economy. We welcome all these developments very much, but nevertheless we are aware of the fact that current policies are not strong enough to ensure that the European bio-based economy will develop in a sustainable direction. In the next chapter our concerns related to this are discussed. Furthermore, current EU policies stimulate the use of biomass for heating and cooling, for electricity production and as biofuels. *Chapter 4* will give recommendations how the EU can stimulate the use of biomass for higher quality applications.

34 EC (2012-g), *Industrial Innovation. Bio-based Products*, at http://ec.europa.eu/enterprise/policies/innovation/policy/lead-market-initiative/bio-based-products/index_en.htm (viewed on 29-06-2012).

3. Concerns

As discussed in the first chapter of this report, the introduction of a European bio-based economy can be a very positive development. However, the net benefit – in terms of ecology, economy and the social dimension – cannot be taken for granted. In this third chapter our concerns relating to the bio-based economy will be voiced. These concerns focus on the greenhouse gas balance, the food supply, land scarcity, water and nutrients scarcity, the role of technology, the hierarchy of biomass use and inadequate governance structures. With a good policy framework, including adequate measures, these problems can be (partly) overcome, as will be argued in *chapter 4*. But before we go to these solutions, it is important to get a good understanding of the concerns at hand.

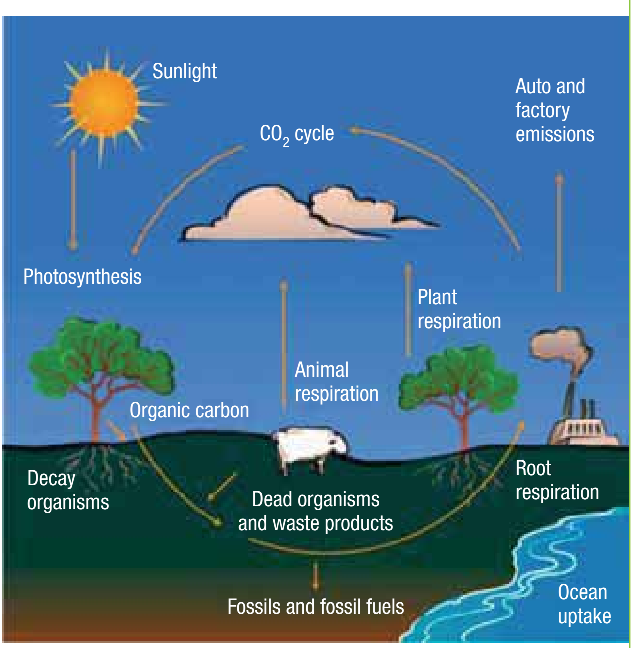
3.1 Concern I: The Carbon Balance

A reduction in greenhouse gas emissions – especially CO_2 – is often quoted as one of the main arguments in favour of the introduction of a bio-based economy. However, a bio-based economy will not, per definition, lead to emission reductions. To explore the consequences of a bio-based economy on CO_2 emission levels, its effects on the carbon cycle have to be analysed.

The Carbon Cycle

A high level of CO_2 in the atmosphere is one of the major causes of climate change. It prevents the heat from the sun being radiated back into space. This is the well-known greenhouse gas effect. CO_2 is the gaseous form of carbon. The amount of carbon on earth is fixed, but its form and place change over time. This can be explained with the "carbon cycle".

Figure 3.1: The Carbon Cycle



Source: UCAR[35]

"Carbon is released to the atmosphere from what are called "carbon sources" and stored in plants, animals, rocks, and water in what are called "carbon sinks."[36] The carbon cycle is made up of several steps. As is seen in *figure 3.1* plants and trees grow by taking, through photosynthesis, CO_2 out of the atmosphere and release oxygen to the atmosphere in return. Plants can hence be seen as carbon sinks. Plants are often eaten by animals, which inhale oxygen and exhale CO_2, which in turn can be retrieved from the air by plants. If plants die, they decompose and the carbon of the plant gets into the atmosphere or it will be sequestrated in the soil. The element carbon is thus omnipresent in our world and it travels through the whole carbon cycle.

The activities of human beings have changed the amount of carbon in the different sources and sinks in the carbon cycle. For example, by logging forests (sinks) to use land for agricultural activities, the amount of CO_2 that can be sequestered diminishes and the amount of CO_2 in the atmosphere increases. But especially since the start of our fossil era the amount of CO_2 in the atmosphere has increased. The reason is that we have taken carbon from the subsurface sinks in the form of oil and gas and have released it in the atmosphere by burning it. Since the bio-based economy does not use these fossil sinks for its carbon, it is assumed that it does not increase the amount of CO_2 in the atmosphere. But there are several steps in the carbon cycle that can lead to an increase in CO_2 in the atmosphere. As will be described below, the bio-based economy has an adverse effect on some of these steps and thus indeed can lead to higher CO_2 emissions.

Land Use Change (LUC) and Indirect Land Use Change (ILUC)

The amount of CO_2 in the atmosphere can increase due to changes in land use. Land use change is often the result of human activity: think, for example, about deforestation. Forests are cut down for the expansion of urban areas or for the expansion of arable land. The forest that is removed can no longer function as a carbon sink and the carbon stored in the wood is burned, and thereby ends up in the atmosphere. Another result of logging forests is that the carbon stock in the ground will be partly released which also leads to higher CO_2 levels in the atmosphere.

But what is the relation with the bio-based economy? The bio-based economy uses biomass as its main source for energy and products and hence the introduction of a bio-based economy will lead to an enormous increase in the demand

35 UCAR, *The Carbon Cycle*, at http://eo.ucar.edu/kids/green/cycles6.htm (viewed on 29-06-2012).
36 TEEIC, *What is the Carbon Cycle*, at http://teeic.anl.gov/er/carbon/carboninfo/cycle/index.cfm (viewed on 29-06-2012).

for biomass. This is something that we already experience today with the biomass needed for biofuels production. For the production of these fuels, more arable land is needed and this land could come at the expense of forests and grass lands (carbon sinks). In this way the bio-based economy can lead to higher levels of CO_2 and hence aggravate the greenhouse effect instead of reducing it.

In order to limit the amount of forested and other highly biodiverse land being converted for biomass production, the EU has designed sustainability criteria for biofuels. The result is that land with high carbon stocks cannot be used for the production of biofuels that count towards the 10% renewable target for transport sector. Solid biomass used for energy production and cooling and heating, as well as biomass used for the production of bio-based products and chemicals, does not have to comply with those sustainability criteria. Hence it is very well possible that the biomass used for these applications will lead to increased deforestation and thus accounts to higher levels of CO_2 in the atmosphere.

Another phenomenon related to land use and the bio-based economy is Indirect Land Use Change (ILUC). This phenomenon can be described by the following example. A farmer who has produced food on a certain piece of land decides to switch to the production of biofuel crops or food crops for the energy market on that piece of land. The result is that, since the demand for food is not decreasing, the amount of food that this farmer produced before now has to be produced somewhere else. This often means that grassland or forests somewhere else are changed into arable land for food production. In this sense the production of biofuels leads indirectly to changes in land use. ILUC CO_2 emissions are thus *indirectly* caused by Europe's demand for biofuels.

The EU Renewable Energy Directive and the Fuel Quality Directive promote the use of biofuels and thereby the policies of the European Union are causing (indirect) land use change. As explained above, biofuels counting to the 10% renewables target for the transport sector do need to fulfil sustainability criteria. Indirect land use change is however not yet incorporated in these criteria. In other words, CO_2 emissions from ILUC are not included in the carbon balance of biofuels. This accounting loophole could lead to the unwanted situation that biofuels are classified as environmentally friendly, while they in reality could be worse in terms of CO_2 emissions than fossil fuels.

The ILUC effects of different sorts of biofuels and bioproducts are not all the same. If the feedstock for biofuels is made up of food crops, this will usually lead to a higher ILUC effect than when biofuels are made of waste streams for example. Biofuel crops grown on degraded lands, which would not be used otherwise, also have a lower ILUC factor.

Carbon Debt

As discussed earlier, the bio-based economy introduces a closed carbon cycle. The carbon used in a bio-based economy is not taken from subsurface sinks (oil and gas) but is taken from biomass, which will grow over and over again, and thereby take up the released CO_2 from the atmosphere again. This does however not mean that the level of CO_2 in the air stays the same at all times. This problem is described as the ´carbon debt´.

Burning biomass will in the short run result in a rise of CO_2 levels in the atmosphere. Several NGOs have already pointed toward the negative climate effects that the use of biomass can have in the short and intermediate term. NGOs such as FERN, BirdLife and the EEB state that "there is a time gap between the instant release of carbon when the biomass is extracted, transported and combusted and the time it will take to rebuild the store of carbon to an amount equal to that released. Until the moment at which this time gap [...] is closed, burning biomass increases atmospheric carbon".[37] It can take decades or, depending on the sort of biomass, even centuries before newly grown biomass has absorbed the same amount of CO_2 as was released during the combustion. One should hence conclude that biomass is not by definition carbon neutral.

"The carbon contained in the trees is emitted upfront while trees grow back over many years".[38] How many years it will take before a carbon benefit will come about, compared to fossil resources,

37 BirdLife, Greenpeace, EEB, ClientEarth and FERN (2012), *NGO Briefing. Sustainability Issues for Solid Biomass in Electricity, Heating and Cooling*, p. 1. at http://www.fern.org/sites/fern.org/files/EU%20Joint%20NGO%20briefing%20on%20biomass%20sustainability%20issues%20for%20energy.pdf (viewed on 29-06-2012).

38 Birdlife (2012), *Bioenergy - A Carbon Accounting Time Bomb*, at http://www.birdlife.org/eu/EU_policy/Biofuels/carbon_bomb.html (viewed on 29-06-2012).

Figure 3.2: Carbon Debt

Table 5 *CN* factors calculated in this study for different source of wood biomass on different time horizons, when biomass substitutes coal. When biomass substitutes oil the *CN* must be reduced by 0.2 and by 0.4 when it substitutes natural gas. The reported figures assume that no indirect land-use change occurs.

Source of biomass	*CN*			
	20 years	50 years	300 years	Notes
Forest residues (constant annual extraction)	0.6	0.7	0.9	Always positive, but not C neutral
Additional thinnings	<0	<0	0.2	Atmospheric benefit after 200-300 years
New forests:				
- conversion from cropland	≥1	>1	>1	C neutral
- conversion from grassland*	>0 to ≤1	≥1	≥1	Positive in the short-term, becomes C neutral in 1-2 decades
- conversion from managed forest to SRC	<0	<0	0.7	Atmospheric benefit after 70 years
- conversion from mature forest to SRC	<0	<0	0.4	Atmospheric benefit after 170 years
- conversion from managed forest to a 60 year rotation plantation	<0	<0	0.3-0.7	Atmospheric benefit after 150-200 years

* The conversion of natural grasslands with high C stock in soil and biomass can produce more emissions and reduce the mitigation potential of the bioenergy produced after conversion.

Source: Zanchi et.al.[39]

depends on the source of biomass. Annual crops regrow very quickly and retake the amount of carbon earlier released very quickly. Trees on the other hand, take a long time before they have incorporated as much as carbon as the trees that were logged or felled for burning. Burning forests instead of fossil resources has no net climate benefit in the first 20 to 50 years and only after two to three centuries will this system lead to real CO_2 emission benefits (*figure 3.2*).

CO_2 emissions need to decline by 2015 in order to prevent atmospheric tipping points from being reached. Stimulating the energy recovery of co-firing biomass, which has a long payback time may be a very unwise decision in this regard. We just lack the time. Climate scientists have made clear that early action to prevent dangerous climate change is necessary and measures that only result in CO_2 emission reductions in the medium or long term are not helpful in this regard. Hence, not all sorts of woody biomass are a desirable source for energy recovery.

Under the EU´s CO_2 emission trading system (ETS) the burning of biomass is considered to be carbon neutral. In other words, while an energy company needs to surrender CO_2 allowances for burning coal, the same is not required for the burning of biomass, since the co-firing of biomass is assumed to be carbon neutral. The combustion of biomass can release as much greenhouse gases as fossil fuel combustion, while it can take many decades before living biomass can absorb an equivalent amount of carbon. Therefore, the carbon neutrality assumption of co-firing biomass should be changed. Only sustainable biomass that leads to reduced carbon emissions in the short term should be considered carbon neutral under ETS.

39 Zanchi G, N. Pena and N. Bird (2010), *The upfront carbon debt of bioenergy*, Graz, Joanneum Research, p. 32.

Life Cycle Analysis
Besides (I)LUC and carbon debt, there are many other variables that determine whether a certain bio-based product or biofuel has a net positive CO_2 balance or not. Variables that have an impact on the CO_2 balance of a product are, for example, crop productivity, the use of residual products, and, for energy from biomass, the efficiency of biomass to energy conversion. Another important variable is transportation. Is it sustainable to transport biomass from the other side of the world to Europe only to burn it in an inefficient coal plant for energy recovery?

In order to assess whether the specific bio-based process or product is reducing CO_2 emissions, it is useful to look at all the stages from the extraction of the raw material to the end-use state. With the method of life cycle analysis, the CO_2 benefit of all steps in the cycle can be assessed and one is able to conclude whether a certain product or process is saving CO_2 emissions compared to its fossil counterpart.

It is important to separate promising – with regard to CO_2 emissions – bio-based developments from developments that do not lead to a CO_2 reduction. If the bio-based economy is promoted as a tool for CO_2 reduction, it is important that this is not a false promise but that it is a reachable objective.

3.2 Concern II: Food Supply

Originally agricultural land is mainly used for the production of food for people and feed for animals. However, with the transition towards a bio-based economy land is also used for the production of crops for biofuels and other applications. Besides an effect on the CO_2 balance (as discussed in the paragraph on (I)LUC above), this has also an important implication for food security and food prices.

Biofuels, Food Prices and Price Volatility
So-called first generation biofuels are fuels derived of food crops such as maize, soy, and sugar. By stimulating the use of biofuels, the demand for these food crops increases. It is commonly agreed that the spikes in food prices in 2007-2008 and in 2010-2011 are partly caused by the increased demand for biofuels. The competition between the production of biofuels and the production of food from crops is quite substantial. On the other hand, bio-based materials and bio-based chemicals do not account for a very big share of biomass use. Hence, the competition between food and the bio-based economy centres around the use of biomass for the production of biofuels. "During the 2007-2009 period biofuels accounted for a significant share of global use of several crops – 20% for sugar cane, 9% for vegetable oil and coarse grains and 4% for sugar beet. These shares in global markets influence both the price levels, which are higher than they would be if no biofuels were consumed, and price volatility, because there is very little elasticity in the agricultural market either as a result of a supply shortfall (such as weather related factors) or demand pressures (such as biofuels)".[40]

Studies on the future effects of EU biofuels policies on food prices show worrying results: "due to EU biofuels policies, by 2020 [the prices of] oilseeds may be up to 22% higher, vegetable oils up to 20% higher, wheat up to 10% higher, maize up to 22% higher and sugar up to 21% higher".[41]

Other pressures on Food
The above figures indicate the negative effects of biofuels on food supply and prices. Biofuels are however not the only factor putting pressure on the availability and price of food. The world population is expected to reach 9 billion people by 2050; so a lot more people need to be fed, putting additional pressure on the demand for food crops.

The consumption of meat is also expected to grow in the future. The production of meat requires the input of animal feed; it is estimated that in order to produce 1 kg of beef, up to 20 kg of feed is needed. An increase in meat consumption therefore will result in extra demand for feed, also putting additional pressure on the demand for food.

Overall, it is estimated that the demand for food will increase up to 70% in 2050[42] and it will be difficult for the supply of food crops to match this increased demand. This problem is exacerbated if nothing is done about our projected use of biofuels and our western dietary patterns of high meat consumption.

40 ActionAid (2012), *Fuel for Thought. Addressing the Social Impacts of EU Biofuels Policies, Brussels, ActionAid International Europe Office*, p. 12.
41 ActionAid (2012), *Fuel for Thought. Addressing the Social Impacts of EU Biofuels Policies*, Brussels, ActionAid International Europe Office, p. 15.
42 SER (2010), *Meer chemie tussen groen en groei. De kansen en dilemma's van een bio-based economy*, Den Haag, SER, p. 87.

Last but not least, climate change and the increase in extreme weather events like droughts or floods will pose (and is already posing) an enormous pressure on the supply of food crops. The future of food is therefore likely to be characterised by increasing demand and fluctuating supply.

Food Security in the Developing World

The populations that will suffer the most from the increase in food prices are the poor people across the world. Reasons for this are, among others, that "lower income consumers spend a larger share of their income on food [and] bulk commodities account for a larger share of food expenditure in low income families".[43]

The production of biofuels also has negative effects on local food security in developing countries. "Local agricultural resources are diverted to biofuels production".[44] Land-grabbing plays an important role in this, but that will be discussed in the next paragraph on land security.

It is often argued that by using marginal and degraded land for the production of biofuels, no competition with food will take place. This reasoning is questioned by ActionAid: "This narrative is (...) seriously flawed and has serious consequences for food security, not least at the local level. It has been proven repeatedly that much of the land considered as 'idle' frequently constitutes a vital source of food and livelihood for poor people by providing fruits, herbs, wood for example for heating or grazing area".[45]

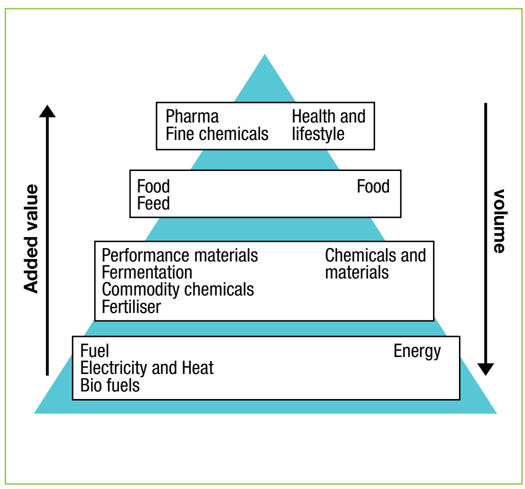
All the above examples show that the social sustainability of biofuels can be questioned since it could have serious implications for food security and food prices around the world.

Food and the Bio-based Economy

As explained *in section 1.2*, a smart use of biomass is guided by economic value together with ecological sustainability and societal concerns. The current EU policies on biofuels could have detrimental effects on global food supply and food prices, a societal concern. Hence this policy is not in accordance with our vision of a smart use of biomass. Where alternatives are available, biofuels should therefore not be promoted. Cars for example could also run on electricity or hydrogen. For certain other transport modes such as aeroplanes and trucks, no real alternatives to oil exist. In these cases, sustainably produced biofuels with limited effects on food supply could be used as fossil fuel alternatives.

The above example clarifies the error of the value pyramid. The value pyramid only incorporates economic value as a parameter. The result is that Food is not on top of the pyramid – where it would have been if societal concerns are taken into account – but is located after Pharma and Fine Chemicals. Another error in the value pyramid is that Food and Feed are in the same category. If societal and ecological concerns would have been taken into account, food is superior to feed. Feed puts additional pressure on the available land while we can switch to lower meat consumption without jeopardizing a healthy diet.

Figure 3.3: The Value Pyramid



Source: Bio-basedeconomy.nl[46]

Food security is a human right; everybody should have access to adequate food. Wide scale production of first generation biofuels threaten this right, therefore its use should be restricted. Second and third generation biofuels are not in direct competition with food production and are therefore more promising. Examples of second-generation biofuels are biofuels derived from woody biomass, from second-generation crops such as Miscanthus or from municipal solid waste. Since these streams of

43 Langeveld, H., M. Meeusen and Johan Sanders (2010), *The Bio-based Economy. Biofuels, Materials and Chemicals in the Post-Oil Era*, Earthscan, New York, p. 265.
44 ActionAid, Ibid., p. 16.
45 ActionAid, Ibid., p. 16.
46 Bio-basedeconomy.nl, *Bioraffinage en Cascadering*, at http://www.bio-basedeconomy.nl/themas /bioraffinage/, (viewed on 29-06-2012).

biomass are not directly used for food production, they do not lead to direct competition with food. Second-generation biofuels are however not always a good choice, since they could indirectly lead to competition with food production. Third-generation biofuels do not compete with food production at all, since these fuels are derived from (micro)algae. "Microalgae represent a very attractive alternative compared to terrestrial oleaginous species, because their productivity is much higher and it does not compete for land suitable for agricultural irrigation or consumption by humans or animals, providing therefore food security".[47] Third generation biofuels are however still in the phase of research and development and it will take some time before these fuels will enter the market. Third generation biofuels will be discussed in *chapter 4* as one of the possible solutions for a transition towards a sustainable bio-based economy. But first, other concerns of the bio-based economy will be highlighted, starting with land scarcity.

3.3 Concern III: Land Scarcity

Biomass production is dependent upon several factors. One of the most important factors is the availability of land. Since land is a scarce resource, the availability of sustainably produced biomass is limited. Below, an overview of the supply and demand of biomass is given and some conclusions on the use of land for the bio-based economy are drawn. Finally, two negative effects of high biomass demand are summarized: biodiversity loss and large scale land acquisition.

Demand of Biomass

The future demand of biomass for energy use in Europe can be estimated by analysing the National Renewable Energy Action Plans (NREAPS). These NREAPs contain national projections for renewable energy use up to 2020. In these plans, projected renewable energy use for the sectors heating and cooling, electricity and transport are included.

The NREAPs rely heavily on biomass as a resource for renewable energy: in 2020 more than 50 per cent of the renewable energy in the 27 EU member states is projected to come from biomass. In total around 12% of the final energy consumption in the EU will come from biomass in 2020. Biomass will make up 19% of total renewable electricity, 81% of total renewable heating and cooling and 89% of total renewable energy in transport in 2020 according to the NREAPs.[48]

Beurskens et al. calculated the total anticipated EU27 bioenergy use in Mtoe for the year 2020, based on the NREAPS. The outcome is shown in *figure 3.4*. The prediction is therefore that the final energy consumption from biomass in electricity, heating & cooling and transport increases from around 85 Mtoe in 2010 to 140 Mtoe in 2020. According to PBL (2012), "because of conversion losses in the production of bio-energy, the input required to substitute 1 exajoule of fossil fuel may be 1.5 to 2 exajoules of biomass". In other words, primary biomass demand for energy would increase from around 130-170 Mtoe in 2010 to 210-280 Mtoe in 2020.

Figure 3.4: EU27 Final Renewable Energy Consumption from biomass in Electricity, Heating and Cooling (H&C) and transport (Mtoe).

	Electricity		Heating & cooling		Transport		Total	
	2010	*2020*	*2010*	*2020*	*2010*	*2020*	*2010*	*2020*
Solid biomass	6.6	13.3	56.6	81.0			63.2	94.3
Biogas	2.5	5.5	1.5	5.1			4.0	10.6
Bioliquids	0.7	1.1	3.6	4.4			4.3	5.5
Subtotal	***8.9***	***19.9***	***61.7***	***90.4***			***70.6***	***110.3***
Bioethanol					2.9	7.3	2.9	7.3
Biodiesel					11.0	21.6	11.0	21.6
Other biofuels					0.2	0.8	0.2	0.8
Subtotal					***14.0***	***29.7***	***14.0***	***29.7***
Total							**85**	**140**

Source: Based on table 5,7,9 of Article of Beurskens et al.[49]

47 WUR (2011), *Research on Microalgae within Wageningen UR. Energy*, at http://www.algae.wur.nl/UK/applications/energy/ (viewed on 29-06-2012).
48 http://www.ecn.nl/docs/library/report/2010/e10069_summary.pdf
49 Beurskens, L.W.M., M. Hekkenberg and P. Vethman (2011), *Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States*, ECN and EEA, at http://www.ecn.nl/docs/library/report/2010/e10069_summary.pdf

The above numbers only refer to biomass for energy use and do not take into account other applications of biomass in the bio-based economy (materials and chemicals). Unfortunately these numbers are not readily available, although we can safely assume that they are not very high at the moment. Bioplastics, for example, are currently a very small proportion of the European plastics market (less than 0.5% by weight) even though they experience rapid growth.[50] Even with this rapid growth, the required biomass for bio-products will remain lower than the amount of biomass required to replace fossil fuels in the transport or energy sectors, see also the below table. The fossil fuels needed as feedstock for the industry is only 7% of total fossil fuel consumption in 2030. In contrast, power generation accounts for more than a third of total fossil fuel consumption. Nevertheless, replacing the total consumption of fossil fuels in the industry (feedstock) sector in 2030 requires around 180-240 Mtoe of biomass.[51]

Table 3.1: Sectoral fossil fuel consumption in BAU scenario for the EU for 2030 (unit: EJ and Mtoe final energy consumption)

Sector	EU-FF (EJ)	EU-FF (Mtoe)
Power generation	23	552
Industry (combustion)	8	192
Industry (feedstock)	5	120
Buildings (houses and offices)	11	264
Road transport	18	432
Aviation	1	24
Shipping	0	0
Total	**67**	**1 608**

Source: PBL (2012), Sustainability of biomass in a bio-based economy, PBL publication number 500143001, The Hague, PBL Netherlands Environmental Assessment Agency

A rough indication for the primary biomass demand by the EU for a 1% increase in the bio-based economy for 2030 is 1.3 to 1.8 exajoule (or around 31 to 43 Mtoe), as estimated by PBL (2012) . Thus a 20% bio-based economy would require 25 to 35 exajoules of primary biomass (or 600 to 840 Mtoe). As highlighted above, the energy and transport sectors are responsible for the big chunk of fossil fuel consumption and therefore biomass demand in such a 20% bio-based economy.

Supply of Biomass

Quite a number of studies are undertaken that investigate the availability of biomass in the EU. One of the most extensive recent studies is the European Biomass Futures Project. This Project provides among other things a "comprehensive strategic analysis of biomass supply options and their availability in response to different demands in a timeframe from 2010-2030".[53] The project has developed two scenarios for which it analyses the potential supply of biomass in the timeframe of 2010 to 2030. The first scenario is the reference scenario, while the second scenario is a sustainability scenario (including compensation for ILUC emissions and sustainability criteria for solid biomass). A second influential, but older, study is from the European Environmental Agency (EEA). The potential supply of biomass from both the EEA and the European Biomass Futures Project are summarized in *Table 3.2*.

50 http://www.biomassfutures.eu/public_docs/workshops_2012/20_march_2012/afternoon_seminar/Cascading%20Use%20Kretschmer.pdf
51 Assuming 1 toe = 42 GJ and conversion losses (1 EJ of fossil fuel requires 1.5 to 2 EJ of biomass).
52 PBL (2012), *Sustainability of biomass in a bio-based economy*, PBL publication number 500143001, The Hague, PBL Netherlands Environmental Assessment Agency
53 Elbersen, B., I. Startisky, G. Hengeveld, M. Schelhaas, H. Naeff and H. Böttcher (2012), *Atlas of EU biomass potentials. Deliverable 3.3: Spatially detailed and quantified overview of EU biomass potential taking into account the main criteria determining biomass availability from different Sources* (Draft), Biomass Futures, p. 8, at http://bit.ly/X2QpWm

Table 3.2: Potentials of biomass supply (Mtoe) in the EU per category for the Biomass futures (2012)[54] and the EEA (2006)[55] study.

Category		Current availability 2010 (Mtoe)		2020 sustainability (Mtoe)		2030 sustainability (Mtoe)	
		Biomass Futures	EEA	Biomass Futures	EEA	Biomass Futures	EEA
Waste	Agricultural residues	89		106		106	
	Secondary forestry residues	14		15		17	
	Tertiary forestry residues	32		45		38	
	Landscape care wood	9		11		11	
	Subtotal	***144***	***99***	***177***	***99***	***172***	***96***
Agriculture	Wastes[56]	42		36		33	
	Rotational crops	9		0		0	
	Perennial crops	0		52		37	
	Subtotal	***51***	***47***	***88***	***96***	***70***	***142***
Forestry	Roundwood production	57		56		56	
	Add. harvestable roundwood	41		35		36	
	Primary forestry residues	20		19		19	
	Subtotal	***118***	***42.5***	***110***	***41***	***111***	***55***
Total		***314***	***188.5***	***375***	***236***	***353***	***293***

As can be seen, both the current and future availability of biomass is lower for the EEA study. The difference can, for a large part, be explained in the different handling of the forestry sector. In the EEA (2006) study, the forest biomass potential is calculated in a demand-driven manner. Projections of future industry demands for wood are taken into account. This is not the case for the Biomass Futures study, where it appears that the total roundwood production is taken for granted, while this roundwood production is only partly available for bioenergy production as competing use with wood use is very large. In the EEA study, the available forestry biomass is assumed to comprise the residues from harvest operations that are normally left in the forest, as well as complementary felling when environmental guidelines are applied.

See also the figure below. In the Biomass Futures Project (2012), of the 380 Mtoe biomass potential in 2020, only around 260 Mtoe is available for the price range 0-199 Euro/Toe. In the year 2030 this is only 180 Mtoe. From 200 to 400 Euro/Toe the additional potential consists of primary and secondary forestry residues and dedicated perennial crops. From 400 to 600 Euro/Toe additional harvestable round wood and round wood production start to contribute significantly to the 2020 potential.

54 https://webmail.europarl.europa.eu/exchweb/bin/redir.asp?URL=http://www.biomassfutures.eu/work_packages/WP3%2520Supply/D_3_3__Atlas_of_technical_and_economic_biomass_potential_FINAL_Feb_2012.pdf, p. 64.
55 EEA (2006), *How much bioenergy can Europe produce without harming the environment?*, Luxembourg: Office for Official Publications of the European Communities, p. 52.
56 Consisting of grass cuttings (part of "Agriculture" under EEA terminology), but also municipal waste, sludges etc (part of "Waste" under EEA terminology).

Table 3.3: Overview of biomass potential (Mtoe) per price class for 2020 and 2030 for the EU (Biomass Futures Project, 2012)

	2020		2030	
	Reference	**Sustainability**	**Reference**	**Sustainability**
0-199 Euro/Toe	284	259	217	179
200-399 Euro/Toe	58	49	55	49
400-599 Euro/Toe	79	72	87	79
600-999 Euro/Toe	4	0	51	46
>=1000 Euro/Toe	5	0	1	0
Total	**429**	**379**	**411**	**353**

The sustainable biomass supply in Europe is 236 Mtoe (EEA, 2006) to 375 Mtoe (Biomass Futures, 2012) in 2020. However of the latter estimate, only around 260 Mtoe is available in 2020 for a price below 200 Euro/Toe. The final bioenergy demand in the EU Member States will be around 140 Mtoe in 2020 or 210-280 Mtoe in primary biomass demand. Nevertheless, CEPI (Confederation of European Paper Industries) expects that a wood supply gap will arise between 2015 and 2020 due to a high demand for wood for energy consumption.[57]

The Energy Vision scenario (Oko-institut, 2011) takes the equal access rights perspective as a principle and finds that the total biomass use in the EU-27 (domestic production plus imports) should not exceed the level of about 30 GJ per capita. Giving a population of around 500 million people, the total biomass use in the EU-27 should thus not exceed 15 EJ or 360 Mtoe.

The national renewable action plans of the Member States show that more than 10% of final energy consumption in the EU will come from biomass in the year 2020, which in theory could still be sustainably supplied for within Europe. Looking at the total economy, it has been estimated that the sustainably available biomass in Europe will be just enough to meet the required amount of biomass for a 10% European bio-economy in 2030.

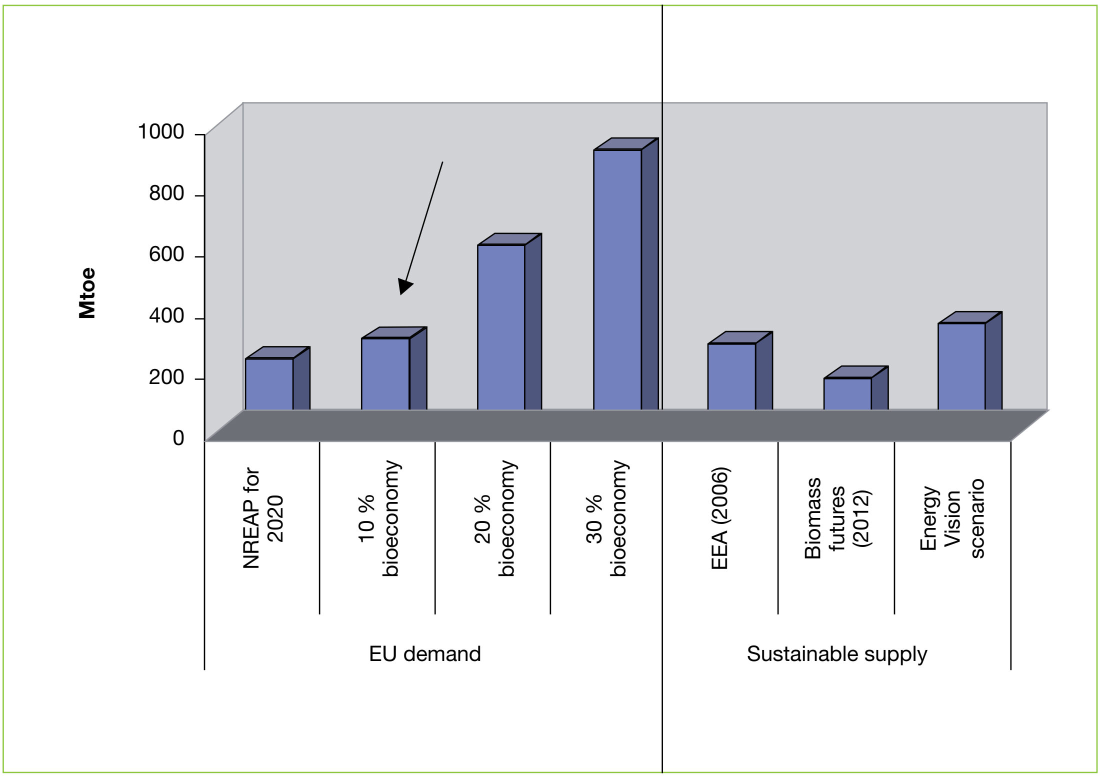
If we take again the estimate of the PBL (2012) study[58] a 10% bio-based economy in 2030 will require 310-430 Mtoe of biomass.

On the other hand, the EEA (2006) study estimates that around 293 Mtoe is sustainably available in 2030, while according to Biomass Futures (2012) only 179 Mtoe is sustainably available in the Europe for a price below 200 Euro/Toe. The Energy Vision scenario that was made for the Greens/EFA group is based on the principle that biomass use should not exceed 360 Mtoe.

PBL (2012) reaches the same conclusion: "It appears realistic that, for the EU, the sustainable biomass supply will be enough to meet about 10% of the final energy and feedstock consumption in 2030. Under optimistic assumptions, this supply might increase to 20%. EU Member States, in their Renewable Energy Action Plans for 2020, already aim to apply an amount of biomass that already approaches this 10%. Therefore, from a sustainability perspective, there is an urgent need to guarantee ecologically sustainable biomass production".[59]

57 Kretschmer, B. (2012), *Cascading Use: A Systematic Approach to Biomass beyond the Energy Sector Biomass Futures Final Workshop*, p. 6, at http://www.biomassfutures.eu/public_docs/workshops_2012/20_march_2012/afternoon_seminar/Cascading%20Use%20Kretschmer.pdf (viewed on 29-06-2012).
58 A 1% increase in the EU bio-based economy for 2030 will increase the primary biomass demand by around 31-43 Mtoe.
59 Ibid., p. 2.

Figure 3.5: EU Primary Biomass Demand Versus Potential Sustainable Supply, 2030



Biodiversity Loss

"Historically, it is known that the conversion of natural habitats to human-dominated land use puts the greatest pressure on global biodiversity".[60] Biodiversity has an intrinsic value, but besides that, natural diversity is vital for the functioning of our ecosystems. For these two reasons it is important that the extra pressure resulting from the demand of biomass for the bio-based economy will not lead to additional loss of species and diversity of natural habitats. The net result of land use for the bio-based economy on biodiversity "depends on (i) the vegetation to be replaced; and (ii) the new method of production".[61]

An example of the first category is when rainforests are logged or when highly biodiverse areas are converted into arable land. These vegetation changes lead to a permanent loss of biodiversity.

The negative effects of the second category, the method of production, could be seen when looking at the state of our European forests. "Most of the European forests are heavily exploited. Exploited forests lack sufficient levels of deadwood as well as older trees which function as habit for numerous species".[62] The European Commission has even concluded that almost two thirds of European forests have an unfavourable conservation status".[63] The additional demand for woody biomass for the bio-based economy could lead to additional pressure on forests and could lead to a further worsening of their conservation status.

The bio-based economy could also lead to increased demand for agricultural crops and therefore add pressures for yield increases of agricultural land. This could result in more monocultures arising in areas that were before more diverse in nature.

60 Langeveld, H., M. Meeusen and Johan Sanders (2010), *The Bio-based Economy. Biofuels, Materials and Chemicals in the Post-Oil Era*, Earthscan, New York, p. 263.
61 Ibid.
62 BirdLife, Greenpeace, EEB, ClientEarth and FERN (2012), *NGO Briefing. Sustainability Issues for Solid Biomass in Electricity, Heating and Cooling*, p.1. at http://www.fern.org/sites/fern.org/files/EU%20Joint%20NGO%20briefing%20on%20biomass%20sustainability%20issues%20for%20energy.pdf (viewed on 29-06-2012), p. 5.
63 Ibid.

Focusing on the biofuel part of the bio-based economy, a study by Eickhout et al. compares the positive effects of GHG emissions reductions due to the substitution of fossil fuels by biofuels with the negative effects of changes in land use for biofuels production. "Eickhout et al. conclude that the intensive production of biofuels has a direct impact on biodiversity in a negative way unless already intensively managed arable land is used".[64]

Biodiversity can increase if monocultures are converted to extensive modes of productions like organic farming, agroforestry and mixed cropping. But given the additional demand for biomass for the bio-based economy, the pressures are the other way around. In other words, without safeguards, we risk that the bio-based economy will lead to a further loss of biodiversity, in Europe and abroad.

Large Scale Land Acquisition

The large scale acquisition of land is another negative effect of the bio-based economy which also transcends the borders of Europe. This acquisition is often termed ´land-grabbing´. Land-grabbing mostly takes place in the global south where investors try to buy agricultural land for production purposes.

Numbers about the exact scale of land acquisition in developing countries differ amongst each other. The World Bank estimates that 46.6 million hectares of farmland were acquired in developing countries in the period October 2008 to August 2009 by international investors.[65] Over the last decade (2000-2010) 71 million hectares are likely to "have been subject to land deals, or in negotiation for land deals", states the International Land Coalition.[66] Almost 80% of these land deals were done for agricultural purposes, and it is estimated that over three quarters of that land will be used for the production of crops for biofuels. Oxfam states that from 2001 until 2011, "227 million hectares of land has been sold, leased, licensed or are under negotiation in large-scale land deals".[67]

Although the numbers differ, all studies make clear that states and corporations buy or lease land in developing countries to make sure that their resource needs are secured. The demand for biofuels is also one of the drivers for land acquisitions.

Due to these land acquisitions indigenous people lose their access to land, and thereby their access to food and water. The land that is ´grabbed´ is often marked as idle or unused, but although no intensive agricultural activities take place on these lands, this does not mean that local groups are not dependent on that land for their livelihoods. "In so many cases land is already being used or claimed – yet existing land uses and claims go unrecognised because land users are marginalised from formal land rights and access to the law and institutions. And even in countries where some land is available, large-scale land allocations may still result in displacement as demand focuses on higher value lands (e.g. those with greater irrigation potential or proximity to markets)".[68] In Africa the vast majority of land is not formally tenured: "most communities do not have a formal legal claim to the land they use and consider their own".[69] The result is that land is often grabbed and used for the resource production for the developed world at the cost of food security and sustainability of livelihoods of the people in the developing world.

In sum, due to the demand for biomass (mainly for biofuels), the bio-based economy puts high pressures on land. The increased pressure on land comes at the expense of biodiversity and has a negative impact on the livelihoods of people in the global South.

3.4 Concern IV: Resource Scarcity

The production of biomass for the bio-based economy requires also other resources besides land. The two most important are water and nutrients. Just like land, the availability of water and nutrients (for example phosphorus) is limited. Without proper safeguards in place, scarce water and nutrients will not be used in the smartest way possible, which means that the bio-based economy will not be sustainable in the long run. Currently, water is used inefficiently, phosphorus reserves are being exhausted and intensive farming methods pollute surface waters.

64 Langeveld, H., M. Meeusen and Johan Sanders (2010), Ibid., p. 263.
65 ActionAid (2012), Ibid., p. 18.
66 ActionAid (2012), Ibid., p. 17.
67 EP (2012), Ibid., p. 10.
68 Cotula, L., S. Vermeulen, R. Leonard and J. Keeley (2009), *Land Grab or Development Opportunity? Agricultural Investment and International Land Deals in Africa*, FAO, IIED and IFAD, p.100, at http://www.ifad.org/pub/land/land_grab.pdf (viewed on 29-06-2012).
69 EP (2012), Ibid., p. 10.

Water

The FAO states that the "increasing stress on freshwater resources brought about by ever rising demand and profligate use, as well as by growing pollution worldwide, is of serious concern".[70] Population growth and economic growth in the developing world cause increased pressure on water resources. The availability of water is limited at a given time and place while demand is rising and this will inevitably lead to tensions and conflicts. The bio-based economy can aggravate this because it puts extra pressure on water demand.

Projections estimate that agricultural water demand will increase at least 20% by 2050.[71] Biofuels will lead to a further increase: "These estimates could become much higher if new biofuel strategies were fully implemented".[72] Several NGOs have already reported negative impacts from biomass plantations on local water security. They have reported "cases where eucalyptus plantations, for example, draw tremendous amounts of water from the soil leading to substantial declines in local ground-water levels."[73] While these impacts are related to biomass used for biofuels, the negative (social) impacts of water usage is also a matter of concern when developing policies for the take-off of a European bio-based economy.

Nutrients and Soil Quality

Like water, nutrients are indispensible for biomass to grow. The most important and well known nutrients are nitrogen and phosphorus. At the moment phosphorus is often used for the fertilization of soil, but an increasing demand will sooner or later lead to depletion. For example, if the world replaces 10 percent of its energy use with energy derived from crops "fossil phosphorus reserves could be depleted within just 50 years time".[74] It is hence of utmost importance that the phosphorus cycle will be closed in the future so that no shortage of phosphorus will arise.

Animals and people eat biological material (food and feed) which is rich of phosphorus. After the material is digested, the majority of the phosphorus ends up in faeces, which in turn is lost in groundwater and oceans. Since phosphorus is a finite resource this is not a smart way of using it. A lot of phosphorous is wasted, while it could be retrieved and recycled instead.

The output, i.e. the phosphorus that leaves animals and people, should become the new input, i.e. the nutrients for crops. Using manure as fertilizer and retrieving phosphorus from the sewer, are important ways to close the phosphorus cycle. Especially the latter is not yet taking place on a big scale.

The bio-based economy, apart from causing extra pressure on the production of biomass, introduces another concern relating to phosphorus: the biomass used in the EU for the bio-based economy often comes from production countries in other parts of the world, such as South America and Asia. By acquiring biomass from these countries and importing it into the EU, the phosphorus balance in the production countries is disturbed. In order to create sustainable trade in biomass, a return stream of nutrients should be organized so that the soil in production countries will not become degraded. The phosphorus should hence be retrieved from the biomass and returned to the land of the production country.

Soil quality is not only dependent on the presence of nutrients. The level of organic matter present in the soil is also of great importance for the soil quality. The use of agricultural rest streams (such as beet leaves and stems) for biofuels and bio-based materials is often advocated as sustainable, because it does not lead to land use change. The use of rest streams can however have negative effects if too much organic matter is retrieved from the land. In this way, not enough organic matter stays on the land to perform the role of a quality enhancer. In other words, rest streams of agricultural production often already have an important function in safeguarding the quality of the soil.

This section on scarce resources, together with the paragraph on land scarcity, has shown that the supply of biomass is not indefinite. It is very well possible that sustainable biomass production cannot meet future demand for biomass.

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70 FAO (2012), *Hot Issue: Water Scarcity*, at http://www.fao.org/nr/water/issues/scarcity.html (viewed on 29-06-2012).
71 SEI (2011), *Understanding the Nexus. Background Paper for the Bonn2011 Nexus Conference*, p. 10, at http://www.water-energy-food.org/documents/understanding_the_nexus.pdf (viewed on 29-06-2012).
72 Ibid.
73 EP (2012), Ibid. p. 11.
74 SEI, Ibid., p. 10.

Technology can nevertheless play an important role in getting the supply closer to the demand. The next section will summarise the role of technology in the bio-based economy and will amplify that its role can have positive as well as negative effects on the sustainability of a bio-based economy.

3.5 Concern V: Technology

In order to benefit from the advantages of a bio-based economy, innovative developments have to be stimulated. Only by the introduction of new innovative technologies, can the bio-based economy lead to lower CO_2 emissions and less dependency on fossil resources. Technological innovation can, for example, contribute greatly to resource efficiency. In short, technology has a key role to play in the bio-based economy.

The role of technology should hence be approached in an open manner and discussed in a constructive way. A polarised debate in which you are either ´for´ or ´against´ technology will not serve the bio-based economy. Technology should be a means to an end, not an end in itself. We do not aim for a future that is completely dominated by technology, but we see that technology can be useful in making our future more sustainable.

The sort of bio-based economy that is advocated in this document is mainly focused on the production of high added value applications of biomass (bio-based materials, chemicals and medicines). But these sectors are still partly in their infancy. We are, so to speak, currently in the middle of the transition towards a high-value bio-based economy. This transition can only be successful when concluded with new technologies. For example, the prospects for biochemicals look very promising, but breakthroughs are still needed in the bioprocesses step, as well as in product separation and purification.

Some concerns that are described in earlier paragraphs – for example, competition with food and land use change – can be (partly) overcome in the future by the introduction of new technologies. If research progresses and technology advances, it can for example, become possible to use micro-algae on a large scale. Algae production does not compete with food nor does it lead to land changes. This is just one example of what technology has to offer.

Biotechnology

Biotechnology is a technology that plays an important role in the production of bio-based products, chemicals and medicines. The definition of biotechnology as laid down in the Convention on Biological Diversity reads as follows: [biotechnology] "means any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use".[75] Or as the European Association for Bioindustries (EuropaBio) states, biotechnology "is using living organisms to make useful products. Production may be carried out by using intact organisms, such as yeasts and bacteria, or by using natural substances (e.g. enzymes) from organisms".[76]

Fermentation, a technique already used for centuries to produce bread and other food products, is an example of a biotechnology. It uses bacteria or fungi to produce products. Fermentation is very important in the bio-based economy, it is for example used in the production of penicillin, ethanol and building blocks for bioplastics.

The above-described biotechnology is called white biotechnology. It "uses enzymes and micro-organisms to make bio-based products in sectors such as chemicals, food and feed, detergents, paper and pulp, textiles and bioenergy (such as biofuels or biogas)".[77] But besides white biotech, there are also branches called red biotechnology, blue biotechnology and green biotechnology. Red biotechnology "refers to a medicinal or diagnostic product or a vaccine that consists of, or has been produced in, living organisms and may be manufactured via recombinant technology".[78] Modern plant breeding techniques are indicated as green biotechnology and blue biotechnology works with marine or aquatic forms of biotech. All of these branches can play a role in the bio-based economy.

GMOs

However, not all technological innovations in relation to the bio-based economy are favourable. Some proponents of gen-technology try to use the bio-based economy as a reason for the (large scale) introduction of genetically modified organisms (GMOs). They argue that genetically modified crops should be introduced as feedstock for the bio-based economy because it is argued that

75 CBD (1992), *Convention on Biological Diversity*, Article 2.
76 EuropaBio, *What is Biotechnology?*, at http://www.europabio.org/what-biotechnology (viewed on 29-06-2012).
77 Ibid.
78 Ibid.

these crops are more efficient and can thereby lead to yield increase and diminished environmental harm by using less water and pesticides. The consequences for human health are still insufficiently investigated and until they remain unclear, the introduction of genetically modified plants should be prevented. The dispersal of GM plants in the environment is also an issue of concern and the effect of GM on biodiversity is negative: the variety of crops that is grown in farming is reduced due to the large-scale introduction of GM crops. "Specific regional crops will soon belong to the past and the future will consist of monocultures".[79] In these monocultures, pesticides will be used that kill weeds and insects, and this will, in consequence, threaten the livelihood of animals which feed themselves with these weeds and insects. To conclude, the current strict admission policy of the EU for GMO crops should not change under pressure of unsubstantiated claims for yield improvements for the feedstock of the bio-based economy.

GM technology can be divided in cisgenic and transgenic technologies. The former is a technology that creates plants in which genes are introduced that are derived from the same (or closely linked) species of that plant, while transgenic technology introduces a trait into a species in which it does not naturally exist. This latter technology in particular, should be followed with caution. Questions that are important in this regard, are whether the transgenic plant can spread its genes into the wild and whether it has an impact on local ecosystems.

Besides environmental and health concerns, there is another negative consequence of the introduction of GM plants. It gives companies that have developed GM crops an enormous amount of power.

Power Concentration

There are several big companies around the world that have a monopoly on the production of GM seeds. The seeds can only be bought from these manufacturers. The GM seeds are patented and can be used by the farmer just once. The next year the farmer has to spend money again to acquire the same seeds for production again. "To ensure [the seeds] can only be used once, the seeds are often sterilised using so-called terminator technology".[80] This is an example of the power of big companies and the unbalanced relationship between these companies and the farmer community.

Another example of this unbalanced relationship is that farmers are often forced to use pesticides and herbicides that are produced by the same company that developed the GM crops. Only these special herbicides/pesticides fulfil their function of killing weeds but not the GM crops. Herbicides/pesticides from other producers cannot fulfil this function because these would also kill the GM crops. "Currently about 70% of GM crops are herbicide resistant, and farmers growing them are dependent on the accompanying herbicide".[81]

The concentration of power at a couple of companies that produce and sell seeds, leads to a loss of sovereignty for the farmers as well as for the consumer. These big companies can produce at the lowest costs, which often leaves farmers no other choice than to use these seeds. Thanks to strict policies in the EU, the European consumer is not forced to eat genetically modified food, but has the option to eat GM-free vegetables and meat and to use products that are not derived from GM plants. As long as contamination of other species and health concerns cannot be excluded, GMOs are not an option in the European bio-based economy.

The unequal distribution of benefits received from the use of genetic resources, like enzymes, genes and molecules, is another example of the concentration of money and power with big companies. Often these companies use resources that grow in other countries without sharing the benefits with these countries or the local communities that own these resources. However, in 2010 the Nagoya Protocol was signed at the tenth Conference of the Parties to the Convention on Biological Diversity, which lays down rules for "access to genetic resources and the fair and equitable sharing of benefits arising from their utilization".[82] This Protocol will enter into force after fifteen of the signatories have ratified it. Hopefully this day will come soon, because the Protocol is a promising example of how the benefits of biotechnology can be shared. It leads to a win-win situation, because companies can further their research and make profit while the access-granting

79 ASEED, *ASEEDs Position on GMOs*, at http://www.aseed.net/new/nl/gentech (viewed on 29-06-2012).
80 Ibid.
81 Ibid.
82 CBD (2011), *Nagoya Protocol.*

party also benefits from the deal. The Nagoya Protocol is the first step in the direction to a more balanced relationship between powerful technology companies and other stakeholders, such as developing countries and local communities.

3.6 Concern VI: No Focus on a High Value Bio-based Economy

Today's transition to a bio-based economy can be characterized by an ever-increasing demand for biomass from a multitude of players. The projected demand of biomass needed cannot be sustainably supplied. If all applications, from bio-energy, biofuels to bio-based plastics and chemicals, will project steep demand curves, it will not be possible to develop a *sustainable* bio-based economy and the above described problems, like land-scarcity, competition with food supply and biodiversity loss, will worsen.

Biofuels and bio-energy are applications that demand massive amounts of biomass and will do so even more in the future – if projected growths are realized. The vast majority of biomass demand will come from these sectors. Therefore, one can argue that the sustainability problems described in the chapters above will be mainly caused by the use of biomass by the biofuel and bio-energy sector.

High value applications of biomass like biochemicals and plastics will only account for a small part of the projected demand for biomass (as can be seen in the value pyramid). If looking at the share of fossil resource use by the synthetic material sector, they account for 8 exajoules, while fuels account for 100 exajoules.[83] Self evidently, if the material sector will be completely transformed to a bio-based sector, the amount of biomass used will constitute a smaller part of the total amount of total biomass demand.

As argued earlier, our vision of a European bio-based economy is not only guided by economic gains, but also by social concerns and long-term ecological sustainability. Since the demands for biomass from the biofuel and bio-energy sector are threatening the ecological and social sustainability of the bio-based economy, we conclude that biofuels and energy recovery from biomass should not be the foci of the European bio-based economy of the future. Other clean alternatives to fossil fuels and fossil energy exist: for example electric vehicles and solar and wind energy. For aviation and shipping currently no viable sustainable alternatives to replace fossil fuels exist. Hence, modal shift, increased efficiency and biomass will have to play an important role in these transport sectors.

Ironically, European and national policy stimulate the shift to biomass for the lower added-value sectors (the energy sectors) instead of the high added-value sectors. For the move towards a long-term sustainable bio-based economy this distorted focus can become a severe problem. Below the discrepancy between support for the use of biomass in lower added-value sectors and higher added-value sectors is summarised.

Discrepancy Between Low and High Value Applications of Biomass

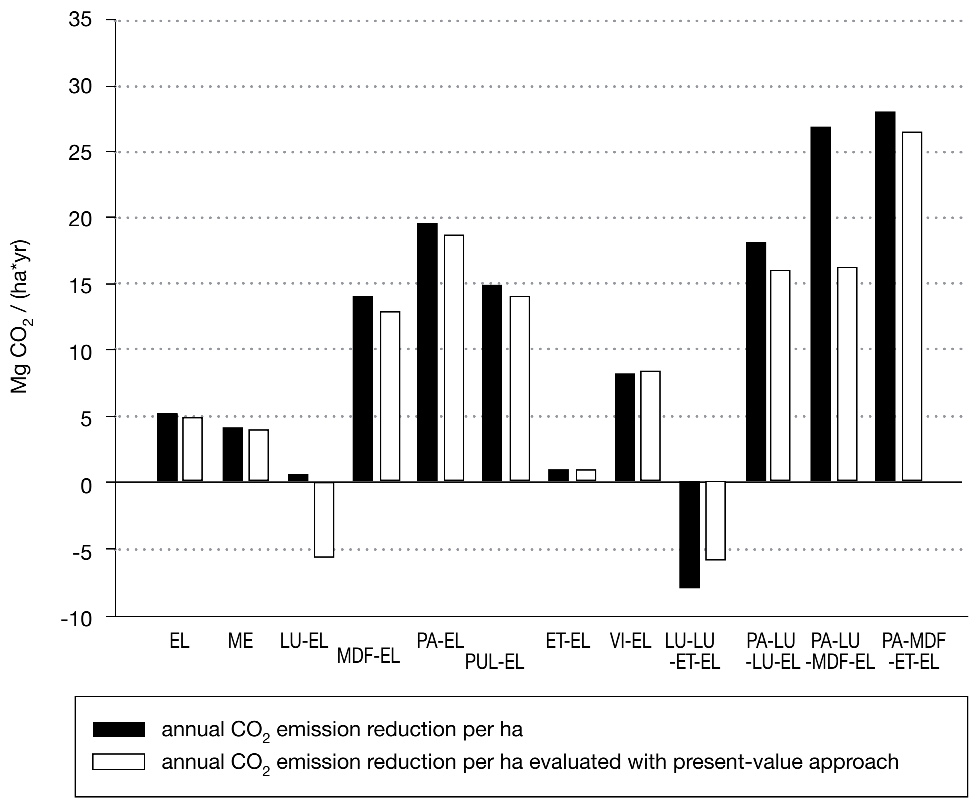
In an ideal bio-based economy, the use of biomass is guided first to applications that lead to high environmental benefits and which use the inherent qualities of the biomass, for example its complicated molecules or the strength of wood which can be used in construction. If it is no longer possible to use these properties of the biomass, the biomass can be used for a lower quality application, and in the end it can be burned for energy recovery.

In reality however, the qualities of the biomass are not decisive for the application of biomass. Instead, European policy measures supporting biofuels and bio-energy decide where the biomass is used. This means that high quality applications of biomass are skipped and the biomass is directly used in lower value applications. In this way, policies distort the optimal use of biomass and thereby, among other things, also limit the climate change mitigation potential of biomass. The cascading use of biomass is thus prevented by European and national policies on bio-energy and biofuels. Current policies lead to inefficiencies in resource use and in a misallocation of biomass. Instead of following all steps in the cascading cycle, the current policies promote the shortcut from step one immediately to the last step.

In *figure 3.6* it is shown that cascading uses of biomass can have considerable advantages if we look at CO_2 emissions. Cascading chains like PA-LU-MDF-EL and PA-MDF-ET-EL (see f*igure 3.7*) should be preferred above a single use of biomass for EL or ME.

83 WTC (2011), Ibid., p. 10.

Figure 3.6: Net Annual CO_2 Emmission Reduction Per Ha (+) or Net Annual CO_2 Emissions (-) of the Different Cascading Chains With and Without Applying a Present-Value Approach



Source: Dornburg, V. and A.P.C. Faaij[84]

Figure 3.7: Cascading chains of short rotation poplar regarded in this study

Abbreviation	Raw material		Primary material		Secondary material		Tertiary material		Energy
EL	SR poplar	→							Elec. IG/CC
ME	SR poplar	→							Methanol
LU-EL	SR poplar	→	Lumber					→	Elec. IG/CC
MDF-EL	SR poplar	→	MDF					→	Elec. IG/CC
PA-EL	SR poplar	→	Pallets					→	Elec. IG/CC
PUL-EL	SR poplar	→	Pulp					→	Elec. IG/CC
ET-EL	SR poplar	→	Ethylene					→	Elec. IG/CC
VI-EL	SR poplar	→	Viscose					→	Elec. IG/CC
LU-LU-ET-EL	SR poplar	→	Lumber	→	Lumber	→	Ethylene	→	Elec. IG/CC
PA-LU-LU-EL	SR poplar	→	Pallets	→	Lumber	→	Lumber	→	Elec. IG/CC
PA-LU-MDF-EL	SR poplar	→	Pallets	→	Lumber	→	MDF	→	Elec. IG/CC
PA-MDF-ET-EL	SR poplar	→	Pallets	→	MDF	→	Ethylene	→	Elec. IG/CC

Source: Dornburg, V. And A.P.C. Faaij[85]

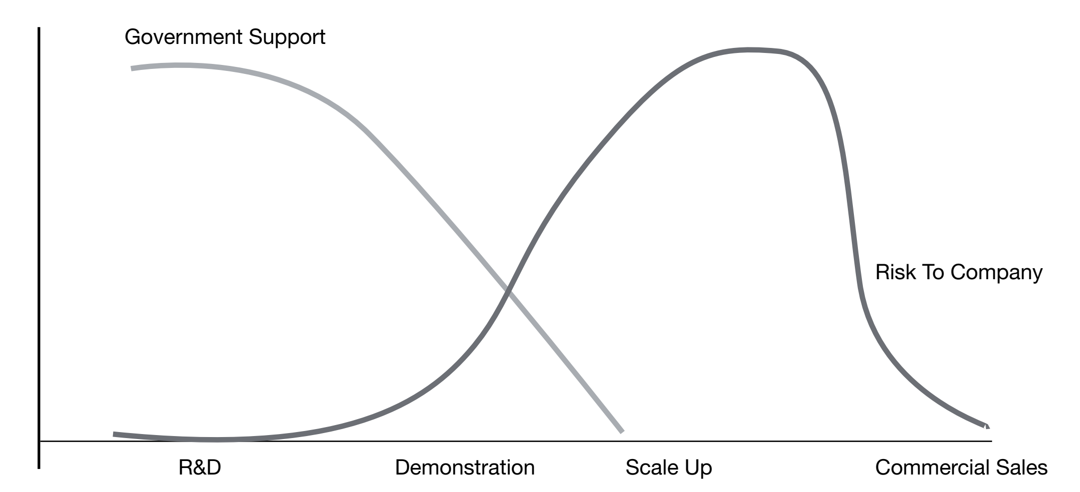
84 Dornburg, V and Faaij, A.P.C. (2005), "Cost and CO_2-Emission Reduction of Biomass Cascading: Methodological Aspects and Case Study of SRF Poplar", in *Climate Change* (71), p. 386.
85 Ibid., p. 383.

The "political and economic framework in the EU does not support the industrial material use of biomass – this is in contrast to bioenergy and especially biofuels, which has expanded rapidly in the EU over the last ten years".[86] The main policy that promotes the use of biofuels and bio-energy at the expense of bio-based chemistry and materials is the renewable energy directive. Europe has set itself a target of 20% renewable energy in 2020 and an accompanying 10% renewable energy target in the transport sector, mostly achieved by using biofuels. The EU is in need of a level playing field between the different uses of biomass, because only in this way can a future European bio-based economy live up to the expectations of being a sustainable solution to the current environmental problems. In *chapter 4* the promotion of high value applications is thoroughly discussed and several policy recommendations will be given, amongst others on the promotion of cascading use.

Innovation and High Added Value in the Bio-based Economy

The production of energy and biofuels has taken an enormous flight over the last years while the production of bio-based materials and chemicals is still in its infancy. It is well known that the road from research to market can sometimes be bumpy. "Particular problems occur at the stage where decision is taken on whether to commercialise an innovation as the risks are greater here than at other stages of innovation. First, the move from a test-series of products to production of commercial volumes of a product requires significant investment. Second, this risk coincides with the stage in the innovation process when public support usually ends, creating a risk profile (see figure below) that is sometimes known as "The Valley of Death" for innovations".[87]

Figure 3.8: Model of risk profile for companies of innovation processes



Source: DTI in COWI[88]

86 Carus, M., D. Carrez, H. Kaeb, J. Ravenstijn and J. Venus (2011), *Policy paper on Bio-based Economy in the EU. Level Playing Field for Bio-based Chemistry and Materials*, Nova-Institute, p.2, at http://www.greengran.com/download/Policy%20paper%20on%20Bio-based%20Economy%20in%20the%20EU.pdf (viewed on 29-06-2012).

87 COWI (2009), *Bridging the Valley of Death: public support for commercialisation of eco-innovation*, Final Report, European Commission, Directorate General Environment.

88 DTI in COWI (2009), *Bridging the Valley of Death: public support for commercialisation of eco-innovation*, Final Report, European Commission, Directorate General Environment, p. 2.

Investments should thus not be limited to the demonstration phase but should be prolonged until commercial activities really take off. Otherwise it is very well possible that the scale up activities will never start in the first place. Investment in these high risk stages is sometimes not found because of the so-called chicken or egg trap: "manufacturers wait until there is a demonstrated demand before they develop and commercialise technologies, but buyers wait to see the product on the market before they demonstrate they will buy it [...]. [An] eco-innovation may well have been developed as a prototype, but reaches a pinch-point at the decision to commercialise, which blocks its development.[89] This problem of the chicken or the egg also accounts for big-scale projects that use biomass as its resource. Since there is no supply stream of biomass yet, nobody dares to start investing in full-scale innovative biorefineries that use biomass as a feedstock. However, the reason that there is no big biomass supply is that there is not yet a demand for it. It is the question of who will put the first step into the right direction. Often what is needed is that policy supports this first step, for example in the form of a public-private partnership, so that after a while the process can "walk" on its own.

Furthermore, innovative companies producing bio-based products are often small and lack financing for the large investments that are needed. Someone from industry described this situation as David versus Goliath. The bio-based companies – often SMEs – can be characterized as David, who has to take up the fight with the big fossil industry, Goliath. These vested companies are not so interested in innovations since they represent the status quo. They have already been operating for a long time and therefore these companies have a comparative advantage, for example, through the advantages of economies of scale. To be able to become competitive with the fossil alternatives, the bio-based SMEs could be stimulated by (European) policies. Smart financing mechanisms for bio-based innovations could be developed.

To conclude, current policies are stimulating low added-value applications of biomass instead of innovative high added-value applications of biomass. In *chapter 4*, policy recommendations are developed that can help change the focus from the low value segment to the high value segment of the bio-based economy. But first, the last concern relating to the bio-based economy will be discussed.

3.7 Concern VII: Lack of Governance Structures

A European bio-based economy will benefit from the development of appropriate governance structures that safeguard policy coherence. Cooperation and consistency are keywords for successful European policies on the bio-based economy. Besides governance challenges inside the EU, governance is also an issue in the biomass producing countries. Often these countries are developing countries in which proper governance structures are lacking. Both governance challenges will be shortly discussed below.

EU Governance

As already stated in *chapter 2*, the bio-based economy relates to several policy areas. EU policies ranging from energy to industry, and from agriculture to biodiversity, affect the European bio-based economy. It is important that policy coherence between these different areas is safeguarded. Without comprehensive cooperation between the different policy areas, this coherency cannot be assured. A permanent interdepartmental structure is not existing at EU level at the moment, while this would definitely benefit the coherency of EU policy, and thereby the successful transition to a high value bio-based economy.

Besides cooperation between parts of the EU institutions, cooperation between different stakeholders in the bio-based economy, ranging from the public to the private sector, is also important. It appears that the Commission's Bio-economy Strategy foresees this need by introducing a bio-economy panel. The exact make-up and activities of this panel are however not clear yet. The Commission states in its Working Document that the "potential of the bio-economy will only be fully realised by working across several disciplines, policy areas and sectors with a strong willingness to jointly address diverse responsibilities.[90] Let us hope that this ambition of the Commission will be realized in the near future.

89 COWI (2009), *Bridging the Valley of Death: public support for commercialisation of eco-innovation*, Final Report, European Commission, Directorate General Environment, p. 2
90 EU (2012-b), Ibid. p. 15-16.

Governance in Production Countries

At the moment a lot of the European biomass demand is imported from countries outside the EU. In the future the aim is to use more European second generation biomass – such as by-products and rest streams – because of the lower negative environmental impacts. It will nevertheless be difficult to develop a European bio-based economy that is completely self-sufficient. The EU might depend on regions outside the EU for a certain share of its biomass use, for example on developing countries.

The governance structures in developing countries are not always very sophisticated. For example, we can develop very elaborate sustainability criteria and measures for our imported biomass, but if the governance structures in the producing countries are not well developed, it will be very difficult to fulfil these criteria, let alone to check the implementation of these criteria by verification, monitoring and evaluation. An example can be given on sustainable harvesting and management of forests: "Among the root causes for deforestation and forest degradation are weak governance structures for forest conservation and sustainable management of forest resources, in particular in developing countries. A large number of countries are party to intergovernmental initiatives to put criteria and indicators to monitor sustainable forest management, but they are not entirely based on common principles and criteria and do not have a mechanism for verifying compliance with the agreed principles".[91] Developing sustainability criteria should thus always go hand in hand with plans to develop governance structures for verification and evaluation in the countries at hand.

In short, in the European Union, as well as in the biomass producing countries, a focus on appropriate governance structures is crucial. By developing more elaborate governance structures, the bio-based economy can fulfil its potential to become the sustainable alternative that is needed to replace our current fossil economy.

91 EP (2012), *Impact of EU Bioenergy Policy on Developing Countries*, p. 18, at http://www.europarl.europa.eu/committees/fr/studiesdownload.html?languageDocument=EN&file=72731 (viewed on 29-06-2012).

4. Conclusion and Policy Recommendations

Provided that a robust policy framework is in place, the change from a fossil based economy towards a bio-based economy can represent an important step towards a more sustainable future.

Biomass can be used as a resource for many applications in the bio-based economy. At the moment, the use of biomass for energy production is one of the most promoted applications. However, the amount of biomass that is sustainably available will never be enough to fulfil current energy demands. A strong reliance on bioenergy as a renewable energy source will hence mean that one has to compromise on issues such as biodiversity and CO_2 reductions. Since sustainability is one of the main reasons to switch from fossil resources to biomass resources, compromising on sustainability for the production of bioenergy is not the way forward.

Our first, and main, conclusion is therefore that a future bio-based economy should not focus on bioenergy as an application of biomass, but instead has to focus on higher value applications of biomass – i.e. chemicals and materials – also because these do not require such big volumes of biomass as feedstock. Our vision for the future European bio-based economy is one that centres on the production of bio-materials and bio-chemicals.

Unfortunately, current EU policies promote exactly the opposite: they stimulate the use of biomass for low value applications – biofuels and bioenergy. Furthermore, there is no level playing field between high and low value applications of biomass. The EU is hence in need of creating such a level playing field between the different uses of biomass, to be able to steer biomass demand away from the most inefficient way to use biomass: for energy purposes.

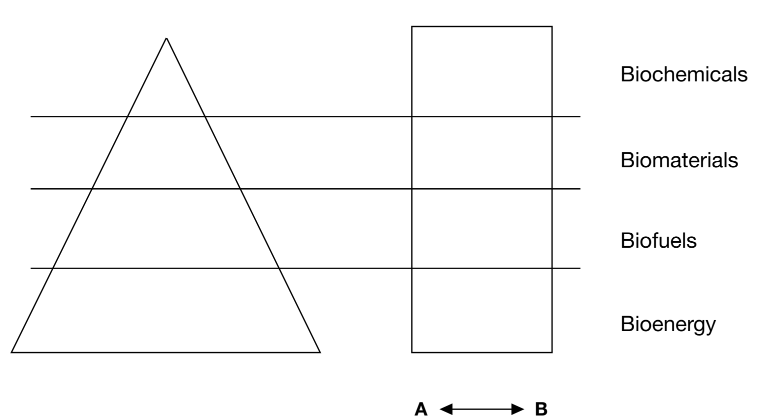
Another focal point of a sustainable bio-based economy is the cascade utilization of biomass. By cascading use, pressures on the environment will diminish, and biomass is used as efficiently as possible. Cascade utilization entails that biomass is used following a hierarchy: it is first directed to the top of the hierarchy (high value applications of biomass) and after its disposal, it can go on to lower applications in the hierarchy.

One of these lower value applications is biofuels. In this document it is argued that biomass should only be used for applications where there is no other sustainable alternative than biomass available. Cars can run on renewable electricity. However, for aviation, shipping and heavy-duty transport there is not such a sustainable alternative at hand. Therefore, these forms of transportation might have to rely on biofuels to replace fossil fuels. It is important that strict sustainability criteria apply to biofuels and that through modal shift and behavioural changes the demand for these transport modes is reduced. Otherwise the volume of the biomass needed for biofuels in shipping and aviation is quite substantial. The success or failure of a sustainable bio-based economy goes hand in hand with the sustainable production of biomass. Research on biofuels other than first generation biofuels has to be one of the priorities of the upcoming years. In particular, the future potential of algae for biofuel production should be investigated.

The application of biomass that is located at the bottom of the value pyramid is bioenergy. As just argued, the total volume of biomass needed for energy production is so huge that the sustainability of biomass production cannot be guaranteed. Furthermore, there are numerous sustainable alternatives for bioenergy like wind, solar and geothermal energy. The success of the bio-based economy will hence also depend on the success of these sources of renewable energy. The EU should support the bio-based economy by stimulating other sources than biomass for the generation of renewable energy and it should divert its support measures from the bottom of the bio-based value pyramid to the upper levels of the pyramid.

Reshaping the value pyramid can visually explain our ideal bio-based economy (*figure 4.1*). More biomass should be diverted to the top levels of the pyramid, while biomass for bioenergy production (lowest level) should be limited. By supporting the high value applications, the pyramid will change more into a column. Since one of the aims of a bio-based economy is resource efficiency, the width (from a to b) should be kept as small as possible to keep biomass use as small as possible. Cascade utilization and biorefining are important activities to make this Biomass Column a reality. These two activities can help ensure resource efficiency.

Figure 4.1: The Value pyramid and the Biomass Column



Specific policy recommendations

Recommendations for the promotion of high value applications of biomass:
The European bio-based economy should focus on the use of biomass for chemical and material applications. Therefore we need:

- to extend the **Ecodesign Directive** (Directive 2005/32/EC) **to cover non-energy related dimensions, such as recycling content, bio-based content, and the use of primary resources**. To ensure an effective implementation of this extension, adequate (financial) resources should become available for the implementation;

- to promote the uptake of sustainable bio-based products by the **European Ecolabel** labelling scheme. These products should meet strict sustainability requirements. By including bio-based products under the Ecolabel, uptake of bio-based products by consumers can be stimulated and **Green Public Procurement** can more easily include bio-based products. In that regard special Green Public Procurement programmes for sustainable bio-based products should be developed;

- to support packaging taxation at Member State level. This taxation should exempt **biodegradable bio-based packaging materials** for a certain time period;

- the European Parliament to adopt an **Own Initiative Report** on the Bio-Economy Strategy of the Commission as soon as possible to drive the political process forward and highlight the direction in which the bio-based economy should develop;

- to create a **Bio-economy Observatory**, as proposed by the Commission's Bio-economy Strategy, which will execute studies and outlooks on a broad range of topics related to the bio-based economy. One of the topics that should be immediately investigated is the sustainable supply and demand of biomass related to the high value segments of the bio-based economy;

- to make sure that money from **Structural Funds, the European Agricultural Fund for Rural Development and the Cohesion Fund** that is being used to support bioenergy and biofuels are in future increasingly diverted to support bio-based products – all criteria for funding should be handled equally;

- to ban fossil based chemicals, plastics and additives which can easily be **substituted by less hazardous (biodegradable in case of plastics) bio-based variants**.

Recommendations for the stimulation of cascade utilization of biomass
In order for the European bio-based economy to use biomass as efficient as possible, we need:

- to develop a **Biomass Framework Directive** which covers all applications of biomass (energy, fuels, materials, chemicals) in a consistent manner;

- to develop the idea of the **biomass hierarchy** based on the cascade utilization of biomass. This biomass hierarchy will be the guiding principle in the Biomass Framework Directive. The Waste Framework Directive (Directive 2008/98 /EC) and its Waste Hierarchy can be seen as examples for this;

- to include in the Biomass Framework Directive the requirement for Members to deliver **National Biomass Action Programmes**, which include plans on how to implement the biomass hierarchy at the national level;

- to realise a fully-fledged **Public-Private-Partnership on the bio-economy** by 2013. This PPP should be partially funded by Horizon 2020. It should focus on the promotion of cascading use of biomass and the development of a network of biorefineries throughout Europe;

- to support the cascading use of biomass by allowing **bio-based products to enter all waste collection and recovery systems**, including composting and recycling.

Recommendations for the use of sustainable biofuels in applications for which there are no other renewable alternatives available
For biofuels to be sustainable, we need:

- to include **ILUC-factors** in the sustainability criteria for biofuels and bioliquids in the Renewable Energy Directive;

- to stimulate research and development on **third generation biomass (algae)** under the Horizon 2020 proposal priority "Food security, sustainable agriculture, marine and maritime research and the bio-economy";

- to ensure that the work of the **European Innovation Partnership on "Agricultural Productivity and Sustainability"** moves away from focusing on increasing agricultural productivity by relying on GM crops and monocultures towards a more sustainable agriculture;

- to develop full **European taxation of CO_2 emissions, including in the transport sector**. We therefore call upon the European Council to adopt the Comission's proposal for the revision of the Energy Taxation Directive. In this way the taxation of labour can be shifted to the taxation of unsustainable practices.

Recommendations for discouraging biomass use for energy applications

In order for the European Bio-based Economy to become less focused on the production of bioenergy, we need:

- to introduce binding, EU-harmonized **sustainability requirements for the use of solid biomass and biogas** in electricity, heating and cooling;

- to implement an **efficiency of use criterion** for bioenergy as one of the sustainability criteria for the use of solid biomass and biogas in electricity, heating and cooling. This criterion should be set at an efficiency rate of 70% or higher:

- to **incorporate carbon debt emissions and a ban on the use of primary wood** in the abovementioned sustainability requirements for the use of solid biomass and biogas in electricity, heating and cooling:

- to **remove the zero emission factor for biomass from Annex IV of the ETS Directive**. Instead, biomass feedstocks should be given the proper CO_2 factors accounting for the direct and indirect life cycle CO_2 emissions;

- to develop a **discount mechanism on CO_2 emissions from biomass under the ETS system**. This discount can be given when the biomass that is used was produced in accordance with strict sustainability criteria that take the carbon debt into account;

- to promote the use of other alternative sources (wind, solar, geothermal etc.) of renewable energy instead of bioenergy.

Other recommendations

The transition from a fossil based to a bio-based economy in Europe should stay within the parameters of sustainability. Therefore, we need:

- to implement the recommendations of the European Parliament's Report on Resource Efficiency, in particular the **development of resource use indicators** (land, water, material, carbon footprint) that have to be adopted by 2013, and the development of targets within one year after the adoption of the indicators to reduce the use of resources;

- to integrate financial incentives for farmers in the Common Agricultural Policy that will improve **logistical capabilities** to collect biomass by-products and residues from agriculture and forestry in a sustainable way;

- to implement the Commission's proposal of environmental requirements in the first pillar of the **new Common Agricultural Policy** (thirty per cent of direct payments should be tied to greening);

- to include the promotion of recycling **nutrients and phosphorus** in the new Common Agricultural Policy;

- to develop a mapping system with traffic light structure (red is a bad nutrient balance, green is a good nutrient balance) of the **nutrient balance of European soils**;

- to encourage an agreement in the Council on an ambitious **Soil Framework Directive**;

- to develop **sustainable forest management criteria**, including minimum standards and support measures for critical areas, in the upcoming EU Forest Strategy 2020;

- to create the **Bio-economy Panel**, as proposed by the Commission's Bio-economy Strategy, as soon as possible. It should become the main European Body for strategic deliberation and cooperation on the bio-based economy. On Member State level the development of **National Bio-economy Panels** should be encouraged;

- to increase the cooperation on the bio-based economy between the different Directorates General of the European Commission (Agriculture, Climate Action, Energy, Enterprise and Industry, Environment, Health and Consumers, Maritime Affairs, Regional Policy, and Research and Innovation) by introducing a **European Commissioner on the Bio-based Economy**;

- to invest in **capacity building** for a **strong and knowledgeable workforce** that can contribute to the European bio-based economy. The Globalisation Adjustment Fund can contribute to this aim;

- to get rid of **harmful subsidies** that protect polluting activities. Environmentally harmful subsidies, including those that encourage inefficient use of resources, should be phased-out as soon as possible and at the least by 2020. The European Semester should be used to track Member with States' progress and request Member States to include strategies for the phase-out of harmful subsidies in their National Reform Programmes.

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In times of shrinking oil resources, the search for alternatives becomes ever more pressing. The bio-based economy offers a way out of this dilemma. It moves away from the fossil economy that runs on petroleum and encompasses the sustainable production of biomass into food, feed and bio-based products such as bioplastics. Bas Eickhout, Greens/EFA member of the European Parliament, in this publication has scrutinised the opportunities and risks of a European bio-based economy.

A central advantage of the bio-based economy is that it makes Europe autonomous from imports of fossil resources. Moreover, the bio-based economy offers an innovation potential for the Europe, which is likely to boost green employment and green growth.

While this report is written with a promising prospect in mind, it does neither negate the recent experiences as regards biofuels and bioenergy, nor the risks involved such as impacts on land use and food prices. The author outlines some of the preconditions of a truly sustainable use of biomass in a bio-economy. Several new EU policies would have to be introduced, and the production of bio-based products will need to be conducted in a framework which computes its real carbon footprint and weighs the efficiency of bio-product crops versus land use for food crops.

The move to a bio-based economy could contribute to a more sustainable economic system – if done in the right way. This publication is an offer to start the debate.

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