Agricultural Resources for Bioplastics

Feedstock for bio-based plastics today and tomorrow

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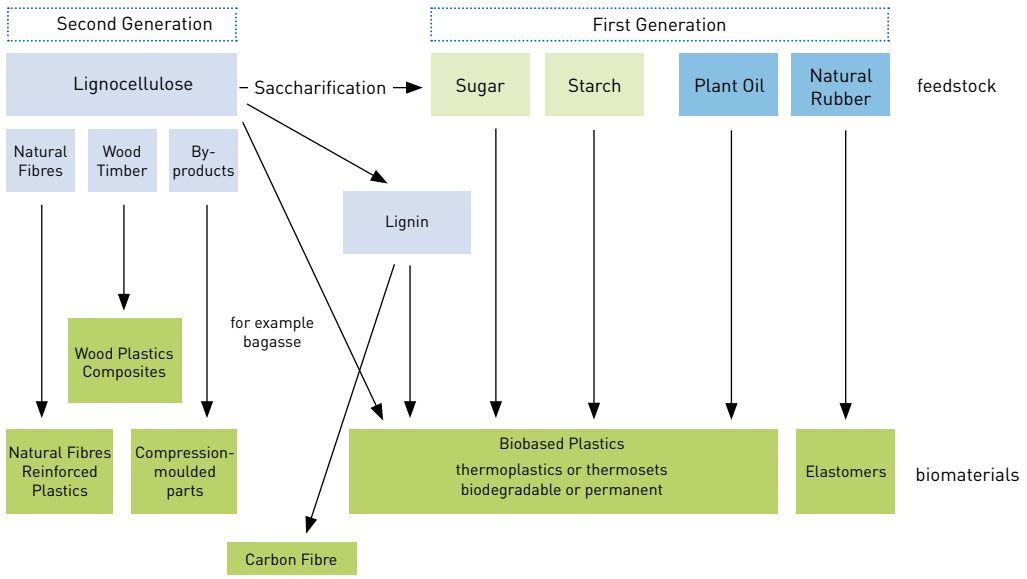
1st and 2nd generation crops: Pros and cons

To produce bio-based plastics there is a broad spectrum of feedstock options. Today bio-based plastics are mainly based on sugar, starch, plant oil and natural rubber, the so-called first generation feedstock. Because of potential competition with food and animal feed politicians and scientists have introduced, in the last ten years, the idea of using lignocellulose feedstock by transforming it into fermentable sugar (whether this will have less impact on food security will be discussed below). Lignocellulose means wood, short rotation coppice such as poplar, willow or miscanthus, or lignocellulose containing agricultural by-products. Another option is to use by-products which contain sugar and starch.

The following table shows the pros and cons for different feedstock options:

Criteria	First Generation (Sugar, Starch, Oil, Natural Rubber)	Second Generation (Lignocellulose – Wood and Short Rotation Coppice)	By-products from agriculture and forestry
Yield per hectare in terms of fermentable sugar equivalents	Broad range, but more or less on the same level		If the by-products have no markets yet, this means an extra yield
Green House Gas Emissions for biomass derived Bio-based Plastics (cradle to factory gate)	Broad range, but more or less on the same level		Very low, because of the methodology of LCA
Technical maturity	Very high	Still a lot to do	Depending on the content of the by-product
Economically competitive	Not yet (except for specific properties)	Not yet	Not yet, but close
Secure supply with raw materials at a reasonable price	Competing for food, animal feed and bioenergy	Competition with bioenergy and traditional industrial material use	Still a huge potential for inefficiently used by-products, or even those not used at all
Direct competition with food and feed	Yes	No	No
Indirect competition to food and feed	Yes – on land use		No
Emergency reserve for food and feed	Yes	No	No



Feedstock for Bio-based Plastics and Composites (source: nova-Institute)

The table shows in a clear way that there is no easy answer. Are second generation feedstocks really a better solution? To answer this question on a solid scientific base nova will conduct a multi-client study in 2012/2013: What is the best sustainable feedstock to generate fermentable sugar? Interested companies and associations can still join the advisory board.

Non-food discussion

Forced by the public discussion during the food crisis in 2008 politics and industry gave a very simple answer to the potential food versus industry conflict: Industry should only use non-food crops as feedstock.

From our point of view the question of food versus non-food crops for industry is itself oversimplified and misleading. The real questions and conflict are different:

- Question 1: Are there - in the EU, in the member states or in the region – free agricultural areas left, which are not necessary for food and animal feed, domestic use and export? If yes (and in many regions the answer is yes), continue:
- Question 2 (the real question): How can we use these free areas for industry with the highest resource efficiency and the highest climate protection?
- In many cases food crops will best fulfil these criteria - just because they have been specially cultivated to produce maximum yields over many, many years and all logistics are established.
- Food crops for industry can also serve as an emergency reserve for food and feed supply – second generation lignocellulose cannot! This is exactly what is happening this year in Brazil. The Brazilian government has reduced the bioethanol fuel quota to save sugar for the demanding food and feed market.

So 'No food crops for industry' can lead to a misallocation of agriculture resources. We need a comprehensive concept for feedstock for food, feed, industrial material use and bioenergy.

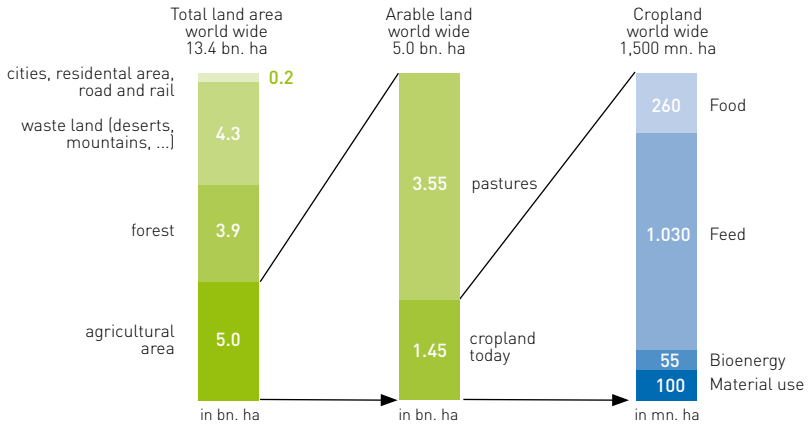
The amount of land needed to grow feedstock for bio-based plastics - How much is needed, and how much will be needed in the future?

Both answers to the above questions show how the agricultural area is used today. Most of the arable land is used for animal feed (69%), followed by food (17%), material use (7%, including bio-based plastics) and finally bioenergy (3.5%). The data on biomass in tonnes look slightly different and the main reasons are different yields per hectare for different crops, dedicated to certain applications. For example cotton, the leading crop for industrial material use, has considerably lower yields than most of the energy crops.

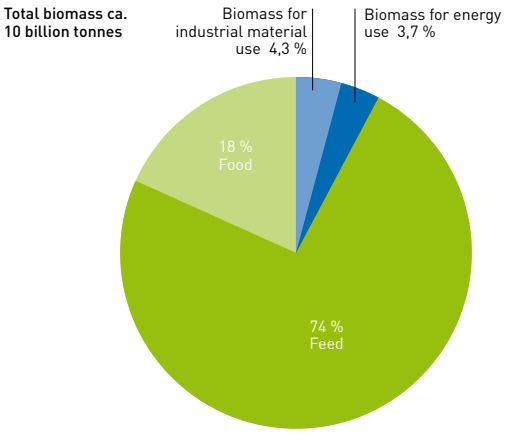
Using the recent data from Prof. Endres (FH Hannover) and European Bioplastics, today (2010) about 724,000 tonnes of bio-based plastics are produced, and this will increase to 1.71 million tonnes by 2015. According to a rough average estimation 2.5 tonnes of bio-based plastics can be produced per hectare and per year. This means that crops for bio-based plastics were grown on 290,000 hectares (0.02% of global arable land) in 2010 and will be grown on 684,000 hectares (0.05%) in 2015.

To substitute all 250 million tonnes of plastics in the world with bio-based plastics will demand 100 million hectares or 7% of the global arable land. This will only happen when crude oil is really scarce and very expensive. Then solar and wind energy will also be taking over the energy sector, including bioenergy, so these arable areas will be set free for bio-based chemicals and plastics.

Global land use for food production and renewable resources 2008 (source: nova-Institute)



Use of harvested agricultural biomass worldwide (2008) (source: nova-Institute)



Allocation of biomass to production target (main product). Respective amounts include raw materials and by products, even if their use fall into a different category.

Source: bioplastics MAGAZINE Click here!

Is there enough land for food, animal feed, bioenergy and industrial material use, including bio-based plastics?

Due to increasing demand for food and animal feed, and also bioenergy and industrial material use, the crucial question is how to increase the biomass production – in a sustainable way. But how to increase the agricultural feedstock worldwide?

1. Increasing the yields
   The tremendous potential for increasing yields in the developing countries is hindered by lack of technology and infrastructure, unfavourable agricultural policies such as no access to credits, an insufficient transmission of price incentives, poorly enforced land rights.

2. Expansion of arable land
   Some 0.6 (nova 2008) to 1.6 billion (FAO 2009) hectares could be added to the current 1.4 billion hectares of crop land (excluding forests, urban areas, protected areas). The figure shows that even in the year 2020 more than 200 million hectares of free arable land will be available.

The solution to points 1 and 2 are: Political reforms and huge investment in agro-technologies. Compared to these potentials, the impact of GMO on the increase of biomass production will stay low.

On the other hand there is also a huge potential for saving biomass:

- To switch from meat to vegetarian food would set free a huge amount of arable land for other uses. To get proteins from cattle demands 40 to 50 times the biomass input compared with proteins obtained from wheat or soya.
- To reduce food losses will also set free huge amounts of arable land: The results of a recent study showed that roughly one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tonnes per year.
- Finally solar energy, which will be fully competitive in 10 to 15 years, is 40 to 50 times more land efficient compared with bioenergy (and biofuels) and also will mainly use non arable land. This will also release huge areas of arable land, today used by bioenergy.

So the conclusion is, yes, there is enough feedstock – but ... due to the results of different nova studies, there will be only enough feedstock for industrial material use including bio-based plastics, if:

- we are able to activate strongly the potentially free areas (0.6 – 1.6 billion hectares) for agriculture and to increase the productivity in developing countries - that means huge investment and political reforms,
- we switch to more vegetarian food and also reduce losses in the food chain,
- we switch from bioenergy to solar and wind energy and significantly increase the use of solar and wind energy,
- we establish a new policy for equal support of bioenergy and industrial material use based on their efficiency, GHG reduction/hectare and employment/hectare ('level playing field' – for more information please look at www.bio-based.eu/policy/en).

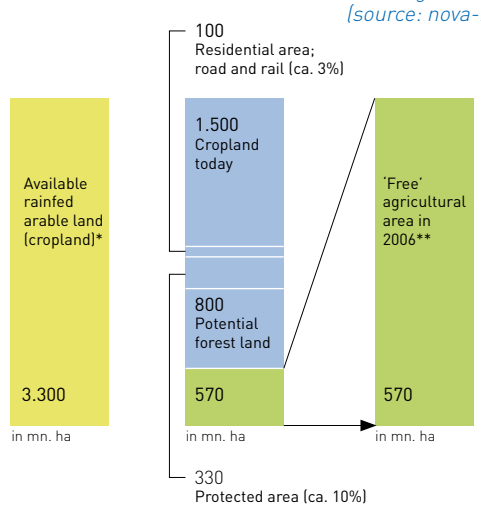
Otherwise 'Food & Feed First', high subsidies for bioenergy and increasing population and meat consumption could mean: No feedstock left for high-volume industrial material use, bio-based chemistry and bio-based plastics.

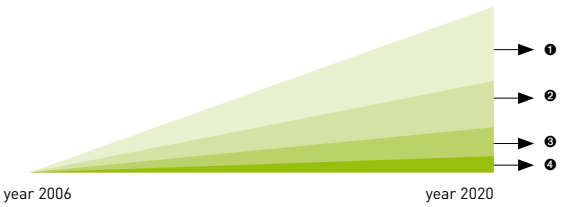
Summary

In principle there are sufficient and sustainable biomass resources available for food, animal feed, bioenergy and industrial material use, including bio-based plastics but we should change and optimize the biomass allocation and therefore the political framework. And we should invest in agriculture, and, not forgetting political reforms in the rural areas of the world, optimizing our food habits to sustainability and switching from bioenergy to solar energy – to secure a sufficient and sustainable supply of biomass for bio-based products also for the next 100 years and further.

www.nova-institute.eu

'Free' agricultural area in 2006 and the global demand of area 2020 (source: nova-Institute)





The global demand on land use in 2020:

❶ Increasing demand of food per capita due to an increase in purchasing power (more meat, ...)	ca. 96 mn. ha
❷ Increasing demand of food due to population growth	ca. 64 mn. ha
❸ Residential area, road and rail	ca. 32 mn. ha
❹ Biofuel in the most important Biofuel countries***	ca. 18 mn. ha
	Σ 210 mn. ha

* FAO 2000 indicates a potential of 4.2 bn. ha
** De facto parts of the 'free' crop lands could be considerably disadvantageous in terms of natural recources or market access
*** The calculation is based on OECD-FAO 2007: It is assured that most of the recourses are from the demand region; yield increase of 1/%a, extrapolation of production from 2006 to 2020