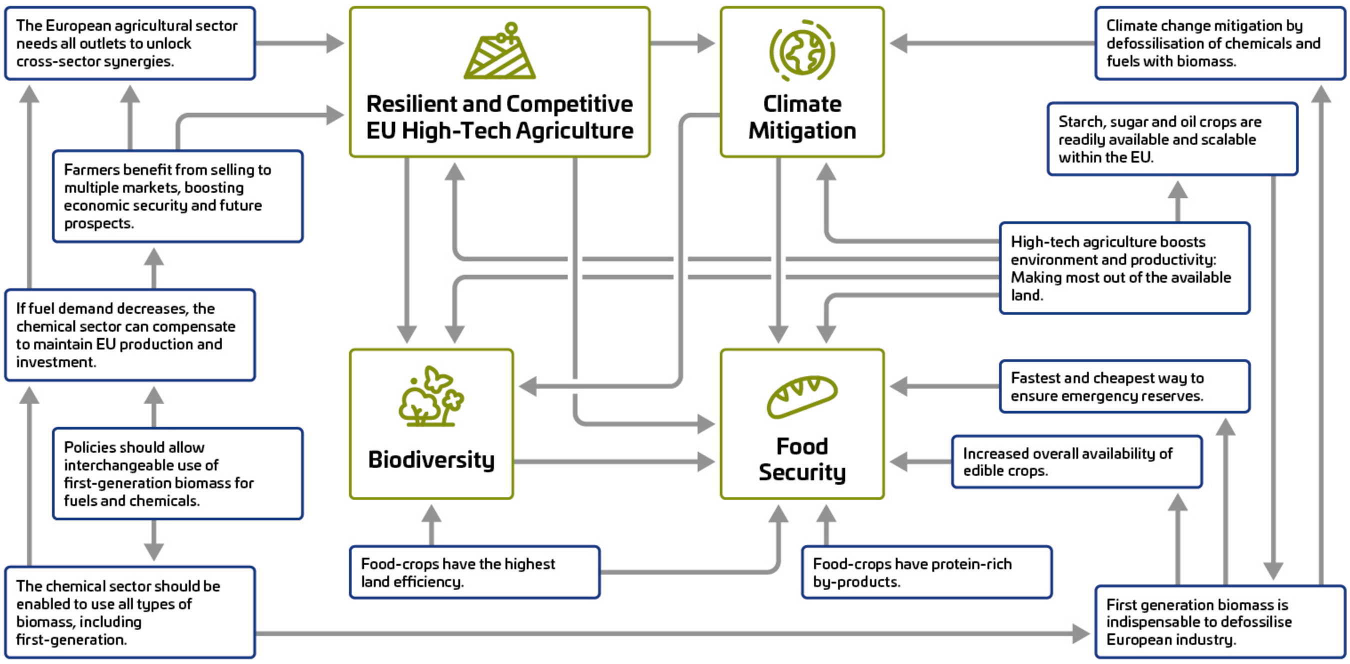
Benefits of Using First-Generation Biomass for Food, Fuels, Chemicals and Derived Materials in Europe

Science-based Argumentation Paper



Commissioned by the European Bioeconomy Alliance (EUBA)

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Commissioned by the European Bioeconomy Alliance (EUBA)

The European Bioeconomy Alliance (EUBA) is a unique cross-sector alliance dedicated to mainstreaming the bioeconomy and achieving its full potential in Europe.
What brings us together: The production and use of renewable resources as feedstock for making innovative, value-added everyday products and materials.
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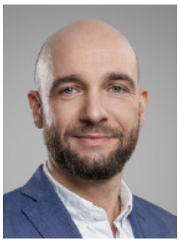
Michael Carus one of the leading European experts, market researchers and policy advisers of the renewable carbon economy – including bio-based, CO_2-based and recycling. At the end of 1994, he and five other scientists founded the private and independent nova-Institute for Ecology and Innovation. Ever since the beginning, Carus has been involved in the company as owner and one of the two Managing Directors. Today nova-Institute has nearly 50 scientists from a wide range of disciplines, covering markets, technologies, sustainability, communication and policy. In the year 2020, Carus founded the Renewable Carbon Initiative (RCI), which has today more than 75 members from chemicals and materials industries.



Kaj Seeger is Expert for Policy and Strategy at nova-institute. He joined the Economy and Policy team in 2025, where he develops strategic policy insights for clients across industries and sectors. Prior to his time at nova-institute, Kaj worked at research institutions such as adelphi and DIFU, founded a carbon-use focussed company, and helped to set up the carbon tech advocacy NGO carbonroundtable E.V.. As a workshop facilitator and trainer, he helped teams, companies and advocacy initiatives to work effectively for a greener future. Besides his proficiency in policy and strategy, his experience also covers fundraising, project management, facilitation and business development on a range of issues around a greener economy, from carbon removal to climate policy to green mobility.

Key messages – Benefits of using first-generation biomass for food, fuels, chemicals and derived materials

First-generation biomass in non-food applications increases food security

Using first-generation biomass for non-food applications strengthens food security by increasing overall availability of feedstock and market stability. At the same time, it also delivers valuable protein-rich by-products addressing the most critical needs for human and animal nutrition. The ability to shift crops between the food, feed, and industrial markets enables the EU and market players to respond swiftly to changes in demand and mitigate the risks associated with supply chain disruptions. Most importantly, using first-generation biomass for non-food applications offers a fast and economical way to set up and ensure an emergency food reserve.

First-generation biomass in non-food applications enhances a resilient and competitive EU agriculture

To be resilient and competitive, the European agricultural sector must access all potential outlets for its products. European agriculture stands to gain significantly from the widespread use of first-generation biomass. By selling to various markets, farmers achieve greater economic security and access new business opportunities. In light of competition with fossil carbon and other sectors, policy needs to enable the chemical sector to use first-generation feedstocks with comparable incentives like quotas. Future high-tech agriculture, primarily applied to first-generation biomass, will contribute to higher productivity and lower resource use, making European agriculture more sustainable, competitive and resilient on the global stage. As an added benefit, the use of first-generation biomass also enhances energy security.

First-generation biomass in non-food applications supports climate change mitigation

Defossilising the chemical and fuel sectors is critical for climate change mitigation. In order to significantly defossilise European industry, the use of first-generation biomass is indispensable. The economic, cost-efficient and scalable production of first-generation commodeties is a key advantage to achieve climate targets. First-generation sugars and starches can be produced at a much lower cost than the second-generation alternatives, making the latter less viable for large-scale industrial use for significant climate impact. Furthermore, high-tech agriculture increases resource efficiency, boosts yields and increases biomass production – all while reducing the environmental impact of crop cultivation. A resilient and competitive EU agriculture sector is central for producing climate-responsible food and biomass in Europe.

First-generation biomass in non-food applications supports biodiversity protection

The loss of biodiversity significantly threatens long-term stability and productivity of agricultural systems. Food crops are the most efficient use of land to produce starch, sugar and plant oil, and reduce the overall need for farmland, leaving more space for nature. Improving practices for first-generation crops benefits both food and non-food markets, enhancing soil health, carbon storage, and biodiversity. With focus on resource efficiency and higher yields, high-tech agriculture also contributes to biodiversity protection by minimising habitat conversion and environmental impacts. As climate change becomes the main driver of biodiversity loss, replacing fossil carbon with first-generation biomass helps reduce emissions and protect ecosystems.

High-tech agriculture further enhances the benefits of first-generation biomass. Development and investment in new agricultural practices will primarily occur in the food crop commodity sector, where they will have the greatest impact and generate the highest returns on investment. Making the most of the available land. Food security and non-food applications of food crops will directly benefit from this development, becoming even more competitive and environmentally beneficial than they are today.

Introduction

Despite widespread concern and frequent policy pushback against the use of first-generation biomass and especially food crops for industrial applications, often originating from concerns of undermining food security, scientific evidence suggests that these concerns are largely misplaced. The debate is shaped by emotional and political arguments rather than robust data or a comprehensive understanding of the global food system. The debate should instead be evidence-based and much more nuanced. The choice of feedstock should be guided by local conditions, sustainability, and social impacts rather than oversimplified assumptions about competition with food crops. In reality, the drivers of food insecurity are complex and primarily include climate change, conflicts, economic inequality, land rights and inefficiencies in food distribution rather than competition between food and industrial uses for crops. Using first-generation biomass for non-food applications like chemicals and derived materials[1] or fuels does not inherently threaten food security; in fact, it can provide multiple benefits for climate change mitigation, biodiversity, agricultural resilience, economic stability, and food security (Figure 1).

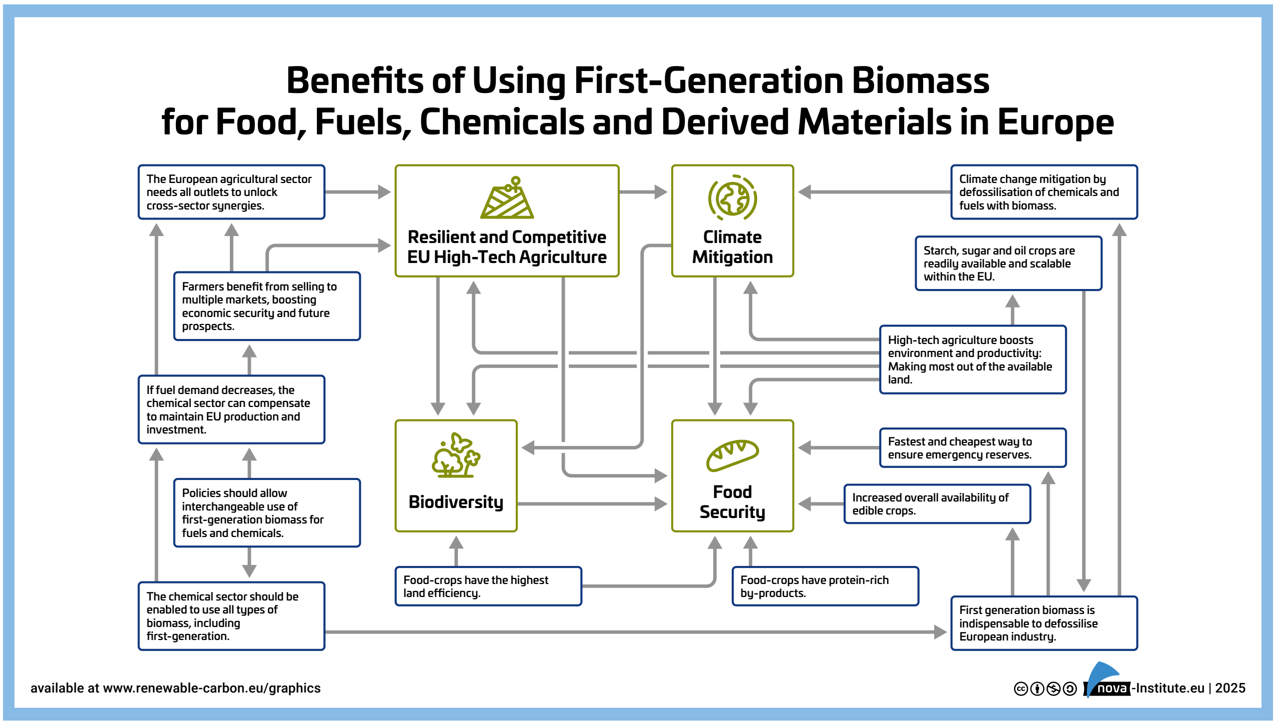


Figure 1: Benefits of Using First-Generation Biomass for Food, Fuels, Chemicals and Derived Materials in Europe

1 Chemicals and derived materials: In this paper, whenever we refer to 'chemicals', we are also referring to all kinds of derived materials. The most important application by far is polymers/plastics and rubber, which account for 65% of the total value of the chemical 'derived materials' chain. Other derived materials include solvents, detergents, additives and personal care and pharmaceutical products. However, it does not cover bio-based materials that are not derived from the chemical industry, such as paperboard packaging or cellulose films.

1 First-generation biomass in non-food applications increases food security

Contrary to popular belief, using first-generation biomass for non-food applications strengthens food security in several important ways.

An increased overall availability of food crops creates market stability. When industry builds up additional feedstock supplies for its own use, the total amount of food crops available in the system increases, which mitigates the risk of shortages. Increasing the overall availability stabilises supply and prices, thereby reducing the risk and volume of speculative peaks.

Analyses of price trends have shown that short-term changes in demand or supply have an effect on prices, but only to a very limited extent and only until the next cultivation period. The agricultural system reacts quickly and reliably.

The use of food crops delivers valuable protein-rich by-products that are essential for human and animal nutrition. Processing wheat, corn and rapeseed for biofuels or chemicals yields, as a co-product, large quantities of protein and fibres for animal feed or even human food. This dual use ensures that critical nutritional component protein are supplied, while carbohydrates and oils are directed towards industrial applications. Thus, the industrial use of food crops enhances food security by providing additional protein sources, which are the key bottleneck in food and feed supply (see graphic below).

Good availability and long-term scalability for starch, sugar and oil crops in the EU. When it comes to first-generation feedstock, the European Union can rely on a steady supply of starch, sugar and oil crops, which are expected to remain available in sufficient and increasing quantities in the long term – although in the specific case of sugar, policy framework needs to enable availability for non-food applications[2]. This reliability makes it straightforward to scale up production for food and industrial use as required, also because even moderate high-tech developments will have significant impacts on biomass production. The ability to shift crops between the food, feed, and industrial markets enables the EU to respond swiftly to changes in demand and mitigate the risks associated with supply chain disruptions.

Most importantly, using first-generation biomass for non-food applications offers a fast and economical way to set up and ensure an emergency food reserve. Although hunger experts emphasise the need to built up storage capacity in food supply chains, this was never realised in relevant volumes because of unclear responsibilities, costs, location and distribution in crisis. Unlike inedible biomass, food crops used by industry can be redirected flexibly to the food market during crises, offering a virtual storage mechanism. Under normal conditions, industry uses the crops as intended, however, in rare times of scarcity, these resources can be redirected to the food supply with compensation for industrial losses. This approach is faster and far more economical than building and maintaining large physical reserves, which have never been established in relevant volume.

2 Sugar beet areas have been in decline for all but two years since 2017. 20 factories have been shut since that year (83 will operate in the 2025/26 campaign. This decline is in contrast to the defossilisation needs for chemicals and derived materials industries.

This emergency reserve mechanism is not just theoretical; it is a reality even in Europe. At the beginning of the Ukrainian war, for example, rapeseed oil imports for the food market fell in Germany. To avoid shortage in supermarkets, biodiesel production was reduced to sustain the food market. A similar situation occurred in France, where sunflower oil and sugar were redirected from non-food to food markets in recent years. This often happened without any political intervention. The food market consistently pays the highest prices and naturally draws biomass away from non-food sectors. This process is largely market-driven and self-regulating. However, policymakers can intervene quickly if necessary.

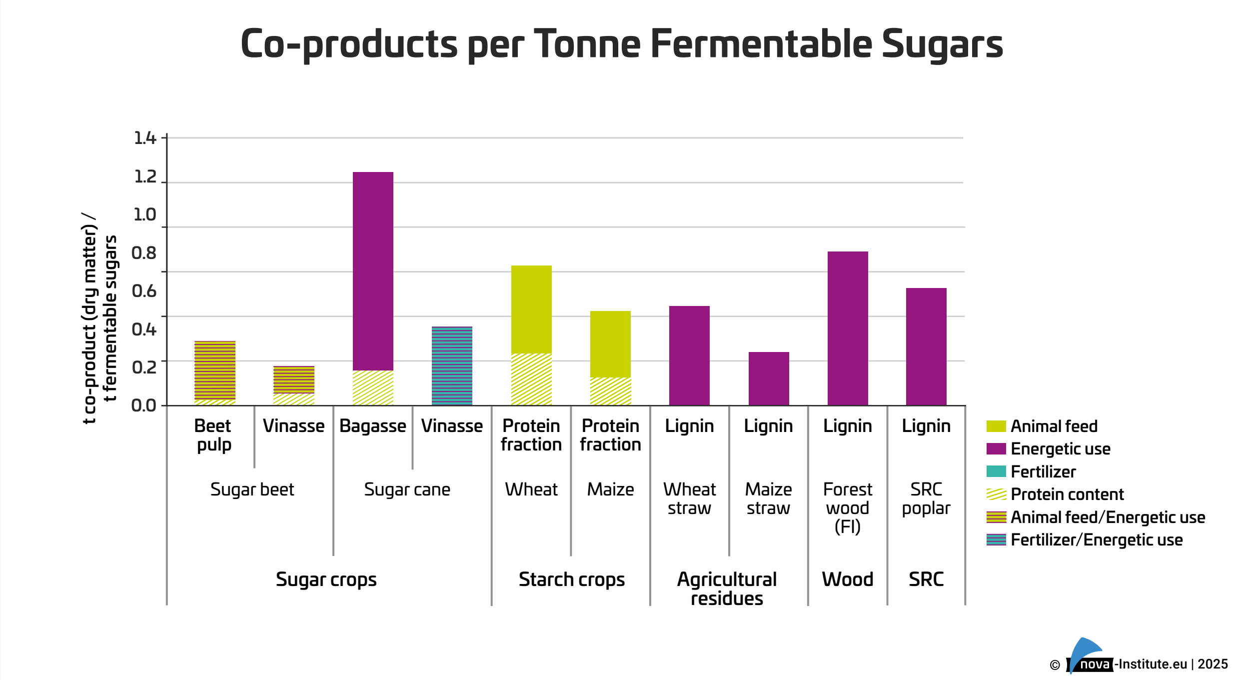


Figure 2: Co-products per tonne fermentable sugars for different types of feedstock. Please note that we have simplified the potential pathways of co-product use to put the focus on food and feed. Only energetic use of lignin is assumed.

2 First-generation biomass in non-food applications increases a resilient and competitive EU agriculture

In order to be both resilient and competitive, the European agricultural sector must have access to all potential outlets and applications for its products. This encompasses food and feed, as well as energy, fuels, chemicals and derived materials, and unlocking synergies between these sectors. Selling crops to multiple markets gives farmers greater flexibility and reduces their vulnerability to price fluctuations in any single sector. It also encourages investment in innovation and sustainable practices, as farmers can diversify their income and adapt to changes in the market. Industrial use of crop-based biomass also enhances energy security by reducing dependence on imported fossil fuels. First-generation biomass also creates several types of by-products along the value chain that can be used to defossilise the manufacturing processes and logistics, making bio-products climate neutral on life-cycle basis. Through this, a robust bioeconomy can support both climate and energy policy objectives.

Policy needs to enable the chemical sector to use all types of biomass, including first-generation feedstocks. Facilitating industrial biomass use will help maintain European production capacity and investment, ensuring that both the agricultural and chemicals sectors remain strong and competitive. Policymakers must create frameworks that enable the use of first-generation biomass in the chemical industry while safeguarding food security and environmental sustainability.

However, chemicals and derived materials face competition from both cheap fossil carbon as feedstock and from other sectors that require biomass to meet their own targets and quotas. Therefore, biomass use for chemicals and derived materials needs to be supported by comparable policy incentives like targets as well. Only such incentives will establish a level-playing field and enable the chemical sector to actually start incorporating biomass in significant volumes. If a level playing field for all biomass feedstocks and applications is achieved, a potential decrease in demand for crop-based fuels can be compensated by an increasing demand from the chemical sector – and existing innovations, investments and implementations in the biofuel sector are not lost.

The farmer benefits – Farmers stand to generate income from the widespread use of first-generation biomass. By selling their produce to various markets, they can achieve greater economic security and access new business opportunities. This is particularly important for young farmers, as stable and attractive prospects are essential for ensuring the long-term vitality of rural communities. Participation in the bioeconomy offers the next generation of European farmers a promising economic future.

High-tech agriculture further enhances the benefits of first-generation biomass. Development and investment in new agricultural practices will primarily occur in the food crop commodity sector, where they will have the greatest impact and generate the highest returns on investment. By increasing resource efficiency, boosting yields and reducing environmental impact, high-tech agriculture enables farmers to maximise the potential of limited agricultural land. Precision farming, advanced crops and improved management techniques all contribute to higher productivity and lower resource use, making European agriculture more sustainable, competitive and resilient on the global stage. Making the most of the available land. Non-food applications of food crops will directly benefit from this development, becoming even more competitive and environmentally beneficial than they are today.

3 First-generation biomass in non-food applications is indispensable for climate change mitigation

Defossilising the chemical and fuel sectors is critical for climate change mitigation. Mitigating climate change is a pressing challenge for Europe, and defossilising the chemical and fuel sectors is a critical part of the solution. Using biomass for non-food applications significantly reduces the carbon footprint compared to fossil fuel-based alternatives. Since plants absorb CO_2 during growth, bio-based fuels and materials can be considered carbon-neutral or in long lasting applications (> 35 years) even carbon-negative (carbon removal).

In order to defossilise European industry, the use of first-generation biomass is indispensable. Generally accepted second-generation biomass, such as lignocellulosic crops and agricultural residues, has a limited supply and cannot easily be scaled up. The growing demand for sustainable aviation fuels, in particular, is putting additional pressure on these resources.

The economic, cost-efficient and scalable production of first-generation commodeties is a key advantage. First-generation sugars and starches can be produced at a much lower cost than second-generation alternatives, which are usually two to three times more expensive, making them less viable for large-scale industrial use. Furthermore, using large-volume food crops avoids the price volatility seen with niche crops or agricultural residues. Demand on specific niche crops or side streams can raise the price by more than 100% over a short period, whereas prices for food crops remain much more stable due to their large production volumes, well-established and multiple markets.

Therefore, first-generation biomass is essential if Europe is to scale up the bioeconomy to achieve its climate goals and a relevant transition to a low-carbon economy.

Good availability and scalability of starch, sugar and oil crops in the EU enables achievement of climate targets
Comprehensive modelling in a recent study[3] by the Renewable Carbon Initiative (RCI), the Bio-based Industries Consortium (BIC) and nova-Institute suggests that a moderate level of high-tech agriculture could supply sufficient biomass for all sectors, but this would rely heavily on first-generation biomass. The long-term availability of starch and oil crops in the EU is expected to grow – sugar would only grow with enabling policy framework as well – , allowing production to be easily scaled up as needed. Scaling is comparable easy because logistics, infrastructure and machinery for first-generation is available at latest technology level, and even better utilised with additional demand. This reliability is crucial for the success of Europe's defossilisation strategy.

3 Carus, M., Porc, O., vom Berg, C., Kempen, M., Schier, F. and Tandetzki, J.: Is there enough biomass to defossilise the chemicals and derived materials sector by 2050. nova- Institut GmbH (Ed.), Hürth, Germany, 2025-02. DOI No.: https://doi.org/10.52548/PIRL6916

High-tech agriculture increases resource efficiency, boosts yields and increases biomass production – all while reducing the environmental impact of crop cultivation. This progress is primarily driven by food and feed crops, which can be used for a variety of applications and capable of supplying the bioeconomy with the substantial volumes of sustainable biomass necessary for defossilisation. Furthermore, high-tech agriculture can produce more resilient crops, supporting both mitigation and adaptation strategies in response to climate change.

Ultimately, high-tech agriculture is critical for ensuring both food security and a sustainable supply of biomass for non-food uses.

A resilient and competitive EU high-tech agriculture sector for first-generation will play a central role in producing food and low-carbon biomass in Europe and exporting advanced agricultural technologies to the rest of the world. Slower climate change, achieved through the use of bio-based materials and fuels, will support stable yields and preserve available arable land for future generations. Investing in high tech agriculture and the bioeconomy will enable Europe to lead the way in sustainable industrial transformation.

4 First-generation biomass in non-food applications support biodiversity protection

The loss of biodiversity poses a significant threat to the long-term stability and productivity of agricultural systems. Reduced resilience, increased vulnerability to pests and diseases, and deteriorating soil health are all consequences of this loss. Protecting and enhancing biodiversity is essential for the sustainability of European agriculture.

Soil health, carbon storage and biodiversity begin at farm level and will be most effectively addressed by improving agricultural practices for large-scale food crops, from which the food and non-food markets directly profit.

Food crops are the most efficient use of land for producing starch, sugar and plant oils. Maximising the productivity of each hectare reduces the total land area required for agriculture, leaving more space for nature and biodiversity protection. Furthermore, improved agricultural practices such as crop rotation, intercropping and regenerative agriculture enhance soil health and ecosystem functions, supporting a wide range of plant and animal species. These technologies are primarily applied for large scale food crops, where the environmental impact is greatest and the benefits to soil health, carbon storage and biodiversity are most significant.

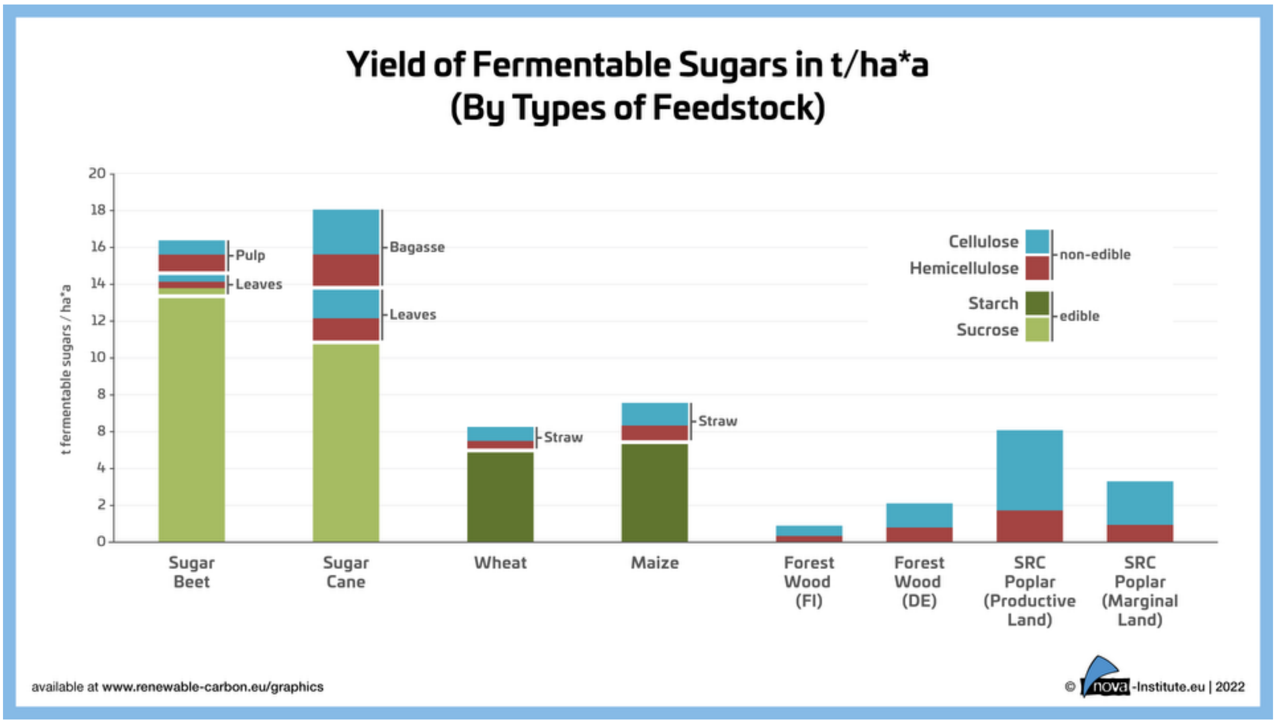


Figure 3: Yield of fermentable sugars in t/ha per year by different types of feedstock

With its focus on resource efficiency and higher yields, high-tech agriculture contributes to biodiversity protection. By making the most of available land, it reduces the pressure to convert natural habitats into farmland. This means that more land can be set aside for biodiversity protection and ecosystem restoration.

The reduced use of fertilisers and pesticides in high-tech agriculture, as well as the continuous monitoring of soil quality, also strongly supports biodiversity. And again, this development is primarily applied to first-generation biomass.

A more resilient and competitive EU agriculture sector, supported by the bioeconomy, is better equipped to protect and enhance biodiversity in the long term.

Climate change is becoming the most significant driver of biodiversity loss. Replacing fossil carbon with frist generation biomass could help Europe significantly reduce its greenhouse gas emissions and slow the rate of climate change. This, in turn, helps protect ecosystems and species vulnerable to changing temperatures and weather patterns. As the most scalable and readily available source of renewable carbon, first-generation biomass is indispensable for both climate mitigation and biodiversity protection.

What would it mean to use only second-generation (2G) sugars instead of first-generation (1G) sugars in biorefineries?

If the industry switched from using sugar and starch from food crops to second-generation feedstock, such as wood or short-rotation coppice, what would the impact be?

First, the same amount of fermentable sugars for the biorefinery would require multiple times the amount of land. The difference in land demand would be between five and 20 times greater, depending on the specific crops and region[4]. This would have a significant impact on biodiversity due to the much higher land demand. It would also increase competition for limited land (see figure below).

Second, there would be less protein supply as important by-product of 1G non-food production. The lack of protein would require higher imports (e.g. soy) for feed, with the corresponding agricultural cultivation and pressure on biodiversity in South America or other regions of the world.

Third, the emergency reserve of first-generation food crops (starch, sugar and plant oils) for food crises would be lost, as second-generation crops cannot provide food by definition. This would create a high risk to food security and incurs extreme costs for building and maintaining physical food storage facilities.

Finally, even with 1G sugar prices, biorefineries and bio-based chemicals and derived materials can hardly compete with fossil solutions; **with 2G sugars being two to three times more expensive, any relevant scaling up for defossilisation is impossible**.

The success of a bioeconomy producing significant volumes is closely linked to the acceptance of using food crops for non-food applications.

4 Dammer, L., Carus, M., Porc, O. 2023: The Use of Food and Feed Crops for Bio-based Materials and the Related Effects on Food Security. Renewable Carbon Initiative (ed.), Hürth 2023. DOI No.: https://doi.org/10.52548/WQXU7327

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nova-Institute is a private and independent research institute, founded in 1994. nova offers research and consultancy with a focus on the transition of the chemical and material industry to renewable carbon.

What are future challenges, environmental benefits and successful strategies to substitute fossil carbon with biomass, direct CO_2 utilisation and recycling? What are the most promising concepts and applications? We offer our unique understanding to support the transition of your business into a climate neutral future.

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