Sustainable First and Second Generation Bioethanol for Europe

A sustainability assessment of first and second generation bioethanol in the context of the European Commission's REDII proposal

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September 2017

Executive Summary

A comprehensive sustainability assessment shows that first generation bioethanol is as advantageous as second generation bioethanol for a feasible climate strategy. The results clearly indicate that the systematic discrimination against first generation bio-fuels of the current Commission proposal is in no way founded on scientific evidence. It would be counterproductive to further lower the share of first generation fuels in the EU's energy mix.

The objective of this study was to compare the sustainability of bioethanol made from different feedstocks, most importantly comparing first generation (sugar, starch) fuels to second generation (lignocellulosic, waste-based) fuels. This was conducted against the background of the ongoing deliberations regarding Europe's Renewable Energy Directive (RED) after 2020. The Commission's REDII proposal of November 2016 suggests an abolition of a dedicated transport target, a strong reduction of first generation fuels and their replacement by second generation fuels. Those measures are supposed to ensure that Europe fulfils its ambitious climate targets while not endangering food security.

Evaluation of sustainability – how to identify the most sustainable bioethanol?
A number of criteria were selected in order to evaluate the sustainability of first and second generation bioethanol. The criteria selection was based on the most current standards and certification systems of bio-based fuels and materials, including environmental, social and economic aspects. A dedicated focus was put on food security due to the continued accusation towards first generation biofuels that they cause harm to food security. After analysing the existing data (both quantitative and qualitative), the performance of the respective fuel option was assessed relative to the others to establish a ranking of the options, based on a traffic light system. Table 1 presents an overview of the results, which are explained in more detail in this brochure. A long version with more detailed background information and calculations is available at www.bio-based.eu/policy.

The results – what is the most sustainable bioethanol?
The analysis of twelve different sustainability criteria shows that all of the researched bioethanol feedstocks offer significant advantages as well as disadvantages in terms of a sustainability:

- All feedstocks realise **significant reductions of greenhouse gas emissions**. While second generation fuels perform better in this regard, this effect is strongly relativised, when offset against the abatement costs. Reducing GHG emissions through second generation biofuels is expensive – and may prevent more efficient climate actions that could be implemented elsewhere.
- When it comes to the often-criticised negative impact on **food security** of first generation biofuels, the evidence points into a different direction. The competition for arable land is counterbalanced by the excellent land efficiency of first generation crops (especially sugar beet) and protein-rich co-products (especially wheat and corn). In this regard, the utilisation of short rotation coppice (SRC) for biofuels poses much stronger competition for arable land, since they use up much larger acreages of arable land for the long term and provide no protein-rich co-products.
- In the case of wheat, most of European ethanol production is based on grain of **non-food quality and on harvest surpluses**, not posing any competition at all, but offering additional outlets to farmers. In the opposite case of bad harvests and rising prices for agricultural crops, bioethanol production often does not pay off, which means that the crops are redirected towards food markets.

The results clearly indicate that the systematic discrimination against first generation biofuels of the current Commission proposal is in no way founded in scientific evidence. This has also been criticised by an independent assessment of the REDII proposal (Impact Assessment Institute 2017).

On the way to a climate-friendly Europe, biofuels made from any kind of feedstock offer advantages in terms of GHG emission reductions and should indiscriminately be part of a viable transitional strategy towards low-emission mobility, as long as they adhere to sustainability criteria.

In order to ensure that the transport sector can contribute to achieving the European Union's ambitious climate goals, the authors suggest the following amendments to the REDII proposal in the ongoing negotiations:

- Keep a dedicated target for the transport sector; set an ambitious target of at least 15% renewables in transport until 2030.
- Keep the existing 7% cap for food-crop based fuels; do not lower the share of first generation fuels further.
- Set a 6.8% target for other sustainable and renewable transport fuels, such as advanced biofuels, as outlined by the RED-II proposal.

A short overview of results per feedstock

Sugar crops

The main strength of sugar beet and sugar cane is their very high land efficiency. No other biomass can produce more bioethanol per ha. High GHG reductions and especially the lowest GHG abatement costs are additional strong points. The infrastructure and logistics are well developed, co-products are used as animal feed. The main disadvantages are the impacts on biodiversity, water, air and soil due to intensive agriculture – but the impacts are limited to small areas because of the very high land efficiency.

Starch crops

The main strength of starch crops are the protein-rich co-products, which are valuable animal feed. The land efficiency is lower than for sugar crops, but higher than for wood. The GHG savings are assumed to be lower than for the other analyzed fuel options, but this is only partly true and is rooted to a large part in the specific LCA standards applied in the RED. The infrastructure and logistics are well developed. The main disadvantages are the impacts on biodiversity, water, air and soil due to intensive agriculture, which is partly counterbalanced by a high land efficiency.

Virgin Wood and SRC

The main strength of wood as a fuel feedstock is the low competition with arable land and consequently the absence of direct or indirect land use change risks (LUC / iLUC). For Short Rotation Coppice (SRC) this is only true if they are not cultivated on arable land. The infrastructure and logistics are well developed for wood, but less for SRC. The GHG reduction is on the same level as for sugar crops, but the GHG abatement costs are much higher. The main disadvantages are the very low land efficiency and the lack of co-products for the feed market.

Table 1: Overview of ranking results. Green = high performance / low risk, yellow = medium performance / medium risk; red = low performance / high risk

Criteria	Sugar		Starch		Virgin Wood		Waste wood		Agricultural Residues	Organic waste
	Sugar beet	Sugar cane	Wheat	Maize	Forest	SRC	Forest residues	Post-consumer wood		
GHG footprint	yellow	yellow	red	red	yellow	yellow	green	green	green	green
Level of subsidies needed / GHG abatement costs	green	green	yellow	yellow	red	red	red	red	red	red
Land use / land efficiency	green	green	yellow	yellow	red	red	red	green	yellow	green
Food security, negative impact on	green	green	green	green	green	yellow	green	green	green	green
Protein-rich co-products	yellow	red	green	green	red	red	red	red	yellow	red
Employment, rural development, livelihood of farmers and foresters	green	green	green	green	yellow	green	yellow	yellow	green	yellow
LUC / iLUC	yellow	yellow	yellow	yellow	green	yellow	green	green	green	green
Logistics/Infrastructure/ Availability	green	green	green	green	green	yellow	yellow	yellow	yellow	yellow
Traceability	green	green	green	green	green	green	green	yellow	green	yellow
Social impacts (land rights, human rights, education..)	green	green	green	green	green	green	green	green	green	green
Biodiversity and marginal land, potential impacts	red	red	red	red	red	red	yellow	green	green	green
Impact on water, air and soil quality	yellow	yellow	yellow	yellow	yellow	yellow	green	green	green	green

Waste and residues

The main strengths of waste and residues as fuel feedstocks are the very high GHG reductions – partly because of the specific LCA standards applied in the RED – and the lowest impacts on biodiversity, water, air and soil. The main disadvantages are the high GHG abatement costs, barely developed infrastructure and logistics, low traceability and most importantly the limited availability.

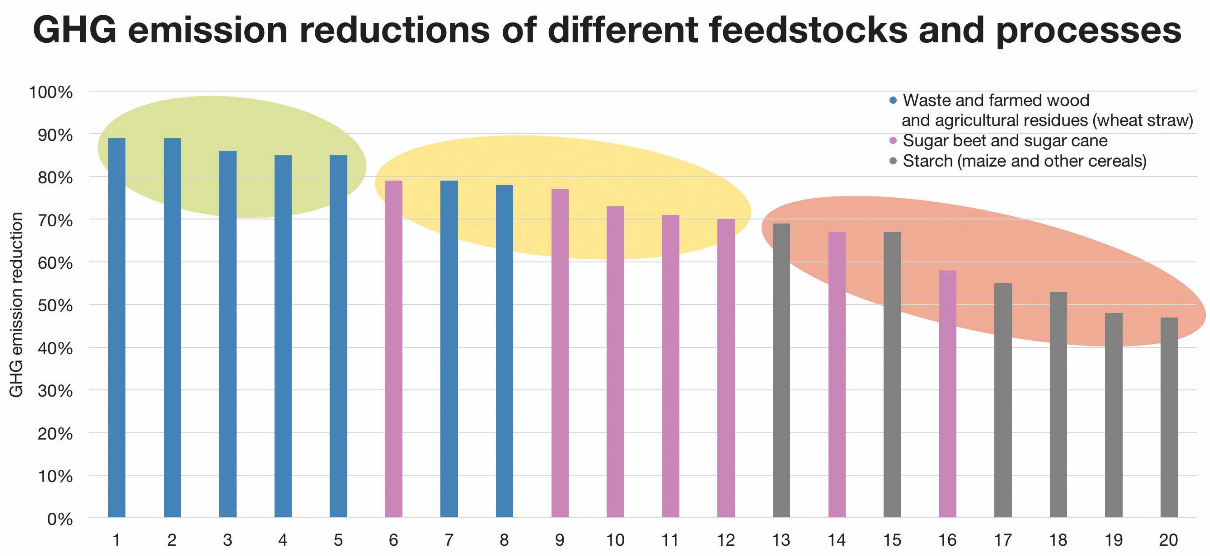
Conclusion: Combine first and second generation

The highest bioethanol yield per hectare results from a combination of first and second generation biomass co-utilised, such as first generation wheat plus second generation wheat straw. The advantage of first generation sugar and starch crops is that they carry the potential of second generation in them by providing their own lignocellulosic co-products, without occupying additional areas and at the same time provide protein rich feed.

Results of the sustainability assessment

Greenhouse gas (GHG) emission reductions

The comparison of GHG emission reductions from different feedstocks and processes is based on the official calculations as included in the newest RED proposal. It shows that overall, fuels from waste, farmed wood as well as agricultural residues perform the best; fuels from sugar beet and sugar cane show medium performance and grain-based fuels perform the relative lowest. It should be kept in mind, however, that the differences between GHG emission reductions are quite small in many cases, especially between wood-based and sugar-based fuels. Additionally, the results are heavily influenced by the calculation methods applied (see box).



Note: **1** = Petrol Fischer-Tropsch from black-liquor gasification integrated with pulp mill, **2** = Methanol from black-liquor gasification with pulp mill, **3** = Methanol from waste wood in free standing plant, **4** = Ethanol from wheat straw, **5** = Petrol from waste wood Fischer-Tropsch in free standing plant, **6** = Ethanol from sugar beet (with biogas from slop, NG as process fuel in CHP plant) **7** = Methanol from farmed wood in free standing plant, **8** = Petrol from farmed wood Fischer-Tropsch in free standing plant, **9** = Ethanol from sugar beet (with biogas from slop, NG as process fuel in conventional boiler), **10** = Ethanol from sugar beet (no biogas from slop, NG as process fuel in CHP plant), **11** = Ethanol from sugar beet (with biogas from slop, lignite as process fuel in CHP plant), **12** = Ethanol from sugar cane, **13** = Ethanol from corn (maize) (forest residues as process fuel in CHP plant), **14** = Ethanol from sugar beet (no biogas from slop, NG as process fuel in conventional boiler), **15** = Ethanol from other cereals excluding maize (forest residues as process fuel in CHP plant), **16** = Ethanol from sugar beet (no biogas from slop, lignite as process fuel in CHP plant), **17** = Ethanol from corn (maize) (NG as process fuel in CHP plant), **18** = Ethanol from other cereals excluding maize (NG as process fuel in CHP plant), **19** = Ethanol from corn (maize) (NG as process fuel in conventional boiler), **20** = Ethanol from other cereals excluding maize (NG as process fuel in conventional boiler)

Figure 1: Typical GHG emission reduction according to RED methodology (2016) for the production of biofuels

LCA standards for biofuels

It needs to be stressed that the GHG emission reduction values as given by the RED are very dependent on the calculation and allocation rules used. And the RED standards are only partly science based, while the other part is strongly influenced by political objectives.

One of the main reasons for the excellent values of fuels made from waste and residues is the fact that no burden of emission is assigned to their production, but only from the point in time when they occur onwards, so to collection, transportation and processing. Furthermore, protein-rich co-products of the biofuel production from first generation crops are not accounted for as substitutes for imported protein, but only for their energy content. These approaches are politically determined, but questionable from a purely scientific point of view. In this regard, the climate advantage of second generation fuels is somewhat of a self-fulfilling prophecy. Nevertheless, this report only refers to the RED standards, as they are the established values for Europe.

For a more detailed explanation, please see the long version at www.bio-based.eu/policy.

GHG abatement costs

The relatively small additional emission savings that advanced biofuels can achieve will cause significant costs to consumers and society as a whole. Put in other words, advanced biofuels are a very expensive way to reduce GHG emissions. **It is therefore doubtful whether the strong focus on advanced biofuels is a feasible strategy from a climate and economic perspective.** Other measures could potentially achieve much higher emission savings for the same amount of financial resources (i.e. investments in first generation biofuels, building infrastructures/insulation, energy efficiency etc.) and it should be a political goal to implement those measures with low abatement costs.

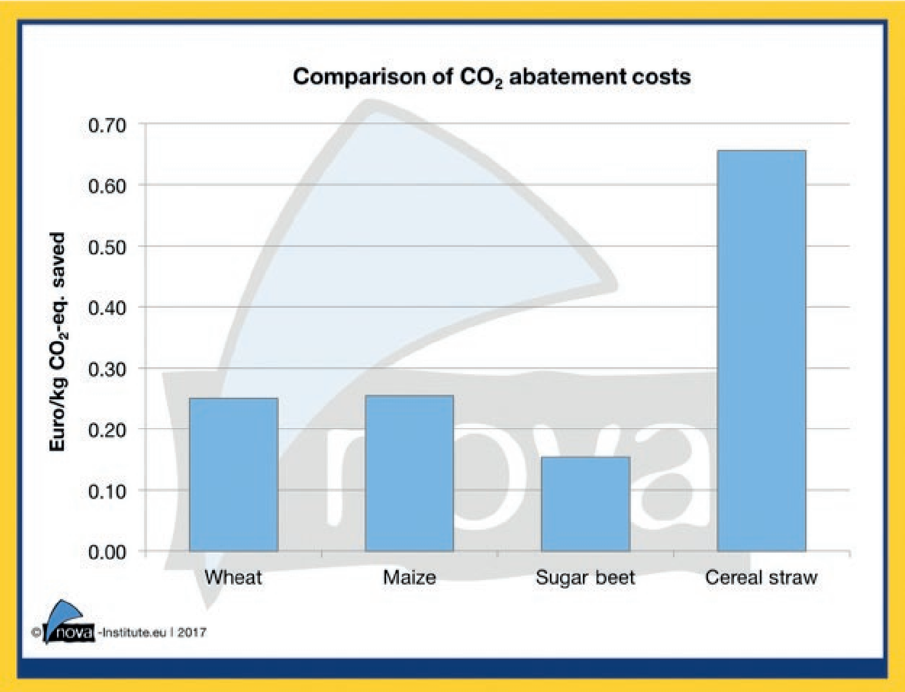


Figure 2: Comparison of CO_2 abatement costs (source: own calculations, based on JRC 2017, Eurostat 2017, Euronext 2017 and GHG emission savings based on REDII proposal)

Land use and conversion efficiency

This criterion assesses how much ethanol per hectare can be produced from different crops. This is a very important aspect, since it influences many other criteria (e.g. employment and rural development, food security, protein-rich co-products). The efficiencies were calculated by assessing hectare yields per crop, carbohydrate content and conversion efficiencies from carbohydrates to ethanol (for more details, see the long version at www.bio-based.eu/policy). The results show that sugar beet and sugar cane perform by far the best in terms of land efficiency, producing more than five times as much ethanol per hectare as the good wood harvest in Germany, and still more than twice as much as SRC cultivation on arable land.

In addition to these results, it is interesting to see how much ethanol can be produced from one hectare under the assumption that every part of a harvested crop is used for ethanol production, including main products as well as most co-products (see Figure 4). Additional fuel can even be produced if the biogenic CO_2 arising from the conversion process is further processed into methanol. For more details, see the long version at www.bio-based.eu/policy.

In practice, such a maximum ethanol production from the whole crop on one site is rather unlikely since the processes for 1G and 2G ethanol are different and usually do not take place at the same facility. However, for a fair comparison between 1G and 2G feedstocks, it is justifiable to compare the whole extracted biomass from 1 hectare of forestry biomass also to the whole extracted biomass from 1 hectare of annual crops.

Taking into account a full utilisation for ethanol, sugar beet could yield more than 15 times more ethanol per hectare than forest wood from Finland. In fact, to fufil only half of the quota of 6.8% of low emission fuels from forest wood, 1.2 times the whole forest area of Finland would be needed. If based on the average annual increment across the EU-28, still 18% of the entire forest area of the EU-28 would be needed to reach this target.

Yields from wheat and maize are much less, but still 1.2-1.4 times higher than SRC poplar on marginal land.

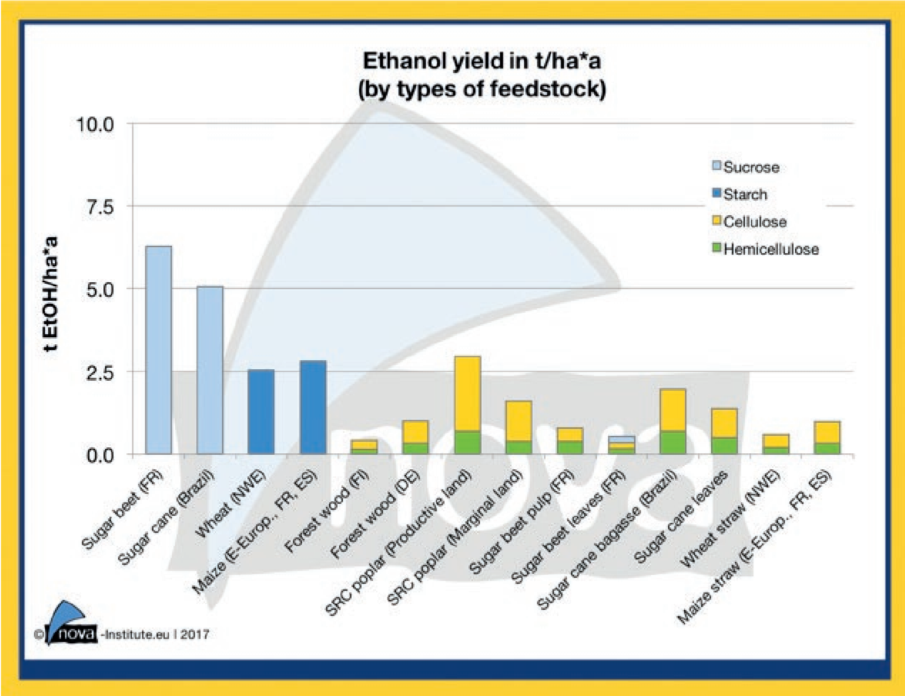


Figure 3: Ethanol yield in t/ha*a by types of feedstock (source: own calculations, based on multiple sources. For details see long version.) Note: Protein-rich co-products such as DDGS and Vinasse are not considered for ethanol production since they are considered feed in the section on co-products (p. 11).

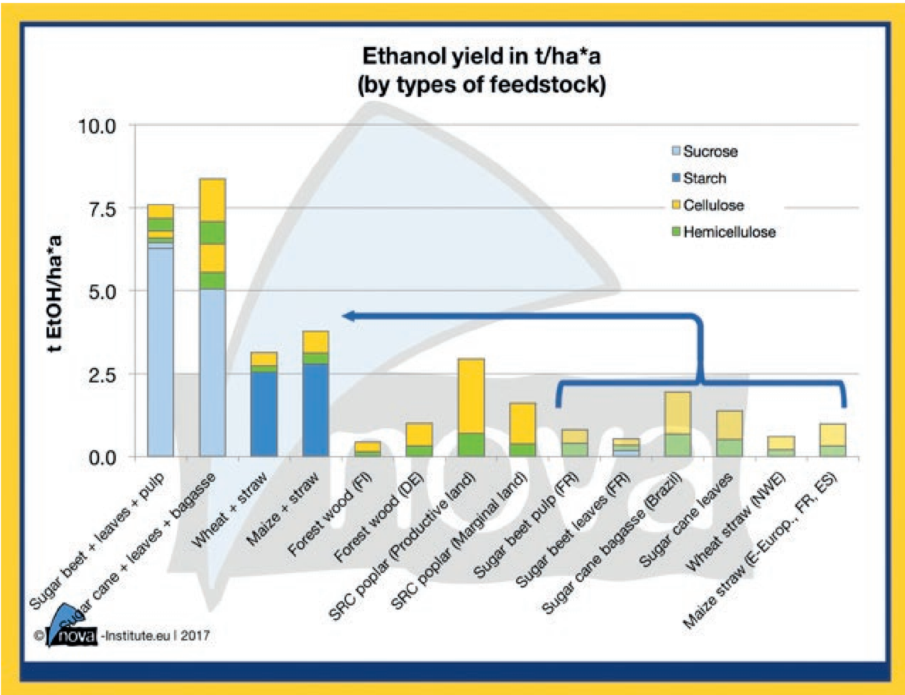


Figure 4: Ethanol yield in t/ha*a for different types of feedstock assuming full utilisation of main and co-products (source: own calculations, based on multiple sources. For details see long version.) Note: Protein-rich co-products such as DDGS and Vinasse are not considered for ethanol production since they are considered feed in the section on co-products (p. 11).

Food security

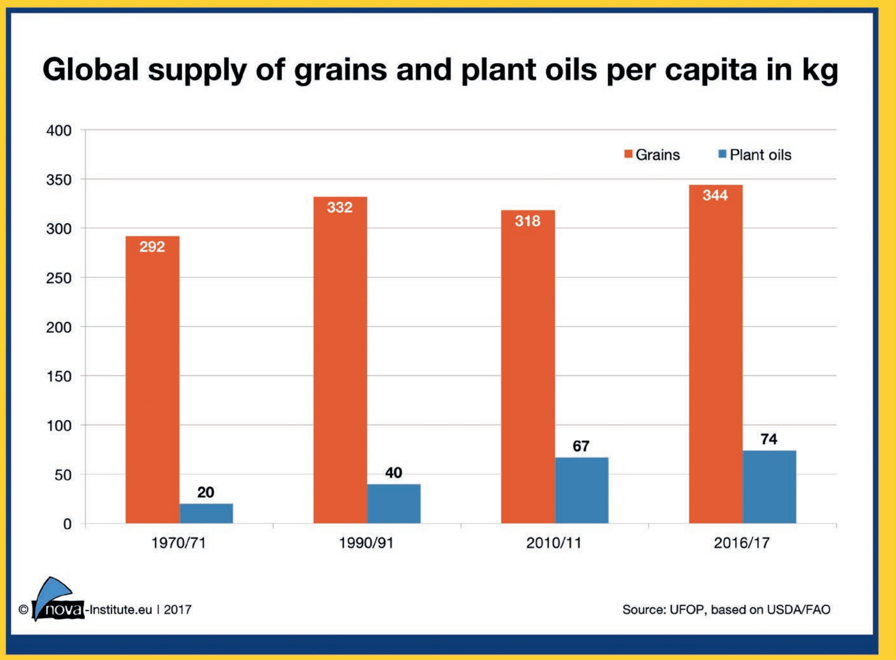


Figure 5: Supply of grains and plant oils, 2016/2017, estimated (source: UFOP, based on USDA/FAO)

There is a widely-accepted allegation that biofuels consumed in Europe, which are produced from so-called "food crops" negatively influence global food security. This argument – and the resulting public pressure – has been the main reason for the last revision of the RED (iLUC Directive) as well as for the planned gradual reduction of biofuels from food crops to 3.8% by 2030 in the new Commission REDII proposal.

However, there is a significant lack of evidence to support this argument. On the contrary, there is growing evidence that the opposite may be the case and food crops grown for other purposes can also contribute to increased food security on a global level. This complex criterion has been split into four sub-criteria to allow for a more precise evaluation.

Availability of food and feed

Scarcity of resources is mainly caused by competition for land, not by the competition for specific crops. That is why from an availability point of view, the most land-efficient crops are preferable for producing a given product, be it food, feed, energy or materials. As shown by the calculations on land efficiency, first generation crops score significantly higher in this criterion. In many cases, cereals of non-food quality are used for bioethanol production which offers additional income to farmers, since without this option they would have had to dump these products on world markets. This means that especially SRC score very badly on this criterion if they are grown on arable land, since they increase the competition for this valuable type of land. Forests do not pose a direct competition to food supply in terms of area needed as long as they are not grown on land which has been used for agriculture before. Also, waste used as a feedstock does not create any competition for land.

Additional areas with food crops also provide a higher overall availability for sugar and starch (see below "emergency reserve", too). The overall supply of food and feed worldwide has been growing according to numbers published by FAO and USDA, although the demand for first generation biofuels has grown in parallel.

Influence on food prices

Several studies have come to the conclusion that the alleged influence of biofuels on the extreme increase of food prices during the crisis in 2008 was much weaker than originally assumed (for more details see the long version at www.bio-based.eu/policy). First and second generation fuels score evenly in this criterion, none of them having had a clear impact on food prices so far.

Contribution to protein supply for human and animal nutrition

In terms of valuable nutrition, protein supply is much more important to both human and animal welfare than the supply with carbohydrates. A lack of protein leads to a form of malnutrition called "protein-energy malnutrition (PEM)"[1], while a lack of carbohydrates can be made up for by digesting

1 http://emedicine.medscape.com/article/1104623-overview

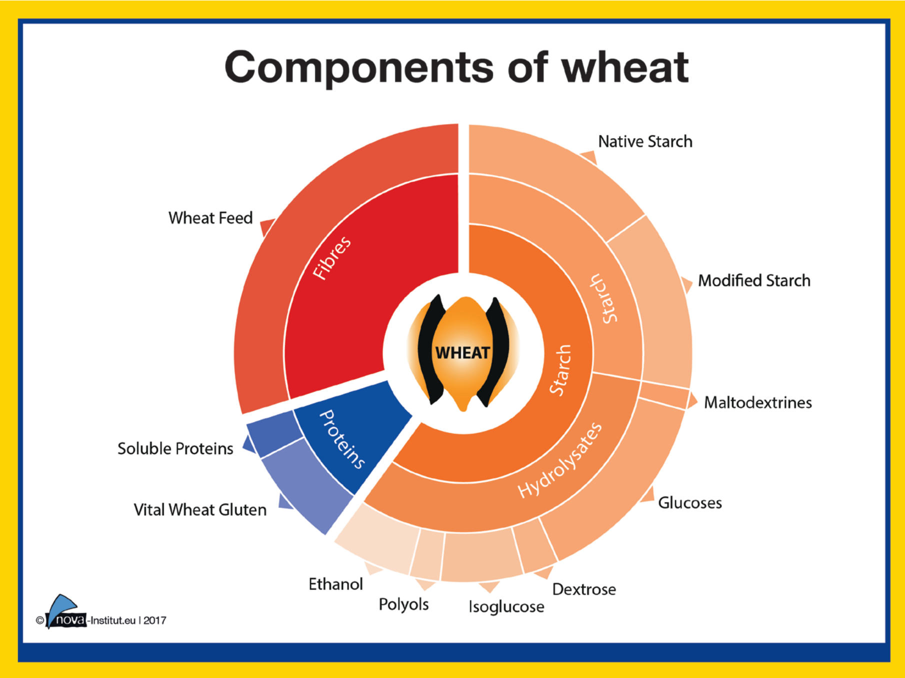


Figure 6: Components of wheat and co-products of wheat processing (source: own drawing)

other energy sources. This means, carbohydrates are replaceable in human diet, while protein is not. The same applies to animal nutrition.

Biofuels, however, are made from sugars, which are carbohydrates. When crops such as sugar beet or wheat are processed into bioethanol, there is a significant amount of protein-rich co-products which are fully utilized in feed applications (see Figure 7). Since the supply of protein is so crucial for human and animal nutrition, the provision of said co-products is most valuable to food and feed security. If these crops were less cultivated in Europe due to a phasing out of first generation biofuels, there would be an increased need for importing protein-rich feed products from other regions, such as soy from Brazil. This would have huge impacts on land use, land use change and transport emissions. The need for increased and independent protein production in Europe is well acknowledged by policy makers which can be seen in the "European Soy Declaration", signed in July 2017 by 14 Member States[2]. Consequently, first generation biofuels score significantly higher on this criterion than second generation fuels. Since wood- or waste-based biofuels do not worsen the situation on protein supply, however, the different types of biofuels have been ranked equally positively for the purpose of this analysis.

Emergency reserve

In the case that humankind really faces a food crisis, food crops targeted to the bioethanol market can also serve as an emergency reserve for food and feed supply – second generation lignocellulose cannot be used as such. Flexible quotas can be used to re-direct food crops to the food market in times of crisis. Of course, for a transitional time, these feedstocks will not be available, exacerbating the food problem for a while. It is even quite probable that such a re-allocation may happen without legal measures: Due to rising prices for agricultural crops, bioethanol production often does not pay off, which means that the crops are redirected towards food markets. In a food crises, lignocellulosic crops such as short rotation coppice only give security to the industrial supply, but offer no emergency reserve for food supply. In addition, SRC can even take away significant amounts of agricultural land. The lignocellulosic biomass will only feed the industry – also in a food crisis. Also, a political focus on strictly waste-based fuels will not help to contribute to any emergency reserves. Consequently, first generation biofuels score slightly higher than second generation biofuels due to the time factor.

Conclusion

As stated in the beginning of the text, the evidence shows that first generation biofuels do not perform worse than second generation fuels made from lignocellulosic feedstocks or from waste with regard to endangering food security. On the contrary, they can even make positive contributions to enhancing food and feed security on a global level. This is counterbalanced by the fact that wood does not

2 http://www.feednavigator.com/Regulation/More-countries-back-EU-soy-declaration

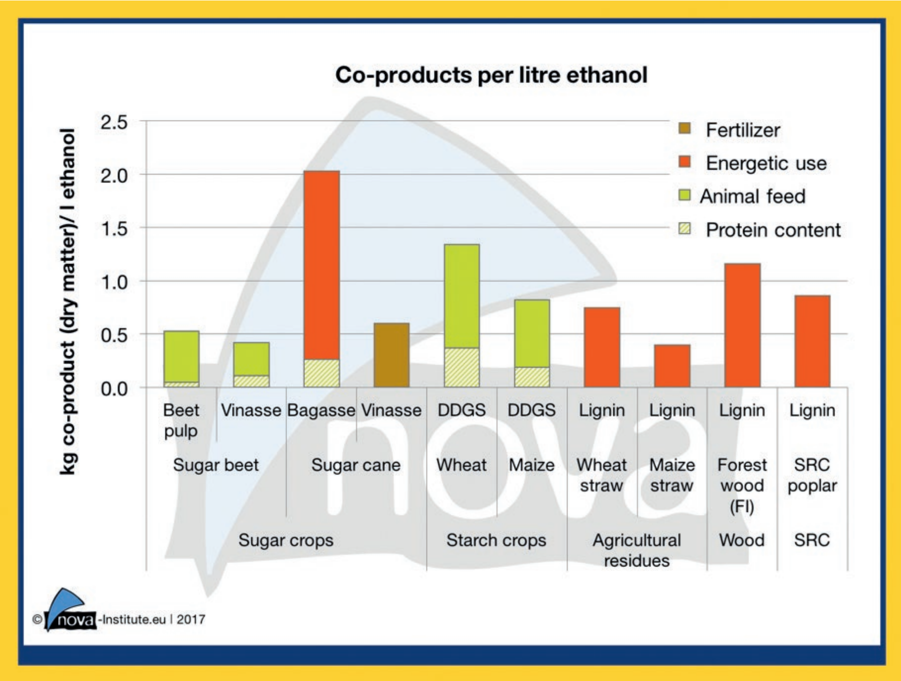


Figure 7: Co-products per litre of ethanol depending on feedstock and process (source: own calculations, based on Hansa Melasse 2017, Soccol et al. 2016, Costa et al. 2015, Heuzé et al. 2017, Heuzé et al. 2015 and Wirsenius 2000)

compete for agricultural land and that in times of crisis, if an emergency reserve cannot be activated quickly enough, the utilisation of wood for ethanol does not cause an immediate restriction to the access to food. Therefore sugar, starch and most lignocellulosic crops have been ranked the same in terms of food security. Only SRC has been ranked lower due to the land competition for arable land at a very low efficiency ratio. The concerns about food security are not well founded when it comes to bioethanol made from sugar or starch plants.

Protein-rich co-products and others

Depending on the feedstock and process, the production of one litre of ethanol can result in different amounts and different types of co-products, which can be used for different purposes. The most common uses are either animal feed, fertilizer or energy. As shown by Figure 6, sugar beet and starch crops are the only feedstocks that provide relevant co-products in terms of animal feed. Since the protein content of starch crops is significantly higher than that of sugar beet, wheat and corn have been ranked as highest performing, while sugar beet was ranked as medium performing.

Employment and rural development, livelihood of farmers and forest workers

Our calculations based on Eurostat and FAOSTAT came to the conclusion that those fuels requiring crops from agricultural cultivation (or semi-agricultural cultivation as in the case of SRC) create more employment per tonne of ethanol than woody and waste biomass.

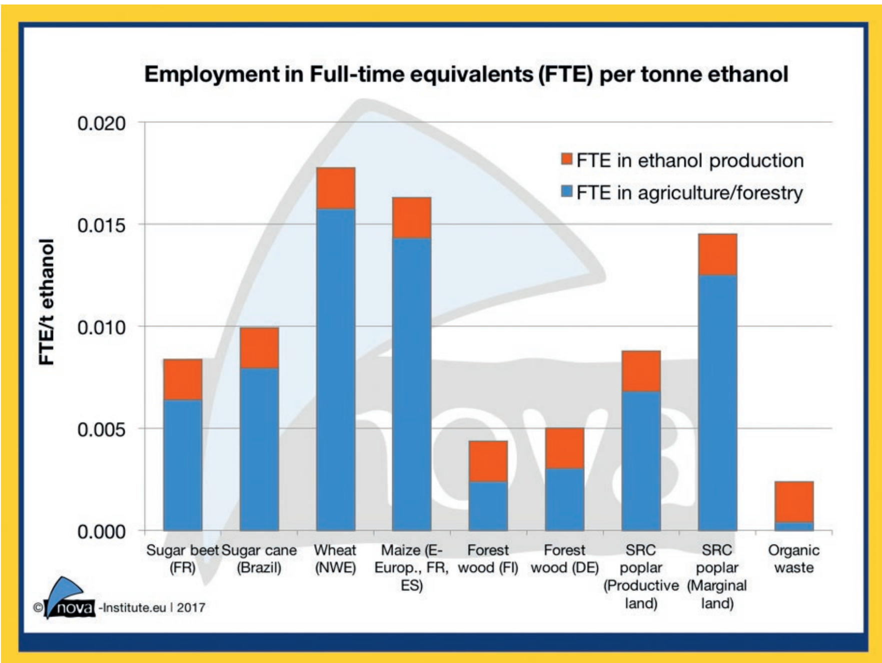


Figure 8: Direct employment generated per t ethanol in full time equivalents (FTE) (sources: Eurostat, FAOSTAT) Notes: FR = France, NWE = North-West Europe (Germany, Belgium, The Netherlands, France, Sweden, Great Britain), E.-Europ. = Czech Rep., Poland, Hungary, ES = Spain, FI = Finland, DE = Germany

European biofuels from agricultural crops also help to reduce agricultural land losses, thereby contributing significantly to stabilising the livelihood of farmers, especially when markets for agricultural products are fluctuating strongly. Since ethanol facilities are mostly built in rural and structurally weak areas, their establishment contributes to the prosperity of the region since the revenue from additional direct jobs will increase purchasing power and benefit other sectors.

Biofuels from woody biomass would also support jobs in rural areas, however not to the same extent as biofuels from agricultural residues or SRC. Therefore, ethanol from forest wood has been ranked as medium performing. In addition to that, the utilisation of waste, would probably create only few jobs, mostly in urban areas, which is why these feedstocks were ranked as medium performing, too. However, if waste-based fuel options are considered as a substitute to 'job intensive' biofuels from crops, a 'red' ranking must be considered.

Land use change (LUC/iLUC)

The results based on Laborde (2011) and the "ILUC Directive" (2015/1513) indicate that oil crops for biodiesel have a high LUC/iLUC risk while sugar and starch crops mainly for ethanol show low to medium risks. The GLOBIOM study (Valin et al. 2015) came to similar conclusions. Other biomass such as agricultural residues, forest biomass or organic waste do not have significant risks of land-use change related emissions provided that sustainable extraction rates are guaranteed. In contrast, SRC on agricultural land shows a significant risk of LUC/iLUC due to the fact that agricultural land for the cultivation of food/feed crops is lost for several years or even permanently and may be made up for somewhere else.

Availability and infrastructure

In terms of existing infrastructure, first generation biofuels score higher, which is not surprising since they have already been established and do not need additional investment. Also in terms of potential / future availability and infrastructure there is reason for doubt whether second generation feedstocks – except for virgin forest biomass – will be available in relevant dimensions at a reasonable effort. In addition to these constraints, availability of waste feedstocks for biofuels needs also to be considered in competition to other uses. For many feedstocks, there are higher value-adding applications, e.g. in material and chemical industries. From an efficiency point of view, it would be more favourable to allow the market to regulate the allocation of these limited feedstocks to the highest value applications. Furthermore, it is very questionable to build a long-term climate strategy on feedstocks that will be dependent on significant subsidies for an infinite time in order to counterbalance this competition.

Traceability of feedstocks

All feedstocks need to provide proof of origin through mass balance certificates. For virgin materials such as agricultural crops or forest biomass, this is relatively straightforward and well implemented. For waste, however, there can be problems with traceability. Often, there is a lack of criteria that define waste which makes it easier to get away with false claims. Also a weak implementation of mass balance certification can lead to wrongful declarations, if, for example, only points of collections are checked and not the primary "producer" of waste. This is especially problematic in the case of imported wastes, such as used oil and fats, since the checking of waste origin in China, for example, has proven to be complex and elaborate, if possible at all.

It should be noted that as long as an incentive system exists which makes it worthwhile to sell falsely declared waste, it is very probably that certain energies will find ways to circumvent any kind of certification and checks.

In our ranking system, these issues mostly apply to post-consumer wood as well as organic waste. Therefore, the risk of false claims of feedstock is higher. These gaps can contribute to artificial generation of "waste", which is in conflict with the European waste hierarchy.

Social impacts: land rights, human rights, education, etc.

The potential social impacts of biofuel production cannot be evaluated for a whole group of feedstocks, since the concrete risks and impacts depend very much on location and specific cultivation practice. Since ethanol used in the European biofuels quota needs to be sustainability certified, the risks for all feedstocks were assumed to be equally low. A slight minus is the absence of social criteria from the mandatory sustainability criteria imposed by the RED; only some of the voluntary certification systems have implemented social criteria. It should be noted that for certification systems only operating in Europe, such criteria might not be necessary since social issues are usually governed by legislation. And since the certification schemes that do include social aspects (ISCC, RSB, Bonsucro) represent the overwhelmingly largest share of the global market, the lack of social criteria from the RED is not seen as a major problem. In conclusion, all feedstocks were ranked equally high.

Biodiversity

Based on an extensive desk research and expert interviews, it was not possible to apply different rankings on biodiversity to first or second generation biomass for bioethanol made from fresh biomass from agriculture or forestry. First generation crops can have more impact per hectare because of intensive agricultural practices utilising chemical plant protection and fertilizers, while second generation biomass has an impact on much larger areas because of lower bioethanol yield per hectare.

More important for biodiversity are the specific local conditions and the management practice, and to avoid biodiversity hot spots by establishing good governance and strong institutions.

Using side and waste streams for second generation biofuels is another matter. Post-consumer wood and organic waste have no impact on biodiversity, also using agricultural residues has a low impact, as long as enough biomass is left on the field to maintain soil quality. Using forest residues is another matter still, because dead wood has high impacts on the biodiversity of mushrooms, insects and other small animals. For these reasons, all virgin materials have been ranked as posing high risks, while being well-aware of the fact that local practisies in agriculture and forestry can differ significantly. Forest residues show medium risk and all waste materials low risk.

Impact on water, air and soil quality

Data about the impact of different fuels on water, air and soil quality are scarce allowing only for a preliminary ranking. Within these limitations, a tentative ranking has been attempted, ranking the agricultural systems and managed forest systems as posing medium risk (the impact of both are mainly dependent on specific practices such as harvesting and processing methods, and co-product handling) and all residues and wastes have been ranked best, because their impact on water and soil is low.

This study has been carried out by nova-Institute and ordered by CropEnergies AG.

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Conclusion: What does this mean for REDII?

The analysis of twelve different sustainability criteria shows that all of the researched bioethanol feedstocks offer significant strenghts and weaknesses for a feasible climate strategy:

- All bioethanol feedstocks realise **significant reductions of greenhouse gas emissions.** While second generation fuels perform better in this regard, the performance of first generation fuels should not be ignored – especially considering the fact that a relevant part of the performance is determined by methodology choices that influence the outcome. Even based on this methodology, the GHG emission reductions of second generation fuels are strongly relativised, when offset against the abatement costs. Reducing GHG emissions through second generation biofuels is expensive – and prevents potentially more efficient climate actions that could be implemented elsewhere.
- Also with regard to the often-criticised negative impact on **food security** of first generation biofuels, the evidence points into a different direction. The competition for arable land is counterbalanced by the excellent land efficiency of first generation crops (especially sugar beet) and protein-rich co-products (especially wheat and corn). In this regard, the utilisation of short rotation coppice (SRC) for biofuels poses much stronger competition for arable land, since they use up much larger acreages of arable land and provide no protein-rich co-products.
- Several studies have come to the conclusions that the influence of biofuels on price peaks of food crops is much lower than assumed shortly after the food crisis in 2008. For a **sustainable food and feed strategy** in Europe, the protein-rich co-products of wheat processing are of utmost importance, reducing the dependence on soy imports from the Americas and preventing indirect land use changes.
- In the case of wheat, most of European ethanol production is based on grain of **non-food quality and on harvest surpluses**, not posing any competition at all, but offering additional outlets to farmers not forced any more to dump their production on world markets. In the opposite case of bad harvests and rising prices for agricultural crops, bioethanol production often does not pay off, which means that the crops are redirected towards food markets.
- While the use of forest biomass does not compete for arable land, their extensive utilisation can also have significant impacts on **biodiversity and soil quality**. Furthermore, biofuels made from lignocellulosic feedstocks create less **employment** than biofuels from agricultural crops, making the latter valuable for **rural development** in many rural areas of the EU.
- A European bioenergy strategy which focuses on **biogenic waste** is in part a contradiction to a waste strategy that targets the long-term prevention of wastes, poses challenges in terms of availability and cost structures and can also lead to significant market distortions, since many of the so-called "wastes" have alternative applications and often have existing markets. These aspects counterbalance the obvious advantages with regard to land use and environmental issues to a certain extent.

The results clearly indicate that the systematic discrimination against first generation biofuels of the current Commission proposal is in no way founded on scientific evidence. This has also been criticised by an independent assessment of the REDII proposal (Impact Assessment Institute 2017).

On the way to a climate-friendly Europe, biofuels made from any kind of feedstock offer advantages in terms of GHG emission reductions and should indiscriminately be part of a viable transitional strategy, as long as they adhere to sustainability criteria.

In order to ensure that the transport sector can contribute to achieving the European Union's ambitious climate goals, the authors suggest the following amendments to the REDII proposal in the ongoing negotiations:

- Keep a dedicated target for the transport sector; set an ambitious target of at least 15% of renewable energies in transport until 2030.
- Keep the existing 7% for food-crop based fuels; do not lower the share of first generation fuels further.
- Set a 6.8% target for other sustainable and renewable transport fuels, such as advanced biofuels, as proposed by the RED-II proposal.