Sustainability of sugar beet

In the focus: Greenhouse Gas Reduction / ILUC

Seminar “Bioethanol”, Lelystad, 4th July 2019

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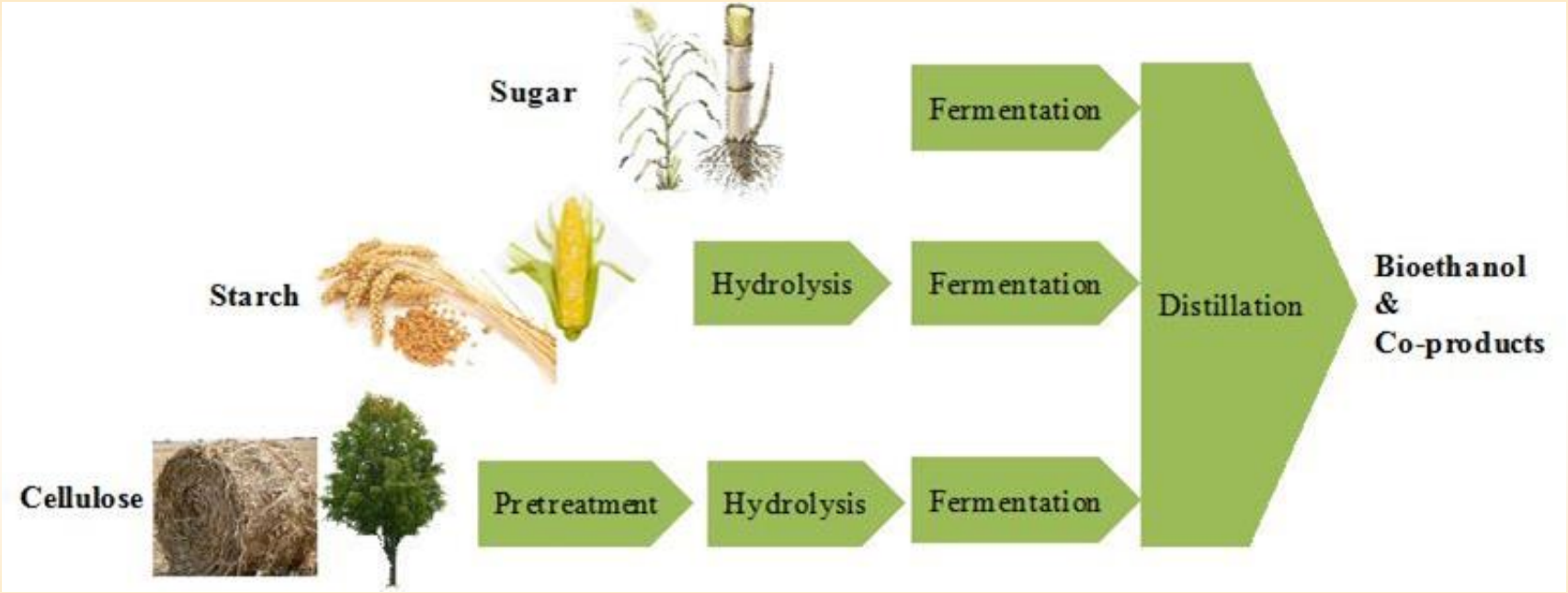

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Sustainable First and Second Generation Bioethanol for Europe.

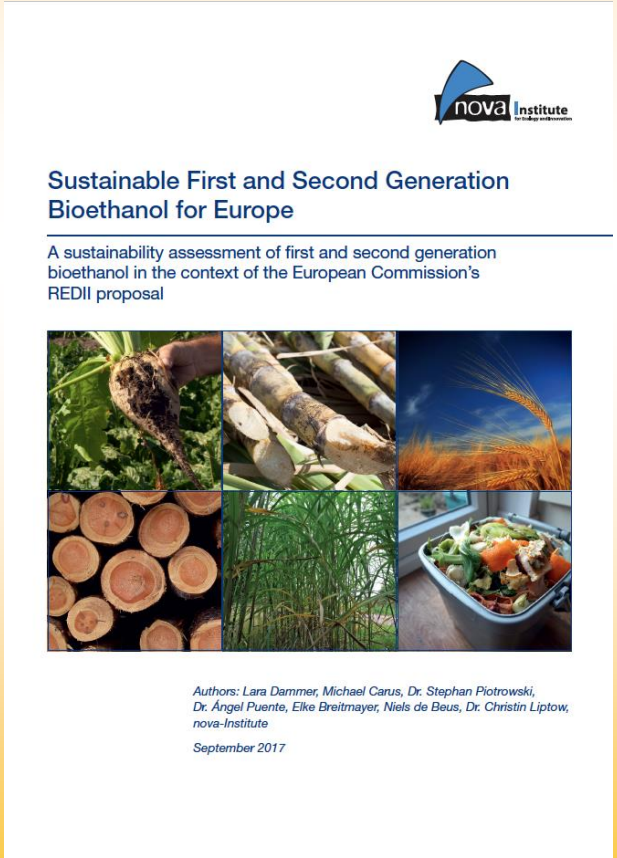
A sustainability assessment of first and second generation bioethanol in the context of the European Commission's REDII proposal

The study

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.

- Short version: 12 pages
  more than 700 downloads
- Long version: approx. 50 pages
  (detailed calculations and scientific background information)
- Executed by order of CropEnergies



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The study

- **Objective**: Assess whether the systematic discrimination against first generation biofuels in the REDII proposal is justified from a comprehensive sustainability point of view.
- **Scope**: Bioethanol from sugar beet, sugar cane, wheat, maize, virgin wood (forest/SRC), forest residues, post-consumer wood, agricultural residues, organic waste
- **Methodology**: Desktop study, cross-check with several renowned experts
- Twelve Sustainability criteria were selected (in accordance with most prominent sustainability certification systems and NGO reports):

  - **GHG footprint**
  - **GHG abatement costs**
  - **Land efficiency**
  - **Food security**
  - **Protein-rich co-products**
  - **Employment and rural development**
  - **LUC / iLUC**
  - **Availability and infrastructure**
  - **Traceability**
  - **Social impacts**
  - **Biodiversity and marginal land**
  - **Impact on water, air and soil**

First generation biofuels are just as sustainable as second generation – both show significant reductions of greenhouse gas emissions

- The analysis shows that all of the researched bioethanol feedstocks offer significant strengths, but also weaknesses in terms of sustainability: All feedstocks realise substantial reductions of greenhouse gas emissions (GHG).
- While second generation fuels perform better in this regard, this effect is strongly relativized, when offset against the abatement costs. Reducing GHG emissions through second generation biofuels is a rather expensive way to mitigate climate change.
- 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).

The main results

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										
Level of subsidies needed / GHG abatement costs										
Land use / land efficiency										
Food security, negative impact on										
Protein-rich co-products										
Employment, rural development, livelihood of farmers and foresters										
LUC / iLUC										
Logistics/Infrastructure/ Availability										
Traceability										
Social impacts (land rights, human rights, education..)										
Biodiversity and marginal land, potential impacts										
Impact on water, air and soil quality										

Land efficiency of biofuels

- Very important: we have limited arable land available on this planet and we need it for the different applications food/feed, materials and energy

  → Therefore, the most land efficient crops provide benefits

- Moreover, GHG, biodiversity, water use are all correlated with the crop yield. The yield is not the only factor, but it serves as one indicator.

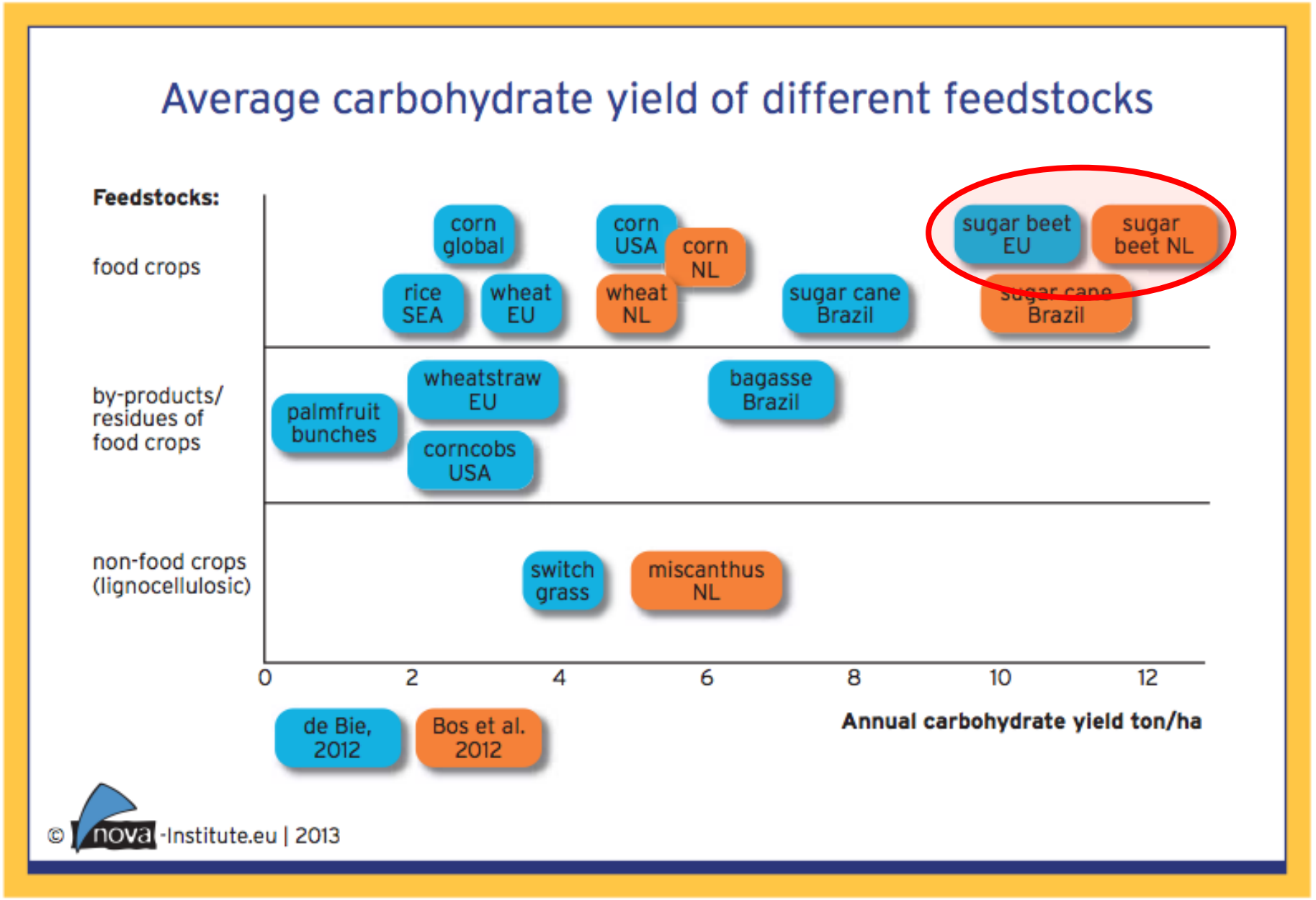
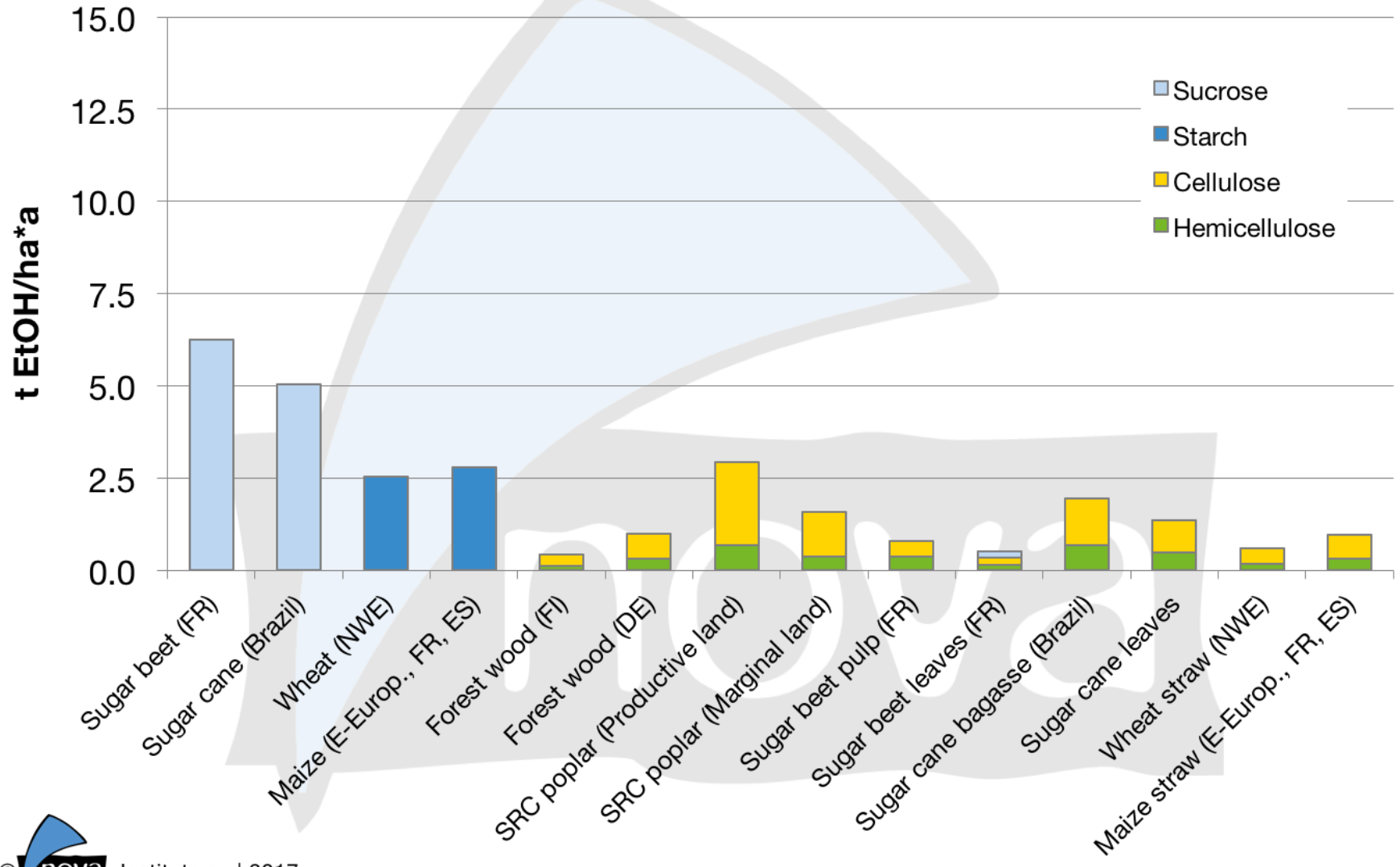
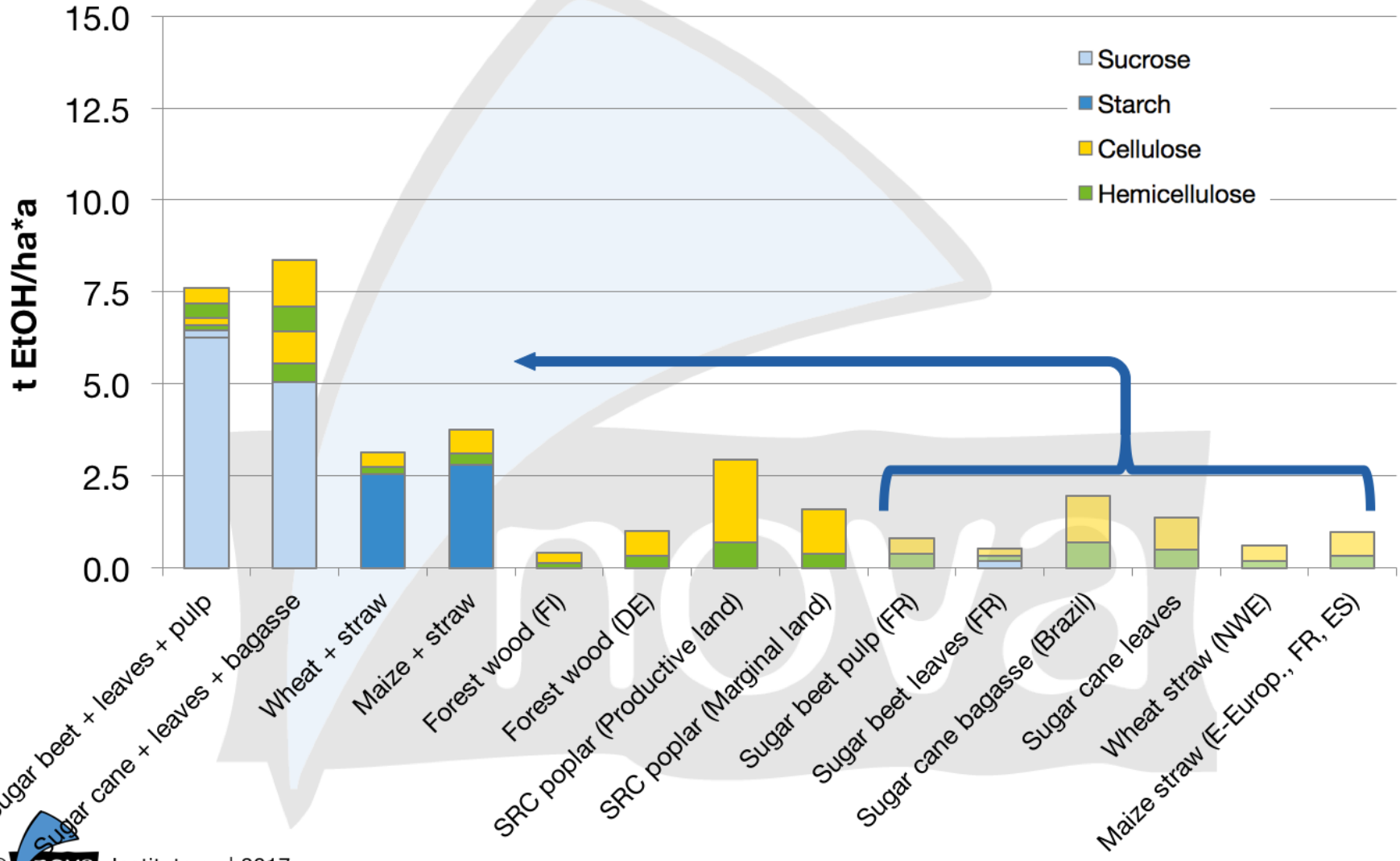


Figure 4: Annual carbohydrate yield per hectare for different feedstocks. (nova 2013, based on de Bie 2013 & Bos et al. 2012)

Ethanol yield in t/ha*a (by types of feedstock)



Ethanol yield in t/ha*a
(by types of feedstock)



The main results – per criterion
3) Land use / land efficiency

Criteria	Sugar		Starch		Virgin wood		Waste wood		Agricultural residues	Organic waste
	Sugar beet	Sugar cane	Wheat	Maize	Forest	SRC	Forest residues	Post-consumer wood		
Land use / land efficiency										

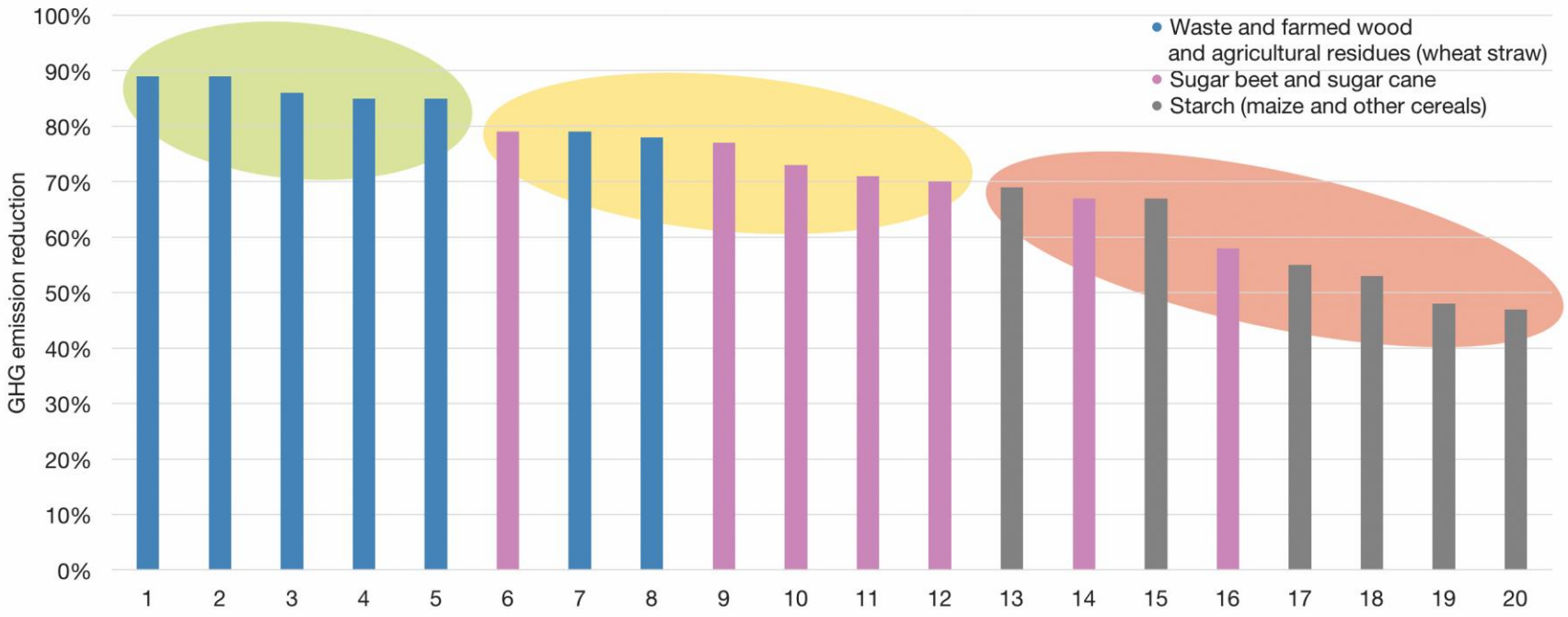
- Most ethanol per ha from sugar crops, least from wood and SRC
- Post-consumer wood and organic waste ranked green, because no land use ratio can be established
- Excellent opportunities to combine 1st and 2nd generation: Use 1st generation crops and utilise their residues/co-products (straw, sugar beet pulp, bagasse, etc.)
- Using arable land for dedicated cultivation of short rotation coppice (SRC) poses the highest competition for land possible
- Details: afternoon presentation

Greenhouse Gas (GHG) footprint

- Reduction threshold for biofuels, according to RED/REDII and FQD
  - 35% from 2011 onwards
  - 50% from 2017 onwards
  - 60% from 2018 onwards (only new installations)
  - 70% from 2020 onwards for advanced biofuels

- REDII Annex V provides “typical” and “default” emission reduction values for different feedstocks and process energy sources → study based on the typical values
  - Often, industry voices claim that the real values are much better than the typical values quoted in the RED Annexes (based on JRC calculations). However, there is no reliable data source to assess these claims, since industries do not publish their GHG performance.
  - RED values are also criticised by other voices for being too optimistic. We are aware of these controversies. This study did not intend to solve all critical issues at once. Rather, taking the agreed-on benchmark values, it assesses whether the policy based on these values makes sense from a holistic point of view.

GHG emission reductions of different feedstocks and processes



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)

Excursus: LCA methodology

- **GHG emission reduction values are very dependent on the calculation and allocation rules used**

- RED standards are only **partly based on science**, while the other part is **strongly influenced by political objectives**.

- One of the **main reasons** for the excellent values of fuels made from wastes and residues is the fact that **no burden of emission is assigned to the production of the feedstock**; but only from the point onwards, when it occurs: so to collection, transport and processing.
  - For example agricultural residues in case of wheat: No burden of emission is assigned to crop cultivation for the straw. 100% emissions are allocated to the small wheat kernel.

    → in common scientific procedure, an allocation would have to be made based on energetic or economic value.

Excursus: LCA methodology

- In the case of wheat, the kernel only accounts for 70% of the total energy content of the harvested wheat crop (straw 30%).
  - Applying energetic allocation, fuel from wheat would show 30% lower emissions than those laid down in the RED.
  - Second generation bioethanol from wheat straw would show 30% higher emissions
    - → **Based on energetic allocation, there would be almost not difference between first and second generation biofuels from wheat**.
- Also assumptions play a role: **For wood-based fuels** it is assumed that all process energy is produced by incinerating wood residues and/or lignin, resulting in much lower process emissions than for first generation fuels (whose process pathways are shorter and less energy intensive).
- Furthermore, **protein-rich co-products of the biofuel production are not accounted for as substitutes for imported protein**, but only for their energy content. This means that the real value of the co-product is underestimated. In the US, protein substitution is the preferred accounting method resulting in high reduction values for biodiesel for example.

Excursus: LCA methodology

- These approaches are politically determined, but questionable from a purely scientific point of view, especially if it concerns parts of plants that have a function, a market and a value.

- **In this regard, the climate advantage of second generation fuels is somewhat of a self-fulfilling prophecy.**

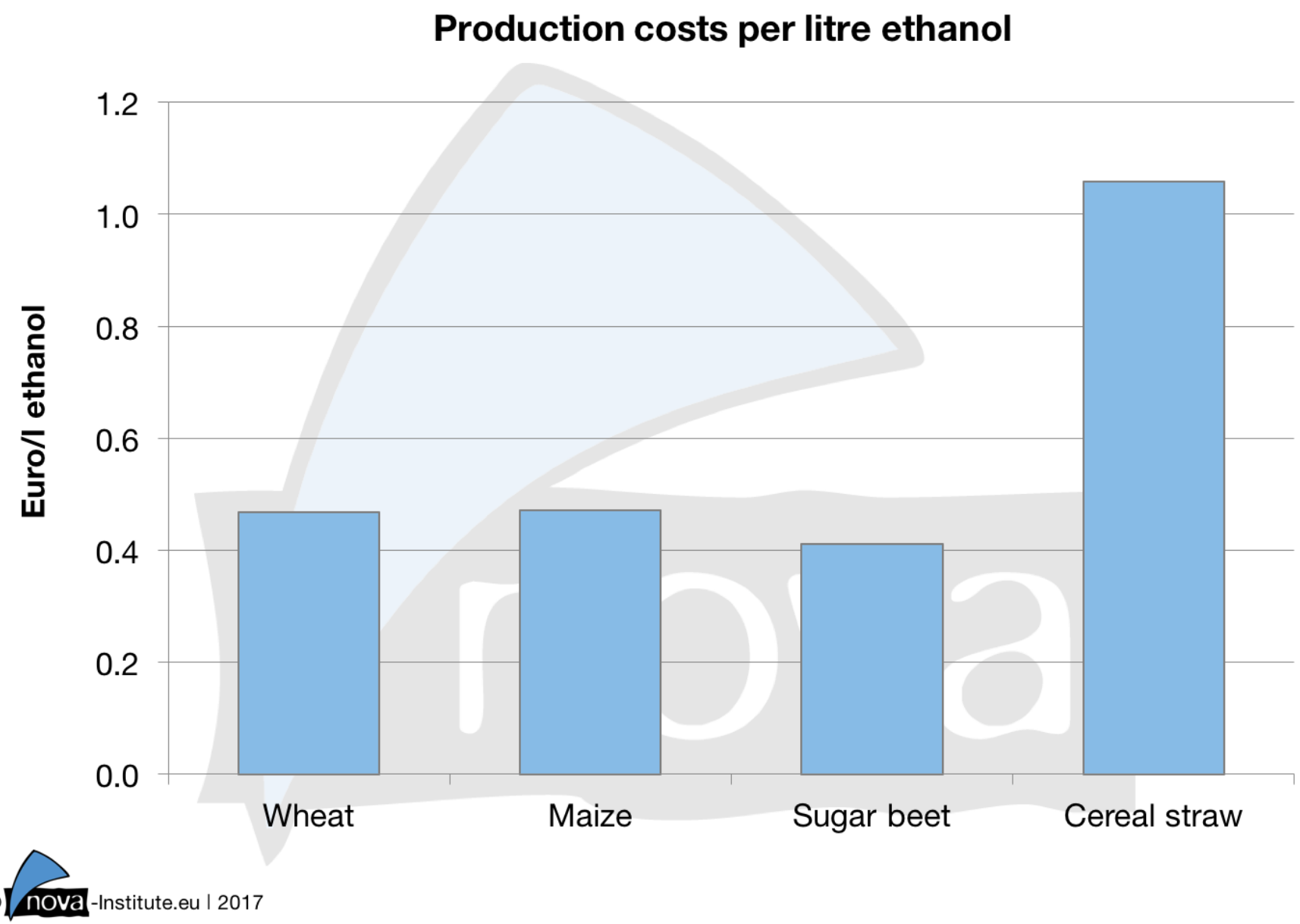
The main results – per criterion
1) GHG footprint

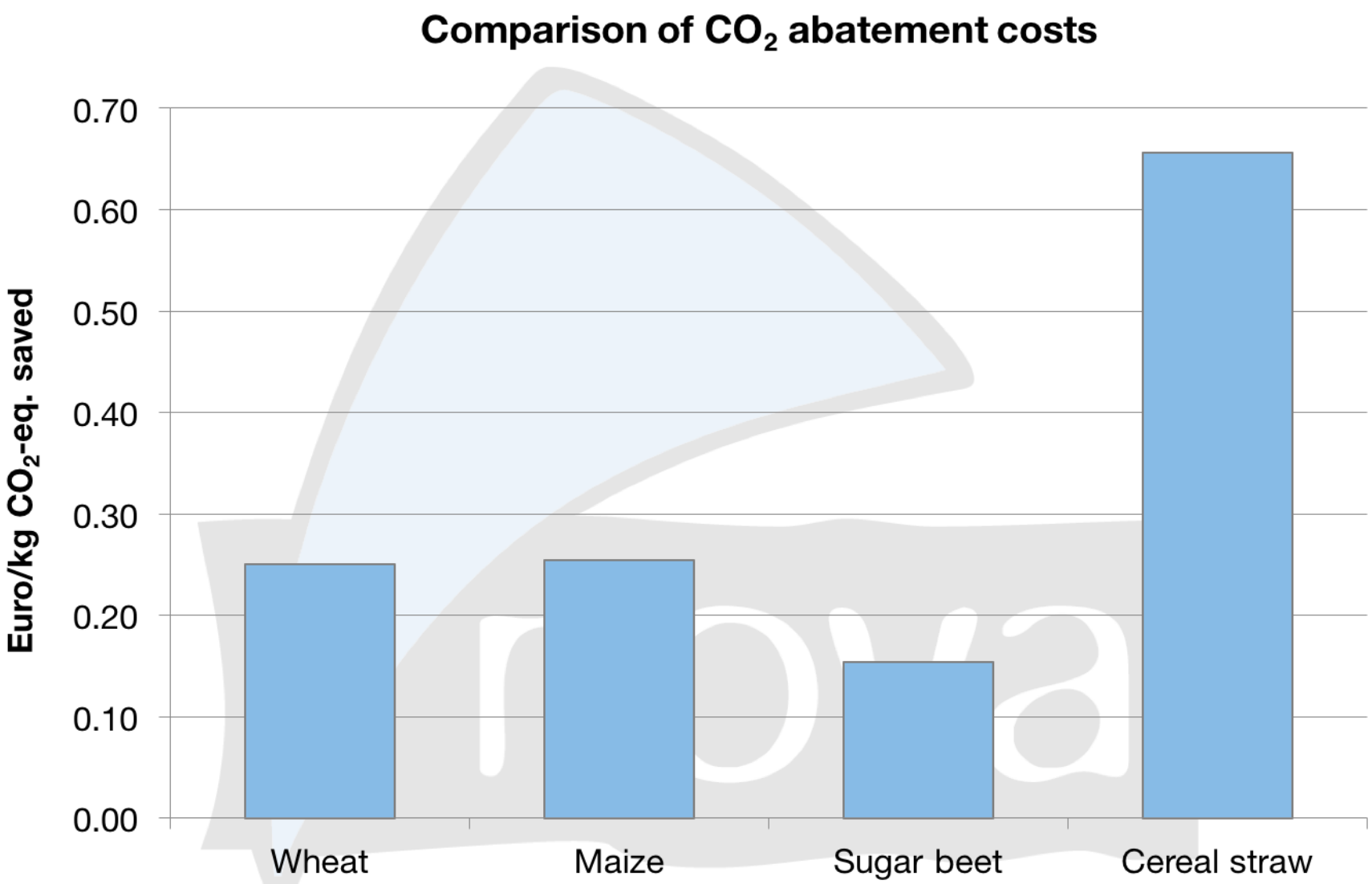
Criteria	Sugar		Starch		Virgin wood		Waste wood		Agricultural residues	Organic waste
	Sugar beet	Sugar cane	Wheat	Maize	Forest	SRC	Forest residues	Post-consumer wood		
GHG footprint										

- Starch crops perform relatively the lowest – GHG emission reduction values still good (up to 69%)
- The values are very dependent on the methodology applied to calculate them

GHG abatement costs

- Comparison of costs for consumers per kg/CO_2 saved
- Production costs calculation based on JRC 2017, Eurostat 2017, Euronext 2017
- Abatement costs calculation based on JRC 2017, Eurostat 2017, Euronext 2017, GHG savings from EC 2016 (REDII proposal), petrol price of 40 c/l (Rotterdam trading price) and equalised for calorific value of petrol and ethanol
- 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.





The main results – per criterion
2) GHG abatement costs

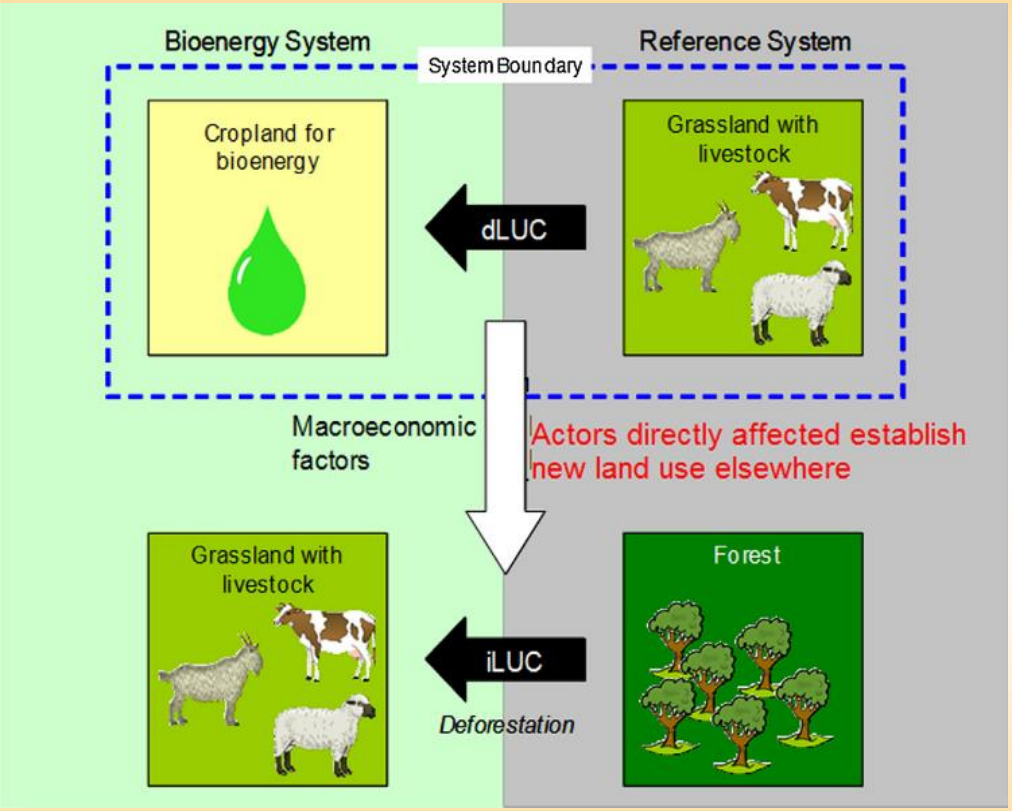
Criteria	Sugar		Starch		Virgin wood		Waste wood		Agricultural residues	Organic waste
	Sugar beet	Sugar cane	Wheat	Maize	Forest	SRC	Forest residues	Post-consumer wood		
GHG abatement costs										

- Best GHG reduction value for money: sugar crops
- Starch crops also very cost-efficient, but lower emission reductions, so relatively ranked below sugar
- Slightly higher GHG emission reductions from 2nd generation crops are expensive

What is indirect land use change (iLUC)?

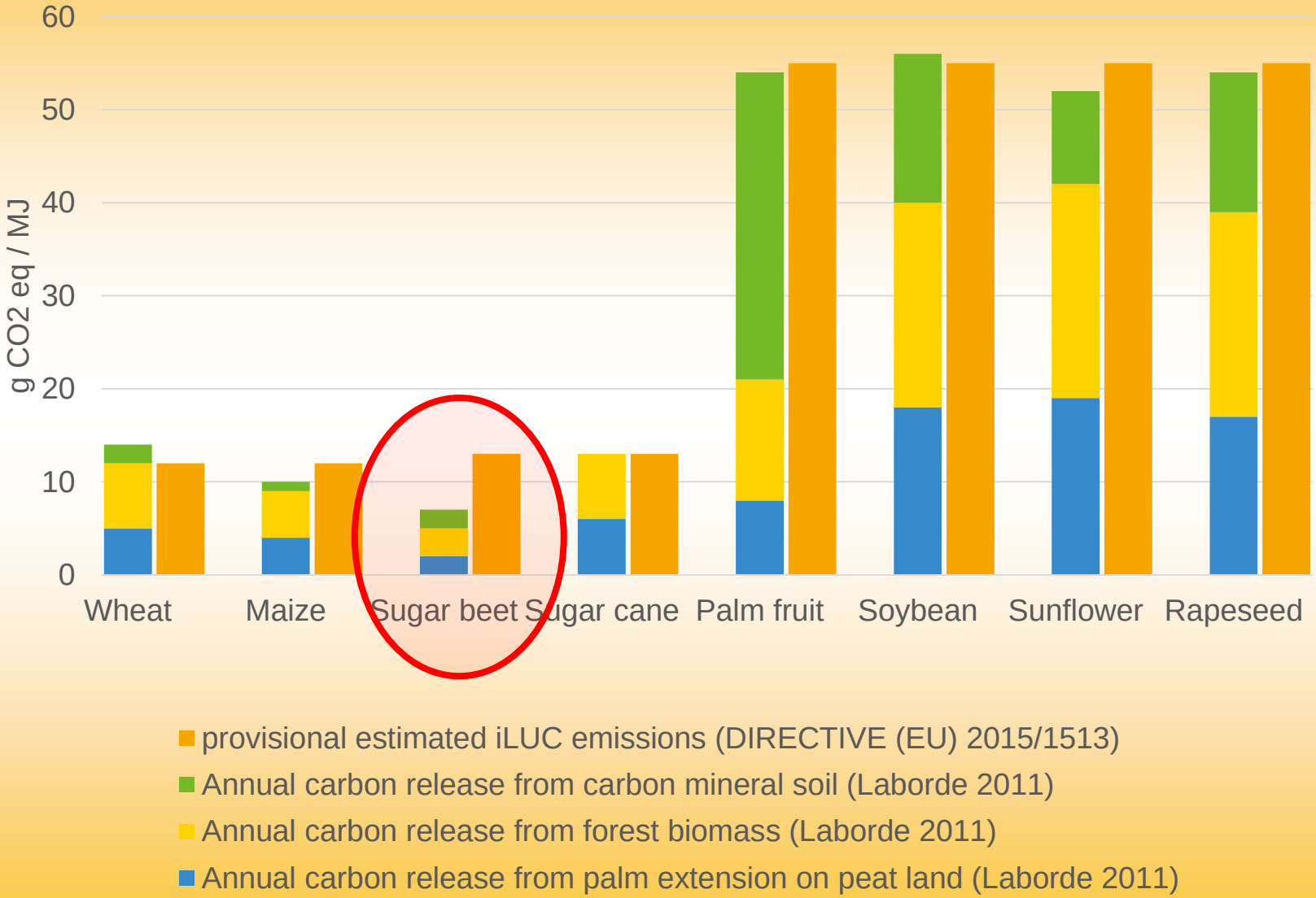
*When **biofuels are produced on existing agricultural land**, the demand for food and feed crops remains, and may lead to someone **producing more food and feed somewhere else**.*

*This can imply land use change (by changing e.g. forest into agricultural land), which implies that a **substantial amount of CO2 emissions are released** into the atmosphere.*



Source: European Commission 2012; Egeskog et al 2016

iLUC



Source: own diagram based on EP 2015, Laborde 2011; all in g CO_2 eq /MJ

The main results – per criterion
7) LUC/iLUC

Criteria	Sugar		Starch		Virgin wood		Waste wood		Agricultural residues	Organic waste
	Sugar beet	Sugar cane	Wheat	Maize	Forest	SRC	Forest residues	Post-consumer wood		
lUC/iLUC										

- Difficult to assess – no scientific agreed standard
- Analysis based on Laborde (2011) and the iLUC Directive (2015)
- Very much depending on local practices and whether feedstocks are imported or domestic
- LUC/iLUC analyses should be taken as “risk” assessments, not as absolute numbers
- Lowest risks with wood, waste and residues

The main results – per criterion
11) Biodiversity and marginal land

Criteria	Sugar		Starch		Virgin wood		Waste wood		Agricultural residues	Organic waste
	Sugar beet	Sugar cane	Wheat	Maize	Forest	SRC	Forest residues	Post-consumer wood		
Biodiversity and marginal land										

- Impacts of agriculture and forestry potentially the same – intensive agriculture could be made up for by smaller areas used
- Overall very hard to assess: More important for biodiversity are the specific local conditions and the management practices, and to avoid transforming biodiversity hotspots by establishing good governance and strong institutions.

… and now?

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The main results – sugar crops

Sugar beet and sugar cane

+ Very high land efficiency

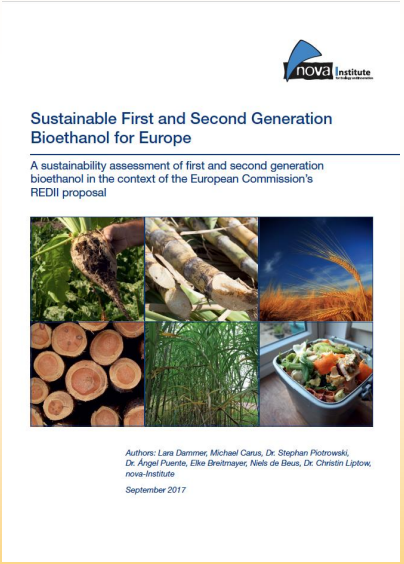
+ High GHG reductions and lowest GHG abatement costs

+ Well-developed infrastructure and availability

– Impacts on biodiversity (but limited to small areas)

– Impacts on water, air and soil quality (but limited to small areas)

Thank you for your attention!



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