GO-GRASS

Grass-based circular business models
for rural agri-food value chains

GO-GRASS international event on green biorefining

23 - 24 May 2023

Aarhus University Foulum, Denmark

DATE: 22.06.2023

AUTHORS (ORGANISATION): PROSPEX INSTITUTE (PI)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

Technical References

Project Acronym	GO-GRASS
Project Title	Grass-based circular business models for rural agri-food value chains
Grant Number	862674
Project Coordinator	Philipp Grundmann Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB) Email: go-grass@atb-potsdam.de
Project Duration	October 2019 – March 2024

Dissemination level [1]	PU
Work Package	WP7
Task	Task 7.3

[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

Document history

V	Date	Beneficiary	Author/Reviewer
1	18/6/2023	PI	Sara Chiba, Carolyn Brand
2	16/8/2023	PI	Sara Chiba, Carolyn Brand

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

GO-GRASS in a nutshell

GO-GRASS project (www.go-grass.eu) aims to create new business opportunities in rural areas based on grassland and green fodder and to support their replication throughout rural communities in the EU. The project develops, deploys and validates a set of small-scale demonstration sites (DEMOs) of a circular integrated agro-food system in four EU countries (Denmark, Germany, Sweden and the Netherlands). The project is expected to develop technologies from the current Technology Readiness Level (TRL) (between 5 and 6) to more advanced ones (8) successfully implemented under real conditions at the end of the project.

The DEMO in Denmark aims to develop small-scale bio-refining technology to extract protein concentrates for monogastric animals from grassland situated in nitrate sensitive areas. In Germany the DEMO targets to produce biochar via pyrolysis or hydrothermal carbonisation of grassland-cuttings from wetlands as supplement for soil improvement. In the Netherlands it is to develop digester and fermentation technology to produce paper and carton products from road-side grass and nature or fauna grass. In Sweden, the aim is to establish briquetting technology at local and small-scale to produce climate-friendly and heat-treated animal bedding using reed canary grass. Beyond the development of the individual DEMOs, the project aims to integrate the technologies and business models across the DEMOs to create additional values and value chain nods.

In order to realize and support its objectives, the project employs the principles of cumulativeness, innovation, replicability, inclusiveness, and circularity. The principles serve as guidelines and requirements for adapting and developing various tools, integrating circular economy in rural areas, ensuring successful demo implementation, creating favourable business environments and maximising the replication potential in other rural areas in the EU.

The tools to be developed by the GO-GRASS project include: online tools for business case assessment and funding; a manual on how to get started and succeed; a tool kit for cluster and network development; training courses for existing and future entrepreneurs; and guidelines on creating favourable business environments.

GO-GRASS will contribute to a range of circular and sustainable business models with high replication potential that can be used by entrepreneurs, local authorities and other stakeholders. It will demonstrate innovative cost-effective technologies, processes and tools applicable within the diverse DEMO scenarios. This will enable to effectively use grassland and shrubs which are being left to decay after mowing causing costs and lost benefits for individuals and society.

To stay up to date with GO-GRASS project events and reports, follow us on Twitter (@GoGrassEU), LinkedIn (GO-GRASS) or visit www.go-grass.eu.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

Disclaimer

Any dissemination of results must indicate that it reflects only the author's view and that the Agency and the European Commission are not responsible for any use that may be made of the information it contains.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

Table of Contents

1. About End-User Engagement 6

2. The event process 10

2.1 Introduction to the demo and project 10

2.2 Green biorefinery opportunities, challenges and developments in the regions across Europe 10

2.3 1st interactive exercise 11

2.3.1 HIGH IMPACT – LOW IMPACT 17

2.4 Policy and industry view 20

2.5 2nd interactive exercise 20

2.6 3rd interactive exercise 25

3. Conclusions 26

4. Annex 1: Presentations 31

5. Annex 3: Evaluations 27

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

1. About End-User Engagement

According to the GO-GRASS Grant Agreement, Prospex Institute (PI) is responsible for organising one End-User Focus Group event at each of the demo sites throughout the course of GO-GRASS, under task 7.3. PI and DK Demo were set to organise the End-User Focus Group event in December 2022, but once the invitation process was in progress it was noticed, that the local farmers (end-users), were not as interested in the event, as the DK Demo had already established excellent connections with local farmers from the beginning of the project. The farmers were therefore already involved, closely following the demo´s developments and at the same time providing feedback about the green protein they were testing on their farms. Therefore the original concept of the End-User Focus Group was consequently changed as PI and DK Demo decided to target a different group of end-users, namely technology end-users, instead of product end-users, and the event was adapted to the specific needs of the demo which is to better understand the possibility of green biorefining technology replication across Europe.

The revised format of the End-User Focus Group event took place at Aarhus University Foulum in Denmark, where the Danish demo is based on 23 – 24 May 2023.
´

The general objectives of this workshop were:

- Share findings of the Danish GO-GRASS demo research and demonstrate the Green Biorefinery Demo-Platform to inspire like-minded experts;
- Discuss green biorefining (potential) in regions across EU, share experiences and learn from each other;
- Inspire innovation to transform natural resources of grass land biomass into valuable assets;
- Identify obstacles and opportunities for the implementation and replication of the new technologies, processes and grassland business models;
- Enable extensive networking to explore the potential of future pan-European collaboration.

OPEN DAY

The GO-GRASS international event started with an Open House event in the afternoon of 23 May 2023, which allowed the participating EU experts to visit the Danish Demo-platform facilities. Morten Ambye-Jensen the lead of CBIO, Aarhus University Foulum greeted the event participants upon arrival and a tour of the facilities followed. The participating EU experts were invited to expect the biorefining system while given a detailed explanation on the GO-GRASS biorefining process, additionally being able to try out the GO-GRASS green protein.

The first day ended with a networking dinner where participants got the chance to get to know each other better and discuss their work in the field of green biorefining and its future aspects.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

INTERNATIONAL WORKSHOP

The intention of the event was to have a better understanding of the general status of green biorefining across Europe therefore the focus of the presentations held throughout the day were opportunities, challenges and developments of green biorefineries in participating regions and countries.

The workshop held on the second day and was sectioned in three parts.

During the morning key speaker's presentations set the scene for the event by presenting the status of green biorefining across Europe, including opportunities, challenges and developments from researchers' point of view. The initial presentations were followed by group work which focused on the identification of opportunities and first ideas on what needs to be done to enable green biorefining across EU. During the afternoon, the workshop looked into opportunities that policy is enabling, including current and future national and EU support to help new developments, complemented with industry´s view and the potential market launch of new products. This was followed by an in-depth discussion focusing on technology replication and commercialization.
The workshop was rounded-up with an intense discussion about a potential Pan-EU Network of Green Biorefineries with an emphasis on alignment of important actors across Europe.
The workshop was concluded with the identification of "who, when and what" needs to be done which highlighted the necessary next steps the EU experts need to take to set up a successful network.

IN PERSON FORMAT

Due to the concept of the workshop, the international event was organised as an in-person event, in 2 different locations: CBIO, AU Foulum Demo Facilities on 23 May 2023 to AU Foulum campus on 24 May 2023.

INVITATION PROCESS

The international event targeted green biorefining experts, specifically representatives of government, industry and research from across EU.
The key speakers and potential participants were identified by GO-GRASS DK Demo and PI, to ensure a good representation of different EU countries at the event, which would provide an opportunity to understand the status of green biorefining across Europe and which steps need to be taken to successfully implement the technology.
The invitees received personal invitations two months before the event. At a later stage, the invitation was also published on the GO-GRASS website and social media.

PARTICIPANTS

The participants, who are listed in the table below[1], came from 7 different EU countries, representing 23 different companies, organisations and universities.

Different GO-GRASS partners' representatives were present at the event.

[1] The participants agreed for their names to be publicly available in this GO-GRASS report

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

From the Danish GO-GRASS Demo team: Morten Ambye-Jensen (Aarhus University Foulum) as the key speaker, Michael Støckler (Food & Bio Cluster Denmark), Karen Thorsted Hamann (IFAU) and Stine Rasmussen (AU).

From Prospex Institute Carolyn Brand as the lead moderator, Katharina Faradsch and Bent Sorensen as group moderators and Sara Chiba as event coordinator.

Additionally, Carmen Socaciu and Anna Paulusz from the GO-GRASS partner Gate2Growth joined the event, as the topic was also beneficial to other GO-GRASS partners.

The workshop was held entirely in English because of its international nature.

	Name, surname	**Company/Organisation**
1	Anna-Lovisa Nynäs	Swedish University of Agricultural Sciences
2	Anna Paulusz	Gate2Growth
3	Aoife Healy O'Driscoll	Carbery Group
4	Bente Møller Marcussen	Energibyen Skive
5	Birgit Bonefeld	Aarhus University
6	Bob Lambrechts	Grassa
7	Bram Koopmans	Grassa-BV
8	Carmen Socaciu	Gate2Growth
9	Cathy Stummann	Energibyen Skive, Skive Municipality
10	Christel Cederberg	Chalmers University of Technology
11	Damian Lopez Fetzer	BCE Aarhus University
12	Gavin Hunt	BiOrbic
13	Håkan Rosenqvist	Agroväst, Chalmers, Own enterprise
14	James Gaffey	Munster Technological University
15	Johan Sanders	Grassa
16	Joseph Sweeney	University College Dublin
17	Karen Hamann	IFAU Institute for Food Studies & Agro Industrial Development
18	Kira Kalsen Nissen	SEGES Innovation
19	Knud Tybirk	Fbcd
20	Kristian Knage-Drangsfeldt	Vestjyllands Andel
21	Laila Thirup	BioRefine Denmark A/S
22	Lene Stødkilde	Aarhus University
23	Marketta Rinne	Natural Resources Institute Finland

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

24	Martin Weisbjerg	Aarhus University, Dep. of Animal and Veterinary Sciences
25	Merete Sørensen	Aarhus Universitet
26	Michael Mandl	TBW Research
27	Michael Støckler	Food and Bio Cluster Denmark
28	Morten Ambye-Jensen	Aarhus University
29	Nina Hilsted Gemal	The Danish Agricultural Agency
30	Noel Ryan	Premier Green Energy
31	Poul Erik Lærke Lærke	Aarhus University
32	Sean O'Grady	Premier Green Energy
33	Steffen Adler	Nibio
34	Stine Rasmussen	Aarhus University
35	Thalles Andrade	Aarhus University
36	Wim Van Doorn	Grassa

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

2. The event process

2.1 Introduction to the demo and project

The lead event moderator, Carolyn Brand from Prospex Institute welcomed the participants to the workshop, introduced the hosting GO-GRASS partners, presented the agenda and highlighted that the intention behind this event is completely open communication as the aim is to discuss and learn from each other so everyone can benefit from the immense knowledge and experiences the participants poses. The welcome was followed by the opening presentation by Morten Ambye-Jensen who introduced the GO-GRASS project and presented the Danish Demo story on green biorefining. The presentation included:

- Research and development done before the GO-GRASS project;
- Potential economics and production scenario;
- Research and development done in scope of GO-GRASS project;;
- Current status of green biorefineries in Denmark
- Future prospects: development of higher value products and optimal use of resources.

All presentations are available at the end of this report as Annex.

2.2 Green biorefinery opportunities, challenges and developments in the regions across Europe

Carolyn thanked Morten and introduced the first set of key speakers to the event participants. The 6 following presentations on green biorefinery status across EU were the basis for the 1st interactive group exercise that was carried out later in the day.

- Michael Mandl from TBW Research and Joe Sweeney from University College Dublin presented the LIFE-farm4more project and current biorefinery challenges, highlighting the system integration, technology and economic optimization, as well as opening up an important question regarding quantification of add-on benefits of green biorefining.
- The second presentation was held by Johan Sanders from GRASSA who emphasized the benefits of green-biorefining and the importance of green protein for the future.
- Marketta Rinne from Natural Resources Institute Finland, highlighted the current status, opportunities, challenges and developments of green biorefineries in Finland and provided some interesting insight into grass treatment.
- Christel Cederberg from Chalmers University of Technology explained the current status of green biorefining in Sweden, highlighting the importance of holistic approach and collaboration among research, farmers, industry and society.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

- James Gaffey from Munster Technological University, presented Ireland´s status, providing some insight into improvement of protein efficiency of grass and mentioned governmental efforts towards technology developments. Additionally, he also emphasized the importance of collaboration with farmers.
- Steffen Adler from NIBIO, concluded the first section of the international event with a presentation on green biorefineries status in Norway, similarly highlighting the challenges and opportunities, as well as providing important information from other interesting green biorefining projects.

Through all the presentations, common needs across EU countries were noticeable:

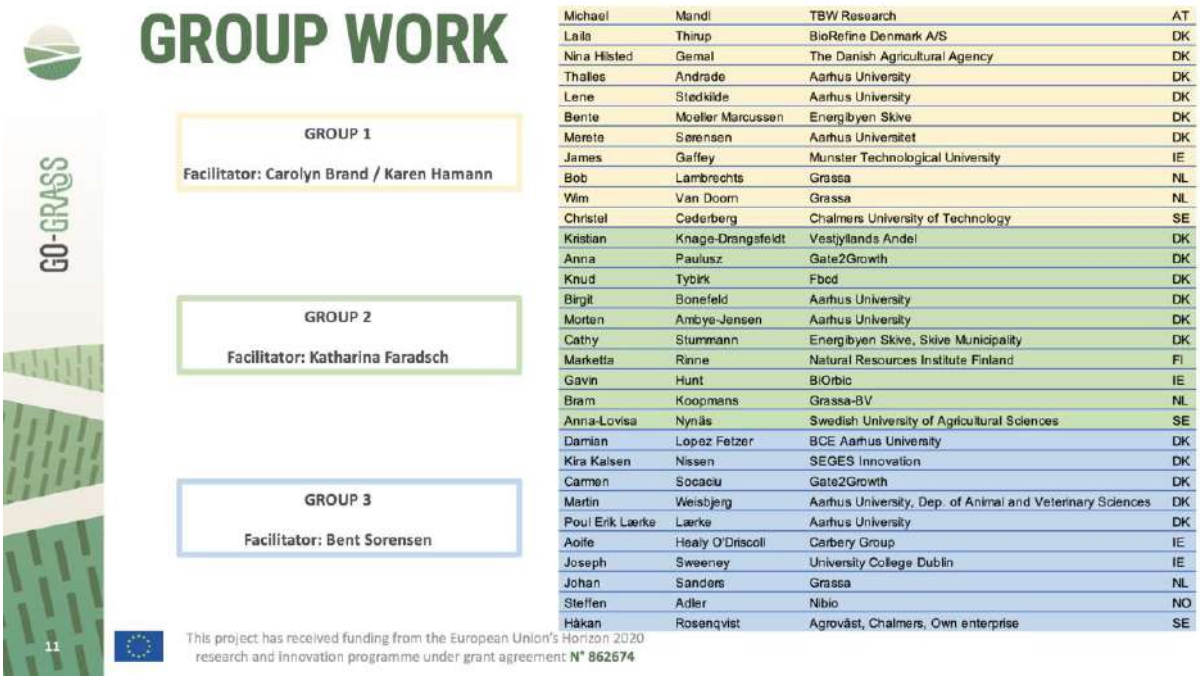
- Importance of collaboration among research, industry, government and society;
- Attracting investments;
- The need for technical and economical optimization of production;
- The creation of an effective business ecosystem, taking into account the holistic approach (economy, environment, food and energy security);
- Potential diversification of grass use;
- Societal acceptance of novel products.

2.3 1st interactive exercise

Following up on the presentations that highlighted the status of green biorefining across Europe, Carolyn Brand presented the group exercise that would help the participants tackle and potentially answer some of the question posed in the initial phase of the international event. The 1st interactive exercise focused on the identification of green biorefinery opportunities across Europe and the participants were asked to identify opportunities for innovation, replication and commercialisation of green biorefineries in Europe.

For the purposes of the exercise, the participants were divided into three working groups. The participants were pre-assigned into groups by Morten Ambye-Jensen, to ensure a versatile representation of counties and companies/universities/organisations in each group. The three group were led by Prospex Institute moderators, Carolyn Brand, Katharina Faradsch and Bent Sorensen to guarantee a quality approach to the topic in question.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674



Michael	Mandl	TBW Research	AT
Laila	Thirup	BioRefine Denmark A/S	DK
Nina Hilsted	Gemal	The Danish Agricultural Agency	DK
Thalles	Andrade	Aarhus University	DK
Lene	Stedkilde	Aarhus University	DK
Bente	Moeller Marcussen	Energibyen Skive	DK
Merete	Sørensen	Aarhus Universitet	DK
James	Gaffey	Munster Technological University	IE
Bob	Lambrechts	Grassa	NL
Wim	Van Doorn	Grassa	NL
Christel	Cederberg	Chalmers University of Technology	SE
Kristian	Knage-Drangsfeldt	Vestjyllands Andel	DK
Anna	Paulusz	Gate2Growth	DK
Knud	Tybirk	Fbcd	DK
Birgit	Bonefeld	Aarhus University	DK
Morten	Ambye-Jensen	Aarhus University	DK
Cathy	Stummann	Energibyen Skive, Skive Municipality	DK
Marketta	Rinne	Natural Resources Institute Finland	FI
Gavin	Hunt	BiOrbic	IE
Bram	Koopmans	Grassa-BV	NL
Anna-Lovisa	Nynäs	Swedish University of Agricultural Sciences	SE
Damian	Lopez Fetzer	BCE Aarhus University	DK
Kira Kalsen	Nissen	SEGES Innovation	DK
Carmen	Socaciu	Gate2Growth	DK
Martin	Weisbjerg	Aarhus University, Dep. of Animal and Veterinary Sciences	DK
Poul Erik Lærke	Lærke	Aarhus University	DK
Aoife	Healy O'Driscoll	Carbery Group	IE
Joseph	Sweeney	University College Dublin	IE
Johan	Sanders	Grassa	NL
Steffen	Adler	Nibio	NO
Håkan	Rosenqvist	Agroväst, Chalmers, Own enterprise	SE

Figure 1: Working group division

Group 1

Group 1 was led by Carolyn Brand, who was accompanied by Karen Hamann from IFAU.

BIOREFINERY OPPORTUNITIES

The following biorefining opportunities were identified in working group 1. The proposals were clustered in the following overall categories:

Commercialisation benefits

- Benefits for the farmers (from raw material point of view, as well as end-user point of view) - a need for a suitable communication in the start of the process, for it to be valued and appreciated.
- An overall framework – collaboration – sharing knowledge, sharing ideas good practices across EU. How can experiences from Denmark help replicate the technology. The use of best practices where they fit best.
- Standardisation across EU – a need for an EU level framework that enables standardisation.
- Top-up / top-down approach - connected to policy. How to incentivise – following from the framework at the EU level. (e.g., if farmers don´t grow crops, they are incentivised to do so – they are paid money not to grow too many same crops. On the other side of the spectrum, there is no incentive for farmers to produce the green material for the green biorefineries.
- If you are an organic farmer there are subsidies, but being an organic farmer is not broad enough to cover farmers that use biorefinery products or side products. How can we incentivise this – because this can have an impact to make a change.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

- Product and market diversification: by-products - which ones have the highest value. Might be the lowest volume but might be the highest value (e.g., pet feed)
- Protein in the EU – desensitise protein imports. How can we turn the green protein into end-product. How can we incentivise the farmers/public to use protein that is grown and produced in EU – incentivise EU protein and desensitise importation.
- Circular economy: The different by-products that are produced – the liquids, the biogas the powder. How can every single element of grass be used.
- Training and education – school for PhD students – vocational education, training for farmers, young farmers, agriculture students. How can we incentivise the new generation of farmers to want to be more sustainable, to want to be climate friendly farmers.
- Business optimisation – how to move away from organic farming title (the only profitable title - if you can prove you are an organic farmer, you can sell your products at a higher price). Could we expand organic farming and call it climate farming – you are not just producing organic food/product, but you are also thinking of the climate – you are thinking of circular economy.
- Business optimisation
- Regulation - the regulatory bodies; how can we encourage them and influence them to come up with the right policies that underpin the opportunities for green biorefining.

LCA ideas

- Solve the challenges with the difficulty of complicated business model;
- Define and execute a funding scheme (present agricultural system that needs change, high value new market, collaborate with textile and fibre industries (not only looking at the protein and biochar), innovation, diversifying applications, investigate the fermentation of brown juice to produce high value products);
- Define a EU wide policy framework that supports green biorefineries - share best practices, protein education, raw material efficiency – meeting multiple needs – also to do with business optimisation, a need for more biomethane production, cascading – use more of the by-products, framework to support the circular economy, standardisation, define and characterise a feed quality standard for grass protein in feeds;
- Plant optimisation – how to optimise the plants (because you can´t produce green protein as the plants don´t grow all year – cross fertilisation of technology and plants to optimise it – use it at full capacity which would improve the business case);
- Increasing competitiveness of primary sectors from a farmers point of view;
- Technoeconomic assessment of pairing different scenarios.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

Group 2

Group 2 was led by Katharina Faradsch, who was accompanied by Morten Ambye-Jensen from Aarhus University Foulum.

BIOREFINERY OPPORTUNITIES

The following biorefining opportunities were identified in working group 2. The proposals were clustered in the following overall categories:

ICT

- Idea of creating a common database to share samples of different technologies, different techniques from different universities and organisations – it is important to work with existing organisations because there is already a lot of developments with the potential to build on.
- A need to identify more synergies working together – knowledge network with all actors – important to create opportunities for exchange (not just for specific partners) with all actors that can additionally have specific networks per actor type but it is also important that there is a network building on knowledge with all actors involved.

Awareness raising and skill development

- Especially among industry and farmers/actors in the farming field – to get them exposed to new ideas, either by biorefining cooperatives or by farmers associations – build a local network, provide farmers advisory and support services so they know what is happening, what are the possibilities before they make a decision whether they want to be part of something new.
- A need to organise farmer markets and fairs in addition to a yearly Pan-EU event and have it decentralised in different locations to create awareness among those that are an important link in the biorefining process (farmers, industry partners).

Education and wider outreach

- Broader public: teaching in public schools to raise awareness among a larger group of people but also have PhD courses and science organisations that can play an important role.

Product diversification

- The opportunities related to products – product diversification for feed products, food products and non-food/feed products. Feed products: alternative for poultry feed in private households, improved liquid feed stability for pigs, full grass diet for dairy cows (silage supplemented with liquid fractions) – different components of green protein process that could potentially be further explored as feed products. Non-food/feed: wool alternative from green grass protein, insulation material.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

Technology development

- Mobile units/technologies to reduce transport costs (huge impact),
- Integration into existing biogas plants,
- Value chains which would further technology development,
- Split the process for logistics optimisation (reducing costs, developing technology).

Business case (linked to technology)

- Redeveloping a robust business case – robot harvesting (less labour intensive),
- Create business cases for smaller biorefineries (is it possible?) – consequently decentralised processes,
- Combining the fresh and the silage produce to make it a yearly production, not production depending on the summer months (looking into possibility of using silage in the winter months).

Climate change and resilience (outside of area of influence)

- Potential to create opportunity (droughts in Europe – more grass is growing because it is more resilient compared to other crops – if you have more grass you also need opportunities to use this grass).
- Water holding capacity of grass is higher – argument to produce more grass. Using necessity for climate change and resilience in favour of grass-based protein production.

Investment and funding

- Important to secure the financing through subsidies or investors at different scales.

Policy and lobbying (decisions and steering)

- Identified as very important, because only with the help of governments on legislation on the novel food regulations there is a potential for something that can be implemented and widely spread across Europe.
- Public monetary compensation for ecosystem services that are provided by grasslands – public incentive to have more grasslands is welcome and could be a push for green biorefineries.
- Politicians – to consider grassland as one of the priorities.
- Fair price on soy (indirect) – if soy is more expensive, green protein for feed could more easily be an alternative.

Connections between different clusters of opportunities: product diversification is influenced by policies (if there are appropriate policies in place there is a bigger incentive to increase product diversification). Policy and legislation also have an influence on financing – only when there is stable legislative framework, investors are more likely to invest, if they know that in a couple of years this will be a viable business model. Policy also has an influence

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

on climate change adaptation and resilience measures. Also, a link between knowledge/awareness raising/education and investments – if there is a good knowledge base, then people would know how to raise investments and get the funding.

Group 3

Group 3 was led by Bent Sorensen, who was accompanied by Michael Støckler from Food & Bio Cluster Denmark.

BIOREFINERY OPPORTUNITIES

The participants in working group 3 posted some 30 proposals on opportunities for the future of green bio-refinery in Europe. The proposals were clustered in the following overall categories:

Organisation and collaboration

- Structure
- Data collection
- Education – PhD-network
- Exchange of good practice – results of pilot projects
- Sharing of information on technical equipment/break throughs
- Involving farmers to ensure quality and optimal logistics
- Use fresh grass in summer, silage in winter

End-user products

- Promote animal feed
- Biogas
- Human food products
- Fiber extracting – try new extraction techniques
- Press cake – a business opportunity
- Certification of products

Communication of results and achievements

- Policymakers (EU Commission, national agencies)
- Agricultural organisations
- Media (general and specialised)

Additional ideas:

- Technology database
- Robots for logistics
- Integrate the biorefinery with other organisations to store CO2 and Nitrat
- Better documentation of eco-system services
- Valorization of the fibers, especially where N is limited – paper, packaging
- Valorization of bio-compounds from final products
- Find ways to utilize the biorefinery all year round
- Subsidies on products instead of building biorefineries
- Communicate the advantages of biorefining to European Commission, politicians by White Paper, meetings with national politicians

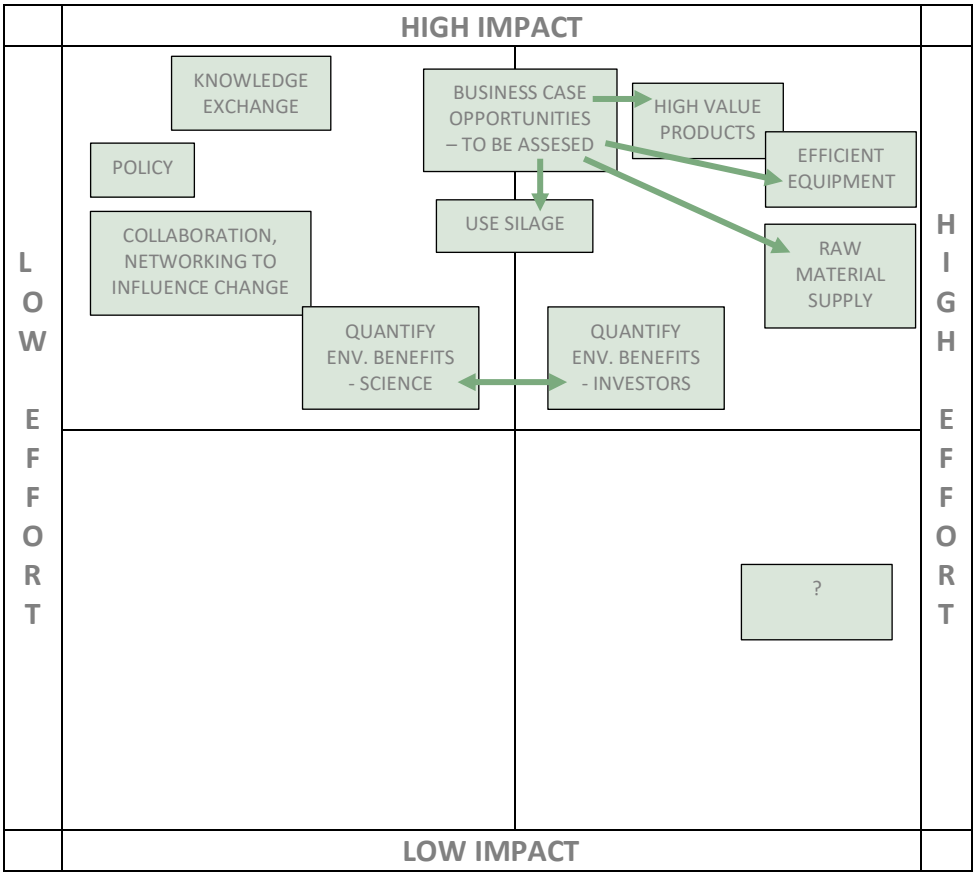
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

2.3.1 HIGH IMPACT – LOW IMPACT

For the second part of the 1st exercise, the groups were asked to position the most important opportunities identified before in a chart, to better understand which opportunities would require more effort, and which less and would potentially be more impactful. This exercise was done, to determine the first steps that should be taken to better replicate the green biorefining technology across Europe.

Group 1

Group 1 was led by Carolyn Brand and Karen Hamann from IFAU. The group positioned identified opportunities in the following quadrats:



Additional remarks:

High impact – low effort

Policy, networking, collaboration, quantifying the benefits from scientific point of view that could be turned into monetary value which could go into quantifying benefits for investors and funding.

High impact – middle effort

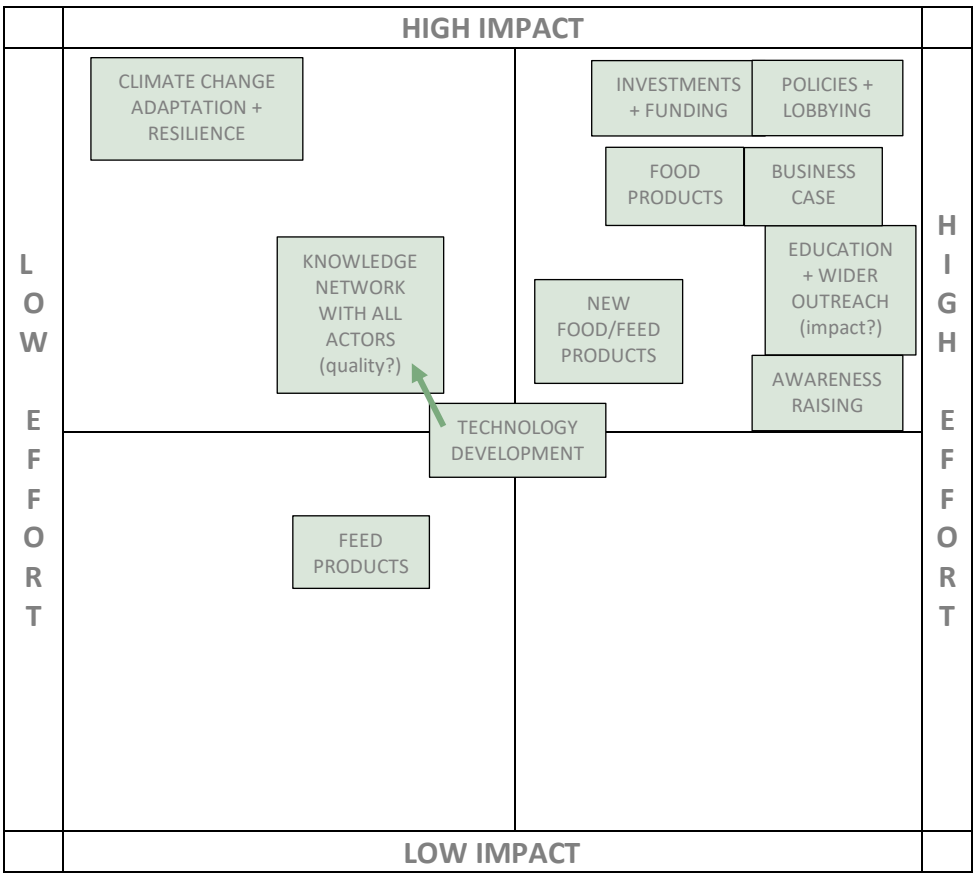
Use silage, assess all the business case opportunities – how to enhance it, more high value products, efficient to use equipment, raw material supply.

Group 2

Group 2 was led by Katharina Faradsch, who was accompanied by Morten Ambye-Jensen from Aarhus University Foulum.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

The group was asked to discuss and position the identified opportunities into corresponding sections of the chart based on their opinion.



High impact – High effort
Investments + funding
Policies + lobbying
Food products
Business case
Education + wider outreach
Awareness raising
Non food/feed products

High impact – Low effort
Climate change adaptation + resilience
Knowledge network with all actors (quality?) → this is the basis for technology development

Middle impact – Middle effort
Technology development

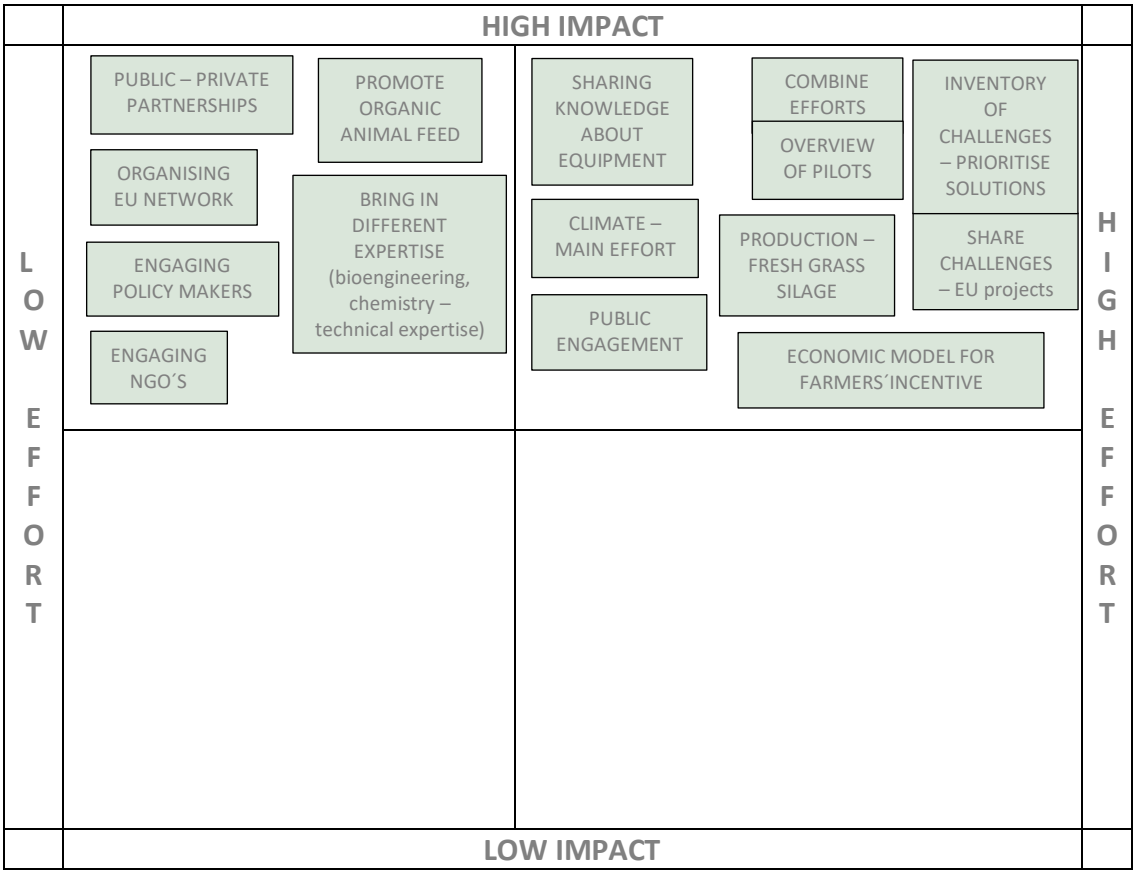
Low impact – Low effort
Feed products

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

Group 3

Group 3 was led by Bent Sorensen, who was accompanied by Michael Støckler from Food & Bio Cluster Denmark.

Group 3 positioned the before identified opportunities in the following quadrats:



High impact – High efforts

Keep focus on main purpose – climate change, reduction of greenhouse gasses, reduction of CO2 footprint
Combine efforts of biorefineries and projects – EU wide overview on pilot projects
Sharing of knowledge – logistics, processes, technical equipment, products etc.
Inventory of challenges – collaboration on solutions
Education/courses in biorefinery - agriculture
All year production – fresh grass/silage
Economic incentives for farmers

High impact – Low efforts

Public-private partnerships
Organising EU-network of biorefineries, researchers and stakeholders
Public engagement – policymakers, stakeholders, NGO's, media, public at large
Promote organic animal feed
Bring in different expertise (bioengineers, chemists, technical expertise etc.)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

2.4 Policy and industry view

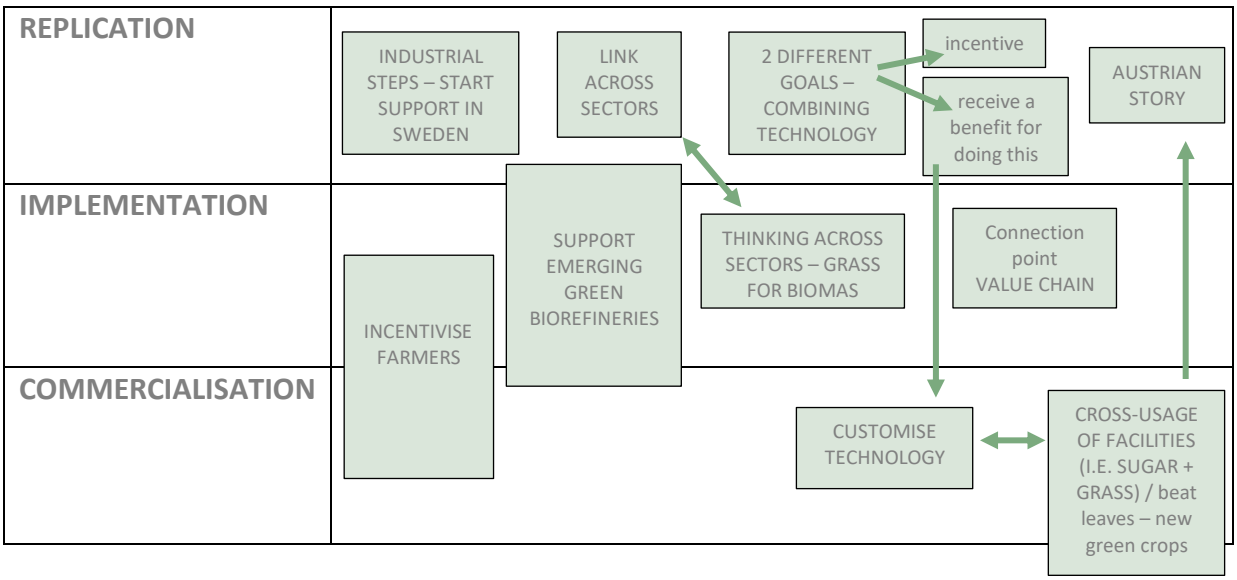
Carolyn Brand welcomed the event participants back into the room after a short lunch break. She introduced the second set of key speakers. The presentations in the second plenary focused on policy and industry, namely policy that could support the replication of biorefining technology and its implementation, complemented by some good practices from industry sector.
The first presenter was Laila Thirup from Biorefine Denmark who presented the biorefining company and its business plan from product to market. Her presentation was followed by Kristian Knage-Drangsfeldt from Vestjyllands Andel A.m.b.a. who presented the company´s activities in the field of biorefining. Another. Johan Sanders from GRASSA rounded up the industry view by providing the Netherlands´ perspective as well as sharing his thoughts on the full potential of grass, with the focus on product diversification.
Nina Hilsted Gemal from the Danish Agricultural Agency provided food for thought when she presented the Danish policy aspect, focusing on the process from political ambition to implementation of subsidies in Denmark.
Lastly, Karen Hamann from IFAU, a GO-GRASS partner presented the White paper which is continuously being developed throughout the project.

2.5 2nd interactive exercise

After the second part of plenary presentations, the participants were again asked to divide into the same three groups as before. The groups then continued discussions based on opportunities identified in the 1st interactive exercise to the topics of Replication, Implementation, Commercialisation and Collaboration.

For this part, the groups agreed on the following:

Group 1



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

COLLABORATION	INNOVATION SUPPORT	CLIMATE FARMERS / CIRCULAR FARMERS

Additional remarks:
Support emerging green biorefinery start-ups, industrialise, link across different sectors, customise technology, address two different key goals by combining technology and incentivising farmers, make the value chain more connected and therefore more valuable (look at the Danish story in regard to ministry and tap into the EU funding – if the Danish farmers can have that, why can´t other EU countries have that also. Learn from the Danish ministry, learn from the Austrian story – 25% of farmers in Austria are organic farmers – how can we increase that to have 50% but call them climate farmers or circular farmers – they are underpinning circular economy, cross usage of facilities and grass and other green crops.

Following the first section of the 2nd interactive exercise, the participants were further encouraged to position the most interesting ideas identified before in three separate quadrats, which would help determine whether an idea should start being discussed, whether the discussions on the idea should continue, and which ideas can already be decided upon.
At this stage, the groups had little time to go in-depth, and the three To Discuss/Keep Discussing/Decided grids below are to be seen as provisoric:

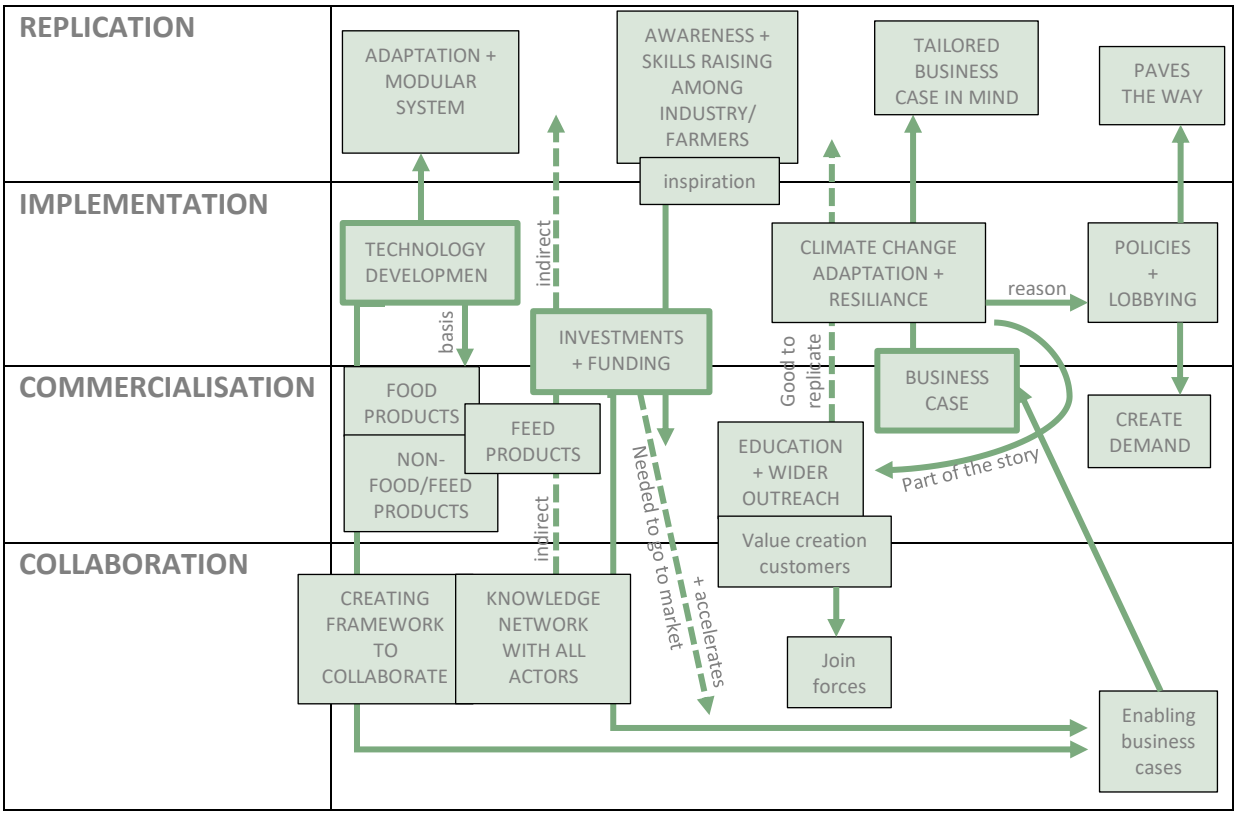
To Discuss	Keep Discussing	Decided
	Cross usage of facilities/equipment	
←	Replication of CAP + EU subsidies + (if Danish can, why can´t all) →	
	Stakeholder management – start talking with EU agencies ↔	Quality environmental + business benefits - Scientific perspective - Regional perspective - EU perspective + - Environmental perspective - Business perspective + market in EU brochures
	Joint research center (JRC in EC) →	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

Additional remarks:

- Cross usage of facilities and equipment underpins all key things from the overall ideas of opportunities (grass and beat leaves in the same facilities, because they grow in different seasons);
- Decided: highly beneficial across EU would be replication of the CAP – EU subsidies (learn from the Danish ministry – how can other ministries in other countries be helped so their farmers can benefit from it;
- Decided: quantify environmental and business benefits from a scientific point of view – can do regionally and from the EU perspective but also from a scientifically environmental point of view (business, market for EU producers);
- Showing the EU and the funders and investors what are the benefits to enhance and support the circular/climate farmers not just organic farmers. How to start doing that?
- Stakeholder management, rather than a green biorefinery network coming up with this idea and suggesting it to an EU body – but rather approach the EU body to start working with them to come up with something they are also looking for;
- Recommendation by the group (James Gaffey) was to contact the JRC in EU Commission and suggest a collaboration - start working from EU perspective to be able to quantify environmental and business benefits of green biorefining –start regional and bring up to the EU level, so that each country's ministry/and EU can see the potential benefits. Start with small steps – scientifically environmental, business, market and then work together to see how it can grow.

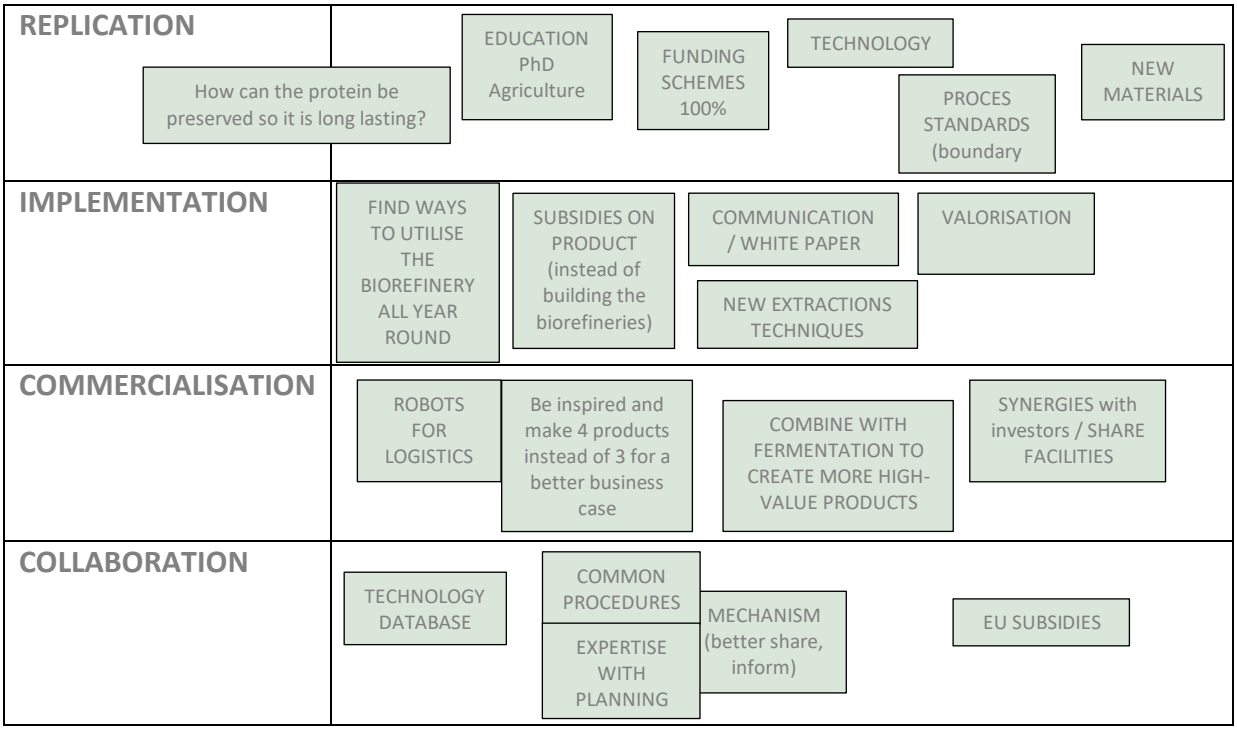
Group 2



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

To Discuss	Keep Discussing	Decided
Climate change adaptation + resilience	Investors (who are most likely investors?) ←	Business case
	Products (so many options) ←	Education (content?)
	Technology development	Policies + lobbying
	Skills	(Open) knowledge network available
		Wider outreach

Group 3



Replication

- Funding schemes, such as the support for feasibility study by the Danish Agricultural Agency
- Education/courses
- Technology
- Standards – boundary conditions

Implementation

- Find ways to utilize biorefinery all year round – combination of fresh grass and silage / a green biorefinery that can use fresh biomass in the summer and ensiled biomass in the winter

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

- Subsidies on products to match the prize of soy
- Try new extraction techniques
- Valorisation of bio-compounds from final products (cosmetics, etc). Valorisation of the fibres (paper, packaging)
- Holistic perspective
- Communicate the advantages of grass biorefining to EU Commission / politicians – White paper. Organising meetings together with national politicians
- Better assessment of eco-system services of grassland

Commercialisation

- Robots for logistics – business opportunity
- Synergies with other industries, share facilities
- Combine with fermentation to create more high-value products
- Synergies with other investors / share facilities:
  - different business consent
  - small – medium – large scale
  - increase knowledge at different levels
  - holistic perspective

Collaboration

- Organising EU-network of biorefineries, researchers and other stakeholders
- EU-network of PhD students in biorefinery
- Technology database
- Common procedures
- Mechanisms to better share/better information (also technical issues + thoughts) – forums / groups
- Apply Danish financing model to build GBR (65%?) to other countries / learn how Grassa found investors without government support to develop the green biorefinery
- Apply major EU subsidies to compare, integrate know-how, speed up green biorefinery initiatives.

To Discuss	Keep Discussing	Decided
Funding – EU-wide	Funding	Education
Business opportunities • products • technology	Business opportunities • products • technology	Collaboration • good practice • challenges
Logistics/planning Harvest/processing	Logistics/planning Harvest/processing	Communication • public • engagement • EU engagement
New materials/innovation	New materials/innovation	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

2.6 3rd interactive exercise

The 3rd and final interactive exercise of the GO-GRASS international event focused on the potential of setting up a Pan-European Network of Green Biorefineries.

Participants were asked to circle around the room and answer four questions. The answers were intended to provide a better insight on how to start the Pan-EU network, most importantly identifying three main points, namely who should be a part of it, what should be the next steps and when should the next steps be taken.

The questions the participants were answering were the following:

- What are your thoughts on setting up a European community about green biorefineries?
- What would be the first steps needed to launch it?
- How do you think we can make it successful?
- Who could/needs to be part of it?

The four event moderators, Carolyn Brand, Bent Sorensen, Katharina Faradsch and Karen Hamann took the participants through the process of identification. Caroly Brand summed up the ideas at the end of the exercise and the results were the following:

WHAT	WHO	WHEN
• Advantages for EU • Set up first launch • Define a peer group • Reach out to other countries (Slovenia, UK, Iceland, Germany, France, Poland, Hungary)	• Norway – Steffen • The Netherlands – Johan • Finland – Marketta • Austria – Michael • Sweden – Christel • Ireland - James • Denmark – Morten (start, potentially have 4-month mandate)	15. June 2023

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

3. Conclusions

Based on the results of the international event on green biorefining it can be concluded that the most important points for the future of technology replication, implementation and commercialisation are the following:

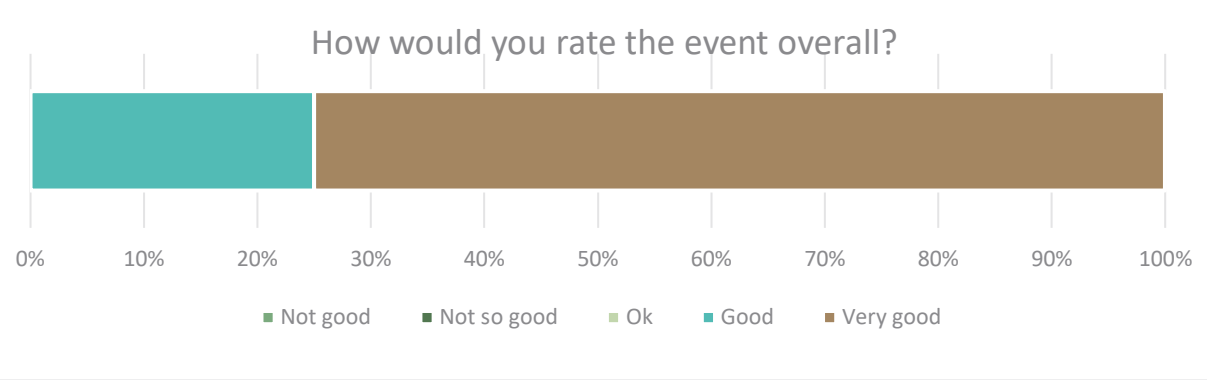
- awareness raising, which would help understand that grass can be an important asset and at the same time influence the policy makers for the right policies to be set up.
- Additionally, cooperation among all actors was emphasized multiple times during the event, including cooperation with farmers, governments, industry and research, as well as cooperation among actors from the perspective of sharing research, sharing facilities, sharing technology, which could consequently help develop a good business plan.

Regarding post-event cooperation, a need for a Pan-EU network of green biorefineries was clearly mentioned and the GO-GRASS international event can be seen as a starting point of EU collaboration among different actors. A month after the event, the GO-GRASS Danish Demo took the initiative and set up the first follow up meeting of the event participants that expressed their interest in being a part of the network.
The work in setting up a functioning network is expected to continue.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

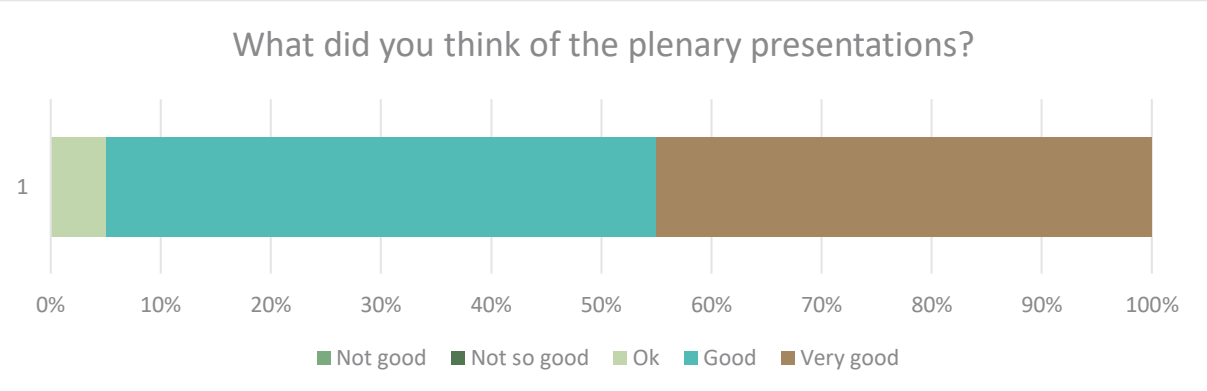
Annex 1: Evaluations

Carolyn Brand closed the workshop by thanking the participants together with Morten Ambye-Jensen. She invited participants to fill in an evaluation form on the workshop. The participants were asked the following questions:



Comments:

Well organized, good discussion
It gives a good overview over what other works with
Too stressed in time
Very good atmosphere. Positive and focused.
Great speakers, inspiring discussions
Strong event with potential High impact
Up to date again, new initiative
Grate organization
Nicely facilitated. Would've been mince to see follower regions from the Go-Grass project, as they would've benefitted greatly from these discussions.
Gratis opportunities to build personal relationships and strong content on the presentations
Super event

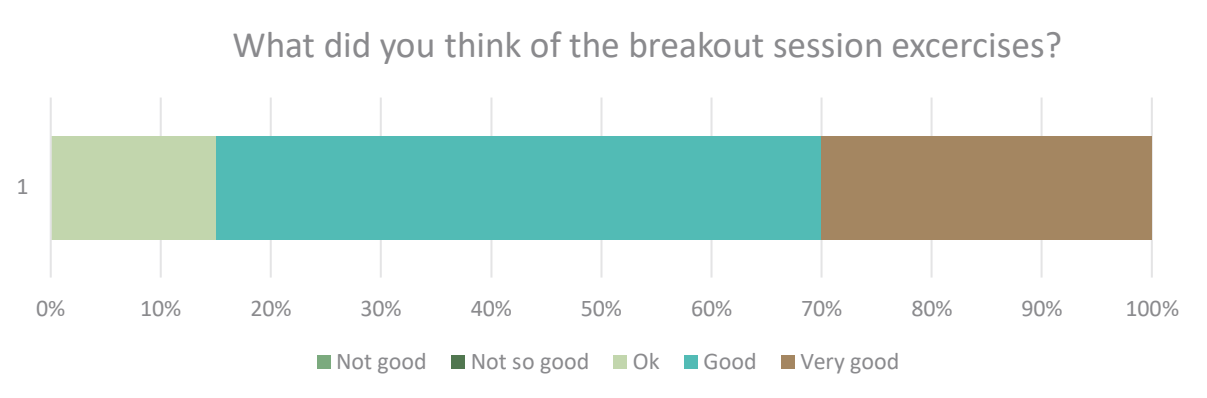


Comments:

Some a bit too detailed as only 15 min were allowed
There was no time for answers unfortunately

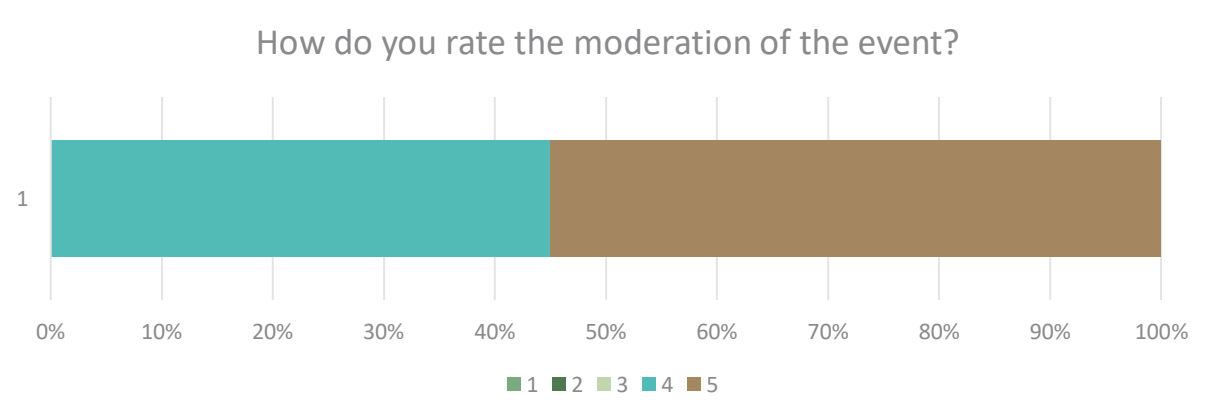
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

Next time it could be more focused, but fine at this first meeting
Great speakers, perfect diversity
A bit of a long stretch for the morning presentations
Really knowledgeable people sharing knowledge

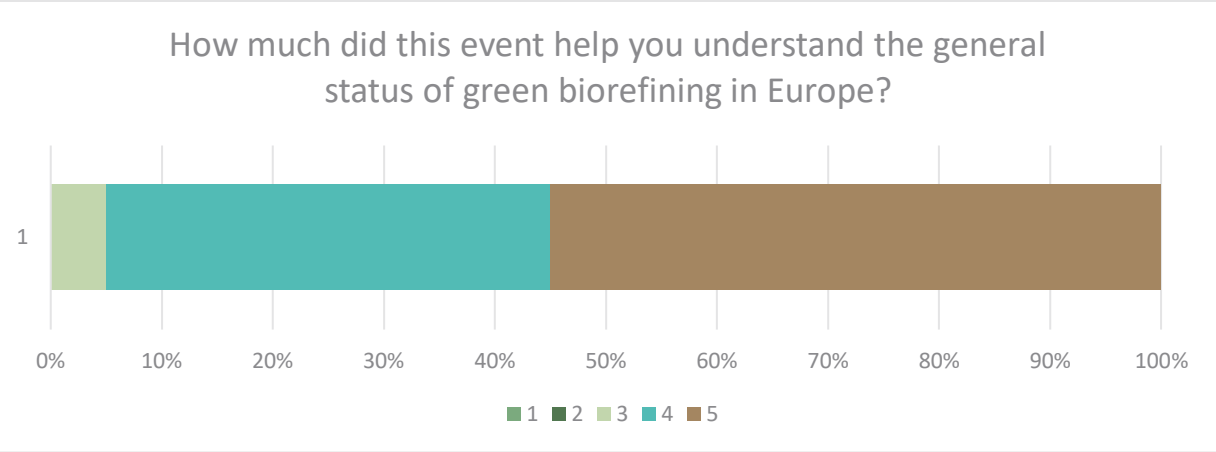


Comments:

Almost very good, but a bit too stressful
Enthusiastic competent facilitation
For me there was to much we should cover
Too little time
Very active!
Nicely organized
Good facilitation to keep on track
Not always clear
Very nice discussions and tangible outcomes



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674



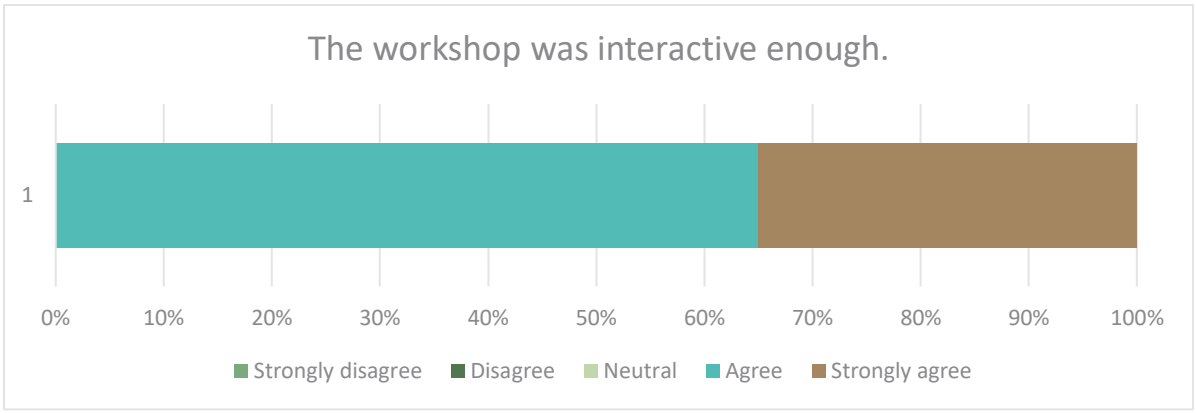
Comments:

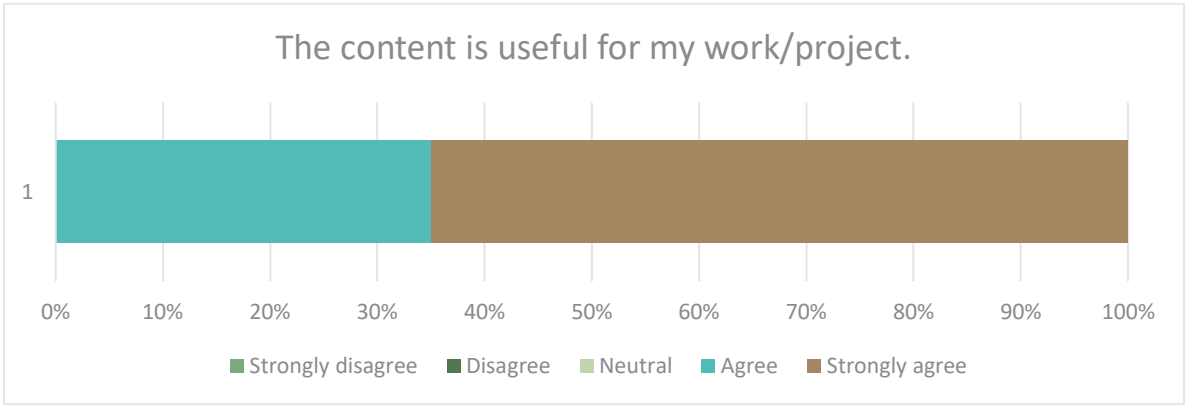
Be aware to distinct between 'green biorefining' and green GRASS biorefining. I got much wiser on the later👍
Got a very well international perspective

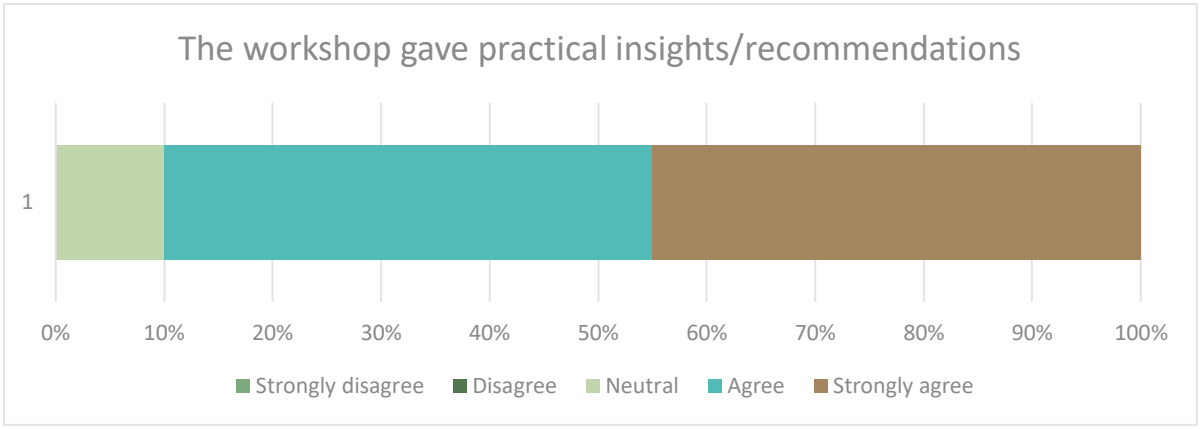
What was completely new to you in this workshop?

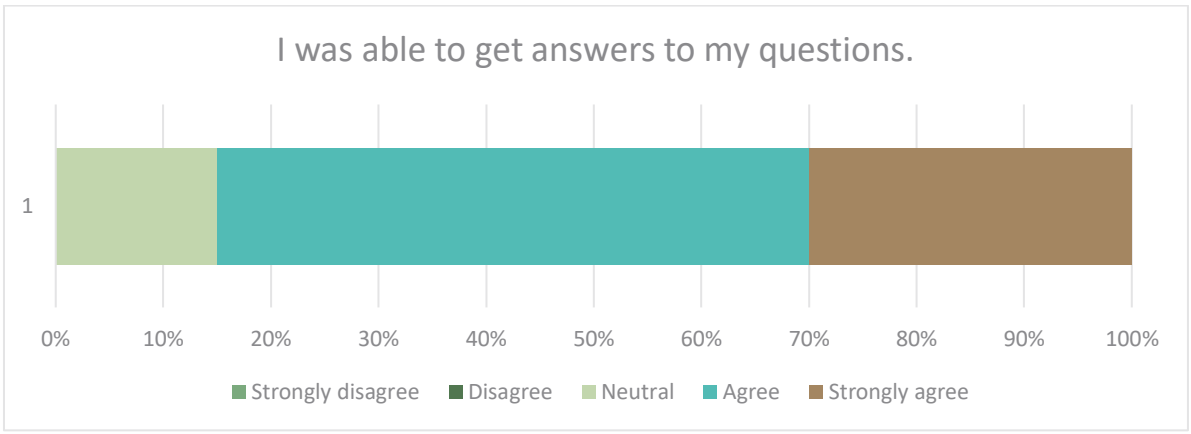
Nothing new
To have a fuller picture of what is on-going in green biorefining
So many works with silage
That the other EU country does not have subsidy schemes
...the amount of Authors on the way
How many we are working in the field of biorefinery
Inspiring new approaches to biorefinery in Europe
Nothing
Brown juice for Manure
Pan European biorefinery initiative
The current level of activities in many countries.
Using grass for cellulose for textiles
Different plants in different countries with similar goals
Pros and cons if Different approaches fresh grass VS silage
That there were so much similar activity in Europe which we didn't not know about
The large bio refinery network that has been around Europe for years and years yet is still far from large scale up
Na
The wide range of biorefinery activities
The funding policy of green biorefinery in Denmark and some of the commercial activity

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

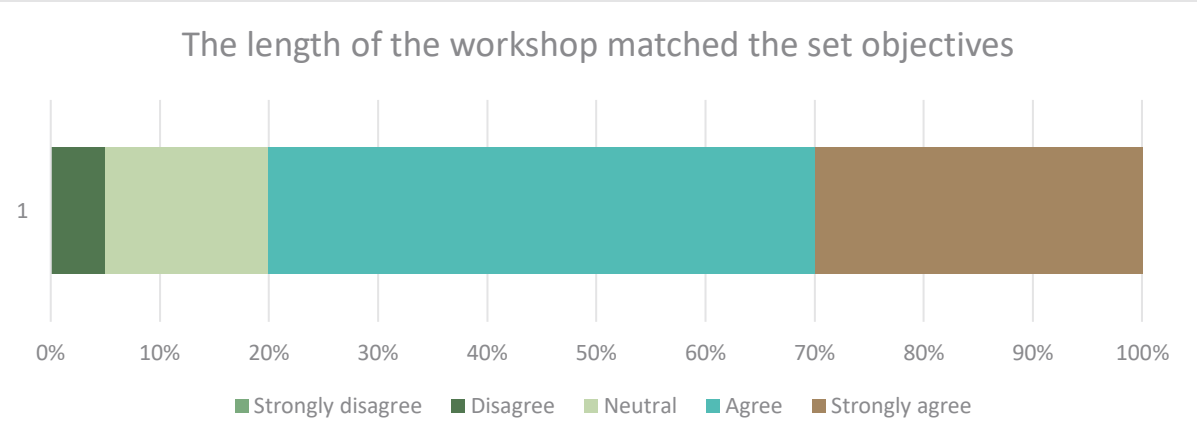








This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674



Comments:

A bit stressing interaction discussion,
2 days would be better
👏
Discussion after plenary speakers would have been good.

Annex 1: Presentations

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°862674

GO-GRASS

International event on green biorefining

24 May 2023

This project has received funding from the European Union's Horizon 2020 research and Innovation programme under grant agreement **N°862674**.

Hosted by the GO-GRASS Danish partners

Aarhus University

Morten Ambye-Jensen

Food & Bio Cluster Denmark

Michael Støckler

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Housekeeping rules

- **Respectful Communication:** Treat everyone with respect and maintain a positive and inclusive environment.
- **Active Participation:** Engage actively in discussions, activities, and exercises. Contribute your ideas, ask questions, and share your experiences to make the most of the workshop.
- **Timing**
- **Open-mindedness**
- **Collaborative Environment**
- **Mobile Device Etiquette**
- **Follow Facilitator's Instructions:** Cooperate with the workshop facilitator(s) and follow their instructions. They are responsible for guiding the event and ensuring a productive and engaging experience for everyone.
- **Enjoy and Have Fun:** Make the most of the workshop by actively participating, networking with others, and enjoying the learning experience.
- Take breaks IF needed, stay hydrated, and maintain a positive attitude.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

OBJECTIVES OF THE EVENT

- Share findings of the **Danish GO-GRASS demo** research and **demonstrate the Green Biorefinery Demo-Platform**
- **Discuss** green biorefining potential across EU, share experiences and learn from each other;
- **Inspire innovation** to transform natural resources of grass land biomass into valuable assets;
- **Enable extensive networking** to explore the potential of future pan-European collaboration.

35 participants
23 organisations and companies
7 countries

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

AGENDA

9:00 – 9:15	**Welcome and introduction**
9:15 – 9:30	Introduction to GO-GRASS and recap of Danish Demo
9:30 – 11:00	Presentations: Green biorefinery opportunities, challenges and developments across Europe
11:00 – 11:15	**Coffee break**
11:15 – 12:15	Exercise: Identification of pan European green biorefinery opportunities
12:20 – 12:50	**Lunch**
12:50 – 14:00	Presentations: Industry and policy view
14:00 – 14:45	Exercise: Effective implementation of green biorefineries
14:45 – 15:30	A European green biorefinery network
15:30 – 15:45	**Closing the workshop**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Introduction to the GO-GRASS project and recap of the Danish Demo

by Morten Ambye-Jensen

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

SPEAKERS

RESEARCH: Green biorefinery opportunities, challenges and developments across Europe	
Michael Mandl / Joseph Sweeney	TBW Research, AT
Marketta Rinne	Natural Resources Institute Finland, FI
Christel Cederberg	Chalmers University of Technology, SE
James Gaffey	Munster Technological University, IE
Steffen Adler	Nibio, NO
Johan Sanders	GRASSA, NL

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

GO-GRASS

COFFEE BREAK

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

GROUP WORK

SESSION 1:

Identification of pan European green biorefinery opportunities which transform natural resources of grass land biomass into valuable assets

SESSION 2:

Industry and policy view

Effective implementation of green biorefining across Europe

SESSION 3:

A “how to” of a pan European green biorefinery network

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement **N° 862674**

50 MINUTES

GROUP WORK

SESSION 1:

Identify opportunities for innovation, replication and commercialization of green biorefinery in Europe ?

Inspire & innovate

- ✓ SHARE IDEAS FREELY
- ✓ NO IDEA IS WRONG
- ✓ NO CRITICISM OR JUDGEMENT
- ✓ THINK OUT OF THE BOX
- ✓ NO LIMITS
- ✓ BUILD ON IDEAS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

GROUP WORK

GROUP 1

Facilitator: Carolyn Brand / Karen Hamann

GROUP 2

Facilitator: Katharina Faradsch

GROUP 3

Facilitator: Bent Sorensen

Michael	Mandl	TBW Research	AT
Laila	Thirup	BioRefine Denmark A/S	DK
Nina Hilsted	Gemal	The Danish Agricultural Agency	DK
Thalles	Andrade	Aarhus University	DK
Lene	Stødkilde	Aarhus University	DK
Bente	Moeller Marcussen	Energibyen Skive	DK
Merete	Sørensen	Aarhus Universitet	DK
James	Gaffey	Munster Technological University	IE
Bob	Lambrechts	Grassa	NL
Wim	Van Doorn	Grassa	NL
Christel	Cederberg	Chalmers University of Technology	SE
Kristian	Knage-Drangsfeldt	Vestjyllands Andel	DK
Anna	Paulusz	Gate2Growth	DK
Knud	Tybirk	Fbcd	DK
Birgit	Bonefeld	Aarhus University	DK
Morten	Ambye-Jensen	Aarhus University	DK
Cathy	Stummann	Energibyen Skive, Skive Municipality	DK
Marketta	Rinne	Natural Resources Institute Finland	FI
Gavin	Hunt	BiOrbic	IE
Bram	Koopmans	Grassa-BV	NL
Anna-Lovisa	Nynäs	Swedish University of Agricultural Sciences	SE
Damian	Lopez Fetzer	BCE Aarhus University	DK
Kira Kalsen	Nissen	SEGES Innovation	DK
Carmen	Socaciu	Gate2Growth	DK
Martin	Weisbjerg	Aarhus University, Dep. of Animal and Veterinary Sciences	DK
Poul Erik Lærke	Lærke	Aarhus University	DK
Aoife	Healy O'Driscoll	Carbery Group	IE
Joseph	Sweeney	University College Dublin	IE
Johan	Sanders	Grassa	NL
Steffen	Adler	Nibio	NO
Håkan	Rosenqvist	Agroväst, Chalmers, Own enterprise	SE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

GO-GRASS

LUNCH

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Speakers

Industry and Policy: Effective implementation of green biorefining across Europe	
Laila Thirup	Biorefine Denmark A/S, DK
Kristian Knage-Drangsfeldt	Vestjyllands Andel A.m.b.a., DK
Johan Sanders	GRASSA, NL
Nina Hilsted Gemal	The Danish Agricultural Agency, DK
Karen Hamann	IFAU, GO-GRASS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

GROUP WORK

SESSION 1:

Identification of pan European green biorefinery opportunities which transform natural resources of grass land biomass into valuable assets

SESSION 2:

Industry and policy view

Effective implementation of green biorefining across Europe

SESSION 3:

A “how to” of a pan European green biorefinery network

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement **N° 862674**

GROUP WORK

45 MINUTES

SESSION 2:

Effective implementation of green biorefining across Europe

Identify which opportunities would underpin success terms of the below topics

1. REPLICATION
2. IMPLEMENTATION
3. COMMERCIALISATION
4. COLLABORATION

DISCUSS / KEEP DISCUSSING / DECIDED

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

GROUP WORK

SESSION 1:

Identification of pan European green biorefinery opportunities which transform natural resources of grass land biomass into valuable assets

SESSION 2:

Industry and policy view

Effective implementation of green biorefining across Europe

SESSION 3:

A “how to” of a pan European green biorefinery network

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement **N° 862674**

GROUP WORK

45 MINUTES

SESSION 3:

How might we build a green biorefinery community

PART 1

a. "What are your thoughts on setting up a European community about green biorefinery?"

b. "How do you think we can make it successful?"

c. “What would be the first steps needed to launch it?”

d. “Who could / needs to be part of it?”

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement **N° 862674**

45 MINUTES

GROUP WORK

SESSION 3:

How might we build a green biorefinery community

PART 2 – NEXT STEPS

- **WHO**
- **WHAT**
- **WHEN**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

GO-GRASS

THANK YOU!

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Event evaluation

(5 minutes)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Follow our journey

@grassEU

GO-GRASS

go-grass.eu

Contact:

go-grass@atb-potsdam.de

Partners

GO-GRASS

[Project coordinator]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Introduction to GO-GRASS & the Danish Demo story on green biorefining

GO-GRASS

Grass-based circular business models
for rural agri-food value chains

GO-GRASS

Grass-based circular business models for dynamic rural communities

This project has received funding from the European Union's Horizon 2020 research and Innovation programme under grant agreement **N°862674**.

The diverse potential of Grassland

GO-GRASS

21*%

of the EU surface Is covered by grassland

Grassland management is **relevant** and of **great interest** for rural communities.

Especially **unused grass** like less productive or less nutritive species and grass from remote/protected areas could open possibilities of **new products** and **value chains**.

*Source: eurostat; EU-28 countries; 2015

The GO-GRASS vision

Upscaling of existing business cases at **local level.**

Replication of existing business cases or models in **other geographical areas.**

Create **additional benefits** for farmers and producers **without competition** to food and feed production.

Highly diverse DEMO sites

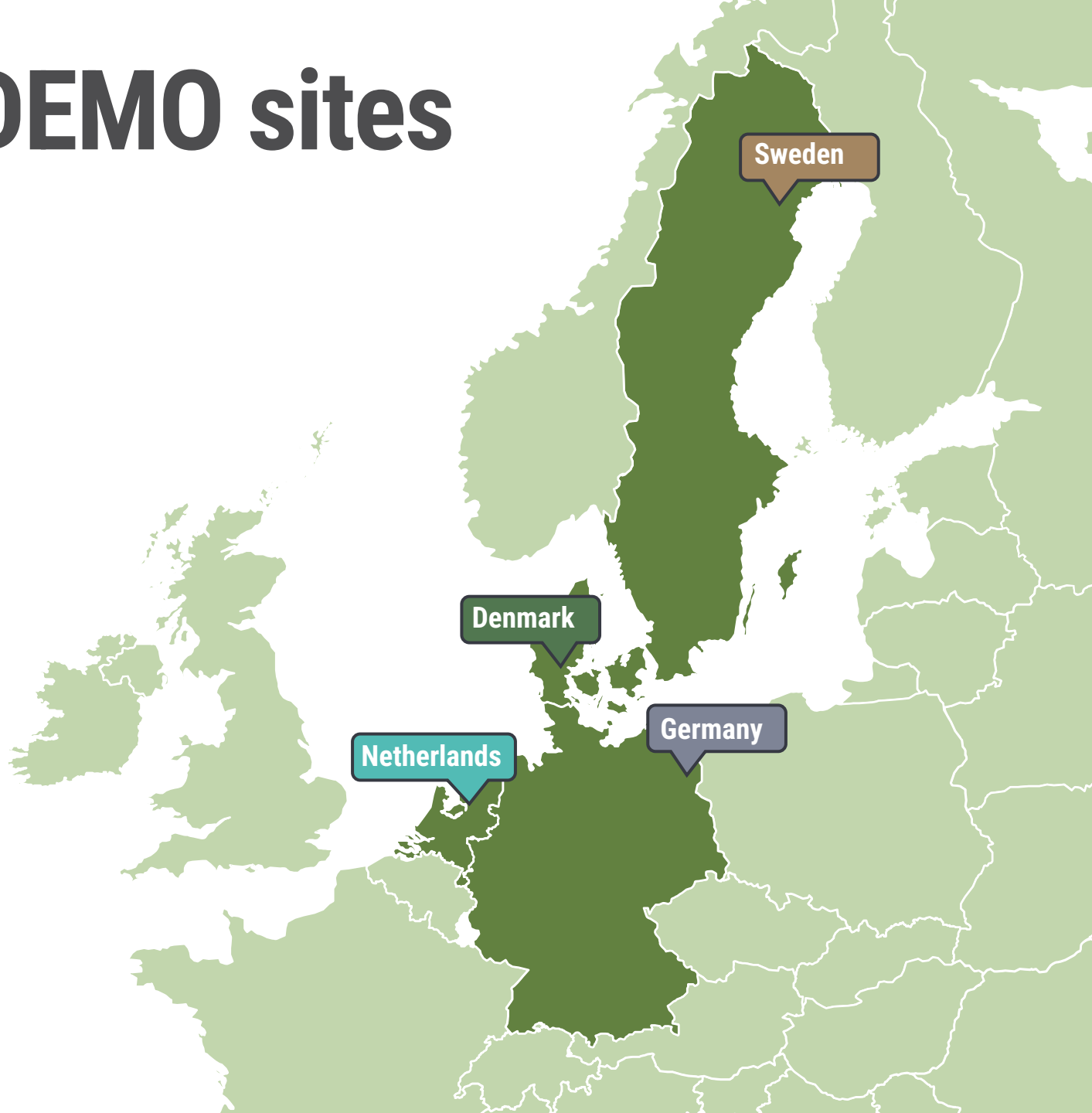
Biomass

Market uptake

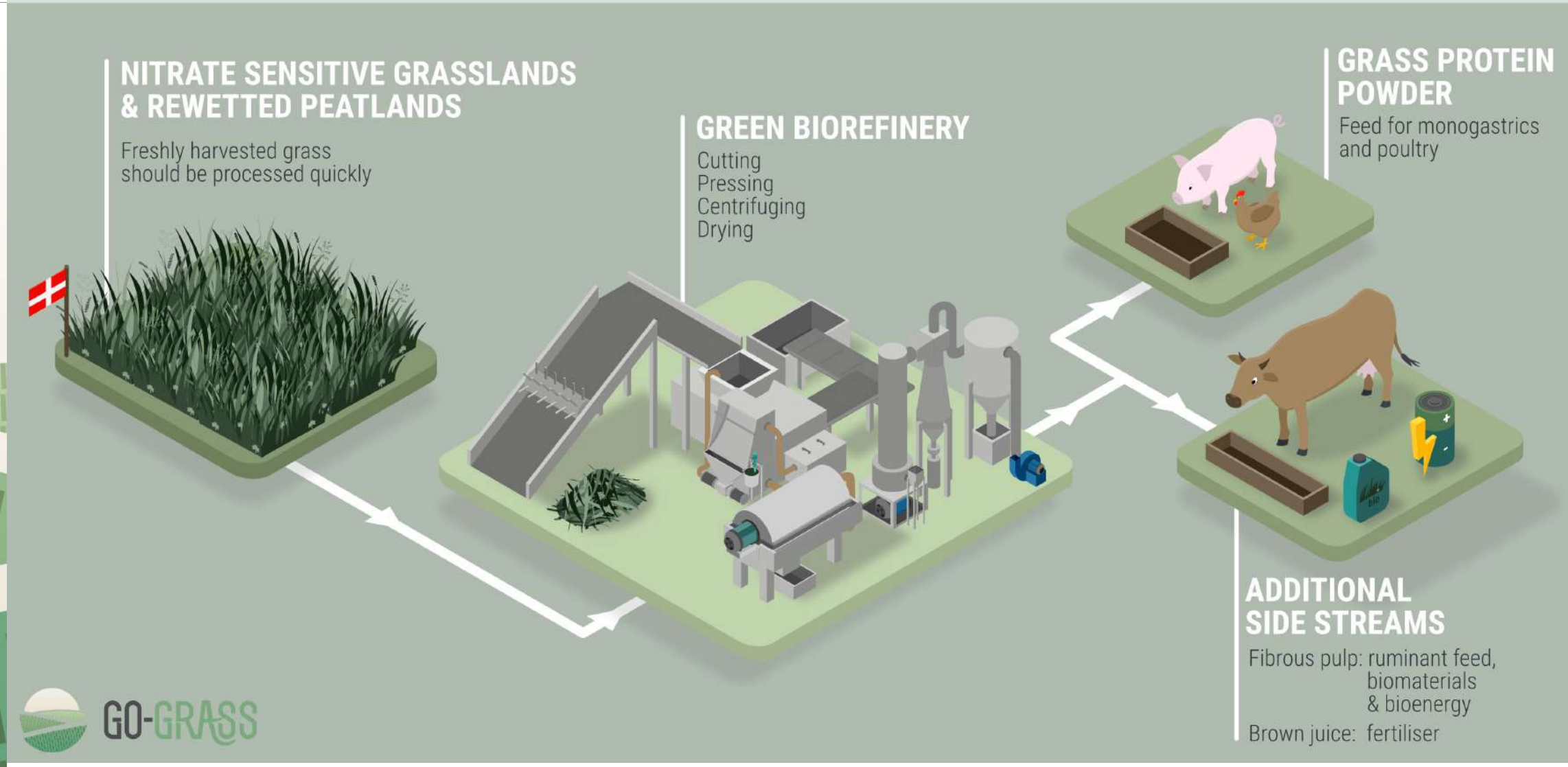
Technologies

Business model maturity and circularity

End-products



Grass protein - sustainable animal feed



Tools and resources

GO-GRASS will develop a set of (online) tools and resources designed for rural entrepreneurs, policy makers and networks.

Online interactive map

Guideline

Accessment & funding

How-to manual

Training courses

Partners

GO-GRASS

ATB Leibniz-Institut für Agrartechnik und Bioökonomie
[Project coordinator]

RI.SE

zabala innovation consulting

Food & Bio Cluster Denmark

Instituttet for Fødevarestudier & Agroindustriel Udvikling - IFAU

GATE 2 GROWTH

A.R.A.D.

European Science Communication Institute ESCI

Greenovate! EUROPE

GLOMMERS MILJÖENERGI AB

Nationalparkverein Unteres Odertal

velas

pi Prospex Institute

Noardlike Fryske Wâlden

SCHUTPAPIER!

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Väståkra Gård

HIEMSTRA BRUIN innovation & technology2market

Application Centre for Renewable Resources ACRRES

ÖMKi Ökológiai Mezőgazdasági Kutatóintézet Research Institute of Organic Agriculture | Forschungsinstitut für biologischen Landbau

CBIO AARHUS UNIVERSITY CENTRE FOR CIRCULAR BIOECONOMY

agaca Asociación Galega de Cooperativas Agroalimentarias

GO-GRASS

Grass-based circular business models
for rural agri-food value chains

Danish DEMO

DK DEMO Partners:

Aarhus University (Dep. of Agroecology, Engineering and Animal Science)
VELAS (Agricultural consultancy – involving local farmers)
IFAU (Institute for foodstudies and agroindustrial development)
Food & Bio Cluster (Cluster of knowledge inst. and industry)
mKjeldal (Consulting for harvest machinery and logistics)

AARHUS UNIVERSITY
mKjeldal
Food & Bio Cluster Denmark
CBIO
AARHUS UNIVERSITY CENTRE FOR CIRCULAR BIOECONOMY
velas

Green Biorefinery in DK

GO-GRASS

Grass-based circular business models
for rural agri-food value chains

After

During

Before

This project has received funding from the European Union's Horizon 2020 research and

CHANGING ANNUAL CROPPING SYSTEMS WITH PERENNIALS

OR

AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

MORTEN AMBYE-JENSEN
ASSOCIATE PROFESSOR

ENVIRONMENTAL REASONS FOR PERENNIAL GREEN CROPS

More perennial green biomass will have several positive environmental impacts.

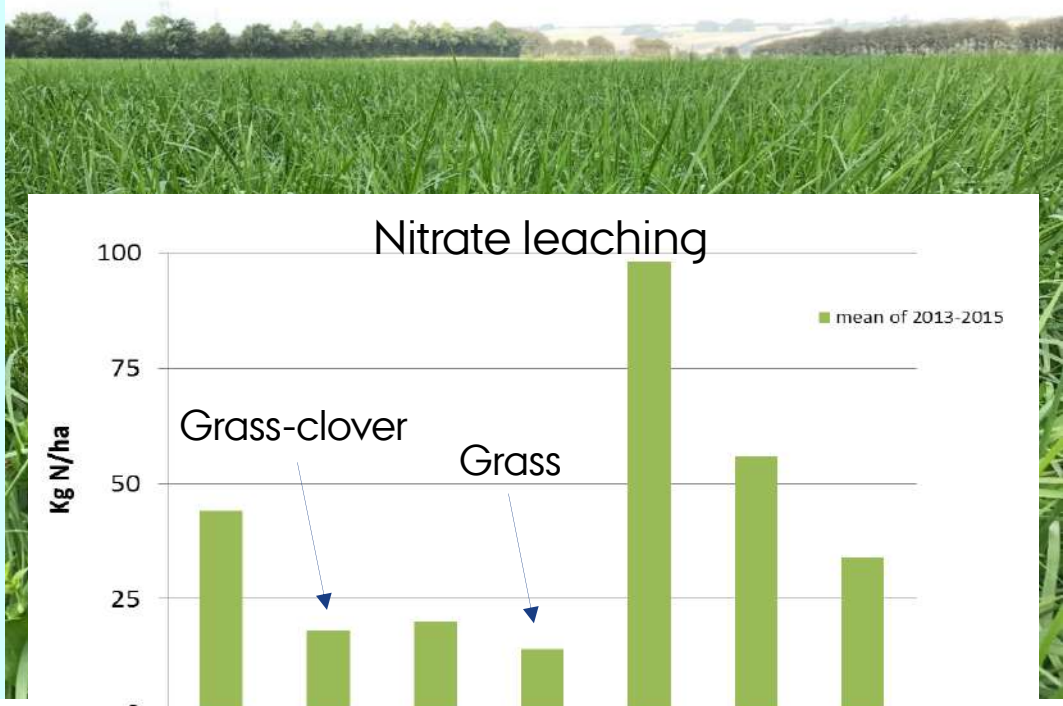
- **Reduced Nitrate leaching compared to cereals and corn**
- **No pesticide use necessary**
- **Positive soil carbon input (for grass around 1 ton C/ha)**
- **Increased biodiversity using crop mixtures (even herbs)**

Manevski, K., et al., Nitrogen balances of innovative cropping systems for feedstock production to future biorefineries (2018) Science of the Total Environment, 633, pp. 372-390.

Manevski, K., et al., Biomass productivity and radiation utilisation of innovative cropping systems for biorefinery (2017) Agricultural and Forest Meteorology, 233, pp. 250-264.

Cong, W.-F., et al., Species interactions between forbs and grass-clover contribute to yield gains and weed suppression in forage grassland mixtures (2018) Agriculture, Ecosystems and Environment, 268, pp. 154-161.

We are specifically focusing on Grasses, Clover and Lucerne



AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

MORTEN AMBYE-JENSEN
ASSOCIATE PROFESSOR

LARGE FOCUS IN DK ON BIOREFINERIES PRODUCING PROTEINS FROM GRASSES AND LEGUMES

DK´s import of soy meal equals to a production area of ¼ of DK area

Several reasons:

- Danish agriculture is one of the worlds most intensive agricultural productions
- World leader in pig breeding and pig meat production - produces 31.8 mio pigs/yr
- → Import of 1 mio ton feed protein per year

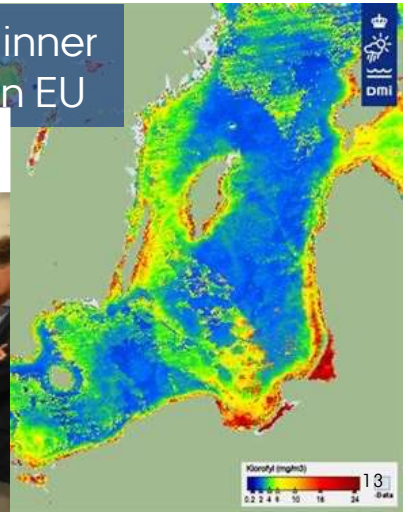
- DK agriculture has environmental challenges, especially with nitrogen leaching.
- Danish agriculture has a specific challenge to apply to the EU Water Directive –next deadline 2027 Directive 2000/60/EC – framework for Community action in the field of water policy

- DK has a committed goal to reduce GHG emissions by 70% in 2030!
- Agriculture is responsible for 25% of total emission

→ Strong political interest for fast implementation

Minister for Environment and Food of Denmark, Jakob Ellemann-Jensen, tasting green protein, 2018

Eutrophication in inner waters in northern EU



AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

BASE CASE VALUE CHAIN

FOCUS ON SIMPLICITY, PRACTICALITY AND BULK APPLICATIONS

Main drivers for the development

Fertilizer

Biogas plant

Manure

Heat/ power

Residual liquid

- Reduced N-leaching
- Reduced pesticide use
- Increased soil carbon

Grass refinery

- Technology R&D for the bioeconomy
- Increase business possibilities in rural areas

Protein concentrate

Fibre

Monogastric animal feed

Ruminant animal feed

Food

- Local production of protein feed
- Reduce environmental impact of animal feed

AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

MORTEN AMBYE-JENSEN
ASSOCIATE PROFESSOR

R&D ON THE GREEN BIOREFINING VALUE CHAIN SINCE 2013
WITH FOCUS ON THE BASE CASE








FIGUR 3: Fodringsforsøg med stigende mængder græsprotein til

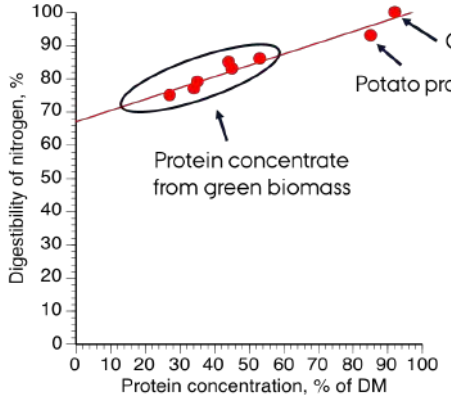
FIGUR 6: Fodringsforsøg med presekage og almindelig græsensilage
til malkekøer (Projekt BioValue).

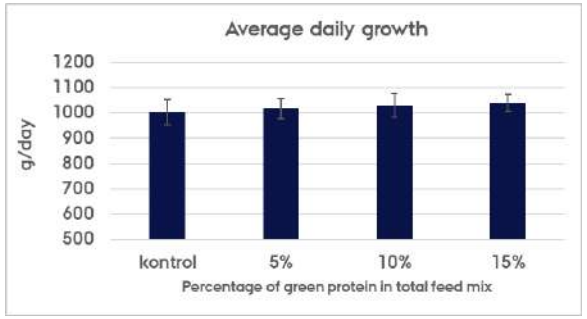
2015

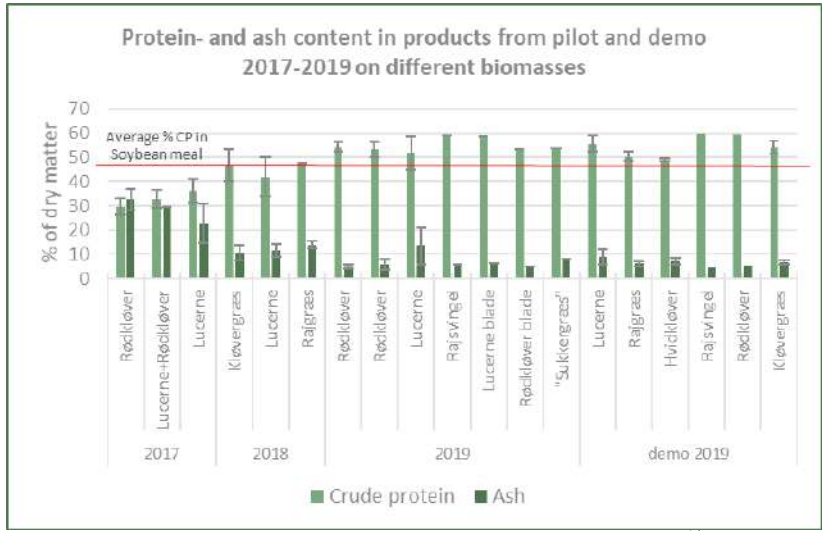
2016

2017

2019







L. Stødkilde-Jørgensen et. al 2021
https://doi.org/10.1016/j.anifeedsci.2021.114943

EARLY EXAMPLE OF ECONOMICS IN A PRODUCTION SCENARIO (2018)

All numbers can vary depending on how we make the refinery and the value chain – important assumptions!

Capacity assumptions:

- 40 ton fresh biomass/hour
- 21.600 t dry matter/year
- 3000 operational hours/year
- In combination with existing biogas

Economic assumptions:

- Biorefinery CAPEX : 3.36 mio EUR
- Depreciation time: 15 year
- 5% Interest rate , 5% Maintenance

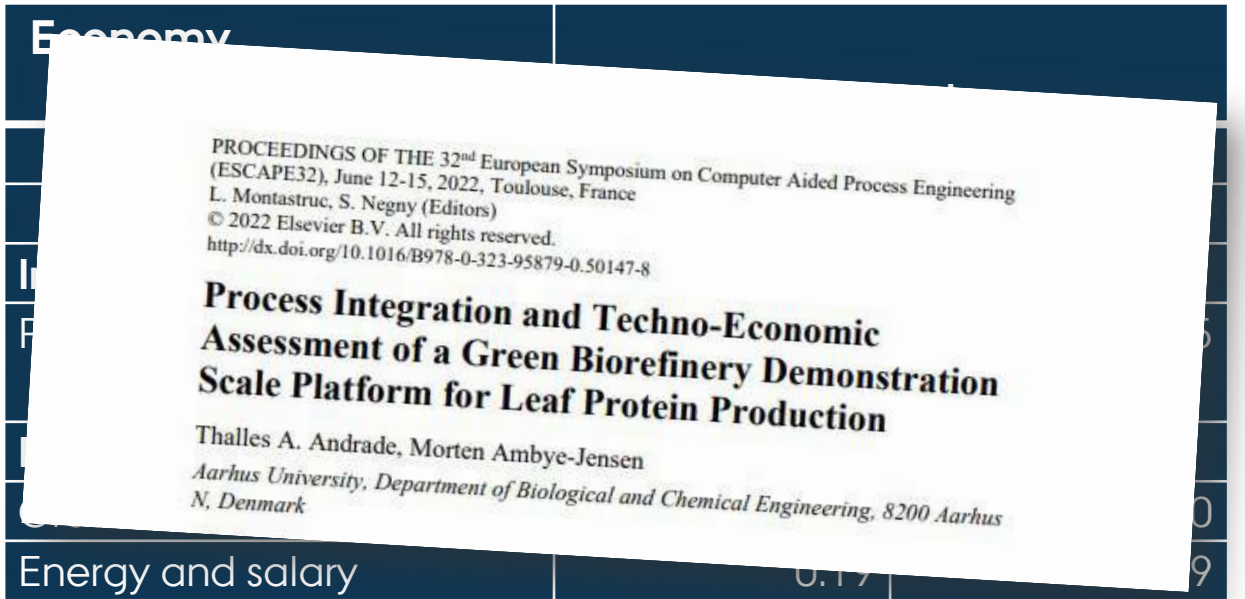
- Grass price
- Organic: 0.15 EUR/kg
- Conventional: 0.13 EUR/kg
- Protein price
- Organic: 0.67 EUR/kg
- Conventional: 0.34 EUR/kg
- Fiber pulp price
- Identical to grass price

- Residue juice is not given either any cost or value - It is used for internal energy production at the biogas plant.

Production		
Protein concentrate	3.643*	t DM/yr
Fiber pulp	15.034*	t DM/yr
Rest juice	2.924*	t DM/yr

* Based on assumed production efficiencies

Economy		
Energy and salary		
Maintenance	0.17	0.17
Depreciation and interests	0.32	0.32
Result	**0.66**	**-0.34**



PROCEEDINGS OF THE 32nd European Symposium on Computer Aided Process Engineering
(ESCAPE32), June 12-15, 2022, Toulouse, France
L. Montastruc, S. Negny (Editors)

http://dx.doi.org/10.1016/B978-0-323-95879-0.50147-8

Process Integration and Techno-Economic Assessment of a Green Biorefinery Demonstration Scale Platform for Leaf Protein Production

Thalles A. Andrade, Morten Ambye-Jensen
Aarhus University, Department of Biological and Chemical Engineering, 8200 Aarhus N, Denmark

GO-GRASS

GO-GRASS

Grass-based circular business models
for rural agri-food value chains

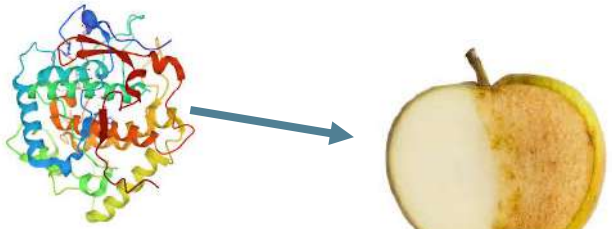
How have GO-GRASS added to the story…?

Focus areas of GO-GRASS DK Demo

- General process optimisation in Demo-scale
  - E.g. Yield optimization
- Test of grassland biomass from paludiculture areas
  - E.g. Tall fescue and Reed canary grass
- Test of harvest methods and logistics
  - E.g. Time from harvest to processing
- Protein concentrate feed trials with pigs testing the digestibility of different protein product qualities
- Press cake fibre feed trial with dairy cows and milk production on farm scale

This project has received funding from the European Union's Horizon 2020 research and

WHAT FACTORS IMPACT THE PROTEIN YIELD?



- **The biomass**, its protein content and especially the distribution of soluble and fiber-bound protein.
- **Biological activity** in the plant that starts immediately after harvest. In particular 1) enzymes that cross-link protein and cause browning 2) enzymes that break down protein into amino acids that cannot be precipitated and centrifuged
- **How we process** that biomass so that as much protein as possible is extracted from the plant, and as little protein as possible is cross-linked and broken down

AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

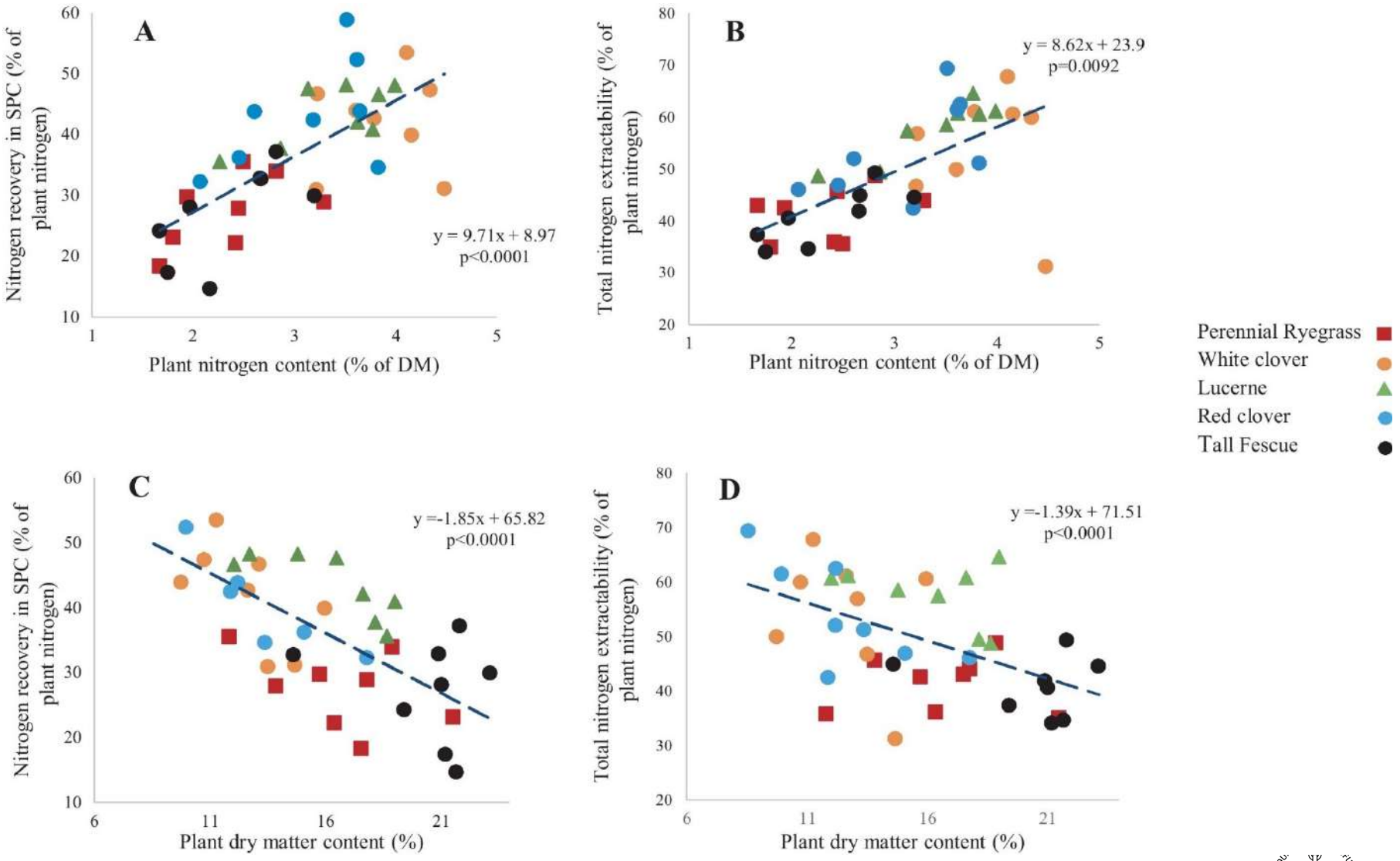
MORTEN AMBYE-JENSEN
ASSOCIATE PROFESSOR

IMPORTANCE OF THE BIOMASS FOR REACHING HIGH YIELDS OF PROTEIN CONCENTRATE

Yield of protein concentrate increases with the plant nitrogen content

Yield of protein concentrate decreases with plant dry matter content

Legumes result in higher yields of protein concentrate than grasses



AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

Enhancing protein recovery in green biorefineries through selection of plant species and time of harvest
Stødkilde, Lene; Lashkari, Saman; Eriksen, Jørgen; Jensen, Søren Krogh; **ISSN:** 0377-8401 , 1873 2216; **DOI:** 10.1016/j.anifeedsci.2021.115016; Animal feed science and technology , 2021, Vol.278, p.115016

OPTIMIZATION OF PROTEIN CONCENTRATE YIELDS

Cutting in-field

Demoscale setup for more severe maceration
→ Higher protein extraction to the green juice

Mixing tank with recir.culated GJ

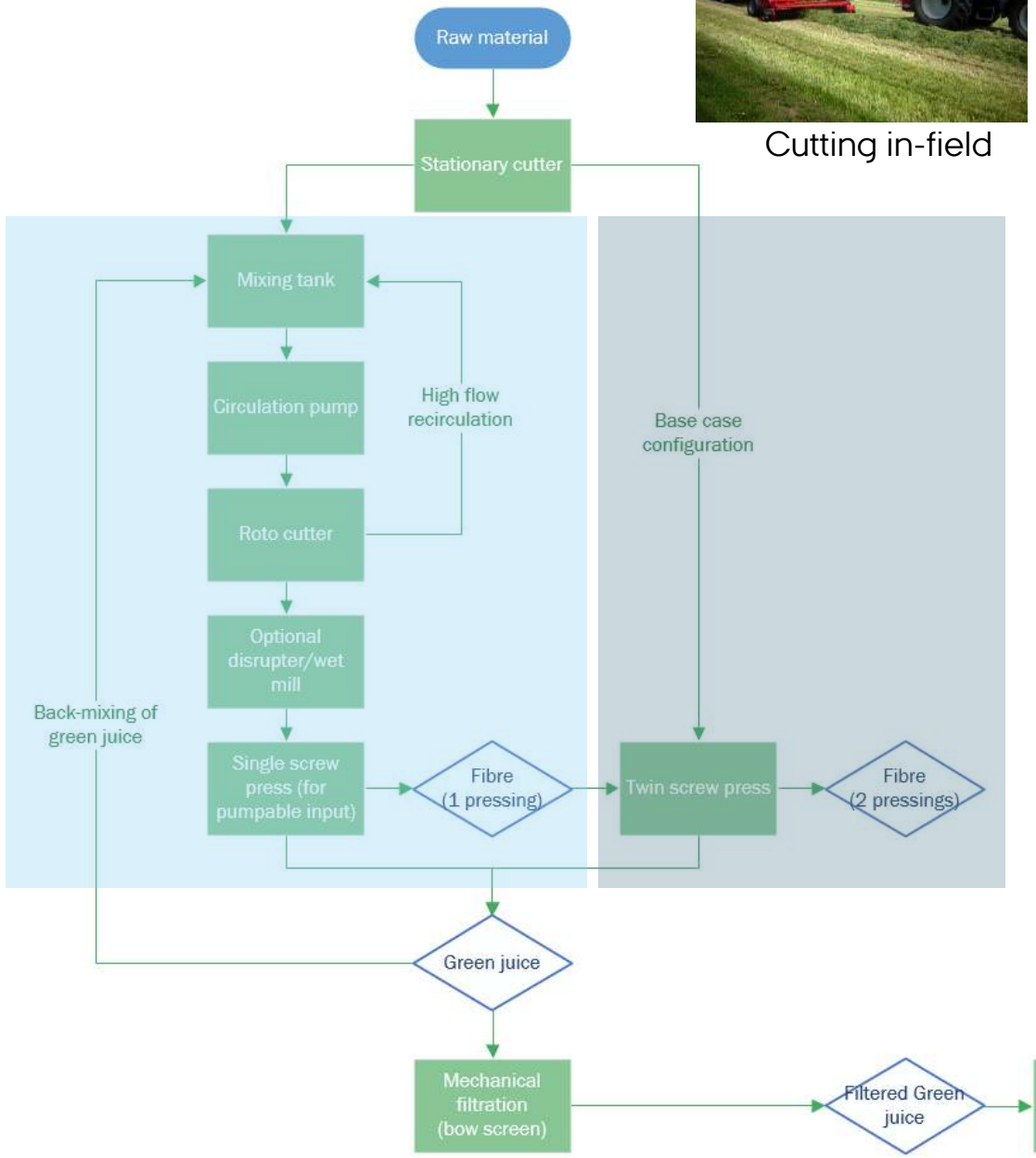
Rota-cutter

Deflaker

Disrupter

Dewatering (press)

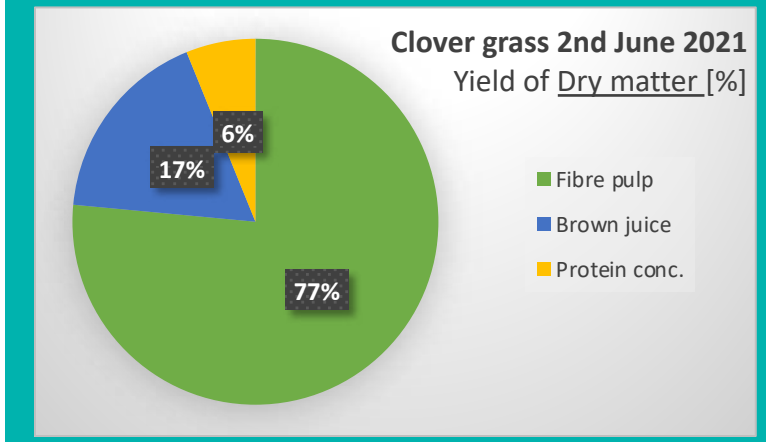
Screwpres

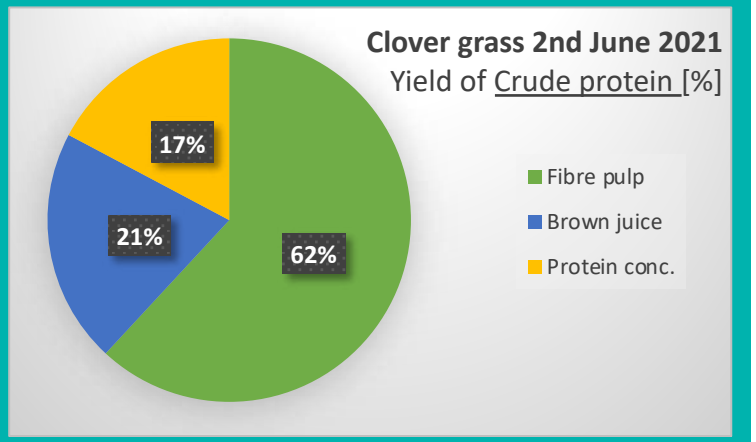


AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

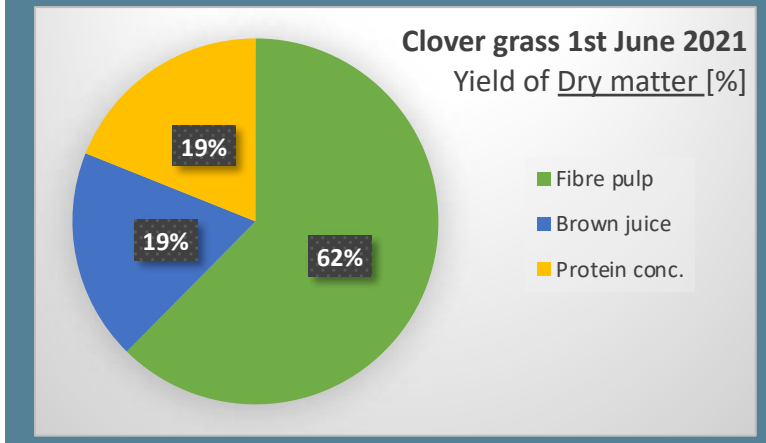
YIELD IMPROVEMENT WITH SEVERE MACERATION TEST 2021, JUNE, GRASS CLOVER

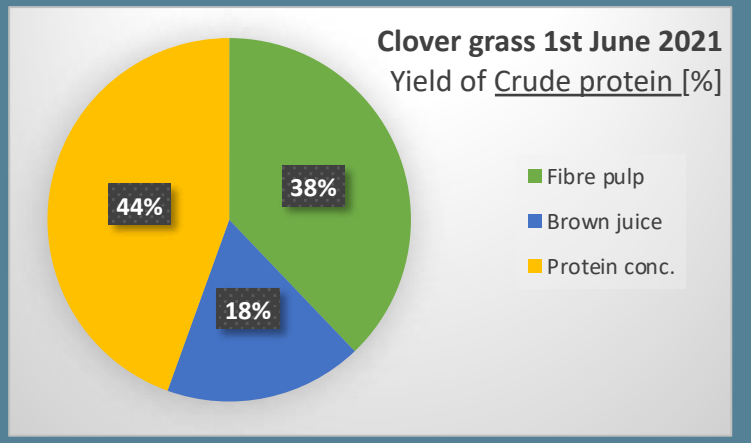
Without severe maceration (only stationary cutter)





With severe maceration (rotocutter + disrupter)



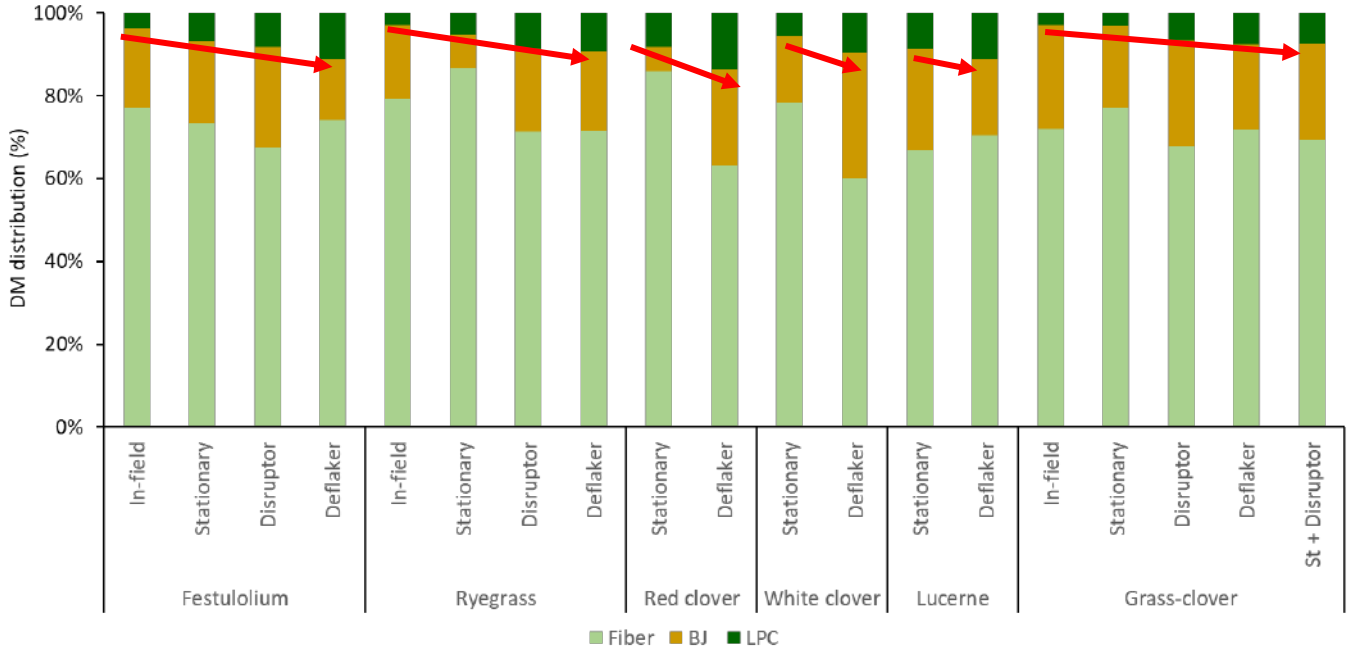


Rota-cutter

Disrupter

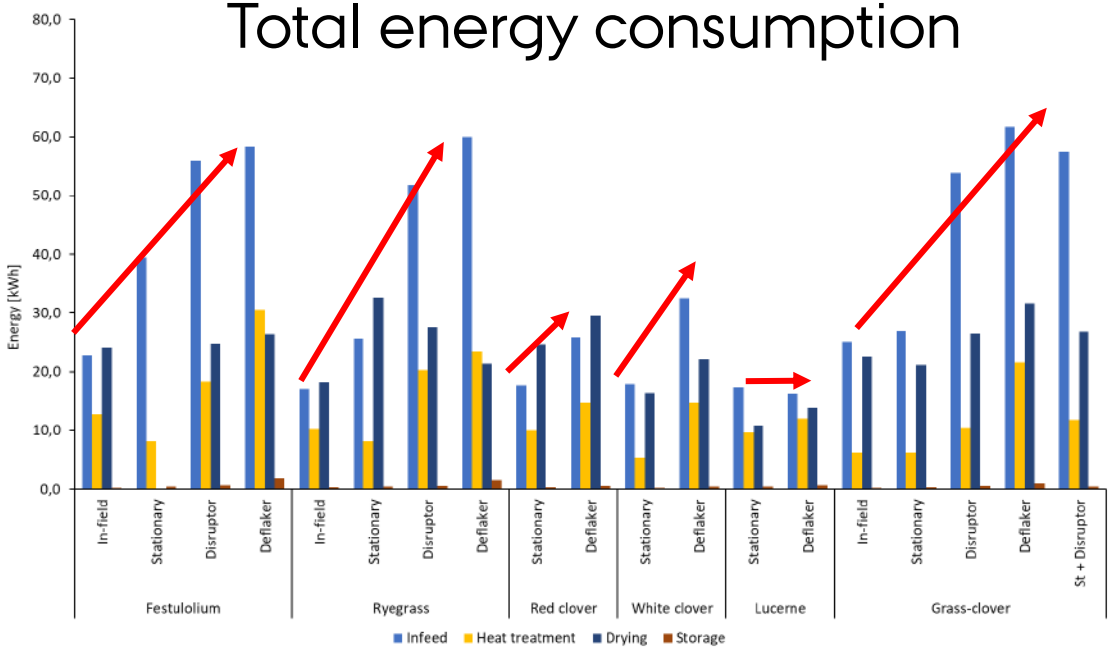
AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

The effect of the severe maceration depends on the specific biomass and on the process efficiency

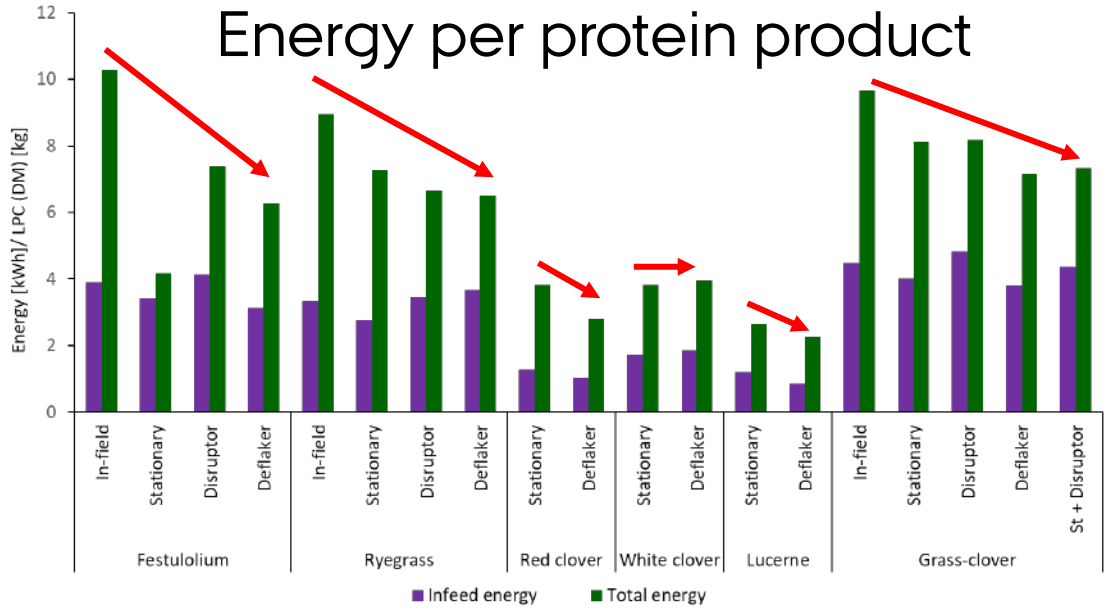


Yields increase, Total energy consumption increase,
→ Energy consumption per kg product does not increase

Total energy consumption



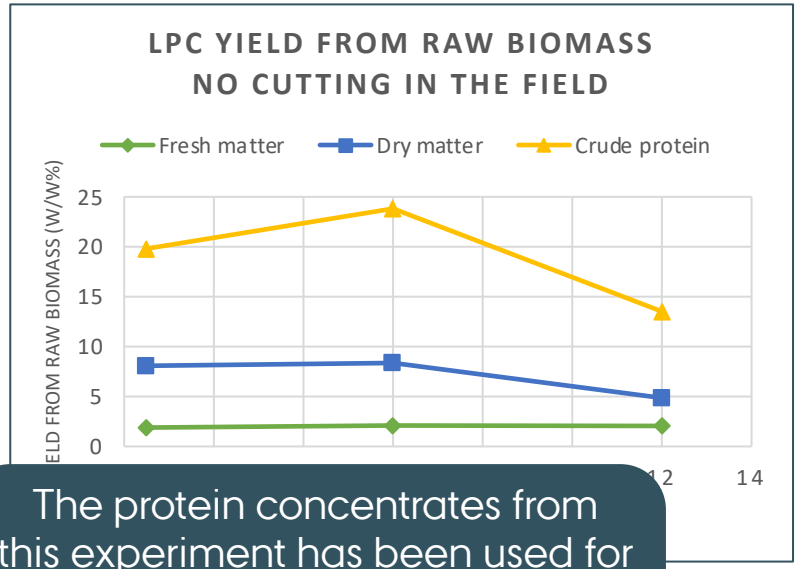
Energy per protein product

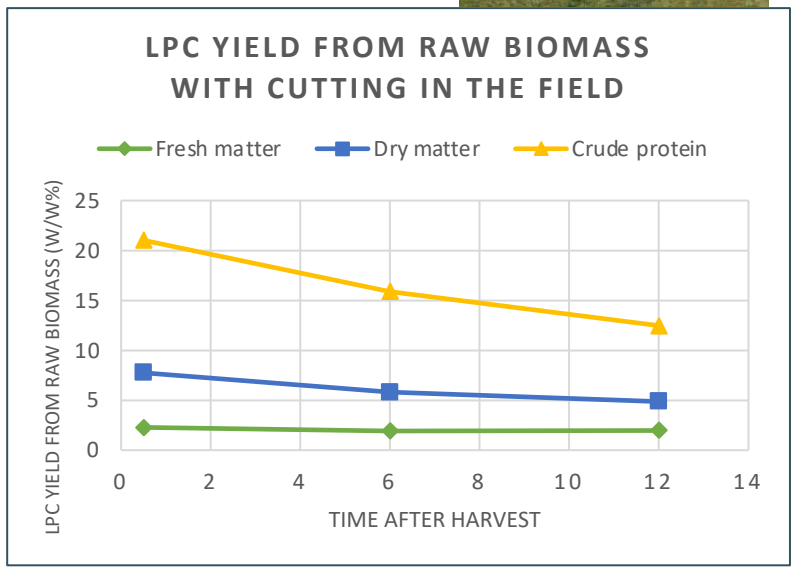


AARHUS
UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

HARVEST EXPERIMENT AUGUST 2021

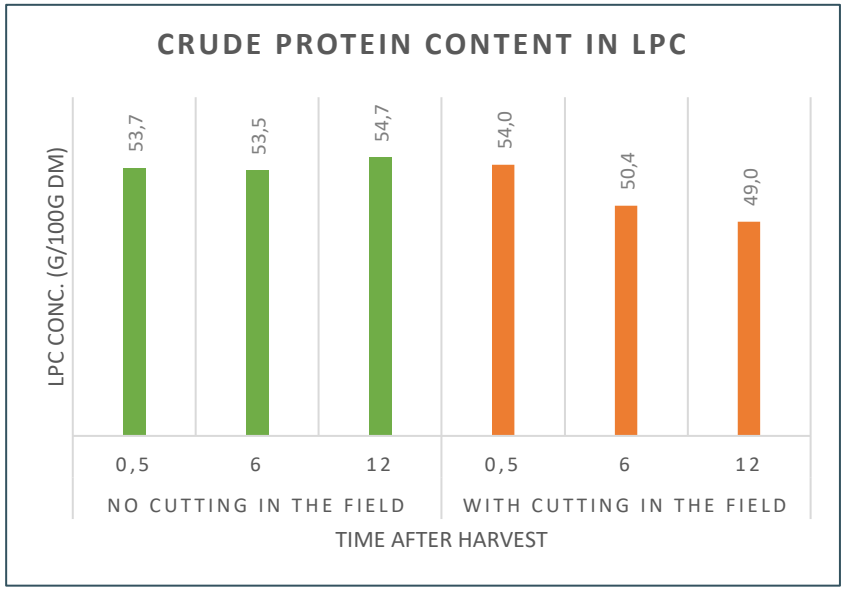
- 30-31. august 2021
- Protein extraction yields for different harvest methods at different times after harvest (0.5, 6,12 hr)
- During the experiments temperature was **15 – 21°C**

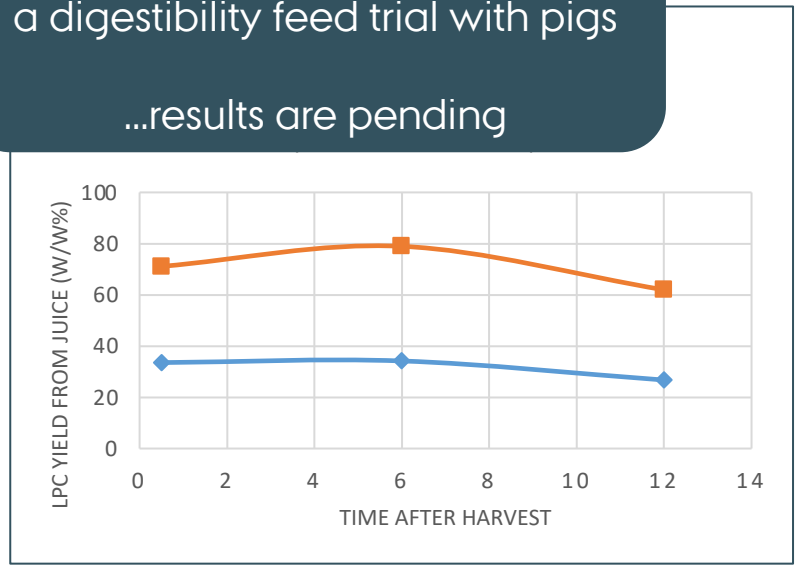


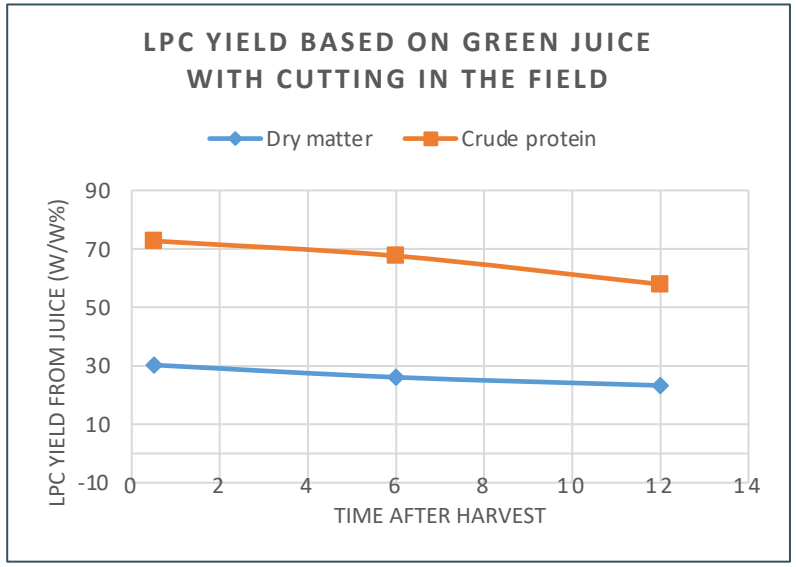


The protein concentrates from this experiment has been used for a digestibility feed trial with pigs

...results are pending







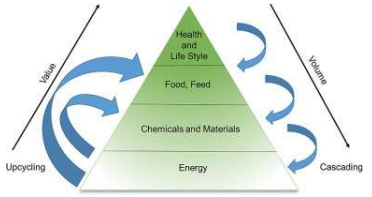
STATUS OF THE GREEN BIOREFINERY IN DK

- The quality of the protein concentrate is good (50-60% crude protein + high in essential amino acids) and can replace soy meal.

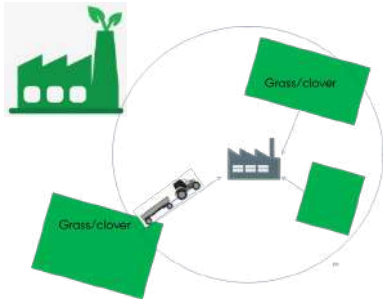
- The fiber pulp can be used both for biogas and for nutrient-rich feed for cattle, the latter, however, requires that there is still enough protein (>14% CP) left.

- The yield of the protein concentrate is often too little (5-15% of TS) and the process requires optimization - We would like yields of 15-20% of TS

- The potential for more higher value products is well under way, but require more R&D. This is a focus for many of the research projects that are underway…



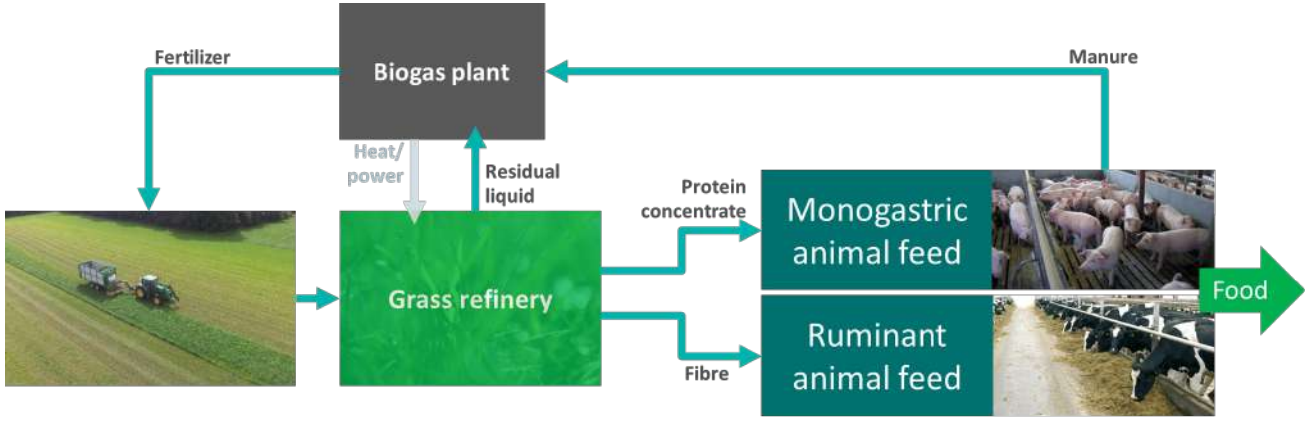
- Commercialization of the "base case" is underway and the first two plants in DK are in operation. But there's still several challenges to overcome to make a good and profitable business. E.g. logistics and continuous high yields



AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

MORTEN AMBYE-JENSEN
ASSOCIATE PROFESSOR

AN INTER-DISCIPLINARY TEAM EFFORT AT AU




AU Agroecology

Uffe Jørgensen uffe.jorgensen@agro.au.dk

Poul Erik Lærke poule.laerke@agro.au.dk

and TEAM!


AU Biological & Chemical Engineering

Morten Ambye-Jensen maj@bce.au.dk

Henrik Bjarne Møller henrikb.moller@bce.au.dk

and TEAM!




AU Animal and Veterinary sciences

Søren Krogh Jensen skj@anivet.au.dk

Lene Stødkilde-Jørgensen lsj@anivet.au.dk

Martin Riis Weisbjerg martin.weisbjerg@anivet.au.dk

Nikolaj Peder Hansen nikolaj.hansen@anivet.au.dk

and TEAM!

CBIO
AARHUS UNIVERSITY CENTRE FOR CIRCULAR BIOECONOMY

CROSS DISCIPLINARY AU CENTER FOR DEVELOPMENT OF BIOECONOMY

AGROECOLOGY ENGINEERING ANIMAL SCIENCE FOOD SCIENCE

QUANTITATIVE GENETICS & GENOMICS MANAGEMENT & CONSUMER BEHAVIOR

Research areas

http://cbio.au.dk/

...IN A VERY ACTIVE DANISH NETWORK FOR R&D IN GREEN BIOREFINERIES!

Universities and knowledge institutions

University of Copenhagen

Aalborg University Denmark

DTU Technical University of Denmark

SDU University of Southern Denmark

Teknologisk Institut

CBIO Aarhus University Centre for Circular Bioeconomy

Farmer associations Industry and Industry clusters

SEGES

Innovationscenter for Økologisk Landbrug

dlg

DLF Seeds & Science

Food & Bio Cluster Denmark

Arla

Danish Agro

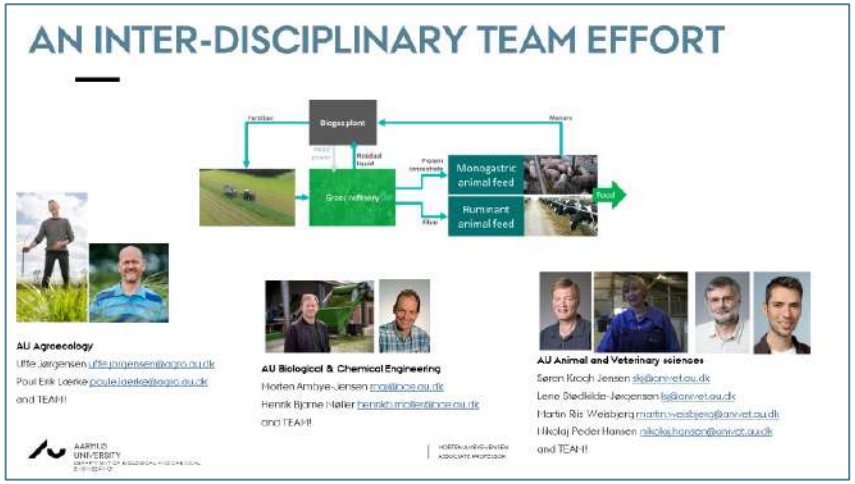
Dansk Protein Innovation

Vestjyllands Andel

Danish Crown

DAKOFO Dansk Korn & Foder

Nordic Sugar Member of Nordzucker Group



DK funding bodies

Promilleafgiftsfonden for landbrug

Innovation Fund Denmark

Miljø- og Fødevareministeriet GUDP

ICROFS Organic RDD

midt regionmidtjylland

GUDP alone has funded a total of 16 R&D projects in Green Biorefining since 2013

Aarhus University
Department of Biological and Chemical Engineering

MORTEN AMBYE-JENSEN
ASSOCIATE PROFESSOR

GO-GRASS

What's next...

This project has received funding from the European Union's Horizon 2020 research and

FURTHER DEVELOPMENT OF HIGHER VALUE PRODUCTS AND OPTIMAL USE OF RESOURCES

Biogas plant

Heat/

Process

Green Biorefinery

Human food

Monogastric animal feed

Ruminant animal feed

Bio-chemicals and -materials

AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

MORTEN AMBYE-JENSEN
ASSOCIATE PROFESSOR

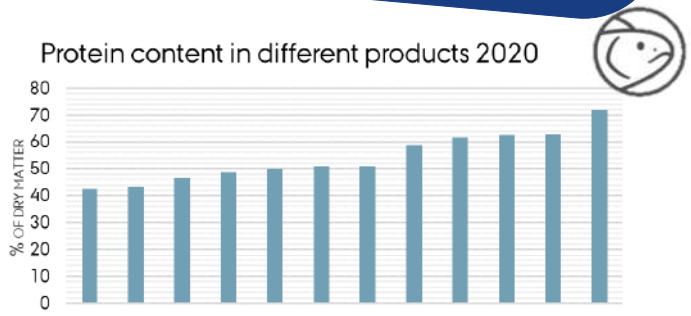
INCREASED VALUE FROM THE PROTEIN CONCENTRATE

High value is good.... **BUT low value products in bulk quantities are necessary** in order to get the substantial environmental benefits

Basic scenario: **Feed alternative to soy meal**

Specialty feed

- Extra high protein purity and digestibility – e.g. for fish and young animals
- Optimized amino acid profile (e.g. higher cysteine)
- Utilization of high fat content (primarily α-Linolenic acid)
- Pre- & pro- biotic effects via fermentation of the products



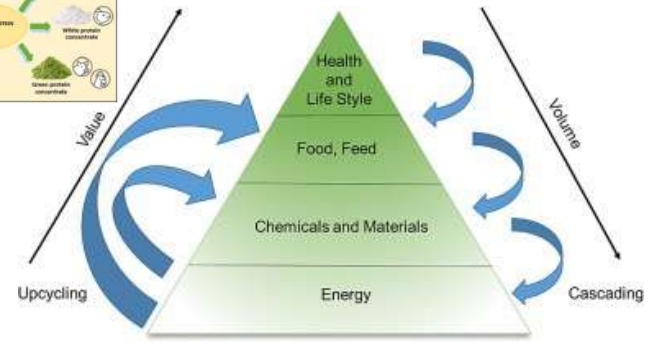
Food protein

- New source of plant based protein for consumption
- New source of functional protein for the food ingredient market

GREEN VALLEYS

Both requires more process development and product quality testing

And for food: a novel food approval!



AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

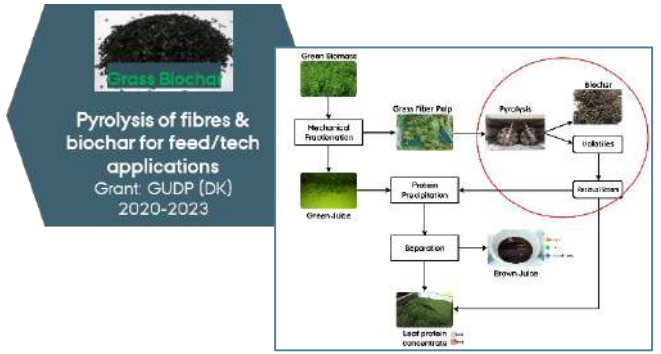
MORTEN AMBYE-JENSEN
ASSOCIATE PROFESSOR

INCREASED VALUE OF THE FIBRE

Basic scenario: **Feed for ruminants or substrate to biomethane**

Thermal conversion, e.g. Pyrolysis / HTL…

- Supply of internal energy needs for heating and drying
- Biochar production
- Biooilproduction



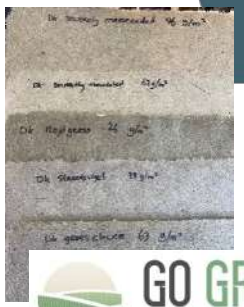
Further conversion of the fibre fraction.

- Lignocellulosic biorefinery (LCF-Biorefinery)

Applications in Biomaterials

- Insulation materials
- Bio-composites
- Packaging
- Biobased textiles
- Horticulture substrates

www.biowert.com



SinProPak
Grass fiber-based paper for sustainable packaging products
Grant: GUDP (DK)
2021-2023

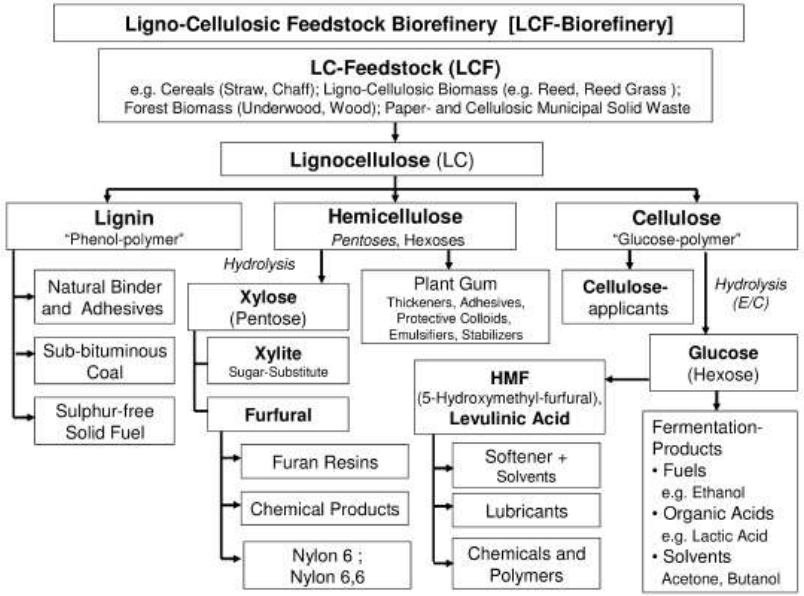


Fig. 1.11 Products of a lignocellulosic feedstock biorefinery (LCF-biorefinery, Phase III) [78, 79, 95].

AARHUS UNIVERSITY
DEPARTMENT OF BIOLOGICAL AND CHEMICAL ENGINEERING

GO GRASS
Grass-based circular business models for rural agri-food value chains

GREEN VALLEYS

MORTEN AME
ASSOCIATE P

INCREASE VALUE OF RESIDUAL JUICE

Illustration: System setup

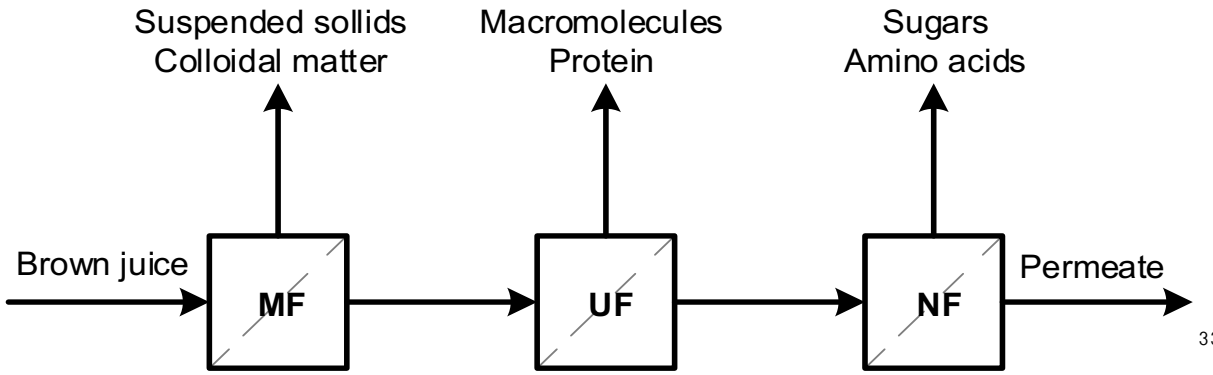
Basic scenario: **Biomethane from the brown juice for internal energy production**

Up-concentrated via membrane technology

- Fermentation substrate with high sugar content

Separated and isolated valuable organic compounds

- Mono- or oligosaccharides
- Organic acids
- Amino acids, peptides or soluble proteins



GO-GRASS

Main message:

Green Biorefineries has huge potential!

In DK we are just about to catch some of it…

But there´s so much more to do…

Let us discuss and work together to catch more of this potential in more places of EU

Tak !

Thank you for listening

Contact:
maj@eng.au.dk

This project has received funding from the European Union's Horizon 2020 research and

CBIO
AARHUS UNIVERSITY CENTRE FOR CIRCULAR BIOECONOMY

life farm4more

Climate Action | Green Feed | Biorefinery

LIFE-farm4more project and biorefinery challenges

Joe Sweeney, University Collage Dublin
Michael Mandl, tbw research GesmbH

HBLFA Raumberg-Gumpenstein Landwirtschaft

BANTRY MARINE RESEARCH STATION

BRID

biocharNergy

Life

An Roinn Comhshaoil, Aeráide agus Cumarsáide
Department of the Environment, Climate and Communications

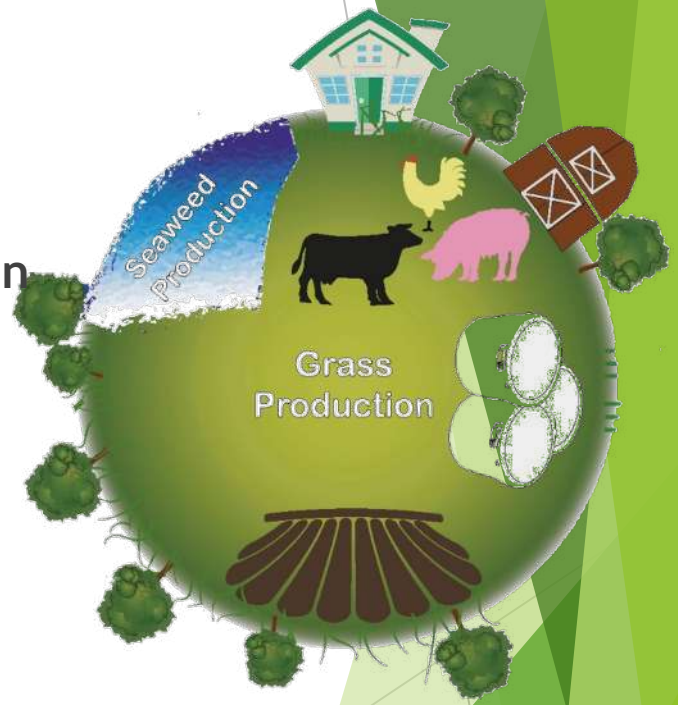
tbw RESEARCH

UCD DUBLIN

CURRENT MODEL

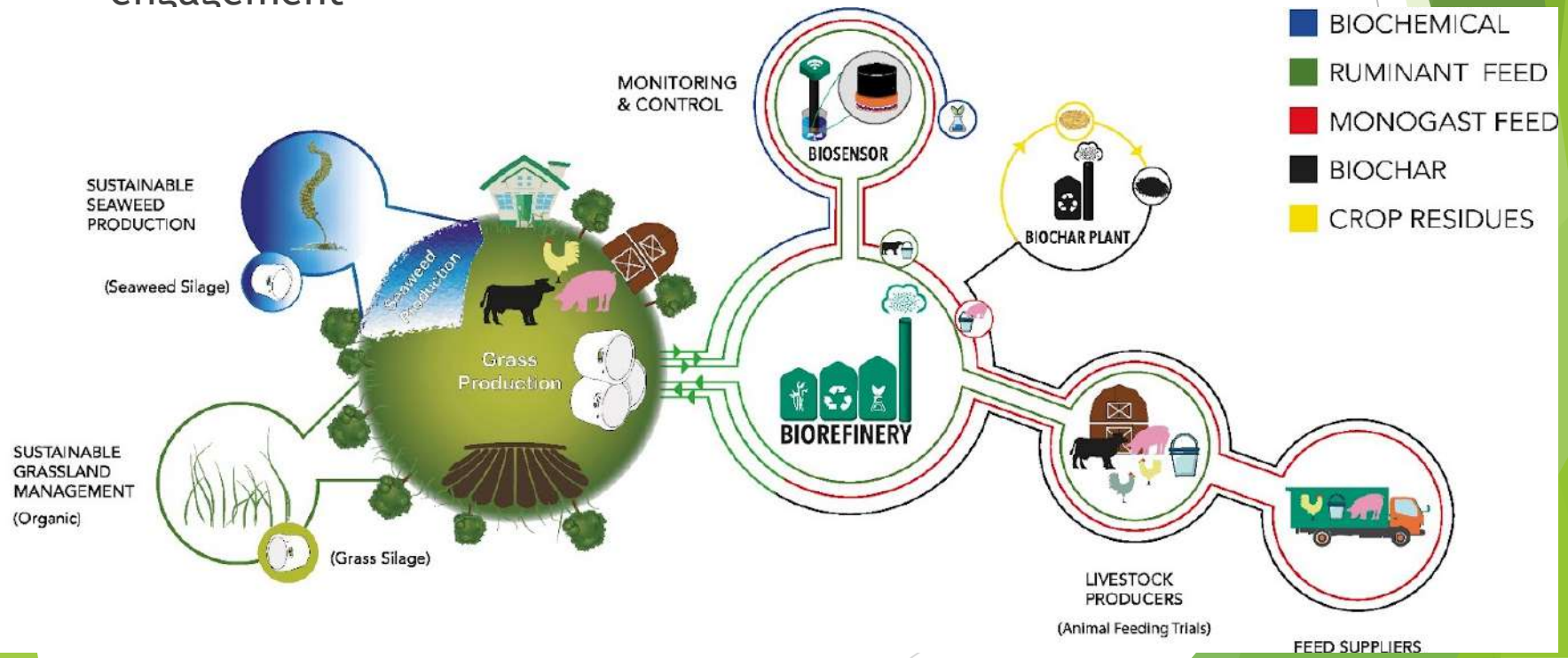
- **LIFE Climate Action project**
  - July 2019 - (60 Months)
  - Total Budget (€5,494,599)
  - Austrian and Irish partners

- **Attempting to effect Climate Change mitigation in animal protein production**
  - Conventional Beef & Dairy farming
  - Conventional Pig & Poultry farming
    - High GHG, N & P emissions
  - Conventional seaweed production
    - High GHG emissions



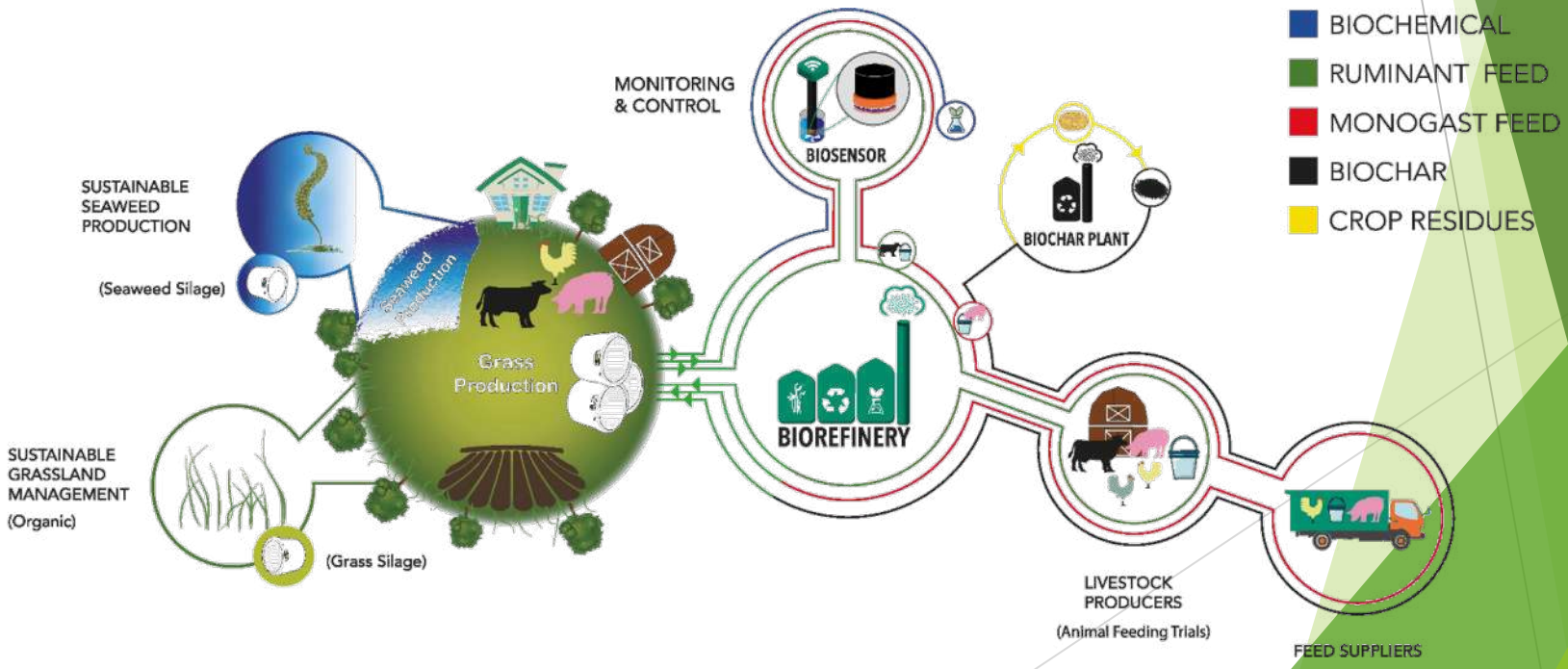
PROJECT SCOPE

- Demonstration of a **Green Biorefinery process** for organic feeds: ruminates (cattle) & monogastric (chicken, pigs..)
- Demonstration of a **small scale Biochar process** to deliver high quality biochar suitable as feed additive
- Implement a Biosensor for monitoring & control
- **Prepare implementation** - define scenarios - stakeholder engagement



Project Climate change mitigation Objectives

- Sustainable land management strategies (organic, Zero N)
- Impact assessment - LCA
- Future/alternative GBR input substrates (BMRS)
  - Sustainable seaweed production (Ensiling as opposed to drying)

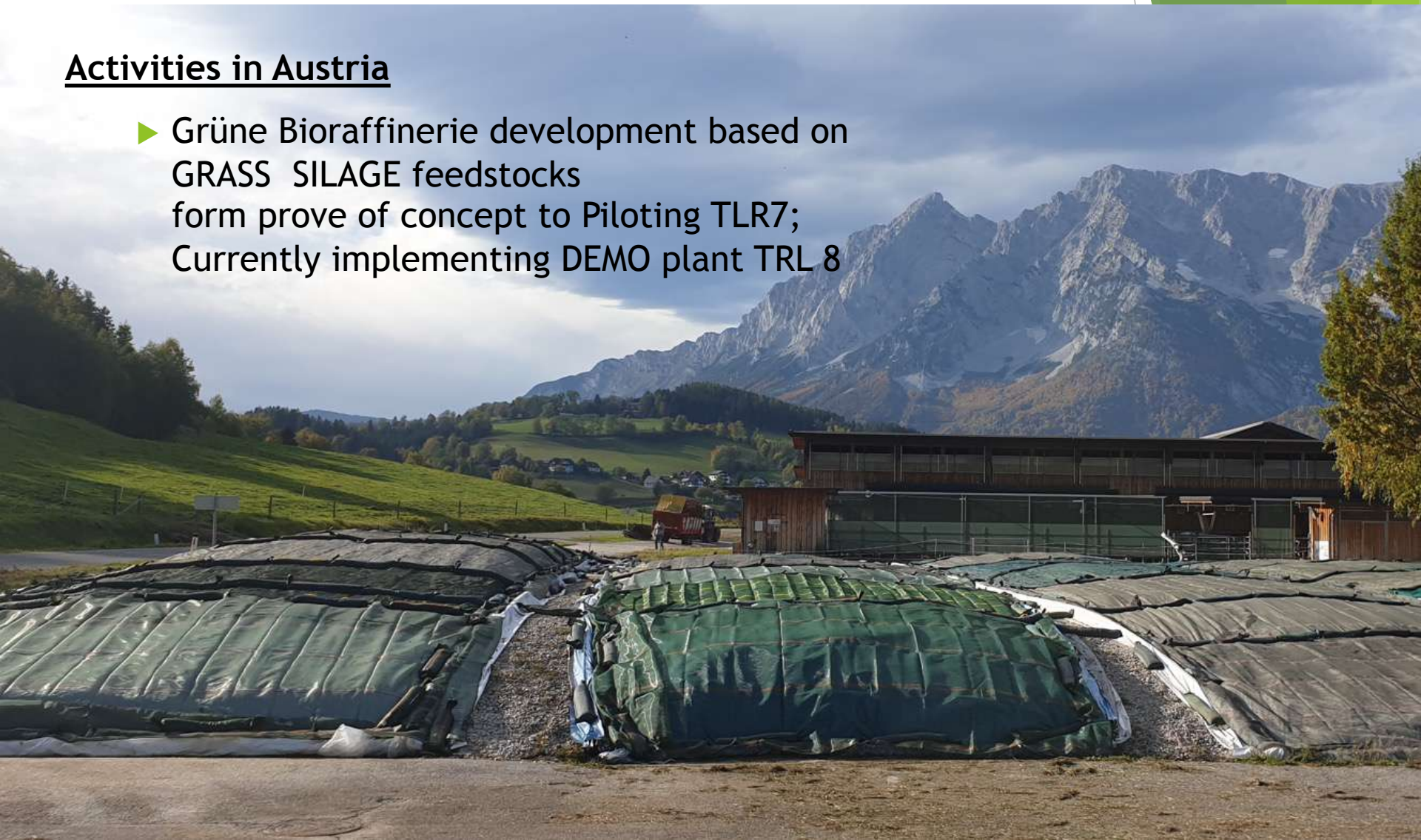


Green Biorefinery – Austrian Perspective

In a nutshell

- **Michael Mandl – environmental engineer; Life-Science and Natural Resources**
  - About 25years in applied research,
  - Involved and managing a series of green biorefinery projects at various scales and TLR
  - …and I really “love” green biorefining
  - Currently implementing Farm4more prototype green biorefinery

Green Biorefinery – Austrian Perspective



Activities in Austria

- Grüne Bioraffinerie development based on GRASS SILAGE feedstocks
  form prove of concept to Piloting TLR7;
  Currently implementing DEMO plant TRL 8

GREEN BIOREFINERY

- **Demonstration green biorefinery for organic feed products**
  - **Raw materials: grass/clover/legumes mixtures**
  - **<u>Process steps</u>**
    - (1) High quality feedstock silage to start with!
    - (2) Extraction process/ pressing: → juice & pulp (solids)
    - (3) Juice processing to accomplish feed properties,
    - (4) Evaporation to concentrate (60-65%dm) for monogastric feed applications
    - (5) Grass pulp conservation (ensiling, drying) for feed; direct use for biogas process
  - **<u>Products</u>**
    - Hydrolysed protein (PPs/AAs) concentrates for feed and alternative uses.
    - Grass press cake for feed (direct use/silage/ dried & pelletised), and for anaerobic digestion.

Green Biorefinery implementation in Fram4more Project

- Implementation of green biorefinery installations is executed in 2 phases:
  - 1st phase: small scale mobile pilot to generate prototype products for feed tests app. (1000kg/h)
  - 2nd phase: full scale green biorefinery to process 10.000 t_{FM}/a organic grass silage feedstocks for industrial prototyping and market uptake, online form 9/2023.
- Primarily Focus is on processing organic certified feedstocks

Green Biorefinery

- **Why organic certified feedstocks?**
  - Austria has a high percentage in organic farming (25% of arable land)
  - Grass/clover/legumes cultivation in crop rotation is well established within organic farming for N-binding
  - Strong organic animal production & dairy farming in Austria and
    -> therefore, a demand for organic feeds
  - The organic niche is more attractive to start implementation due to higher revenues
  - No adding of single AAs allowed in organic feeds

GREEN BIOREFINERY PROTOTYPING

- July 2021 – GBR campaigning at HBLFA Raumberg - Gumpenstein

Green Biorefining Campaiging at HBLFA -Raumberg - Gumpenstein

…and who will do the dishes?

EVAPORATION AT DIFFERENT SCALES

- Industrial scale: 3-effect fall film evaporator
- Pilot scale- on site evaporation

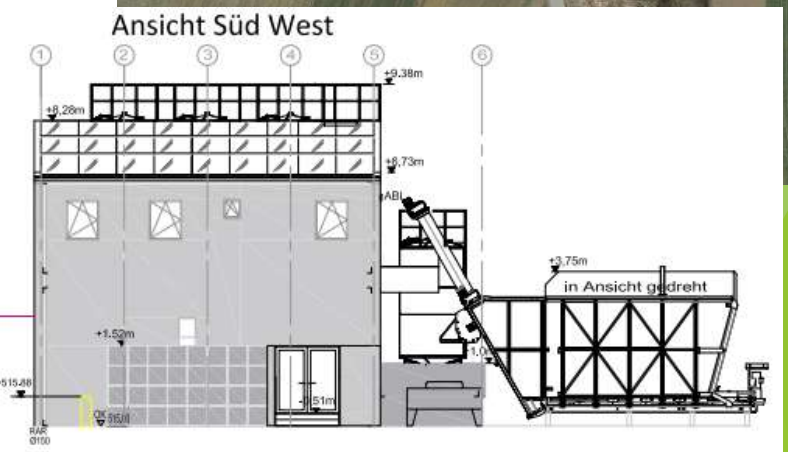
Prototyping new chicken Feeds

- Mixing 14 % AA-concentrate into 3 tons of pre-mixed feed, homogeneously!

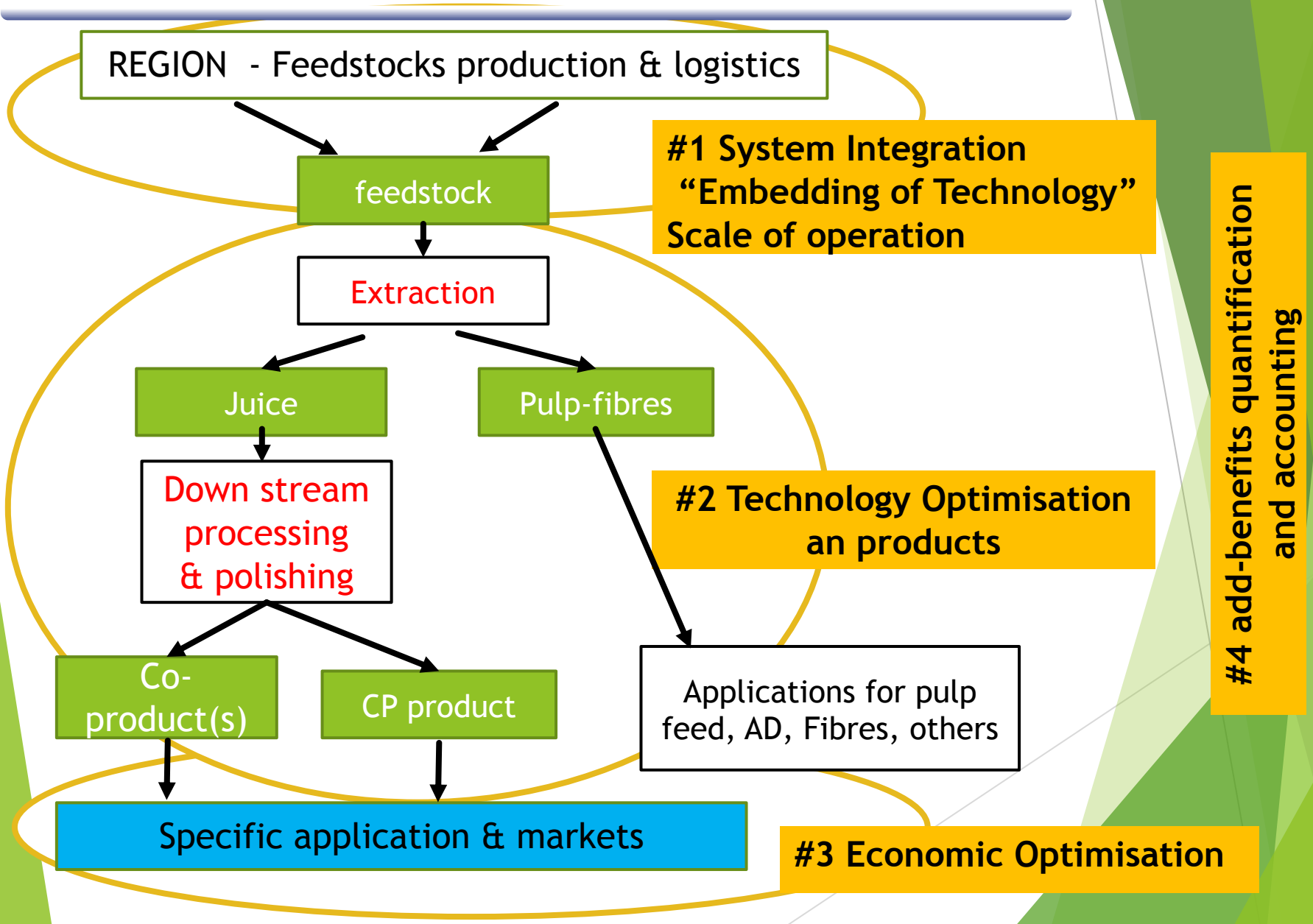
- Final feed pellet including AA concentrates

FULL-SCALE GREEN BIOREFINERY IMPLEMENTATION

- Implementation of full-scale green biorefinery has been delayed …currently implemented to be online 9/2023
- Supply chain 10.000 t FM/a organic silage
- Green biorefinery is integrated with existing a biogas plant in Japons to facilitate synergies in feedstock supply, process heat and utilities



Green Biorefining Challenges



Challenge #1 in Green Biorefining
System integration

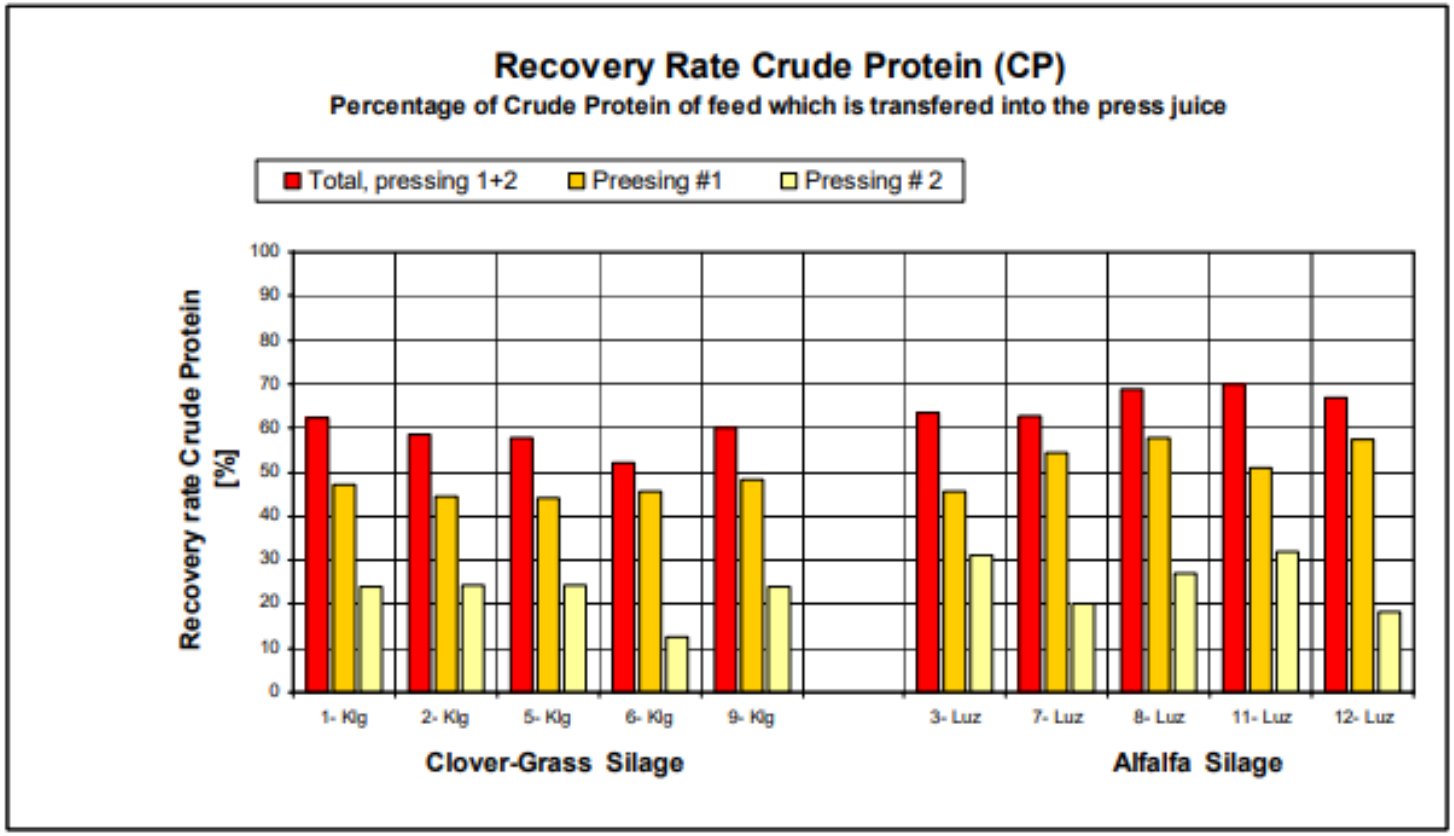
- **"Embedding" of Technology** to fit to a specific regional situation and framework
- **Raw material potential available to determine an operational mode and size of a green biorefinery.**
- **Logistics of feedstock is a very important parameter**
- **Mobile / decentral processing vs. centralized processing?**
- **How is the grass pulp to be used**
  - **directly fresh/ dried/ ensiled**
  - **as ruminant feed in the region**
  - **For biogas production / or fibre use**
- Are regional Synergies possible?
  ..e.g. with other actors or existing infrastructure

Challenge #2 in Green Biorefining Technology & Products

- **Optimisation of Technology** to deliver on fit to a specific regional situation and framework
  - **Optimized Recovery Rate** for Products and Intermediates
    kg_{CP}/ t_{dm} grass;
  - **Optimized specific energy demands** (power and heat) in processing
    kWh_{el}/ kg $_{prod}$; kWh_{th}/ kg $_{prod}$
  - **Consumables and Wastes** are often underestimated
  - **Deliver on product properties**
    CP content, aminogram, "impurities" etc…
- **Feedstock quality is** very important and is part of the technology optimisation
- **Contradicting goals**:
  Optimising juice yields….is degenerating pulp feed properties
- **Simple process vs. advanced processing** (e.g. multiple products)

Challenge #2 in Green Biorefining Technology & Products

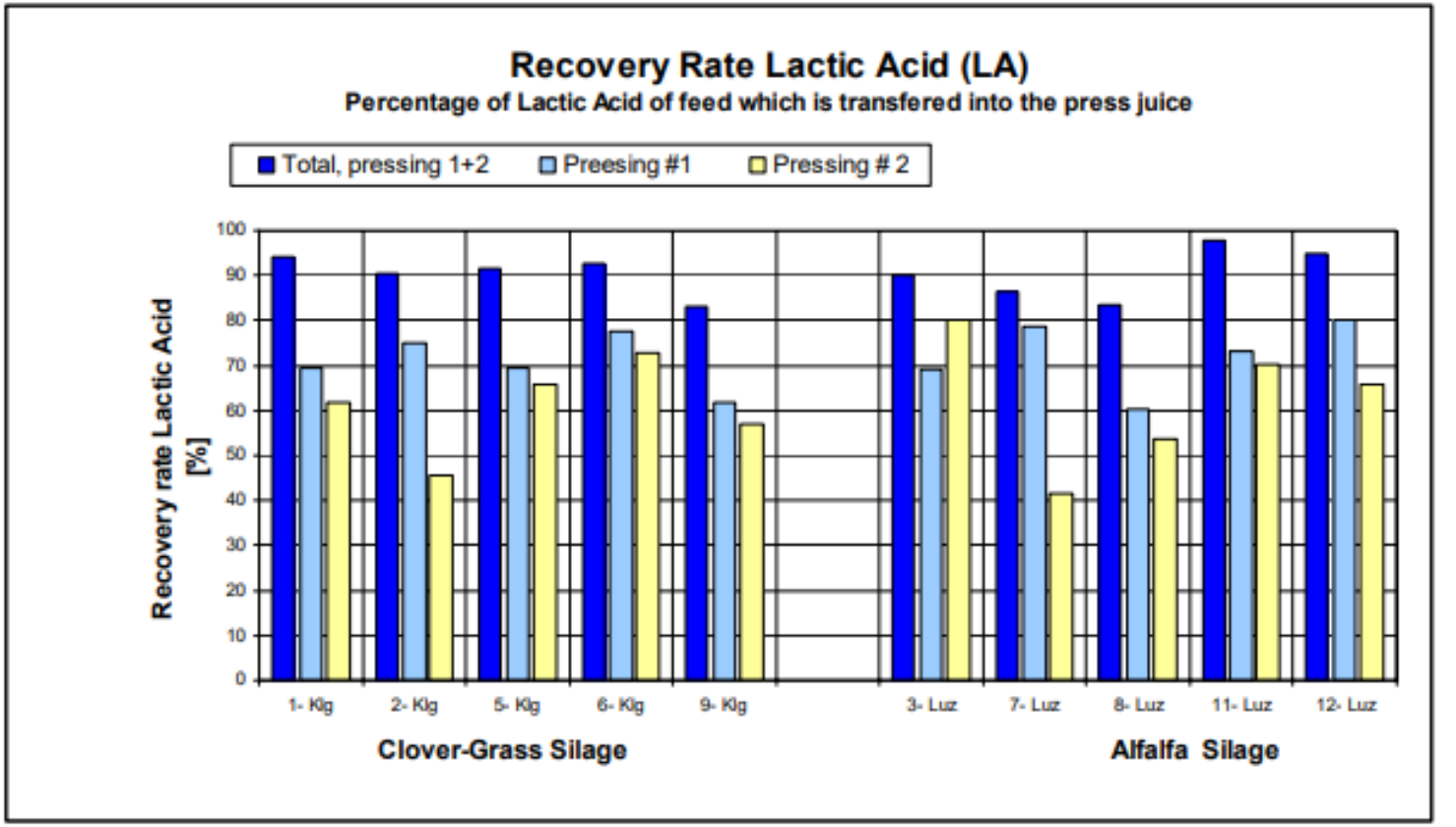
- Primary processing – solid –liquid separation
  Crude protein recovery from silage feedstocks



Ref.: Mandl et al 2006

Challenge #2 in Green Biorefining
Technology & Products

- Primary processing – solid –liquid separation
  Lactic acid recovery from silage feedstocks



Ref.: Mandl et al 2006

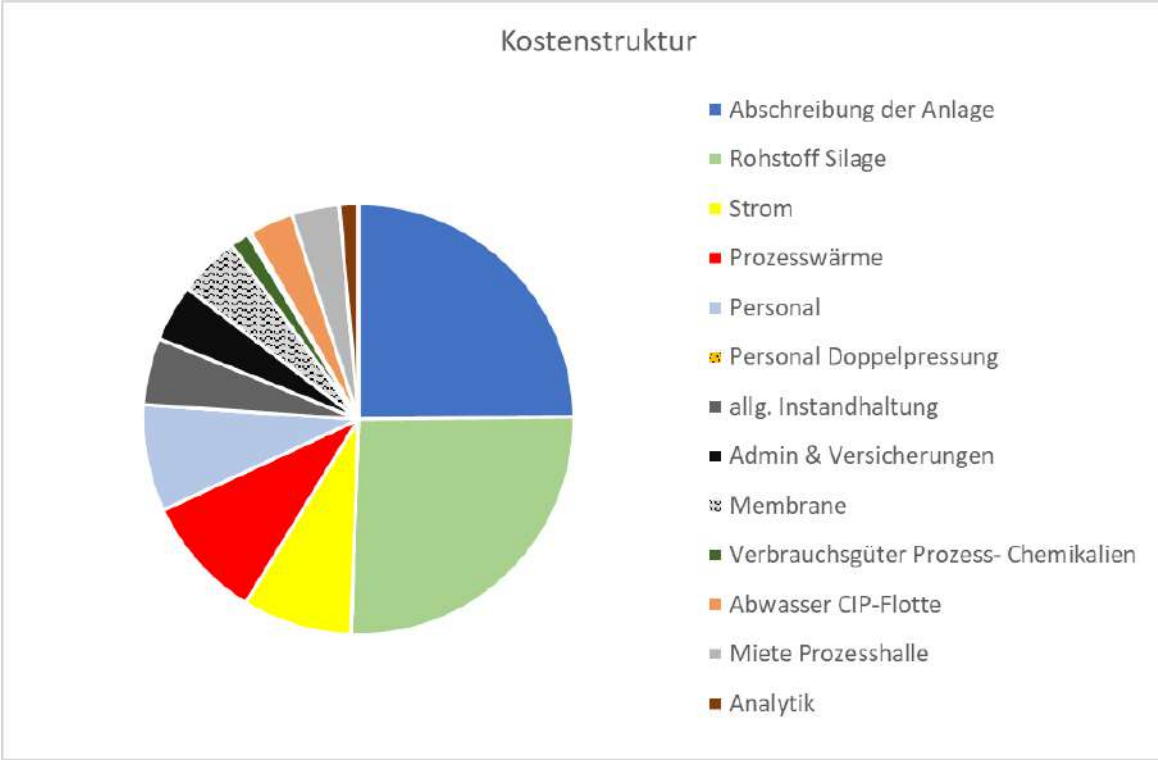
Challenge #3 in Green Biorefining Economics

- **How can an economic set-up and green biorefinery operations be achieved?**
- **Green biorefinery a lacking to date a clear economic proposition, (from an investors point of view).** They are most likely not offering a much cheaper solution for products & services.
- **The economic framework and model is "tight",** benchmark products (such as soy etc..) are well established well and produced worldwide on a competitive market.
- There is a **upper revenue limit of 3-3,5€/kg CP equ. (organic)** for alternative feed applications
- **Co-products can improve the business case,**
- **Economy of scale** and operational time
  large processing plants to perform economically better
- **How to account for "green effects" and GHG emission reduction?**

Challenge #3 in Green Biorefining Economics

Some characteristics

- Investment costs for green biorefineries are substantial
- Prices of feedstocks and transport need to be low, also quality feedstocks quality is important
- Process have substantial Energy costs
- Feedstock quality is worth money
- Using existing infrastructure is wise synergies between partners (e.g. access to cheep energy) is a key issue



Challenge #3 in Green Biorefining
Economics- market- bulk or niche

- Bulk markets for implementing green biorefineries in large scale are FEED and Energy
- Should we initiate policy support to subsidise green biorefinery system for being economic in feed & energy markets?
  Directly / indirectly?
- Should we instead focus on for higher revenue product & markets to improve economics?
  - Such as FOOD applications;
  - Add on more co-products and technology platforms
    (e.g. fermentation….other pulp applications)

Challenge #4 in Green Biorefining
add-on benefits Quantification

- **Are we delivering only new products or does green biorefining deliver on additional benefits/ impacts as well?**
- **….such as** positive effects in
  - improved LCA …and GHG benefits
  - rural development & employment,
  - improved national economy,
  - decreasing soy imports, increased self sufficiency
  - ….
- How can we **quantify these benefits** and take them into **account in an economic model?**
- **How to explain and communicate** add-on benefits of green biorefining to general public?

…FOR TODAYS WORKSHOP

GO-GRASS project workshop wants to

tackle and discuss

Challenges and business models in green biorefinery

On multi expert level.

"Wenn Du eine weise Antwort verlangst,
muss du vernünftig fragen".

(J.W. Goethe)

….hope to get networking and interaction!

ACKNOWLEDGEMENTS

Thank you!
More information on Farm4more
https://www.farm4more.ie

Michael Mandl
tbw research GesmbH
Grünberstraße 15, 1120 Vienna, Austria
m.mandl@tbwresearch.org; www.tbwresearch.org

This project has received funding from the Executive Agency for Small and Medium Sized Enterprises (EASME) under grant agreement LIFE18 CCM/IE/001195 and from the Department of The Environment, Climate & Communication (DECC). The EASME receives support from the European Union's LIFE Programme.

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Overview Feeding Tests

- **Biochar as feed additive** for ruminates and chicken to evaluate
  - reduction of methane emission in cattle breeding,
  - reduction of ammonia emission in chicken fattening.

- Characterisation/ feed value of press cake and CP/AA concentrates
- Storability / Re-ensiling of press cake

- **Grass silage press cake** as ruminates feed (dairy cows, organic)
- **CP/AA concentrates** integrated in chicken feed

- Feeding test nearly finished, but data not yet complete analyzed

STORABILITY OF PRESS CAKE: RE-ENSILING

Re-ensiling of **silage press-cakes after extraction**
small scale (60L) and round bales scale (app 800-1000kg)

Re-ensiling of **silage press-cake works quite well (**without additives needed) if done properly within 1 day after pressing.

25 May 2023

Green biorefinery opportunities, challenges and developments in the regions across Europe - Finland

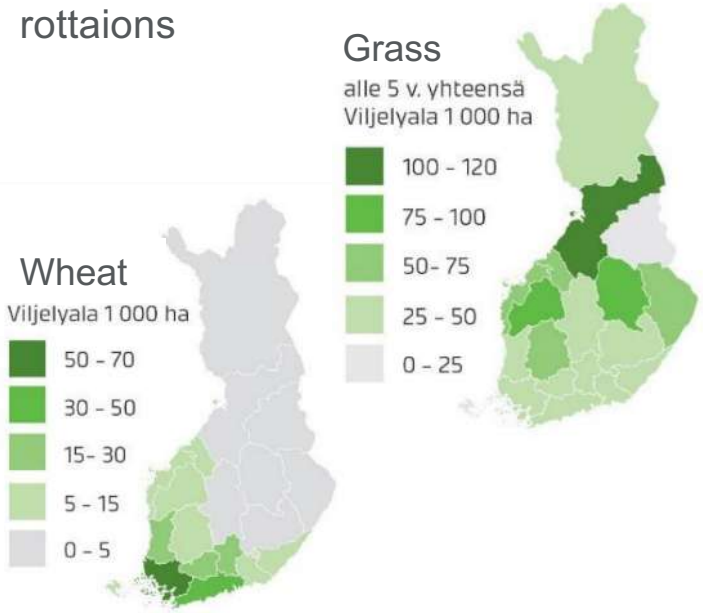
Research professor Marketta Rinne
Natural Resources Institute Finland, Jokioinen
www.luke.fi

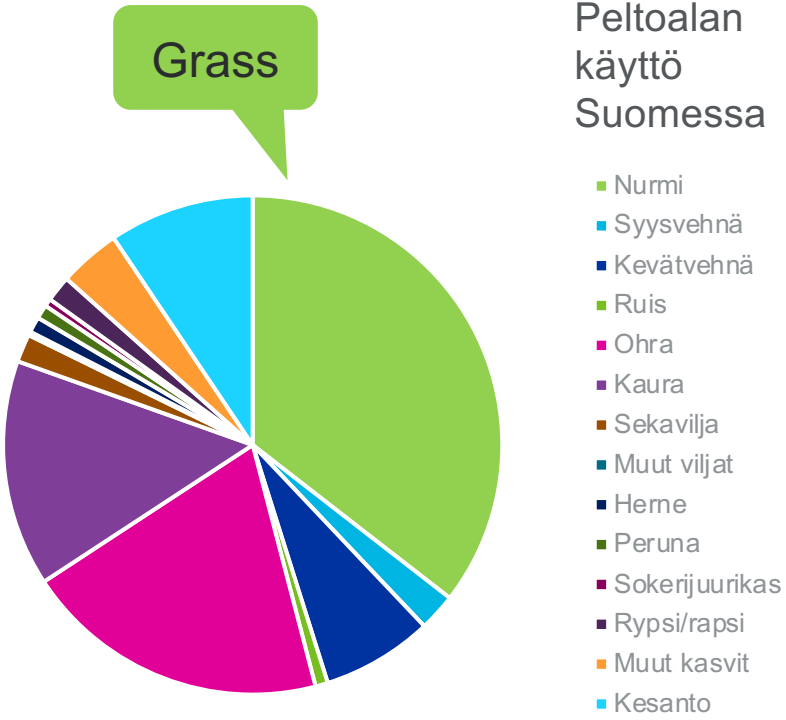
Luke
LUONNONVARAKESKUS

Finnish conditions favour grass biomass production – cool, humid and short growing season

Grass DM yield is double compared with cereal grains

Use of field area in Finland is geographically polarized – gras suse in southerm Finland would improve crop rottaions

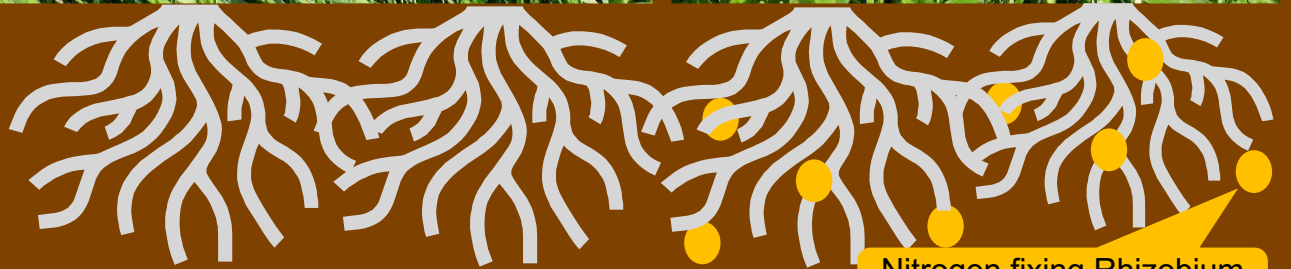




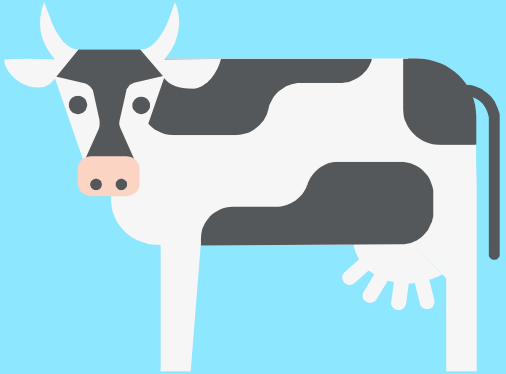
Lähde: stat.luke.fi

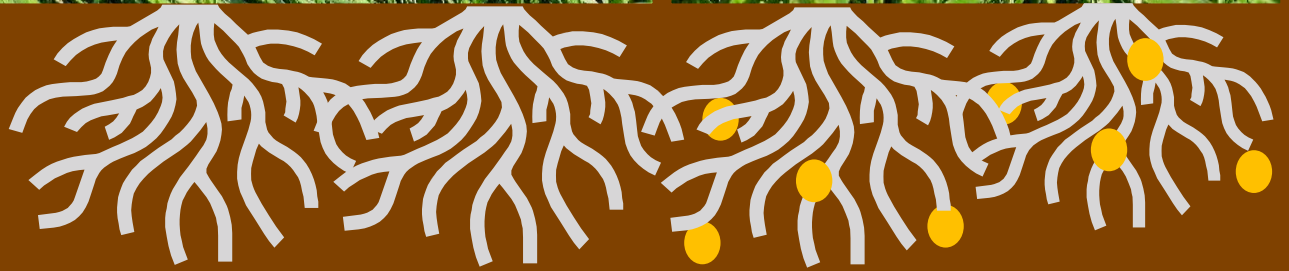
Perennial forage plant species absorb light efficiently during early season when annual fields are barren

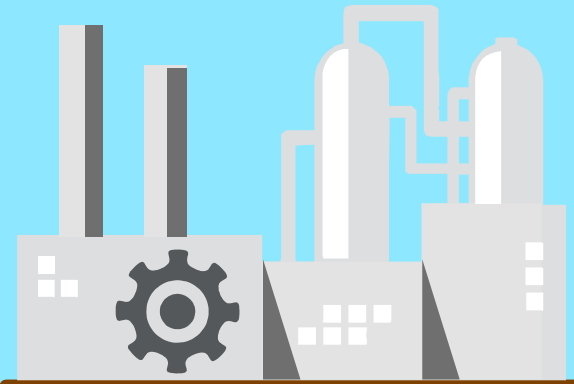
Perennial forage plants have large root systems – efficient extraction of water and nutrients and large soil carbon stock



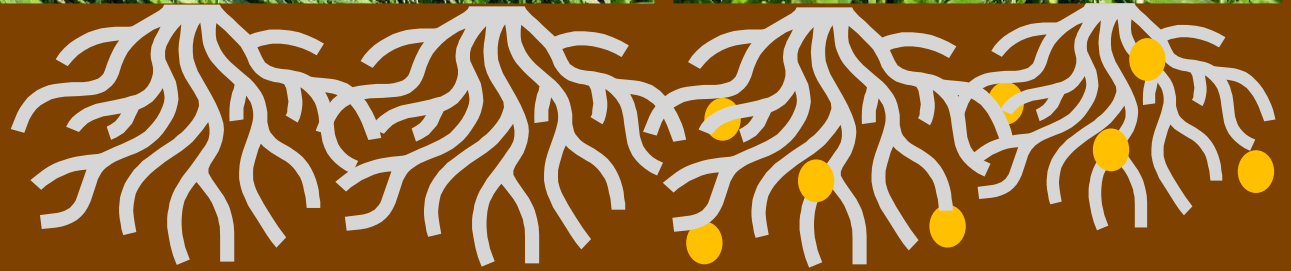
Currently green biomass can mainly be utilized through ruminants and converted to milk, meat and manure







Use of green biorefineries provides opportunities to use the green biomass for a variety of uses: protein feed for monogastrics / food, bioenergy, fertilizers, materials…

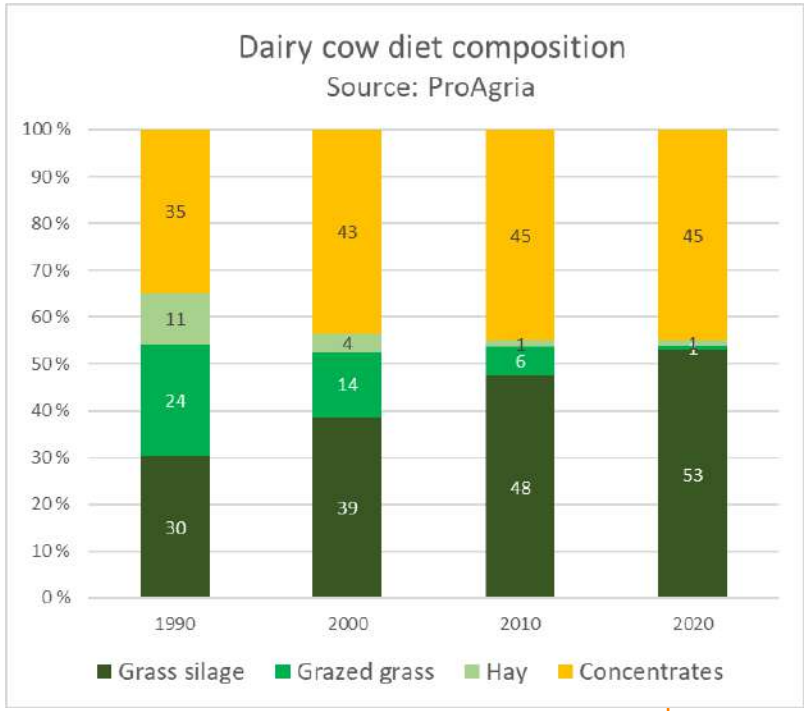


Dairy and beef production in Finland relies heavily on silage production

Our approach is to use ensiled forages as the raw material for green biorefining

Finland has strong traditions in silage making based on acid based additives

- A.I.Virtanen patented the use of acids in silage preservation in 1920's
- Virtanen was awarded the Nobel Prize in Chemistry in 1945
  - http://www.nobelprize.org/nobel_prizes/chemistry/laureates/1945/virtanen-bio.html
- The use of formic acid as a silage additive started in a large scale in 1960's



Ensiled biomass as the feedstock for a green biorefinery

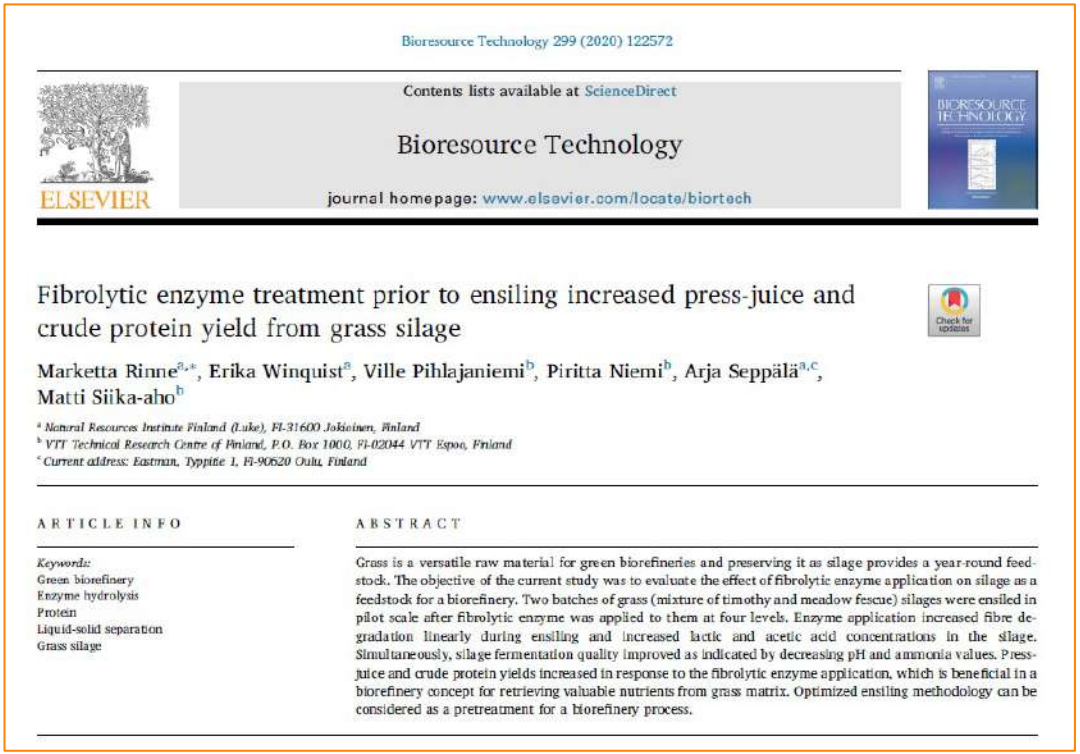
Benefits:

- Stable raw material – relatively stable products
- All-year around operation
- Silage making well established – contractors available
- Higher liquid yield – fermentation as a pretreatment

Challenges:

- Some degradation of protein – but typically only 5 – 10 % of N in non-amino form (ammonia)
- Acidic – precipitation of protein not possible
- Sugars are converted to fermentation end-products (mainly lactic and acetic acid)
- Smell, taste altered

Ensiling as a pretreatment for a biorefinery process – positive effects of fibrolytic enzyme application



Bioresource Technology 299 (2020) 122572

Contents lists available at ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Fibrolytic enzyme treatment prior to ensiling increased press-juice and crude protein yield from grass silage

Marketta Rinne[a,*], Erika Winquist[a], Ville Pihlajaniemi[b], Piritta Niemi[b], Arja Seppälä[a,c], Matti Siika-aho[b]

[a] Natural Resources Institute Finland (Luke), FI-31600 Jokioinen, Finland
[b] VTT Technical Research Centre of Finland, P.O. Box 1000, FI-02044 VTT Espoo, Finland
[c] Current address: Eastman, Typpitie 1, FI-90620 Oulu, Finland

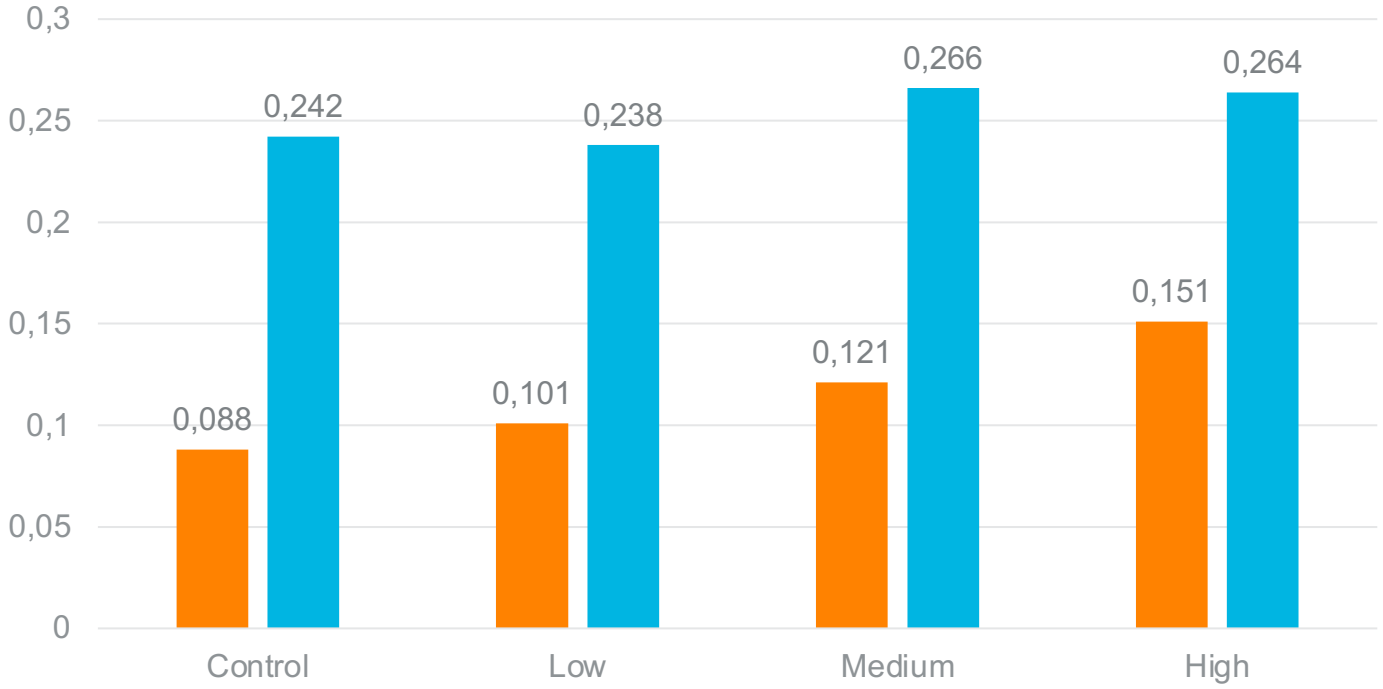
ARTICLE INFO

Keywords:
Green biorefinery
Enzyme hydrolysis
Protein
Liquid-solid separation
Grass silage

ABSTRACT

Grass is a versatile raw material for green biorefineries and preserving it as silage provides a year-round feedstock. The objective of the current study was to evaluate the effect of fibrolytic enzyme application on silage as a feedstock for a biorefinery. Two batches of grass (mixture of timothy and meadow fescue) silages were ensiled in pilot scale after fibrolytic enzyme was applied to them at four levels. Enzyme application increased fibre degradation linearly during ensiling and increased lactic and acetic acid concentrations in the silage. Simultaneously, silage fermentation quality improved as indicated by decreasing pH and ammonia values. Press-juice and crude protein yields increased in response to the fibrolytic enzyme application, which is beneficial in a biorefinery concept for retrieving valuable nutrients from grass matrix. Optimized ensiling methodology can be considered as a pretreatment for a biorefinery process.

CP in press juice from the original biomass CP in response to fibrolytic enzyme adidtion



P<0.01 in both sets for the linear effect ofenzyme application

How does silage composition affect liquid extraction in a biorefinery process?

Received: 19 November 2018 | Revised: 2 March 2019 | Accepted: 11 March 2019
DOI: 10.1111/gfs.12421

ORIGINAL ARTICLE

Grass and Forage Science WILEY

Grass silage for biorefinery—A meta-analysis of silage factors affecting liquid–solid separation

Marcia Franco | Timo Hurme | Erika Winquist | Marketta Rinne

Natural Resources Institute Finland (Luke), Jokioinen, Finland

Correspondence
Marcia Franco, Natural Resources Institute Finland (Luke), Jokioinen, Finland.
Email: marcia.franco@luke.fi

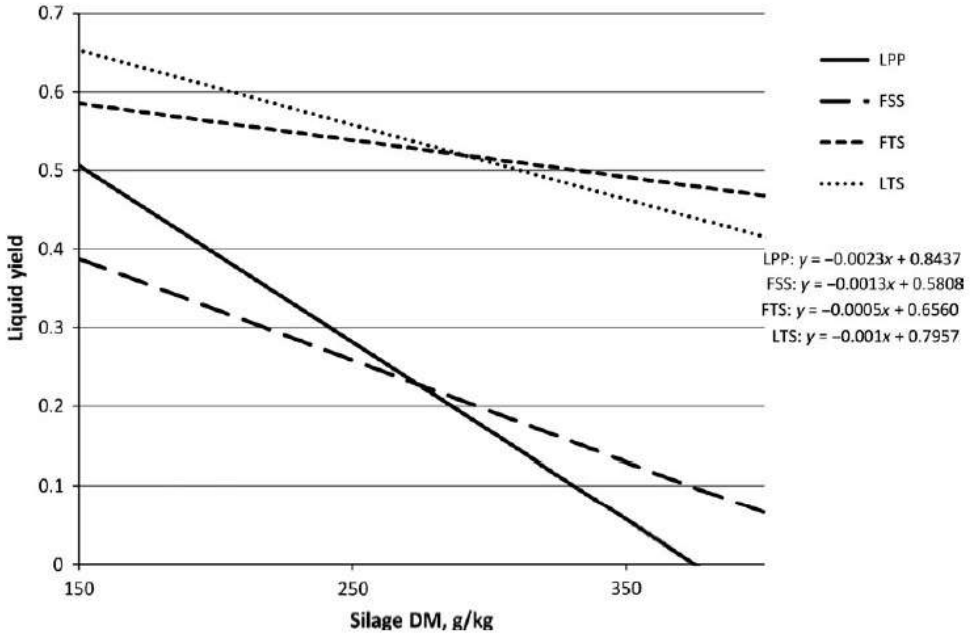
Funding information
Business Finland, Grant/Award Number: 1472/31/2015

Abstract

This meta-analysis based on 19 studies from Finland comprising 43 grass silages was undertaken to evaluate the effect of silage quality on liquid yield, liquid composition and retained compounds in liquid using four different liquid–solid separation methods. Silages were classified according to species (grass, clover or a mixture of them), additive treatment (no, biological or formic acid-based additive) and harvest (primary growth or regrowth). A mixed model regression analysis with random study effect was used to evaluate the impact of silage characteristics on biorefinery efficiency. There was a large variation in silage quality in the data set. Silage dry-matter concentration was the characteristic most highly correlated with liquid yield for all separation methods, and when used as an independent variable in the model, it resulted in the best predictions. The liquid–solid separation methods presented a great variation in the liquid yield, ranging from 0.26 to 0.56 when silage dry-matter concentration was standardized to 250 g/kg. There was no effect of additive treatment and harvest in the estimation of the biorefinery potential, but species was a significant variable in predicting liquid yield for the laboratory-scale presses with higher liquid yield for mixed grass and legume. The high correlation between silage quality and liquid yield and liquid composition provides potential to predict the biorefinery potential based on equations developed for each separation method. This information can be used to modify the silage production systems so that they best meet the requirements of a green biorefinery process.

KEYWORDS
biomass, fractionation, processing, screw press, separation

Meta-analysis quantified the effect of silage DM content on liquid yield – optimum around 25 % (?)



Source: Franco, M., Hurme, T., Winquist, E. & Rinne, M. 2019. Grass silage for biorefinery – A meta-analysis of silage factors affecting liquid-solid separation. Grass and Forage Science 74: 218-230, DOI: 10.1111/gfs.12421.

FIGURE 1 Prediction of liquid yield using regression equations based on silage dry matter (DM, g/kg) for different separation methods. FSS: farm-scale single-screw press; FTS: farm-scale twin-screw press; LPP: laboratory-scale pneumatic press; LTS: laboratory-scale twin-screw press.

Comparison of fresh, frozen, dried or ensiled grass regrading liquid and CP extraction efficency

https://doi.org/10.1016/j.biteb.2023.101356 Bioresource Technology Reports 21 (2023) 101356

Contents lists available at ScienceDirect

Bioresource Technology Reports

journal homepage: www.sciencedirect.com/journal/bioresource-technology-reports

The effects of grass biomass preservation methods, organic acid treatment and press type on the separation efficiency in the green biorefinery

Nisola Ayanfe *, Marcia Franco, Tomasz Stefański, Nora Pap, Marketta Rinne

Natural Resources Institute Finland (Luke), FI-31600 Jokioinen, Finland

ARTICLE INFO

Keywords:
Pretreatment
Press juice
Biomass conversion
Extraction
Additive
Fractionation
Screw press

ABSTRACT

Processing green biomass into novel products provides opportunities to improve the sustainability of the bioeconomy. The objective of this study was to evaluate the effects of biomass types (fresh, frozen-and-thawed, dried-and-rehydrated and ensiled grass) as well as formic and propionic acid-based additive on the efficiency of liquid-solid separation and crude protein (CP) yield. Three different pressing methods for liquid-solid separation were used. All preservation methods improved biorefinery efficiency compared to fresh grass, and the effect of additive was more profound on the fresh biomass than other materials. However, due to lower CP concentration in the liquid, presumably caused by lower nitrogen solubility, the amount of CP retained in the liquid was not improved in response to the additive treatment. The type of processing technology plays a key role in the extraction of relevant compounds from biomass. With less efficient separation methods, the effects of pretreatments were more pronounced.

Lu

Challenges

- Highly perishable (fresh grass, biorefinery fractions)
- Availability is seasonal
- Poor hygienic quality

Solutions (Preservation methods)?

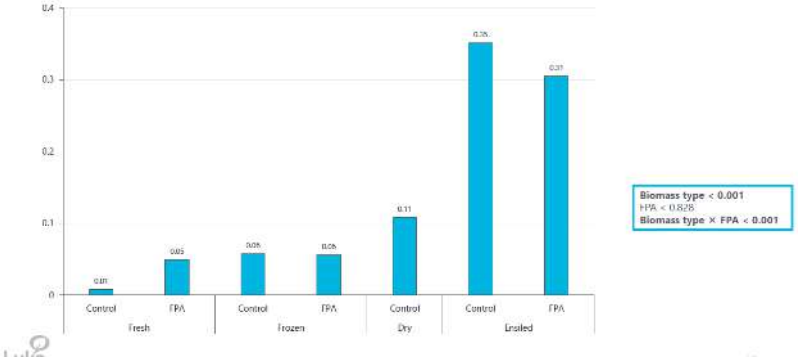
- Ensiling
- Freezing
- Drying and rehydrating
- Organic acid application

Chemical composition of fresh and ensiled biomass

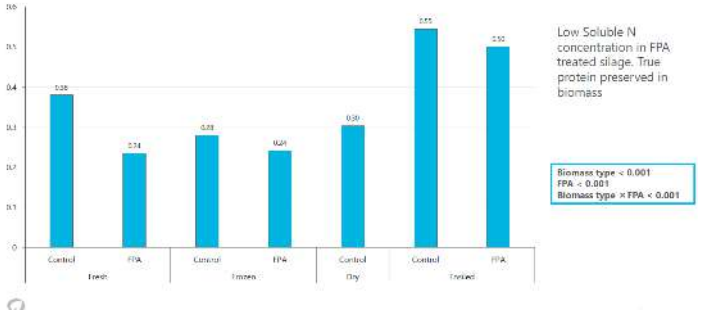
Grass treatment	Fresh	Ensiled	
Use of additive	Control	Control	FPA
Dry matter (DM), g kg^{-1}	218	208	208
Crude protein, g kg^{-1} DM	123	122	123
pH	6.14	3.87	3.96
Buffering capacity, g lactic acid 100 g^{-1} DM	2.97		
Ammonia N, g kg^{-1} N		66.2	31.8
Soluble N, g kg^{-1} N	232	588	449
In DM, g kg-1			
Water soluble carbohydrates	125	38	106
Lactic acid		96	57
Acetic acid		26.2	17.5
Proponic acid		0.33	0.05
Butyric acid		0.05	0.05

Treatments of grass (freezing, drying or ensiling) increased CP retained in the liquid fraction comapred to fresh grass

Effects of biomass type and additive treatment on **CP** retained in liquid (g/g) using **LabPress**

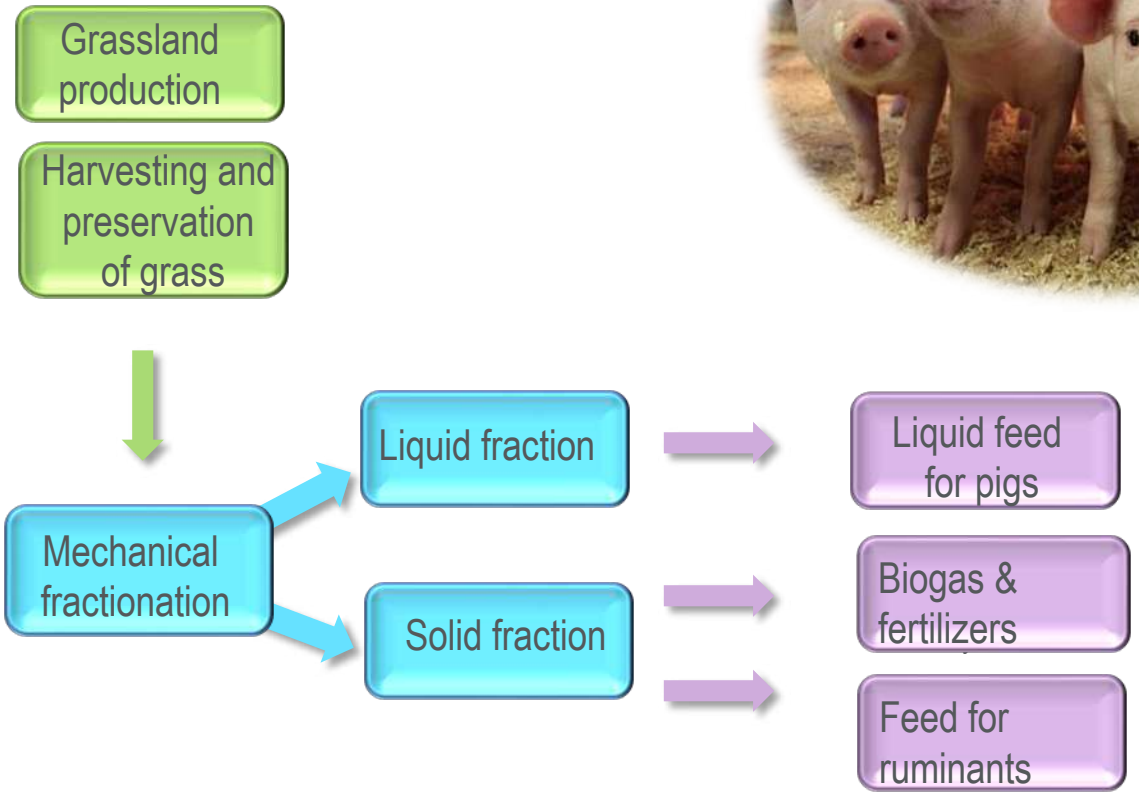


Effects of biomass type and additive treatment on **CP** retained in liquid (g/g) using **LabScrew**

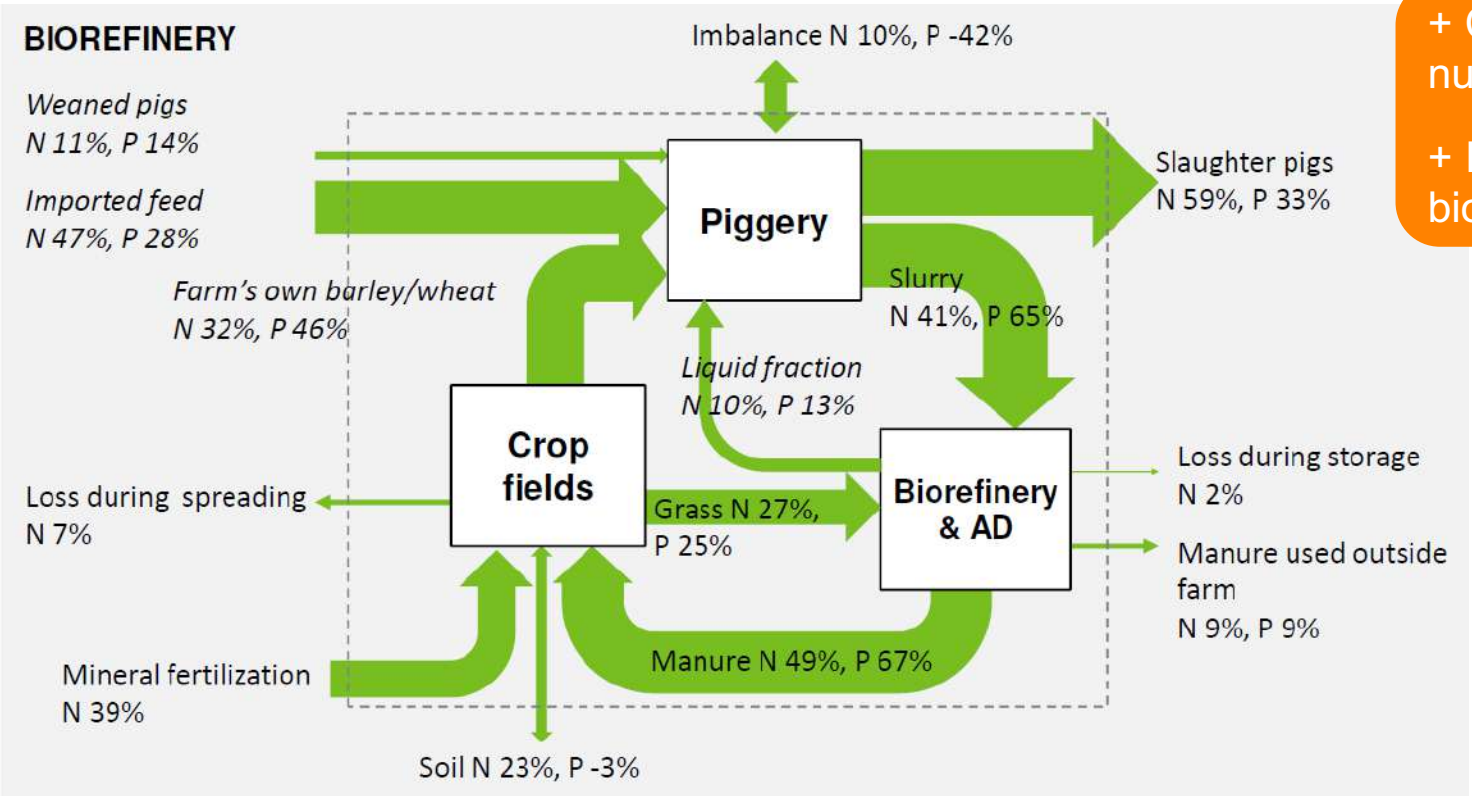


Simple example of a green biorefinery concept

Photo: Luke /Niina Pitkänen



Green biorefinery can help balance the nutrient flows on a pig farm



+ Control of nutrients

+ Increased biodiversity

Source: Tampio, E., Winquist, E., Luostarinen, S. & Rinne, M. 2019. A farm-scale grass biorefinery concept for a combined pig feed and biogas production. Water Science and Technology 80: 1043-1052. doi: 10.2166/wst.2019.356.

We are not solely concentrating on ensiled forages ☺

Rinne, M., Franco, M., Stefanski, T., Ghalibaf, M., Fidelis, M., Järvenpää, E. & Pap. N. 2022. Legume biomasses produce high soluble protein yields in a green biorefinery concept. Proceedings of the 29th General Meeting of the European Grassland Federation, Caen, France. June 26-30, 2022. Grassland Science in Europe 27: 268-270.

Red clover

White Clover

Green pea

Galega/Goat's rue

Faba bean

NurmiProteiini – GrassProtein
Protein from grass for feed and food

Aspects related to green biomass processing have been addressed in several projects. Currently ”NurmiProteiini” is on-going.

Kuva: Luke/Marketta Rinne

Luke LUONNONVARAKESKUS

VTT

Valio

Atria® PERHETILOILTA VUODESTA 1903

How can investments be attracted?

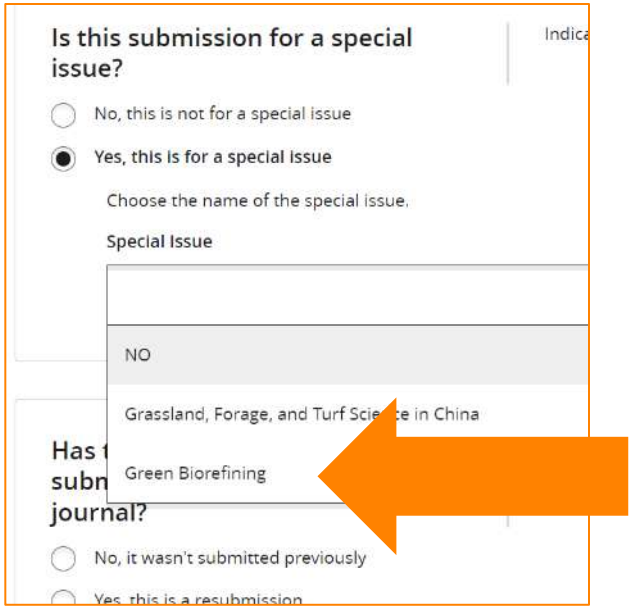
How can the new business ecosystems be created?

How can new product processes be optimized technically and economically?

Are consumers & EU ready to accept novel products?

A Special issue goming up in Grass and Forage Science about Green Biorefineries

Sustainable production systems are needed for feed and food proteins, biochemicals, biomaterials and bioenergy from green biomasses such as grasses and legumes. This special issue aims to contribute on the knowledge on research-driven development of a new biobased industry from sustainable grassland crops with the aim of producing sustainable feed and food protein, materials and services for the green transition.



Guest editor: Marketta Rinne

Kiitos!

Luke
LUONNONVARAKESKUS

Green biorefinery opportunities, challenges and developments - Sweden

Christel Cederberg
Chalmers University of Technology, Gothenburg

DANISH GO-GRASS INTERNATIONAL EVENT ON GREEN BIOREFINING
Aarhus University Foulum, Denmark 24 May 2023

CHALMERS | Institutionen för RYMD,- GEO- OCH MILJÖVETENSKAP

Green biorefinery R&D activities in Sweden

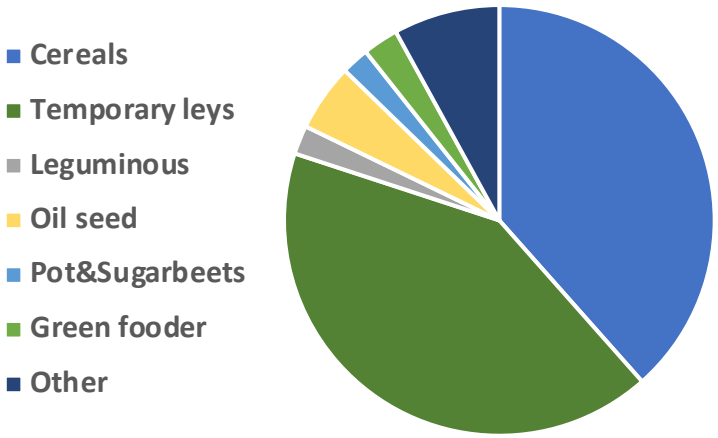
Test pilot, ”farm-scale size” in the Interreg project **Green Valley 2.0**
R&D on e.g. tech development, feeding, system analysis (incl economy)
Researchers: SLU (Skara, Uppsala), Chalmers Univ Tech, Rise

Projects: **PlantProteinFactory** 2018-22
SLU Alnarp **GreenLeaFood** and **Green2Feed** 2022-
Grint4Pro 2023-

Lab scale

Pilot scale

Cropland use in Sweden

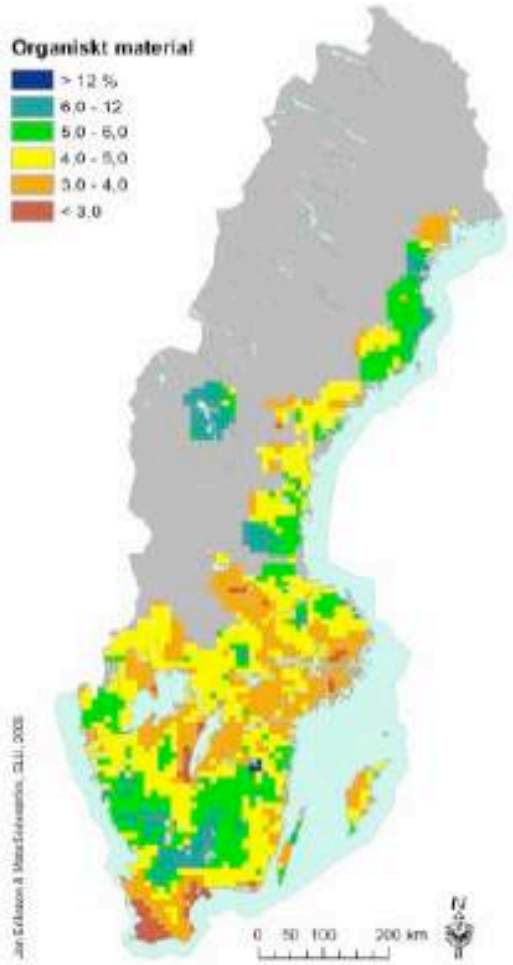


- Temporary leys and cereals on around 80% of SE cropland
- Exports of cereals (15-20% of yearly production)
- Imports of protein for animal production (soymeal and rapeseed meal)
- Imports of vegetable protein for direct human consumption

Temporary leys and perm grassland foremost in inland, and mid+ north SE

http://www.cec.lu.se/sv/forskning/multifunktionella-landskap

Arable farming, dominated by cereals in the plains in southern SE



Karta 4. Halt organiskt material i matjorden. Data från omdrev 1 och 2 sammanslagna. Antal värden 5 179.
Map 4. Organic matter content in the topsoil. *Data from sampling series 1 and 2 combined (n = 5 179).*

Soil monitoring program shows lower Soil Organic Carbon (SOC) in agricultural regions with dominating annual crops

Soil Org Matter, %

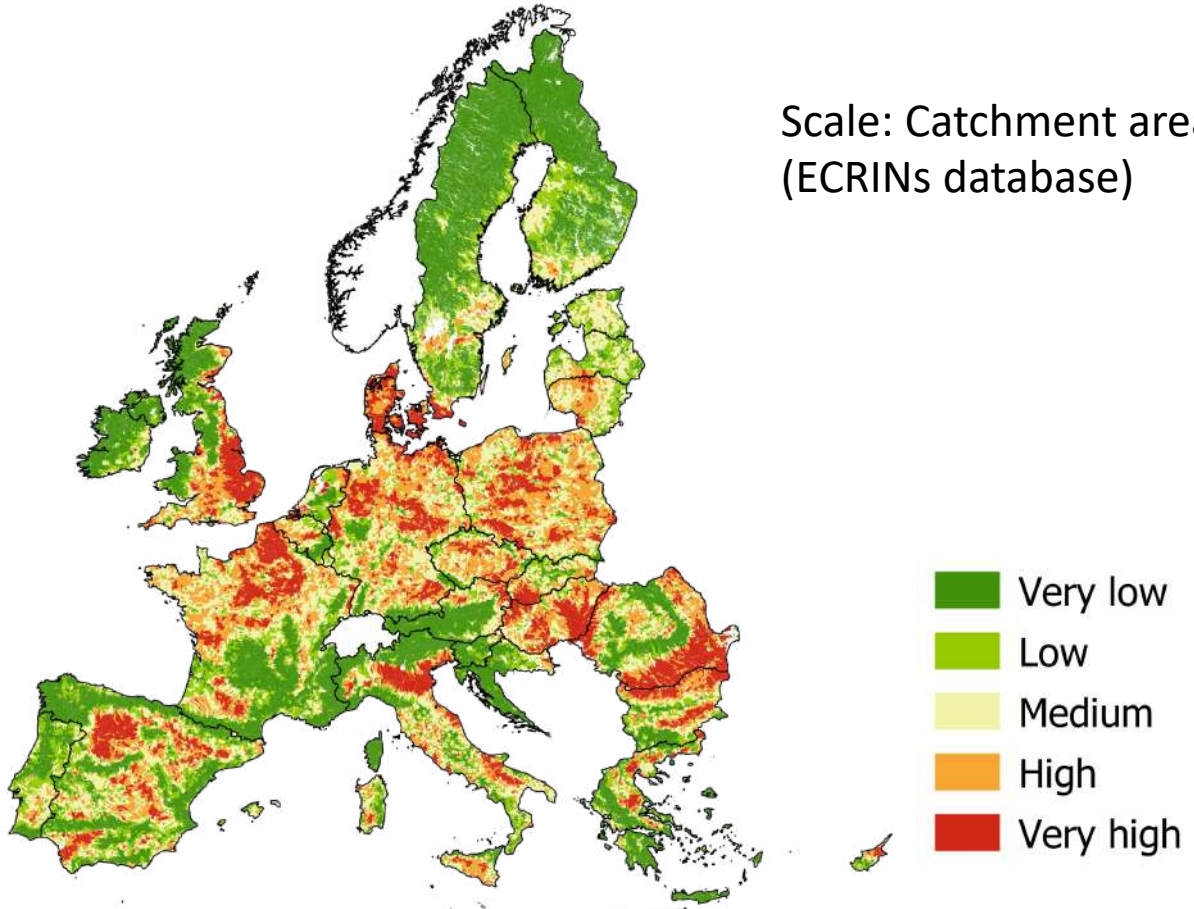
6,0 - 12
5,0 - 5,99
4,0 - 4,99
3,0 - 3,99
<3

Swedish monitoring program on status for arable soils concerning content of organic matter, pH, nutrients and trace elements conditions (>2000 sampling points)

Soil sample data from the Swedish monitoring program of arable soil.
Naturvårdsverkets rapport no 6349

Relation dominance of annual crops and cumulative SOC losses

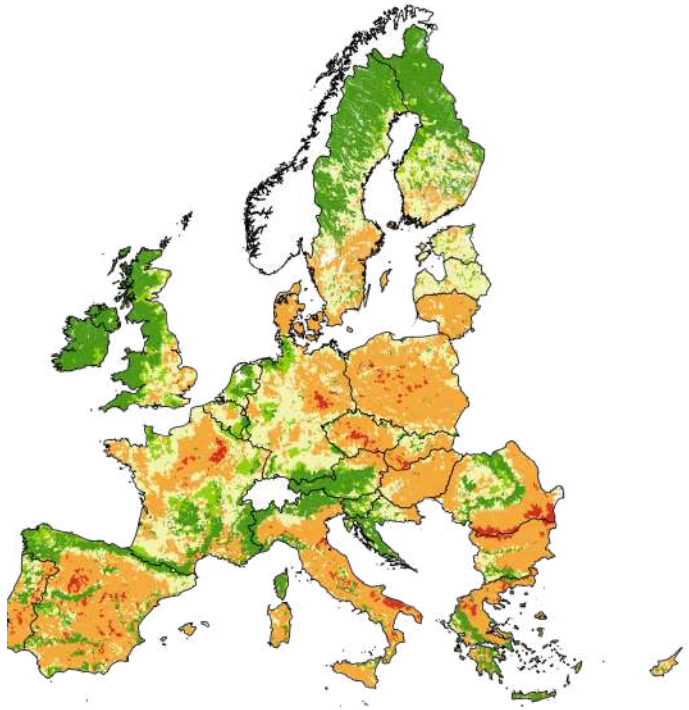
Dominance of annual crops



Scale: Catchment areas (ECRINs database)

Very low
Low
Medium
High
Very high

Cumulative SOC losses



Englund, Oskar, et al. "Beneficial land use change: Strategic expansion of new biomass plantations can reduce environmental impacts from EU agriculture." *Global environmental change* 60 (2020): 101990

Swe Univ Agric (SLU) has several long term field trials, important for our knowledge on SOC changes in soils, example here from Skåne and V Götaland

Swedish **35 year** field trials
Soil Carbon Changes at **0-50 cm** depth

Mono-culture cereal rotation

4 yr rotation: 3 yr grass-clover & 1 yr cereals

Sites: Skåne and Västra Götaland

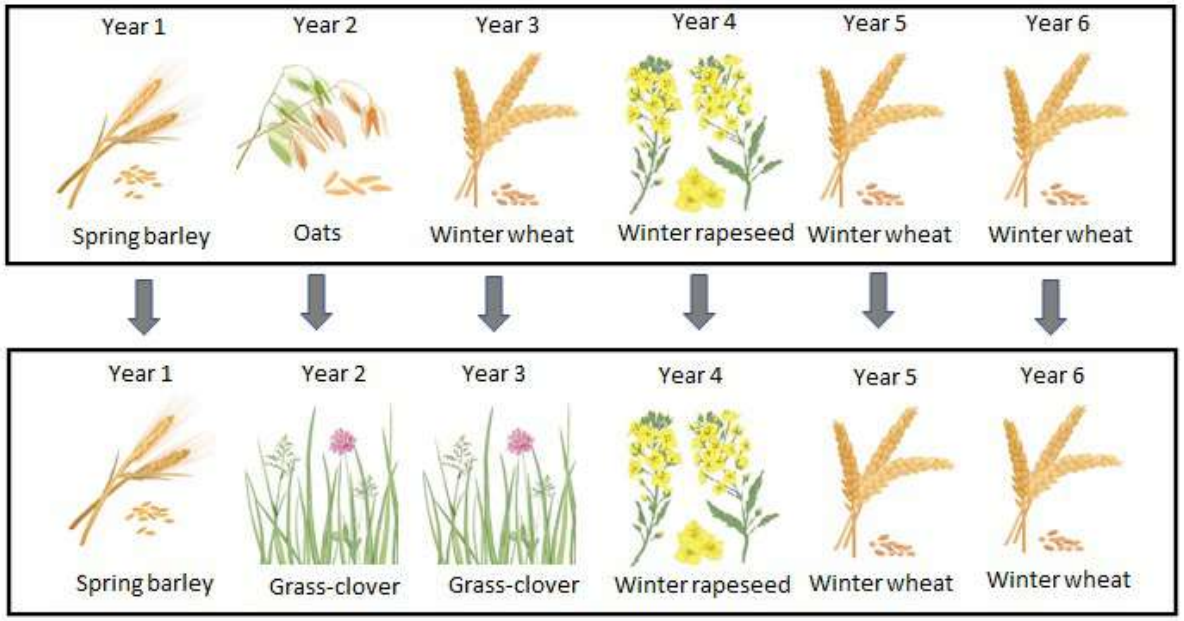
Lanna (Västra Götaland)
43% clay
Changing rotation led to Soil Carbon change
+0.32 tC/ha*yr in overall rotation

Lönnstorp (Skåne)
15% clay
Changing rotation led to Soil Carbon change
+0.85 t C/ha*yr in overall rotation

Verifying Soil Carbon Changes when changing crop rotation is challenging e.g. due to:

- Too few long term field trials
- Trials often measure only top soils (0-20 cm) (subsoil changes can be important!)
- Variation between sites and type of crop rotations
- Verify with soil samples in short periods - uncertain
- Soil Carbon modelling used – but uncertainties

Börjesson, G., Bolinder, M. A., Kirchmann, H., & Kätterer, T. (2018). Organic carbon stocks in topsoil and subsoil in long-term ley and cereal monoculture rotations. *Biology and Fertility of Soils*, *54*(4), 549-558



Crop rotations

Sequences of (different) crops at field level during a number of years

Diversifying crop rotations means many agronomic gains, e.g.

- Better weed and pest management
- Improved soil properties and better soil fertility
- Higher yields
- Higher soil carbon sequestration (or reduced soil carbon losses)
- Enhance biodiversity, both at field level and at landscape level

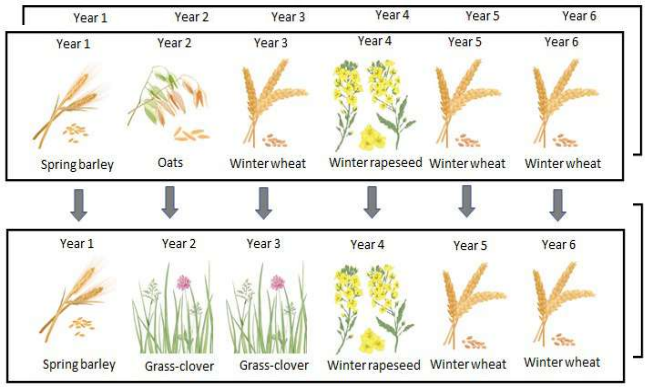
Grass-clover in rotations on cropland

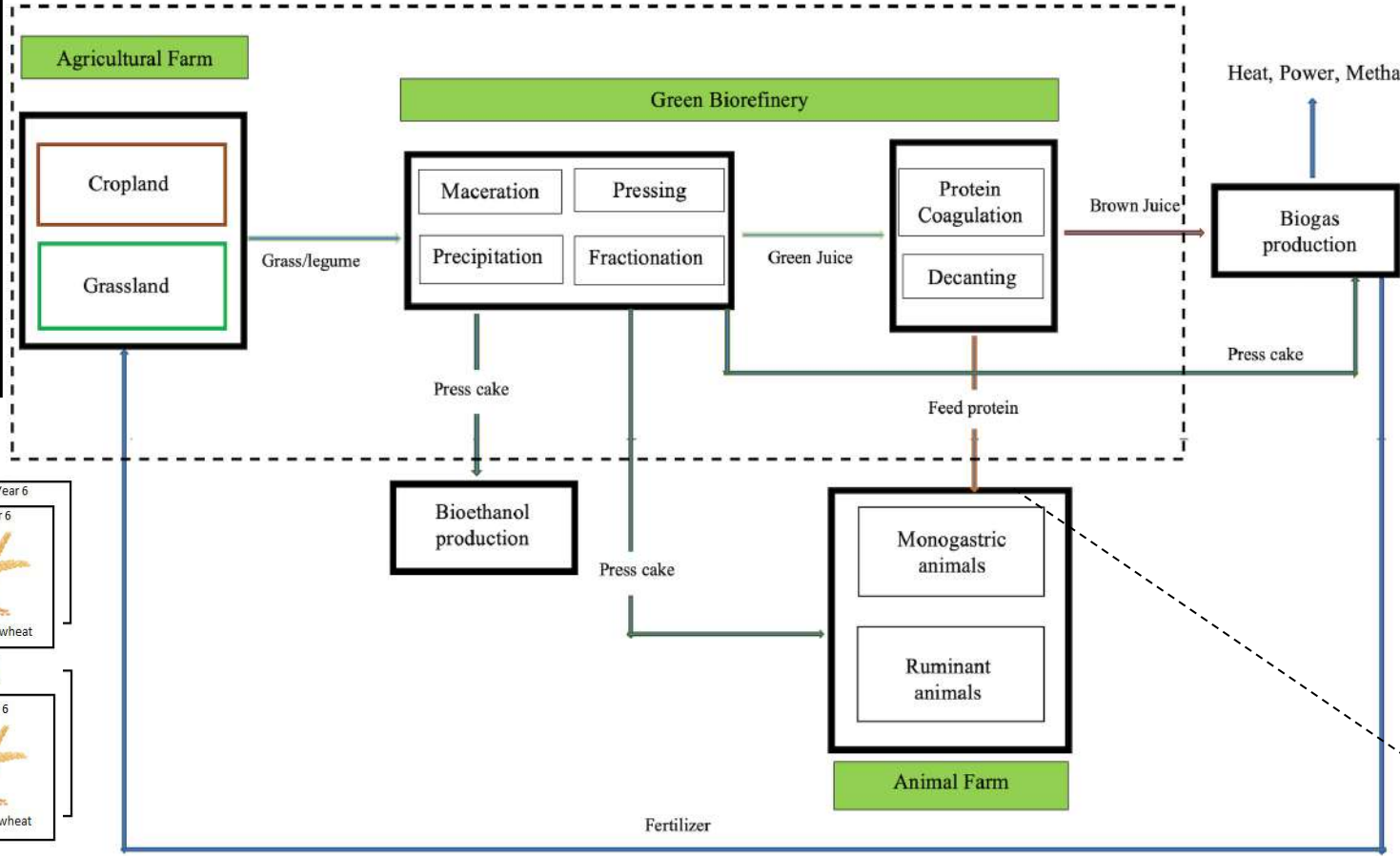
Typically 2-4 years with grass-clover and 2-4 years with annual crops

Diversifying roations with perennial crops (grass, leguminous such clover, alfa-alfa) adds on extra to the diversity gains

System Analysis
Introducing biorefinery integr with biogas, example question

How does Carbon balance change?

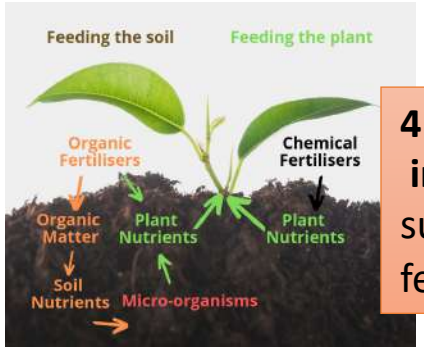




1 At farm: cereals → grass-clover

- Use of diesel & fertiliser
- N2O emissions from soils

- Soil Carbon increase

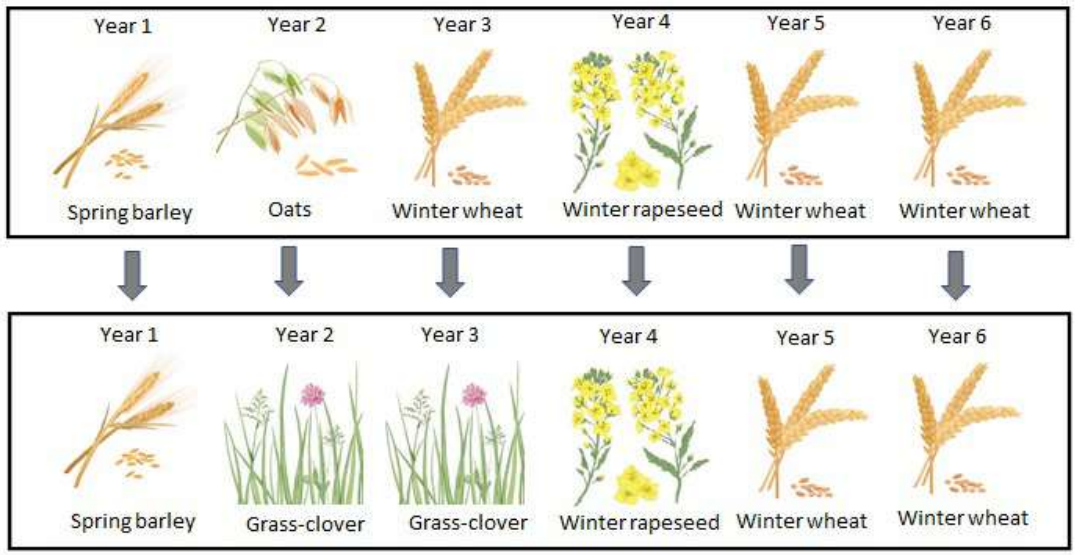


4 Biofertiliser production in biodigestor
substitute imported synthethic fertiliser

3 Biomethane production
substitutes imported fossil gas

2 Green protein products
substitute imported soymeal

Opportunities

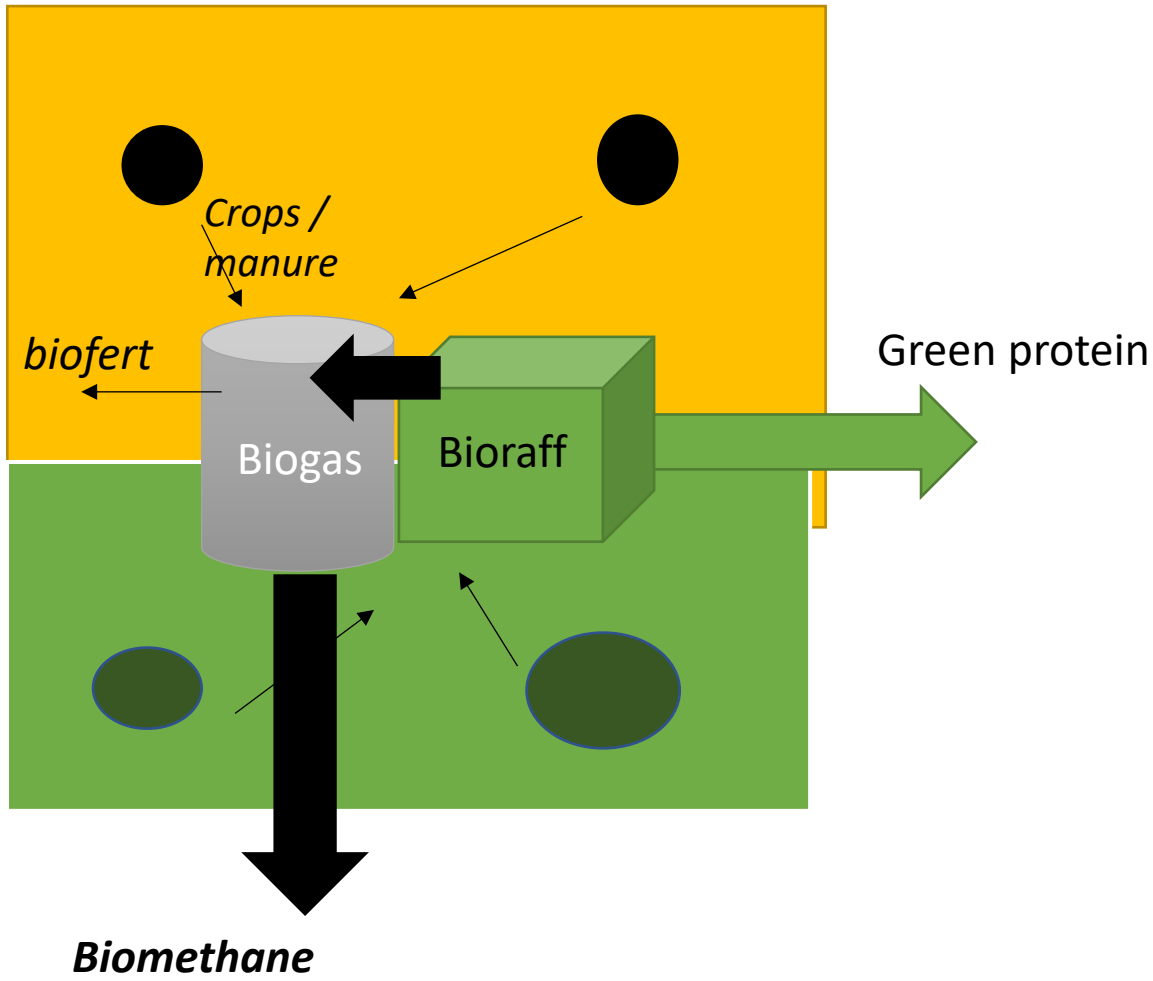


- Farmers´ interest in improving soil fertility, disease pressure, resilience etc with more diversified crop rotations
- Grass/clover ley is a well known crop, easy to implement at large scales
- Large societal interest for increasing domestic protein production
- Large societal interest for increased production of biomethane
- Increasing interest for national CO2 Removals (CDR)
- Many environmental problems associated with present agriculture can be reduced (leaching, pesticde use, biodiversity loss)

Challenges

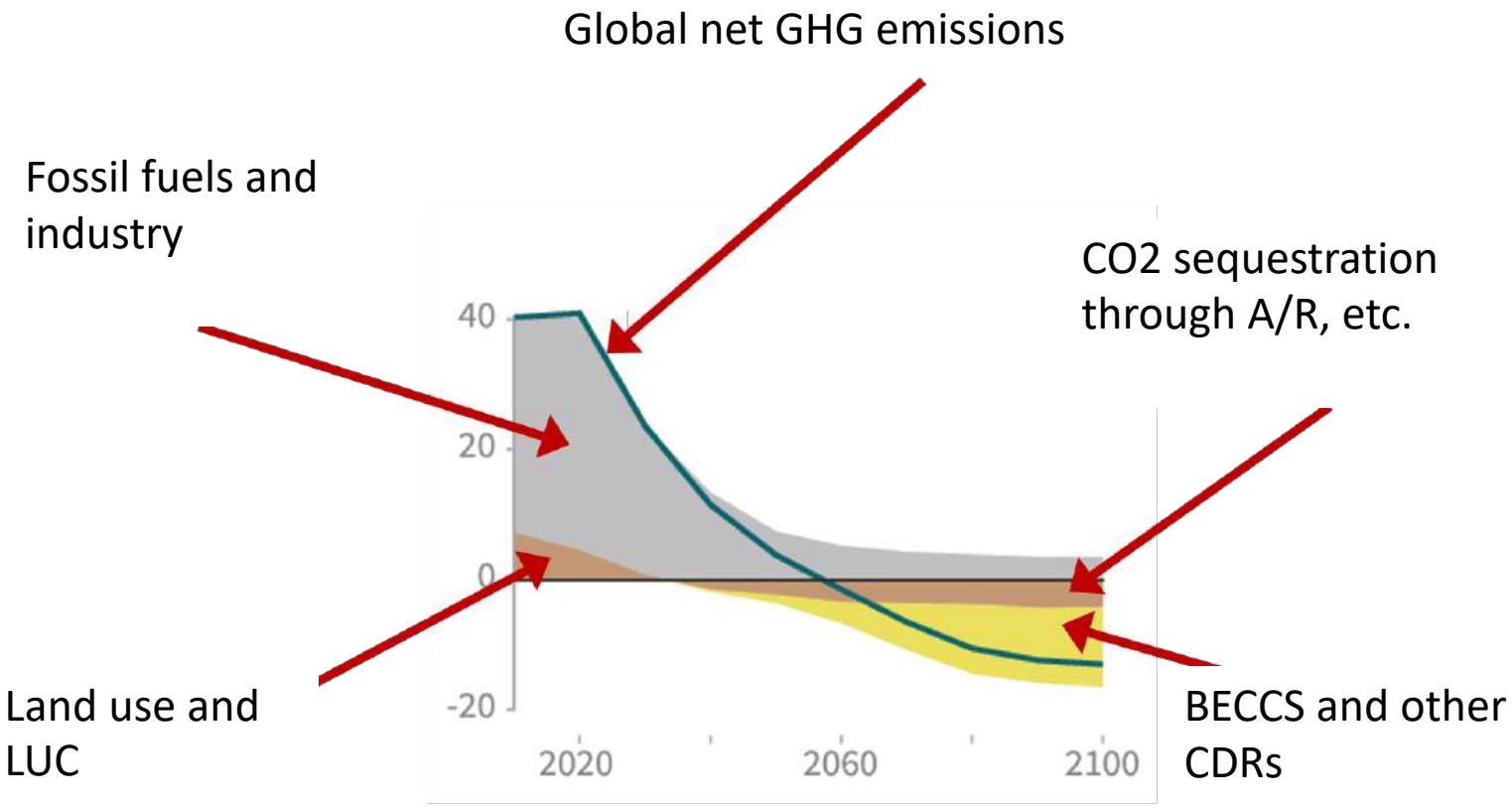
- **Business models – many, difficult to navigate..**
- **… Logistics, planning depending on business model, site- specific conditions (many possibilities/challenges….)**
- **Economy of course…. (very important factor is stable protein-yields in the biorefinery and a market for the proteins, and also societal economic benefit, e.g. carbon credits)**
- **(Some) farmers´ not so change-oriented...**
- **Social acceptance in rural community (probably not a general issue but could be)…**

One example of case, Bioref integrate with biogas-prod with crops and manure, ley crops added, green protein new prod, press cake feedstock for biomethane



Many biobased products and many possible uses

Roles of green biorefineries in sustainability transitions likely to vary as countries differ concerning natural conditions, industry&energy infrastructure, agriculture&forestry, and political goals



Developments

- R&D need to work in close collaboration with industry, farmers and society
- Technology development for improved yields, new products from fibre, efficient production etc…
- Holistic approach in system analysis (economy, environment, food and energy security)

Thank you for your attention

contact information

- **Projects SLU Alnarp**

Anna-Lovisa Nynäs

anna-lovisa.nynas@slu.se

- **Green Valleys 2.0**

Christel Cederberg
christel.cederberg@chalmers.se

Håkan Rosenqvist
hak.rosenqvist@telia.com

MTU
Ollscoil Teicneolaíochta na Mumhan
Munster Technological University

Green Biorefinery Challenges & Opportunities Ireland

James Gaffey

23.05.2023

www.mtu.ie


MTU
Ollscoil Teicneolaíochta na Mumhan
Munster Technological University
CIRCBIO
research group
CIRCULAR
BIOECONOMY
CLUSTER
SOUTH-WEST
IKC3
CARBON, CLIMATE
& COMMUNITY
ACTION

Share of total area by type and land cover (%), 2018

	Total area (km2)	Woodland and shrubland	Cropland	Grassland	Water areas and wetland; bareland	Artificial
EU	4 125 107	46.8	24.2	17.4	7.3	4.2
Belgium	30 666	27.8	29.1	28.2	3.3	11.7
Bulgaria	110 996	48.8	32.3	14.7	2.0	2.3
Czechia	78 871	39.3	33.7	20.1	2.4	4.4
Denmark	42 925	21.9	47.7	19.7	3.8	6.9
Germany	357 569	35.7	32.3	20.8	3.7	7.6
Estonia	45 336	58.7	12.9	16.2		1.7
Ireland	69 947	24.2	5.5	57.7		4.2
Greece	131 694	57.6	20.5	13.8		4.0
Spain	498 502	50.1	27.4	12.8	6.0	3.7
France	549 060	36.0	29.9	24.6	3.8	5.7
Croatia	56 594	59.2	16.6	17.4	3.7	3.2
Italy	302 072	41.2	31.7	16.4	4.2	6.6
Cyprus	9 253	46.5	30.4	10.9	6.0	6.2
Latvia	64 585	56.0	15.4	20.9	5.9	1.7
Lithuania	65 284	39.6	32.0	21.9	4.3	2.1
Luxembourg	2 595	36.9	21.8	32.9	1.1	7.4
Hungary	93 012	28.2	43.5	17.5	6.8	4.0
Malta	316	16.9	28.7	18.5	8.4	27.5
Netherlands	37 377	16.8	23.0	34.2	13.3	12.6
Austria	83 878	48.5	15.9	24.2	7.3	4.2
Poland	311 929	37.6	34.7	20.7	3.3	3.6
Portugal	89 103	56.2	16.3	15.8	5.3	6.4
Romania	238 398	37.0	32.6	22.9	4.7	2.8
Slovenia	20 273	65.8	11.0	17.8	1.2	4.3
Slovakia	49 035	49.5	27.5	17.6	2.0	3.4
Finland	338 411	69.6	5.3	5.7	17.6	1.7
Sweden	447 424	68.5	4.0	5.5	20.1	1.8

57% grassland

Source: Eurostat (online data code: lan_lcv_ovw)

eurostat

The “green island”

The “not so green island”

25% emissions reduction target agreed for agriculture

Stella Meehan

July 28, 2022 3:54 pm

Succeeding Together

www.mtu.ie

The protein challenge

More co-ops import fodder to address 'critical' shortage

A number of milk processors and mart operators have sourced fodder overseas or are planning to import to bridge the fodder supply gap.

IRISH FARMERS JOURNAL

SEARCH

BEEF DAIRY SHEEP AGRIBUSINESS MACHINERY TILLAGE PEDIGREE BUILDINGS PROPE

Sustainable protein essential going forward

As consumers become more aware of where their food comes from, there is a growing demand for more sustainable feed ingredients.

Siobhán Walsh

MORE > CLIMATE AND ENVIRONMENT

11 August 2021

M&S cuts soya from production of milk to curb deforestation

UK retailer worked with dairy farms to end use of destructive cattle feed, but critics say move could 'shift problem elsewhere'

2.3m tonnes of imported animal feed was genetically modified

Aisling O'Brien

November 23, 2022 12:30 pm

www.mtu.ie

Diversification and Biorefineries as part of the Just transition

Ollscoil Teicneolaíochta na Mumhan
Munster Technological University

Department anaerobic digestion strategy in the works

Grass will be the primary feedstock of anaerobic digesters planned to reduce carbon emissions.

Opinion: the untapped potential of bioenergy in Irish agriculture

A blindspot exists in Irish policy and support towards bioenergy compared to other renewable energy technologies, writes Seán Finan, CEO of the Irish Bioenergy Association.

The time has come for a Just Transition in agriculture

Improving the protein efficiency of grass

Treatment		
Item	GS	PC
DMI (kg DM/d)	19.33	18.00
Feed efficiency	1.31	1.27
Milk yield (kg/d)	28.02	27.33
No significant difference in milk quality		
Nitrogen Intake and Output		
Intake kg/d		
Feed N Intake (kg/d)	0.71[a]	0.61[b]
N output (kg/d)		
Milk	0.19	0.18
Faeces	0.23[a]	0.19[b]
Urine	0.27[a]	0.22[b]
NUE (%)	27.33[a]	31.90[b]
Methane Emissions Analysis Rusitec		
Gas production (l/d)	1.31	1.26
Methane (mmol/d)	6.61	5.71

Making grass protein accessible for pigs

clean technologies

MDPI

Article

Production of Green Biorefinery Protein Concentrate Derived from Perennial Ryegrass as an Alternative Feed for Pigs

Rajeev Ravindran [1,*], Sybrandus Koopmans [2], Johan P. M. Sanders [2], Helena McMahon [1] and James Gaffey [1]

[1] Circular Bioeconomy Research Group (CIRCBIO), Shannon Applied Biotechnology Centre, Munster Technological University, Dromtacker, V92 CX88 Tralee, Ireland; helena.mcmahon@mtu.ie (H.M.); James.Gaffey@mtu.ie (J.G.)
[2] Grassa BV, 5928 SZ Venlo, The Netherlands; bram@grassa.nl (S.K.); johan@grassa.nl (J.P.M.S.)
* Correspondence: rajeev.ravindran@mtu.ie

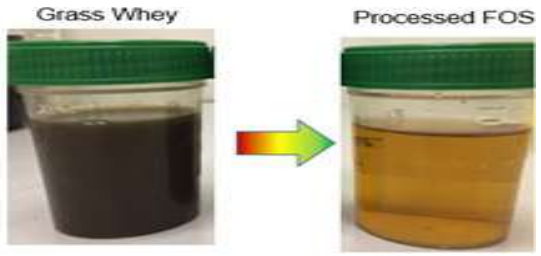
Abstract: Perennial rye grass is a widely used forage species in Ireland, on which the ruminant sector of agriculture is heavily dependent. While this species of grass is the primary source of fodder for cows, it is also abundant in plant protein, which could form a potential alternative ingredient in monogastric animal feed using a green biorefinery approach. In this study, perennial rye grass was

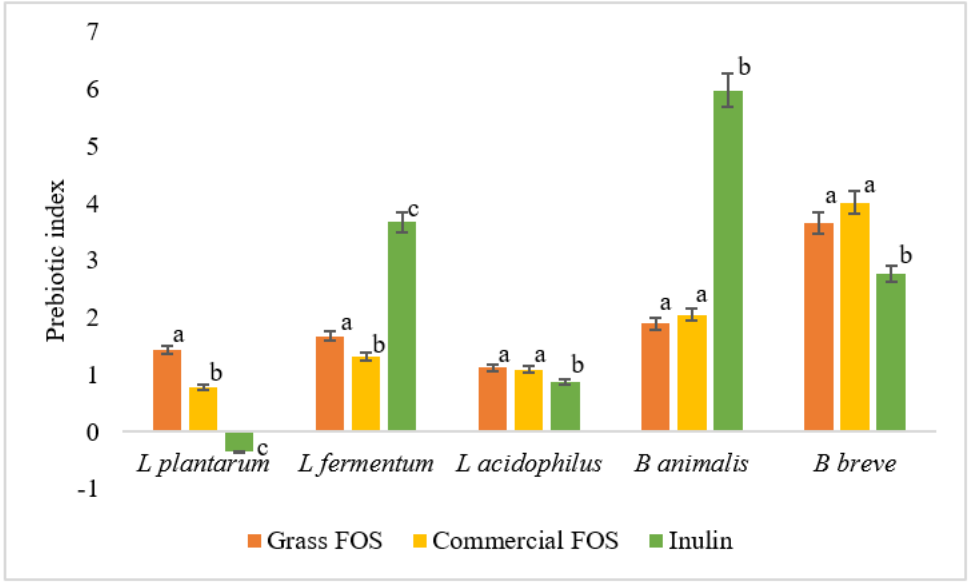
Date of Weighing	Daily Feed Intake (kg/d)		Feed Conversion Ratio		Average Daily Gain (kg/day)	
	Treatment	Control	Treatment	Control	Treatment	Control
Period 1	1.022	0.991	1.77	1.67	0.577	0.592
Period 2	1.247	1.182	1.83	1.83	0.683	0.646
Period 3	1.386	1.301	1.90	1.86	0.729	0.699
Period 4	1.512	1.400	2.04	2.05	0.742	0.682

Results of weaner trial comparing treatment (grass-protein based) v/s control diet

Feed Source	Crude Protein	Lysine	Methionine	Cysteine	Threonine	Crude Fibre
Soybean Meal	44 – 48	2.81 – 3.20	0.60 – 0.75	0.69 – 0.74	0.71 – 2.00	3.0 – 7.0
Sunflower Meal	24 – 44	1.18 – 1.49	0.74 – 0.79	0.55 – 0.59	1.21 – 1.48	12.0 – 32.0
Rapeseed Meal	34 – 36	2.00 – 2.12	0.67 – 0.75	0.54 – 0.91	1.53 – 2.21	10.0 – 15.0
Cottonseed Meal	24 – 41	1.05 – 1.71	0.41 – 0.72	0.64 – 0.70	1.32 – 1.36	25.0 – 30.0
Grass protein (Biorefinery Glas)	**33.9**	**1.81**	**0.65**	**0.18**	**1.5**	**6.1**
Grass protein (FZC to date unpublished)	**42.8**	**2.03**	**0.72**	**0.21**	**1.71**	**3.9**

Diversification – and not only grass to gas





Open Access Article

Biogas, Biomethane and Digestate Potential of By-Products from Green Biorefinery Systems

by Rajeev Ravindran [1], Kwame Donkor [2], Lalitha Gottumukkala [2], Abhay Menon [1], Amita Jacob Guneratnam [1], Helena McMahon [1], Sybrandus Koopmans [3], Johan P. M. Sanders [3,4] and James Gaffey [1,*]

[1] Circular Bioeconomy Research Group, Shannon Applied Biotechnology Centre, Munster Technology, V92 CX88 Tralee, Ireland
[2] Celignis Limited, Unit 11 Holland Road, Plassey Technology Park, Castletroy, Co., V94 7Y42 Limerick, Ireland
[3] Grassa BV, Campus Building Villa Flora, Box 72, Villaflorapark 1, 5928 SZ Venlo, The Netherlands
[4] Biobased Chemistry and Technology, Wageningen University and Research, Bornse Weilanden 9, 6708 WG Wageningen, The Netherlands
* Author to whom correspondence should be addressed.

Clean Technol. **2022**, *4*(1), 35-50; https://doi.org/10.3390/cleantechnol4010003

Received: 13 November 2021 / Revised: 13 December 2021 / Accepted: 6 January 2022 / Published: 17 January 2022

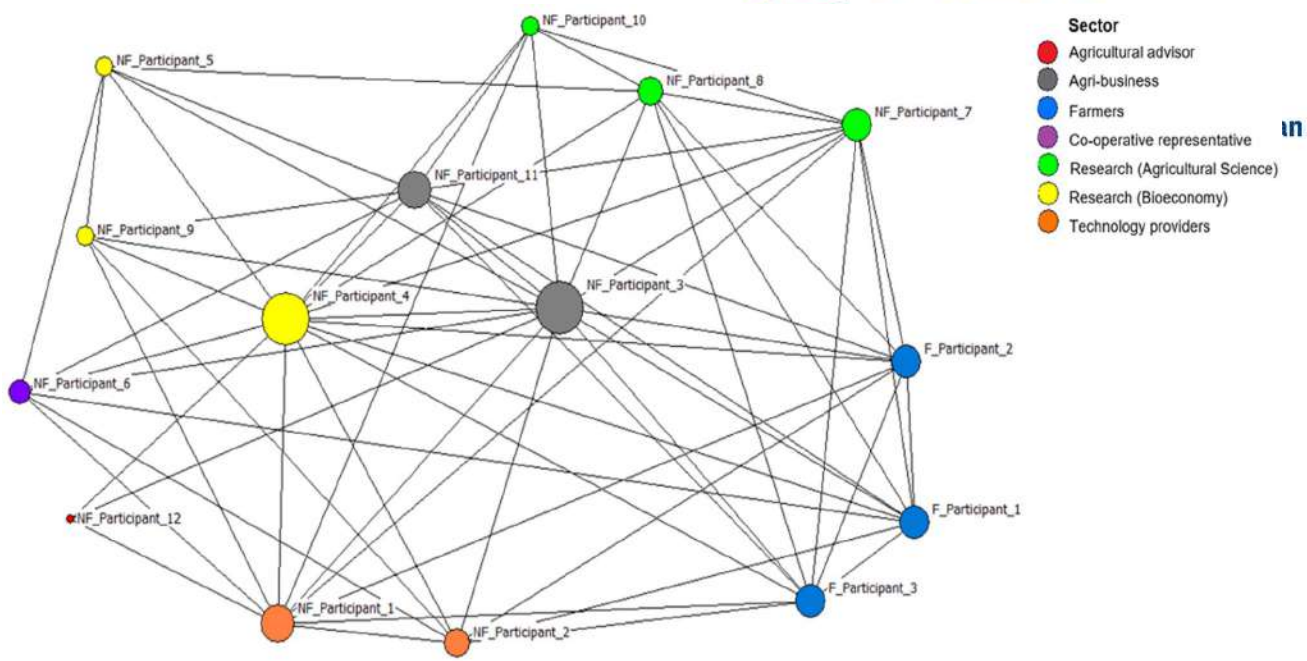
(This article belongs to the Special Issue Feature Papers for Clean Technologies 2021)

Download | Browse Figures | Versions Notes

Abstract

Global warming and climate change are imminent threats to the future of humankind. A shift from the current reliance on fossil fuels to renewable energy is key to mitigating the impacts of climate change. Biological raw materials and residues can play a key role in this transition through technologies such as anaerobic digestion. However, biological raw materials must also meet other existing food, feed and material needs. Green biorefinery is an innovative concept in which green biomass, such as grass, is processed to obtain a variety of protein products, value-added co-products and renewable energy, helping to meet many needs from a single source. In this study, an analysis has been conducted to understand the renewable energy potential of green biorefinery by-products and residues, including grass whey, de-FOS whey and press cake. Using anaerobic digestion, the biogas and biomethane potential

Bringing farmers on board



Order Article Reprints

Open Access Article

An Analysis of Irish Dairy Farmers' Participation in the Bioeconomy: Exploring Power and Knowledge Dynamics in a Multi-actor EIP-AGRI Operational Group

by Kieran Harrahill [1,2,3,*], Áine Macken-Walsh [2,3], Eoin O'Neill [1,3] and Mick Lennon [1]

[1] School of Architecture, Planning & Environmental Policy, University College Dublin, D14 E099 Dublin, Ireland
[2] Teagasc-The Irish Agriculture and Food Development Authority, Rural Economy & Development Programme, Mellows Campus, Athenry, H65 A063 Galway, Ireland
[3] BiOrbic—SFI Bioeconomy Research Centre, University College Dublin, D04 V1W8 Dublin, Ireland
[*] Author to whom correspondence should be addressed.

Sustainability **2022**, *14*(19), 12098; https://doi.org/10.3390/su141912098

Received: 19 July 2022 / Revised: 14 September 2022 / Accepted: 19 September 2022 / Published: 24 September 2022

(This article belongs to the Collection Sustaining Rural Innovation: Reflexivity, Diversity and Co-creation)

Download | Browse Figures | Versions Notes

Abstract

The European Commission's European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI), part of the European Commission's Europe 2020 strategy, aims to 'achieve more and better from less' by bringing together a diversity of innovation actors to harness their combined knowledges to creatively achieve sustainability goals. The creation and novel use of biomaterials remains both a significant challenge and opportunity and bringing together all the relevant actors from primary production through to refinement and processing is anticipated to make progress in bringing into practice pilot operational approaches on the ground. For the bioeconomy, a nascent sector, it is a significant challenge for it to become established; grow; innovate and engage all the relevant actors. It has been noted internationally that primary producers, among other cohorts, remain marginalised from bioeconomy activities, which significantly compromises how inclusive and innovative the bioeconomy is likely to be henceforth. In this context, an interesting case study is the *Biorefinery Glas* Operational Group (OG), located in Ireland. The OG was a 'small-scale-farmer-led green biorefinery supporting farmer diversification into the circular bioeconomy'. The central research question of this paper concerns the dynamics of

Next Steps

MTU
Ollscoil Teicneolaíochta na Mumhan
Munster Technological University

AD: Department provides €3 million funding to UCD and MTU

Charles O'Donnell
January 31, 2023 12:46 pm

gov.ie Departments Consultations Publica

Press release

Ministers McConalogue and Heydon announce €3 million for integrated anaerobic digestion and green biorefining demonstration initiative

Biotechnology Advances 66 (2023) 108168

Contents lists available at ScienceDirect

Biotechnology Advances

journal homepage: www.elsevier.com/locate/biotechadv

Research review paper

Green Biorefinery systems for the production of climate-smart sustainable products from grasses, legumes and green crop residues

James Gaffey [a,b,c,*], Gaurav Rajauria [a,b], Helena McMahon [a,b], Rajeev Ravindran [a,b], Carmen Dominguez [a,b], Morten Ambye-Jensen [d], Macella F. Souza [e], Erik Meers [e], Marta Macias Aragonés [f], Dubravka Skunca [g], Johan P.M. Sanders [h,i]

[a] Circular Bioeconomy Research Group, Shannon Applied Biotechnology Centre, Munster Technological University, Tralee V92 CX88, Ireland
[b] BiOrbic Bioeconomy Research Centre, University College Dublin, Belfield, Dublin 4, Ireland
[c] Dept. of Environmental Engineering, University of Limerick, Castletroy, Limerick V94 T9PX, Ireland
[d] Aarhus University, Department of Biological and Chemical Engineering, Nørregade 44, 8000 Aarhus C, Denmark
[e] Laboratory of Bioresource Recovery (RE-SOURCE LAB), Ghent University, Coupure Links 653, 9000 Ghent, Belgium
[f] Technological Corporation of Andalusia (CTA), C Albert Einstein S/N, INSUR building, 4th floor, 41092 Seville, Spain
[g] Faculty of Business and Law, MB University, Teodora Drajzera 27, 11040 Belgrade, Serbia
[h] Grassa BV, Villafloraweg 1, 5928, SZ Venlo, the Netherlands
[i] Valorization of Plant Production Chains, Wageningen University, Bornse Weilanden 9, 6708 WG Wageningen, the Netherlands

ARTICLE INFO

Keywords:
Biorefinery
Grass

ABSTRACT

Grasses, legumes and green plant wastes represent a ubiquitous feedstock for developing a bioeconomy in regions across Europe. These feedstocks are often an important source of ruminant feed, although much remains unused or underutilised. In addition to proteins, these materials are rich in fibres, sugars, minerals and other components

https://doi.org/10.1016/j.biotechadv.2023.108168

References

- Serra, E., Lynch, M.B., Gaffey, J., Sanders, J.P.M., Koopmans, S., Markiewicz-Keszycka, M., Bock, M.H., McKay, Z.C. and Pierce, K.M., 2023. Biorefined press cake silage as feed source for dairy cows: effect on milk production and composition, rumen fermentation, nitrogen and phosphorus excretion and in vitro methane production. Livestock Science, 267, p.105135.
- https://doi.org/10.1016/j.livsci.2022.105135
- Ravindran, R., Koopmans, S., Sanders, J.P., McMahon, H. and Gaffey, J., 2021. Production of Green biorefinery protein concentrate derived from perennial ryegrass as an alternative feed for pigs. Clean Technologies, 3(3), pp.656-669.
- https://doi.org/10.3390/cleantechnol3030039
- Ravindran, R., Donkor, K., Gottumukkala, L., Menon, A., Guneratnam, A.J., McMahon, H., Koopmans, S., Sanders, J.P. and Gaffey, J., 2022. Biogas, biomethane and digestate potential of by-products from green biorefinery systems. Clean Technologies, 4(1), pp.35-50.
- https://doi.org/10.3390/cleantechnol4010003
- Harrahill, K., Macken-Walsh, Á., O'Neill, E. and Lennon, M., 2022. An Analysis of Irish Dairy Farmers' Participation in the Bioeconomy: Exploring Power and Knowledge Dynamics in a Multi-actor EIP-AGRI Operational Group. Sustainability, 14(19), p.12098.
- https://doi.org/10.3390/su141912098
- Gaffey, J., Rajuaria, G., McMahon, H., Ravindran, R., Dominguez, C., Jensen, M.A., Souza, M.F., Meers, E., Aragonés, M.M., Skunca, D. and Sanders, J.P., 2023. Green Biorefinery systems for the production of climate-smart sustainable products from grasses, legumes and green crop residues. Biotechnology Advances, p.108168.
- https://doi.org/10.1016/j.biotechadv.2023.108168

MTU
Ollscoil Teicneolaíochta na Mumhan
Munster Technological University

Thank You!

For more information, please email james.gaffey@mtu.ie

James Gaffey

23.05.2023

NIBIO
NORSK INSTITUTT FOR BIOØKONOMI

Green Biorefinery i Norway

GO-GRASS International Event, Foulum 23-24 May 2023

Steffen Adler, NIBIO

Green Biorefinery i Norway

- Ongoing projects in Norway
- Opportunities
- Challenges
- Development

Norwegian Institute of Bioeconomy Research (NIBIO)

Green Biorefinery i Norway

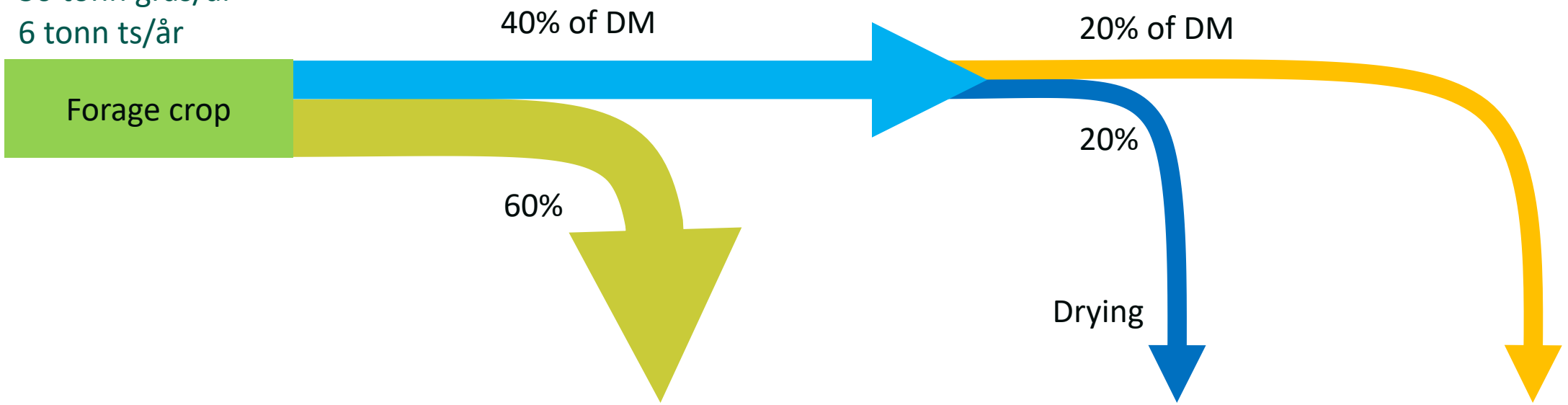
- Animal husbandry and aquaculture are depending on imported feed protein
- Trends in Norwegian agriculture
  - Less dairy cows
  - More beef cattle
  - Decreasing number of farms
  - Loss of culture landscape and biodiversity
- Goal to increase self-sufficiency in feed
- Biorefinery approach is based on recent development in Denmark

Green Biorefinery i Norway

Ley
1 ha
15-20% DM
15-20% CP
30 tonn gras/år
6 tonn ts/år

Screw press

Precipitation
Green juice 6-10% DM
12 tonn green juice/år



Pulp
30-35% DM
15-20% CP
3.6 tonnes of DM/year

Green protein concentrate
90% DM
35-60% CP
1.2 tonnes of DM/year

Brown juice
6% DM
15-20% CP
1.2 tonnes of DM/year

Green Biorefinery i Norway

Previous studies in Norway

- Experiments with **silage effluents** (Randby et al. 1990, 1991, 1992, 1995)
- **Small-scale screw press** experiment (Norsvin, NLR, 2016, Langeland, Mutsaers)
- **Gress juice for pigs** (Gjerlaug, 2017; Johansen, Hjelkrem, 2018; Adler et al., 2018)
- ProRefine, biorefinery of **forage legumes** in organic farming (2018-2022, Adler et al., 2020, Micke et al., in prep.)
- Green**Poultry** (2019, Johanssen et al., 2020)
- **Foods of Norway** (NMBU)

Green Biorefinery i Norway

Ongoing studies in Norway

- NØFF, protein feeds in organic farming (NIBIO, 2021-2023)
- SUSFEED, feed systems in Norway's agri- and aquacultural sectors (Ruralis, 2021-2025)
- ONETWO (NIBIO, 2023-2025, Kismul et al., 2023)

Facilities

- Pilot plant NIBIO Steinkjer

Green Biorefinery i Norway

Opportunities

- Good conditions for forage production
- Animal production and aquaculture sector request sustainable feed
- Leys are beneficial in crop rotation
- Maintanance of grasslands important to mainatin landscape value
- Wider product spectrum

Green Biorefinery i Norway

Challanges

- High-cost investments
- Technology
- Scale
- Agronomy
- Preservation ethcniques
- Labour demands
- Logistics
- Business models
- Economy
- Sustainability

Green Biorefinery i Norway

Project ONETWO

- 2023-2025
- Biorefinery methods
- Pulp as forage for dairy cows
- Green protein concentrate for broiler chicken
- Business models
- Sustainability

Project partners

NIBIO, Ruralis, Aarhus University, TINE, Felleskjøpet fôrutvikling, Scandi Energy, Orkel Direkte

Funding

- Forskningsmidlene for jordbruk og matindustri

Green Biorefinery i Norway

We are looking forward to cooperate with you!

Steffen Adler, Haldis Kismul, Ghulam Qasim Khan, Abirami R. Ganesan, Hanne Mæhre, Gjermund Bahr, Dmitry Kechasov, Jørgen Mølmann +++

Thank you for listening!

NIBIO

GO-GRASS: White Paper for grassland opportunities

Nathalie Bargues (Greenovate! Europe) and Karen Hamann (IFAU)

24 May 2023

This project has received funding from the European Union's Horizon 2020 research and Innovation programme under grant agreement **N°862674**.

White Paper on Grassland Opportunities

GO-GRASS

Objective of the White Paper:

This White Paper aims to demonstrate a wide range of opportunities for valorising grasslands based on the findings from GO-GRASS cases, and relevant best practices at local, national, and European levels.

The focus is on value chains, enabling business environments, policy gaps and best practices for policies that promote valorisation of grasslands and grasses.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

White Paper on Grassland Opportunities

Context and background:

Grassland is an important type of land use due to its large surface and the large number of ecosystem services it provides, such as **carbon sequestration, enhancing biodiversity and protecting water.**

To boost the development of a bio-based economy as a contribution to the EU's climate goal of achieving net zero emissions by 2050, there is a need for **business models** that can be replicated in a variety of locations and contexts, with relatively low levels of investment, risk and technical sophistication.

A wider range of rural entrepreneurs needs to get involved in the emerging bio-based business sector, including farmers, forest owners, their associations, policy makers, small rural businesses and advisors. This is key to **diversify and revitalise** the economy and create quality jobs in rural areas.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

White Paper on Grassland Opportunities

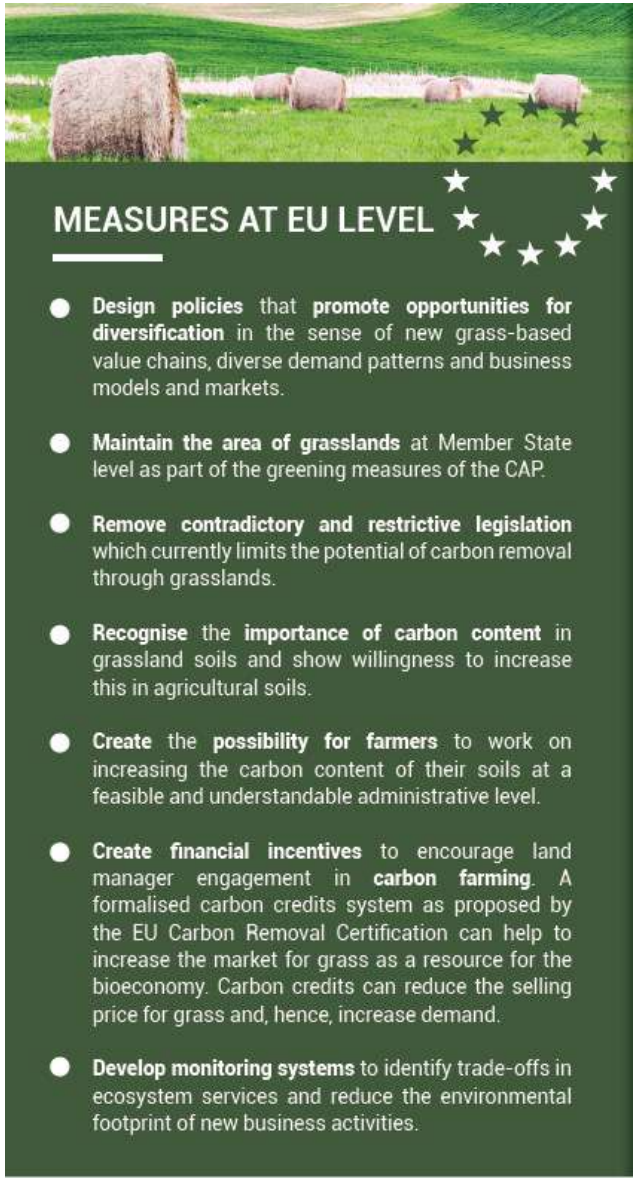
The policy recommendations are designed to support **European decision makers and regulators, planning and rural development agencies, and local authorities** to develop targeted policies for a circular and sustainable use of grassland in collaboration with researchers, networks, and farmers.

CONTENT:

- The **needs and current challenges** for grassland valorisation in Europe;
- Grasslands is a key resource to revitalise rural areas, explaining the **opportunities** for their valorisation
- **Innovative technologies and value chains** that can contribute to the development of new circular grass-based business models;
- How innovative grass-based business models are supported by **suitable business environments;**
- The main **policy gaps** that need to be addressed to improve value creation of grasslands and **best practices** (INTERREG, LIFE, H2020): CAP Pillar I and Pillar II, land use management, policy recommendations for biogas, biochar, paper derived products, animal bedding, grass-derived proteins,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

White Paper on Grassland Opportunities - Recommendations



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

White Paper on Grassland Opportunities - Recommendations

MEASURES AT NATIONAL & REGIONAL LEVEL

- **Take a holistic view** to **valorising grassland biomass**, covering environmental, climatic, social-economic, and technological perspectives. Potential support of government incentives and regulatory-push effect need to be coordinated.
- **Support conversion of arable land into grassland** to preserve the environment, build up soil carbon, and facilitate the delivery of resources for biorefineries that can produce feed, food, materials, and bioenergy.
- **Develop** specific **actions supporting the maintenance of grasslands** threatened by abandonment and provide targeted policy support to maintain the ecosystem services related to grasslands (fire control, tourism, biodiversity, high soil carbon content).
- **Align fertiliser regulations at EU and national levels** and provide policy support and advisory services for small- to medium- scale circular biochar business at national or regional level.

SUPPORT MEASURES

- **Increase awareness** of the **benefits of grasslands** through training, workshops, and outreach to consumers via non-specialised media.
- **Develop ready to use business solutions** sold or made available through licensing.
- **Organise** engaging and **open policy dialogues** to discuss best practices.
- **Establish** adequate **knowledge transfer actions** that allow farmers to understand the new products delivered from grasslands.
- **Promote** the establishment of **farmers cooperatives**.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Recommendations - Grass-based proteins

The technique to produce protein products is based on specific types of grasses and legumes, and it should be adapted and expanded considering the different composition they have in their grasslands.

This may be reached through the implementation of **operational groups** in those countries.

The value of new permanent grassland areas to increase soil carbon content and of old grasslands to keep a high stock of soil carbon should be included in the **EU carbon removal tools**.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Recommendations – Animal Bedding

The **technique** to develop products is based on specific types of grasses, which could be **expanded to other countries** where animal bedding products are in shortage.

An analysis of the potential use of different types of grass as raw material for animal bedding and a comparison with the competitor's end-products should be carried out at demos sites level.

The funding from operational groups could be key to develop the **business models across Europe.**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Recommendations - Biochar

The production of biochar should be directly fostered by policy makers in the different regions of Europe.

The biochar production should consider social aspects linked to the farming context where farm size, number of cooperatives linked to environment uncertainties associated with the grass production should be carefully considered.

Improvement of access to organic fertiliser from residues and waste, should provide opportunities for the producers of grass biochar.

Member States should include this mitigation activity as part of the IPCC accounting and the **certification scheme of carbon removals** to help reach net zero emissions.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Recommendations – Grass-based paper

The innovative use of grass to deliver grass-based paper products means that this business model is in a very early stage of development.

Member States should support either the development of new companies with this business model or help in the **transformation of already existing tree-based paper production companies.**

This could be carried out through direct payments or tax reduction incentives.

Payments in the future should be governed by the actual benefits and negative effects of producing and harvesting grasslands and forests respectively.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Recommendations – Biogas

The policy formulation should consider:

- the level of readiness of the business models in the starting phase when the **farmers and rural entrepreneurs are more dependent on economic support to have adequate infrastructures**,
- the **access to the grid network and training to produce biogas**,
- and the creation of a **business environment** that supports the use of the biogas by end-users.

From a CAP point of view, both the agri-food system and the farm scale should be incorporated to account for the benefits of using the grass as part of fuel production, ensuring direct **CAP payments for the grasslands delivering the grass within the climate neutrality goal of the EU Green Deal**.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

What is the GO-GRASS project?

GO-GRASS is a Horizon 2020 project which is developing **circular and sustainable business models that can be used by entrepreneurs, local authorities and other stakeholders.**

Since October 2019, the project connects 22 partners from 8 countries, which are developing small-scale demonstration sites in four EU regions (Denmark, Germany, Sweden, and the Netherlands).

The project is testing and replicating the technologies and business models in regions of Spain, Romania, and Hungary.

This is enabling effective use of grassland, being left to decay after mowing, causing costs and lost benefits for individuals and society.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **N° 862674**

Ministry of Food, Agriculture and Fisheries of Denmark
Danish Agricultural Agency

Green biorefining

from political ambition to implementation of new subsidies in Denmark

GO-GRASS International event
24. of May 2023

I will cover…

- The political landscape
- From ambition to reality
- The stepping stones
- Creating awareness

Grøn bioraffinering

Hvad og hvorfor grøn bioraffinering?

Ministeriet for Fødevarer, Landbrug og Fiskeri
Landbrugsstyrelsen

Green biorefining: From ambition to real life

Two new subsidies to expand green biorefining in Denmark

Feasibility Study of a Green Biorefinery

The two subsidies are independent from each other

Establishment of a Green Biorefinery

A brief status

Feasibility Study of a Green Biorefinery
The first application round closed 26. January 2023
12 applicants applied for between 50.000 and 120.000 Euro
In total 1,3 million Euro – twice as much as expected

Establishment of Green Biorefinery
The first application round opens 1. November 2023
The legal framework is in public hearing until 30. may 2023

Ministry of Food, Agriculture and Fisheries of Denmark
Danish Agricultural Agency

In brief
Feasibility Study on a Green Biorefinery

The subsidy scheme: Feasibility Study of a Green Biorefinery

Impact
Enable the different players to investigate and asses the potential for establishing a green biorefinery.

Regulatory basis
Measure programmed in the Rural Development Program (RDP, pillar II)
Co-operation Measure (Art. 35, M 16)

The project must be
A co-operation between at least to independent players (co-operations)
At least one farmer

Financing
The eligible expenses are 100 pct. EU-funded
The current financial pool is 2 million Euro.

Yearly round of application
2022 - 2024

Project content

- The players have 12 months to prepare a feasibility study

- The projects final conclusion:
  a) the project is viable, b) has the potential to be or c) isn't viable

The feasibility study - table of contents

- Conclusion
- Timeline for the establishment of the facility
- Ownership and location
- Supply of biomass
- Physical and technical constructions
- Production and operating conditions
- Marketing conditions
- Financing and business plan
- Need for permissions

Ministry of Food, Agriculture and Fisheries of Denmark
Danish Agricultural Agency

In brief
Establishment of a Green Biorefinery

The subsidy scheme: Establishment of a Green Biorefinery

Impact
To expand green biorefineries in DK so the Danish agriculture becomes more self-sufficient in protein feed, thus contributing to the green transformation

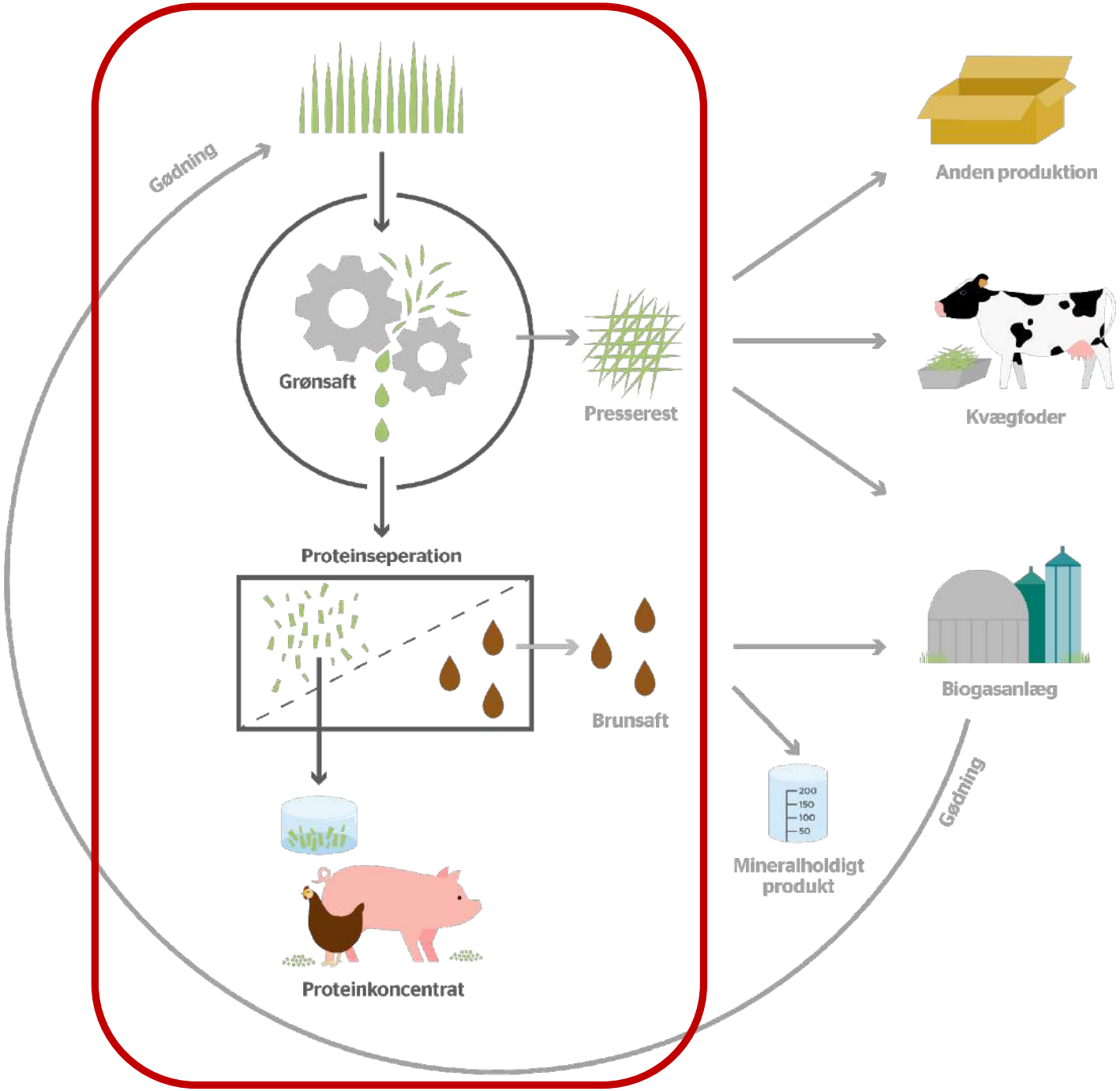
Regulatory basis
Intervention in CAP Strategic Plan (CSP, pillar II)
Investment (Art. 73)

The biorefinery must after the maximum of 24 months be able to
Refine grass, clover, alfalfa, etc. to protein concentrate for animal feed for monogastrics
The protein concentrate has to have minimum 35 pct. crude protein per dry matter content

Financing
The eligible expenses are 65 pct. EU-funded
The current financial pool is 33 million Euro

Yearly round of application
2023 – 2025

The focus of the subsidy



Ministry of Food, Agriculture and Fisheries of Denmark
Danish Agricultural Agency

Models for prioritizing the applicants

EU regulations states that prioritization is mandatory

How did we get there

The stepping stones

Establishing the knowledge base
Contributions from Aarhus University - Fall 2022

The template for the feasibility study
Online user tests with 4 players – Feb. 2022

Designing the legal framework
Written feedback and dialogue with 11 stakeholders – Jan. 2022

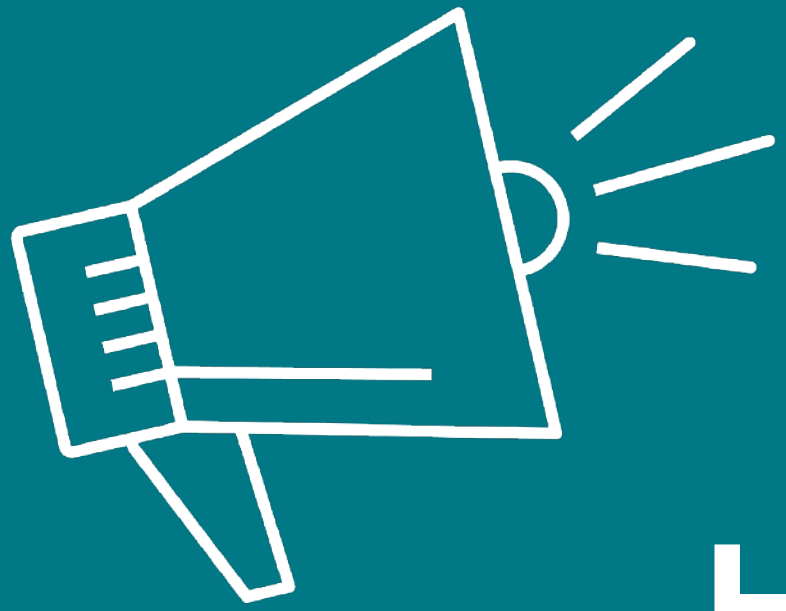
Design of models for prioritization
Written input and workshop with 3 experts Dec. 2021

Gathering knowledge
Interviews with existing players June 2021

Ministeriet for Fødevarer, Landbrug og Fiskeri

gudp

Green Development – and Demonstration Program



Ministry of Food, Agriculture and Fisheries of Denmark
Danish Agricultural Agency

How did we create awareness

Creating awareness

Stakeholder involvement

Vestjyllands Andel
Sammen om praktisk innovation
DAKOFO
Dansk Korn & Foder
Dansk Agroindustri
ANDRITZ
FEED AND BIOFUEL
dlg
AUSUM 1778
GAARD 1901
Innovationscenter for Økologisk Landbrug
NIRAS
BioRefine
PlanEnergi
AALBORG UNIVERSITET
AARHUS UNIVERSITY
Biogas Danmark

Key issue for our minister

Conference – Green Biorefining from Idea to Real Life

Key points

- To succeed, the players need to co-operate
- Immature markets calls for engagement of stakeholders
- Flexibility and simplicity needs to be balanced

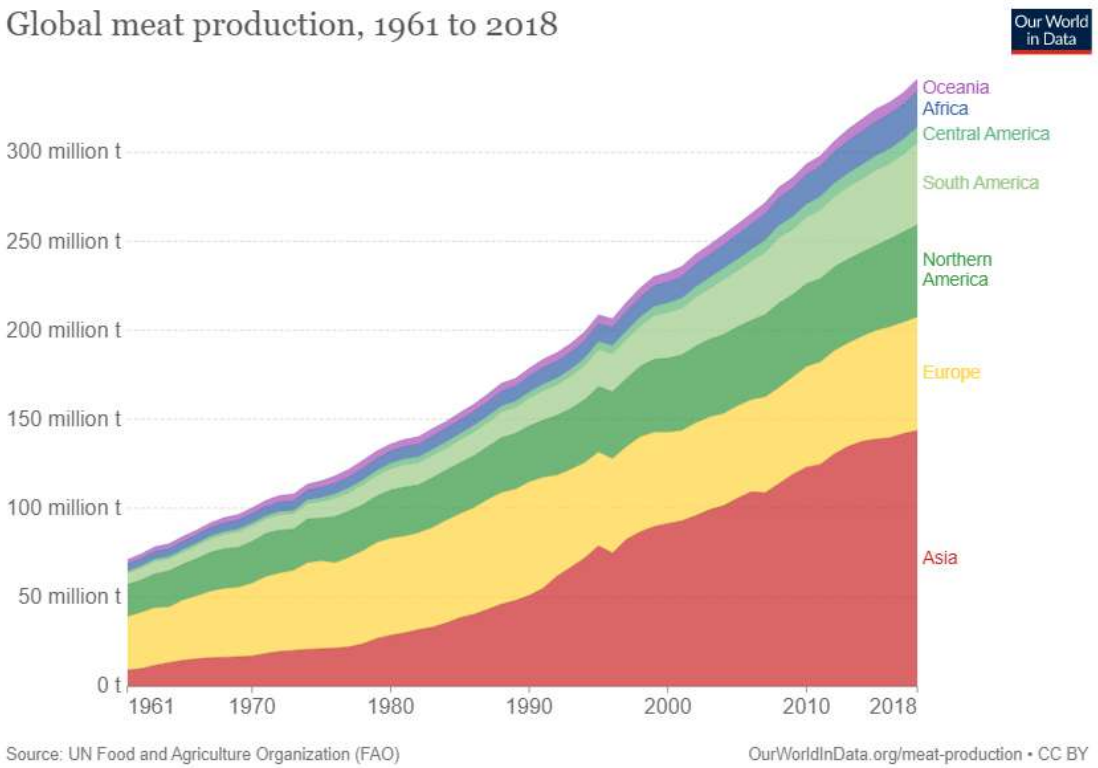
BioRefine Denmark A/S

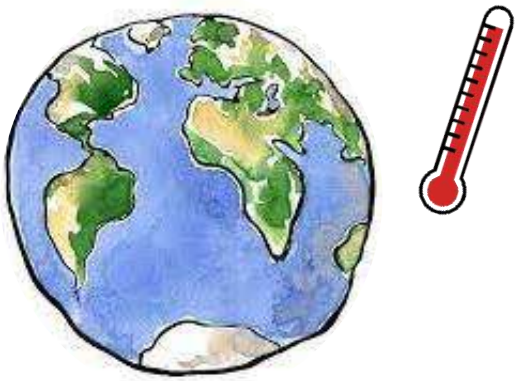
Laila Thirup 24th May 2023

BioRefine

- BioRefine was established 2020. The plant ready for the first season May 2021
- Owned by danish farmes through DLG, Danish Agro and DLF
- Plant capacity: 40 ton biomass/hour
- Cover nearly 3000 ha, aim for 4500 ton organic protein concentrate/year

Need for protein + global warming = Need for new solutions





Protein from clover grass and alfalfa is climate-friendly:

- Locally produced protein from clover grass has a better climate-profile than soy; and deforestation can be avoided
- A clover grass crop release less CO2 than a cereal crop

BioRefine

Perspective

- Import of organic soy to Denmark: 50.000 ton/year
- Total import of soy to Denmark: ~1,5 mill ton/year
- Total import of soy to EU: ~30 mill ton/year

Process

Producing local protein feed that can replace soy for poultry and pigs

Clover grass
Alfalfa grass

Juicing/pressing

Green juice

Protein precipitation (heat)

Centrifu-gation

Drying

Fiber

Brown juice

Green protein concentrate

Product to market

BioRefines protein concentrate is purchased by two of its owners: DLG and Danish Agro

They use the product in compound feed for poultry and pigs

Several feed trials with poulty and pigs has been conducted by Aarhus University, developing the process

The color of the product ensures a yellow egg yolk when used by layers

BioRefine is GMP+ B2 certified (feed safety)

BioRefine

Harvest management

Contract farmers

BioRefine organize harvest (when and where)

Harvest: Agricultural service supply contractor

Harvest management

- Timing of harvest is essential for max protein content
- Wheather has a huge impact on raw material quality
- Raw material needs to be fresh. Durability a challenge when chopped in the field
- Only cutting at the rootbase result in biomass with 3 times lower density, massive need for more trucks, and is unmature harvest-technology

Economical challenges, and wishes for new policy to support green biorefineries

- Price for clovergrass and alfalfa: hard to compete with other crops as cereals, or even grass that go directly to biogas plants. This calls for a change in agricultural subsidies; to support farmers who grow crops for green biorefineries
- A future CO2 charge in the agricultural sector will benefit climate friendly products as BioRefines
- The side-streams fiber and brownjuice can go to biogas, but price is uncertain in a 10-15 years perspective
- Further value creation, enabling production of food quality protein in co-production with feed-protein, or develop higher value products of side-streams is important!

BioRefine

Grassa

GREEN REFINED SOLUTIONS

Unlocking the full economical and sustainability potential of grass

Johan Sanders, Bram Koopmans, Bob Lambrechts, Wim van Doorn

GO-GRASS

Grass-based circular business models for rural agri-food value chains

DANISH GO-GRASS INTERNATIONAL EVENT ON GREEN BIOREFINING

Aaurhus University Foulum, Denmark

23 - 24 May 2023

Problems to solve

- 2/3 of all agricultural land in the world is used for animal feed; further biodiversity losses should be stopped or better reversed
- We now have to feed 8 billion people with at least 60 gram protein per day, within the Planetary boundary of 90 M tonnes/ year. This means 12 kg Nr per person/year. In the Netherlands we need 24 kg/person.year. In EU we need 36 kg/person.year.
- Dutch policy is to reduce the number of animals. This will cost 24 billion € to reduce nitrogen deposition on Natura 2000 areas and move our problem 200 km to the East!
- Protein supply will become scarce in the world.
- The only solution is to become much more efficient with the use of nitrogen.

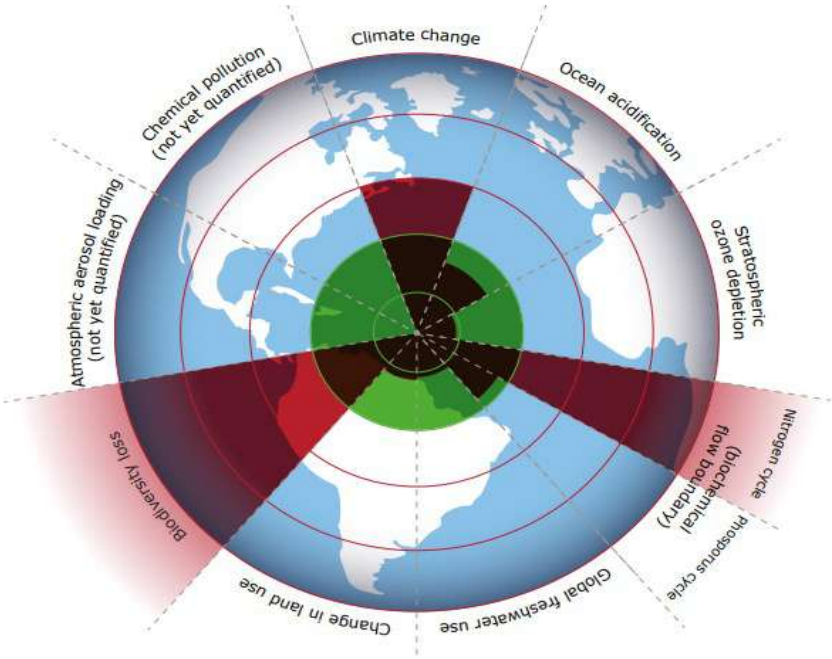


Figure 1: Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable (Rockström et al. (2009)).

- **We need radical changes:**
  - Inputs of Nitrogen in Agriculture should be reduced
  - Increase protein and nitrogen use efficiency
  - Increase revenues per ha for farmers
  - local for local (no long transports, no import of minerals)

Nitrogen flows in EU Agricultural sector

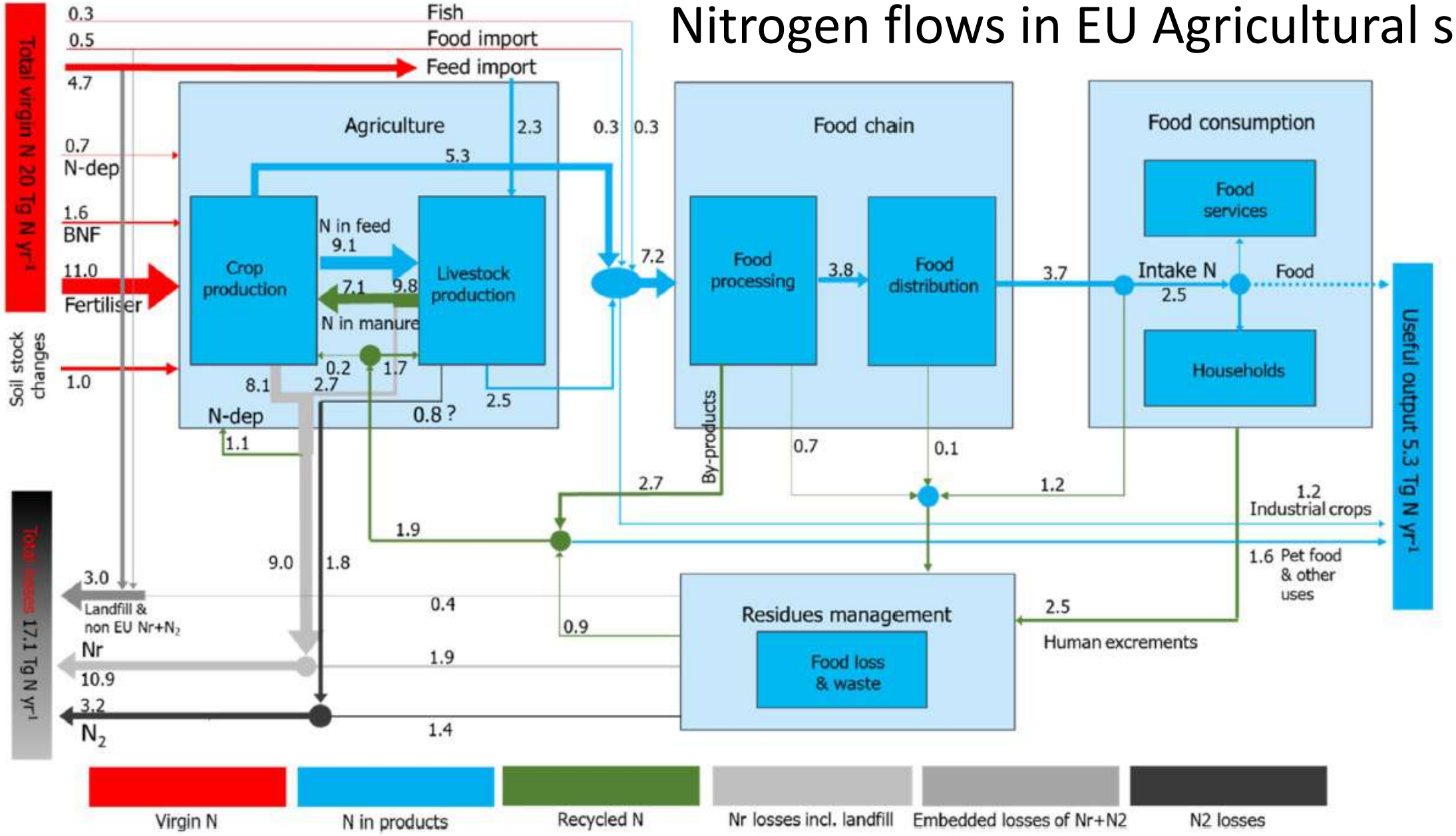
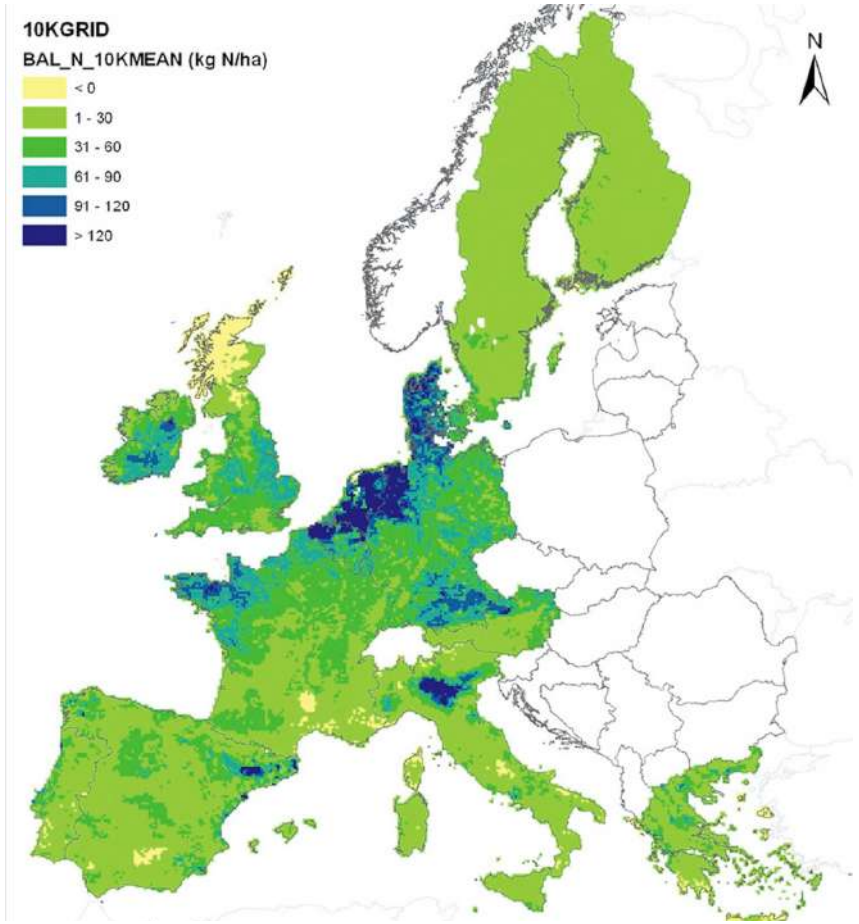
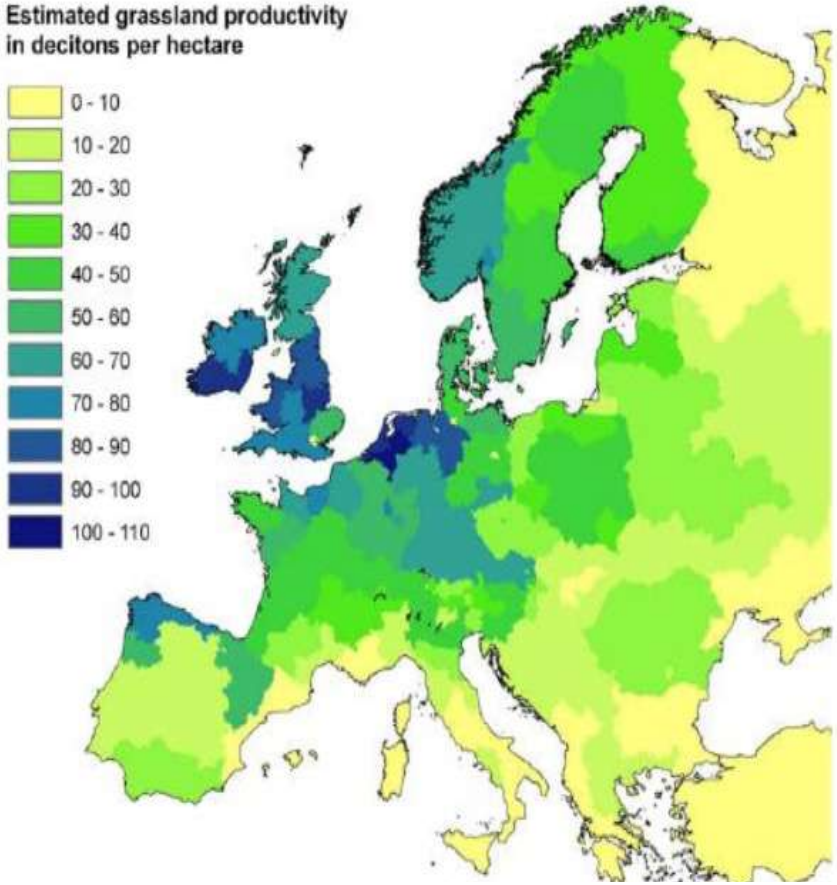


Fig. 1. Consolidated nitrogen budget for the agri-food system of the European Union in 2015 based on data from Eurostat, Corrado et al. (2020) and system definitions by Westhoek et al. (2015). See Table SI1.
Quantities are reported in Tg N yr^{-1} (BNF: biological N fixation).

From Leip et al, 2022

Nitrogen Balance and grass production in Europe





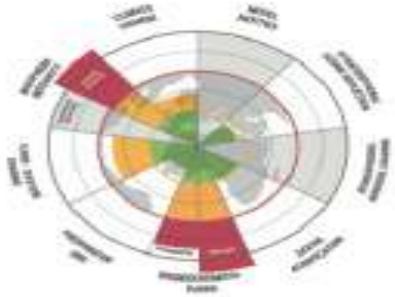
Grassa

GREEN REFINED SOLUTIONS

Unlocking the full potential of grass

Challenges

- Necessity to reduce emissions
- Market is looking for an alternative to soy
- Circular agriculture needs to be stepped up
- Economic yields of grass too low for arable farming
- Improved revenue model for farmers is required



Grass, a crop full of potential

++ Up to 2.5x more protein yield per ha than soy
++ Availability, also on marginal grounds (>50% Dutch grassland)
++ Very good CO_2 binding
++ Improved biodiversity when used in strip and resting rotation cultivation
+- Monopoly by ruminants for protein production, but with a lot of waste

Unlocking the full potential of grass

grass protein concentrate

High quality protein, suitable for animal and human consumption. The local sustainable high quality alternative for wasteful soy

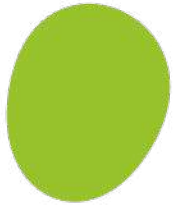
pre biotic FOS

Food and feed ingredient with pre biotic characteristics. Increasing the immune system, lowering the use of anti-biotics

plant based fertilizers

Vegan alternative to artificial and animal fertilizers

opened grass



Sustainable high quality roughage. Feeding this opened grass to cows reduces nitrogen, phosphate and methane emissions, while production remains the same

The Grassa Circularity Summary

Local & circular

- replacing GMO soy protein
- reducing CO_2 footprint with 80%
- local manure on local land

Emission

- **30% less NH_3 – ammonia**
- **30% less P-phosphate**
- **15% less CH_4 - methane**

1.5-2.5x

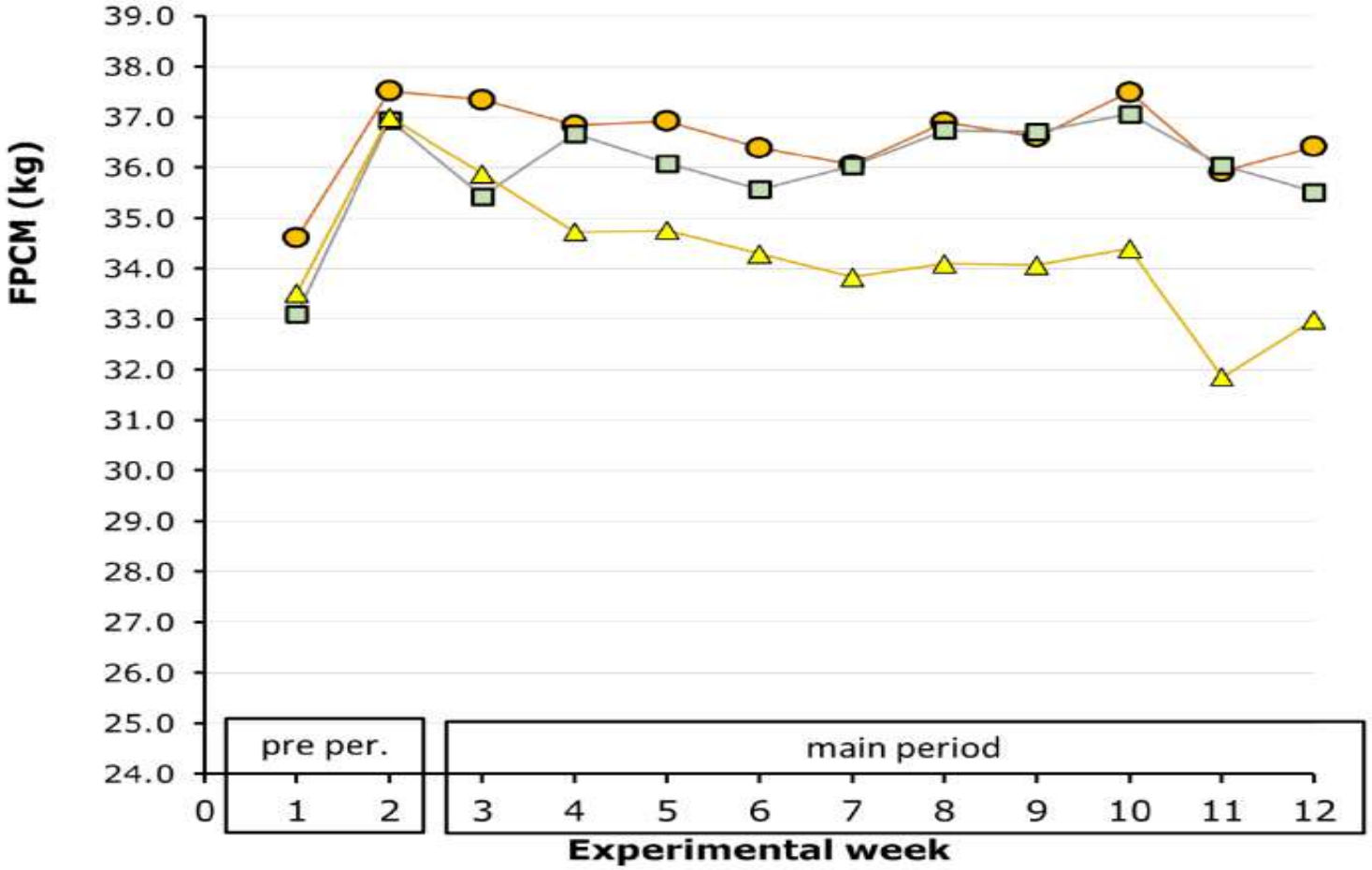
Improved food efficiency

- **more food from existing grass**
- **availability for monogastric creatures**
- **higher production of milk and meat**

Better soils and biodiversity

- **facilitates land exchange / strip farming**
- **inclusion of herbs and clover**
- **higher CO_2 binding**

Wageningen UR trial 3*20 cows with Grassa presscake



DIET_pos — 16% CP

DIET_gra — 15% Including Grassa presscake

DIET_neg — 15% negative control

Earlier and similar results with Grassa presscake:

Pijlman, J. et al,. 2018. Effect of feeding the grass fibrous fraction obtained from biorefinery on N and P utilisation of dairy cows. p. 431-433.In: 20th Nitrogen Workshop: "Coupling C-N-P-S cycles". Rennes, France. 25-27

Serra, E. et al., 2023. Biorefined press cake silage as feed source for dairy cows: effect on milk production and composition, rumen fermentation, nitrogen and phosphorus excretion and in vitro methane production. Livestock Science 267:105135.

Outlook: increase of NUE by grass biorefinery combined with mixed species swards and NH_3 stripping by Byosis technology

- Legumes in swards containing 6-9 different plant species do not require no/little N fertilizers because these plants can fixate N from the air at even higher protein yields per ha

- Biorefining of these leaves increases the protein efficiency for cows so that some 40% of the protein can be fed to pigs at equal milk yields per hectare

- 50% of the nitrogen in the cow and pig manure can be recovered by stripping of ammonia; the other 50% goes back to the swards. **Instead of buying N fertilizer, the farmer can sell it**

Nitrogen Use Efficiency	Traditional grazing	Traditional grazing Including pig feed	Grass biorefinery	Biorefinery and Mixed species swards
No stripping	0,16	0,18	0,29	0,39
NH_3 stripping		0,23	0,33	0,45

Presscake, juice and protein

Grassa
GREEN REFINED SOLUTIONS

Grassa
GREEN REFINED SOLUTIONS

membrane fractionating to prebiotic and mineral concentrate

Baling the presscake

Grassa in Fort Portal Uganda

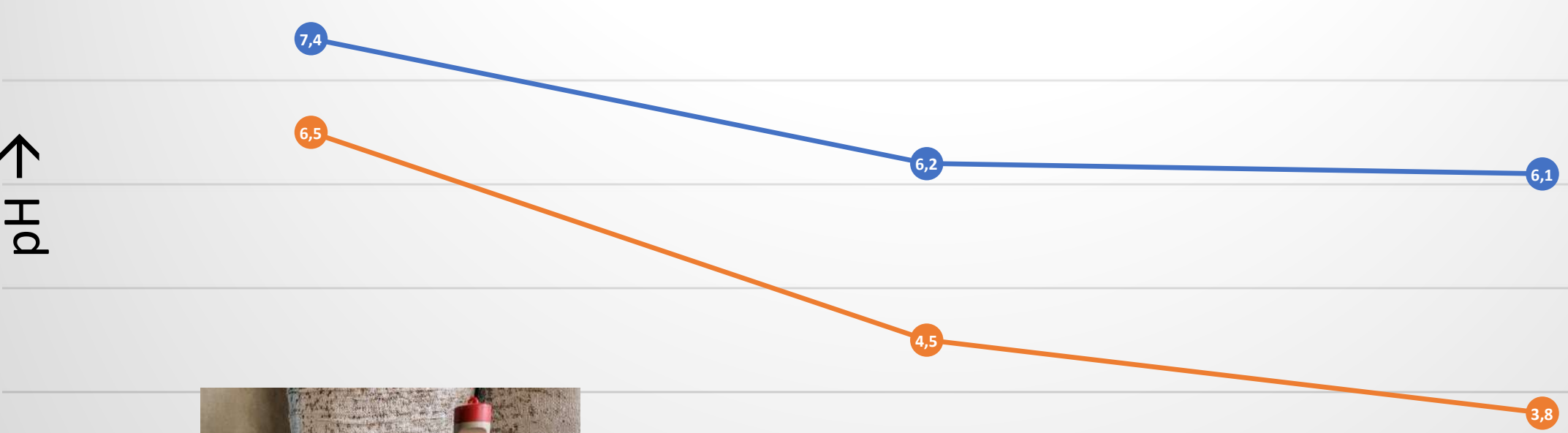
BIO4AFRICA

This project has received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreeement no 101000762

Ensiling grass at Savanet and KRC

This project has received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement no 101000762

ensiling using fermented whey



In tropical regions there is a lot of rain but during 4-6 months it is ver dry. Fermented grasswhey can contribute

This project has received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement no 101000762

Unexpected contribution of fermented grasswhey to reduce NH3 and CH4 emissions.

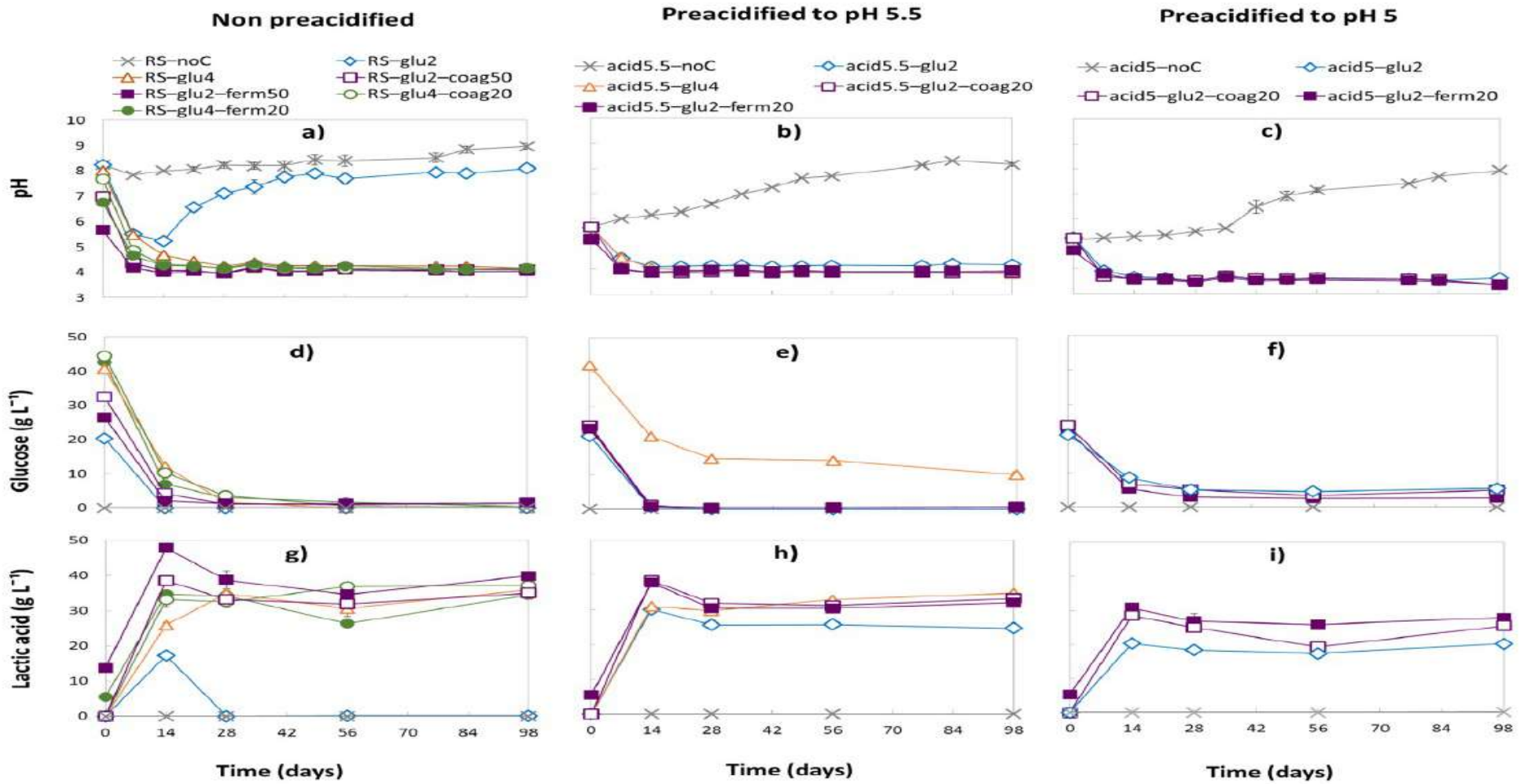


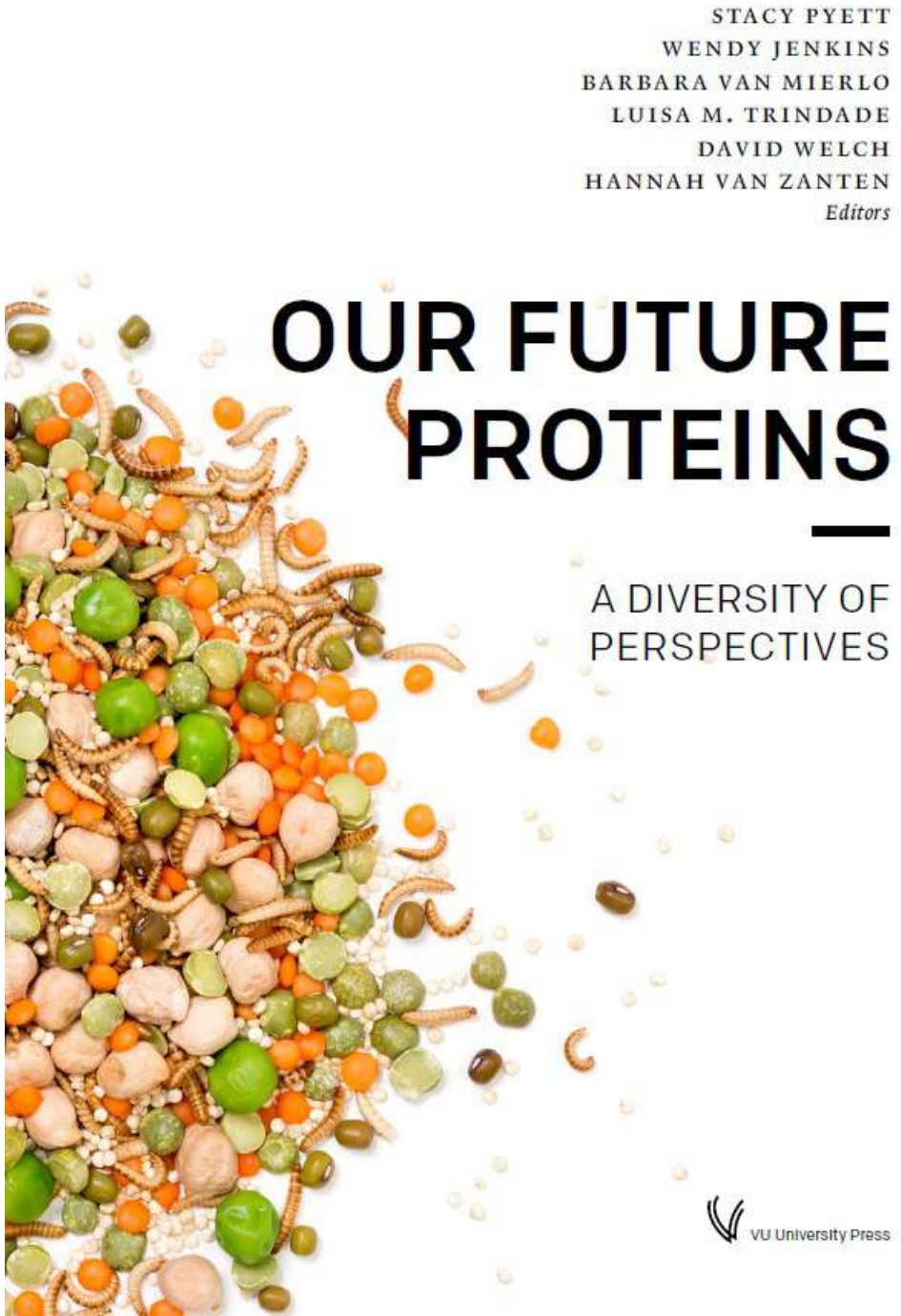
Fig. 1. Treatment effect on pH (a-c), glucose consumption (d-e) and lactic acid production (g-i) over time. Error bars represent the standard error of the mean ($n = 3$). For abbreviations of treatments, see Table 1.

Bio-acidification of animal slurry: Efficiency, stability and the mechanisms involved I. Regueiro a, B. G´omez-Mu˜noz a, M. Lübeck b, M. Hjorth c, L. Stoumann Jensen a,* 2022

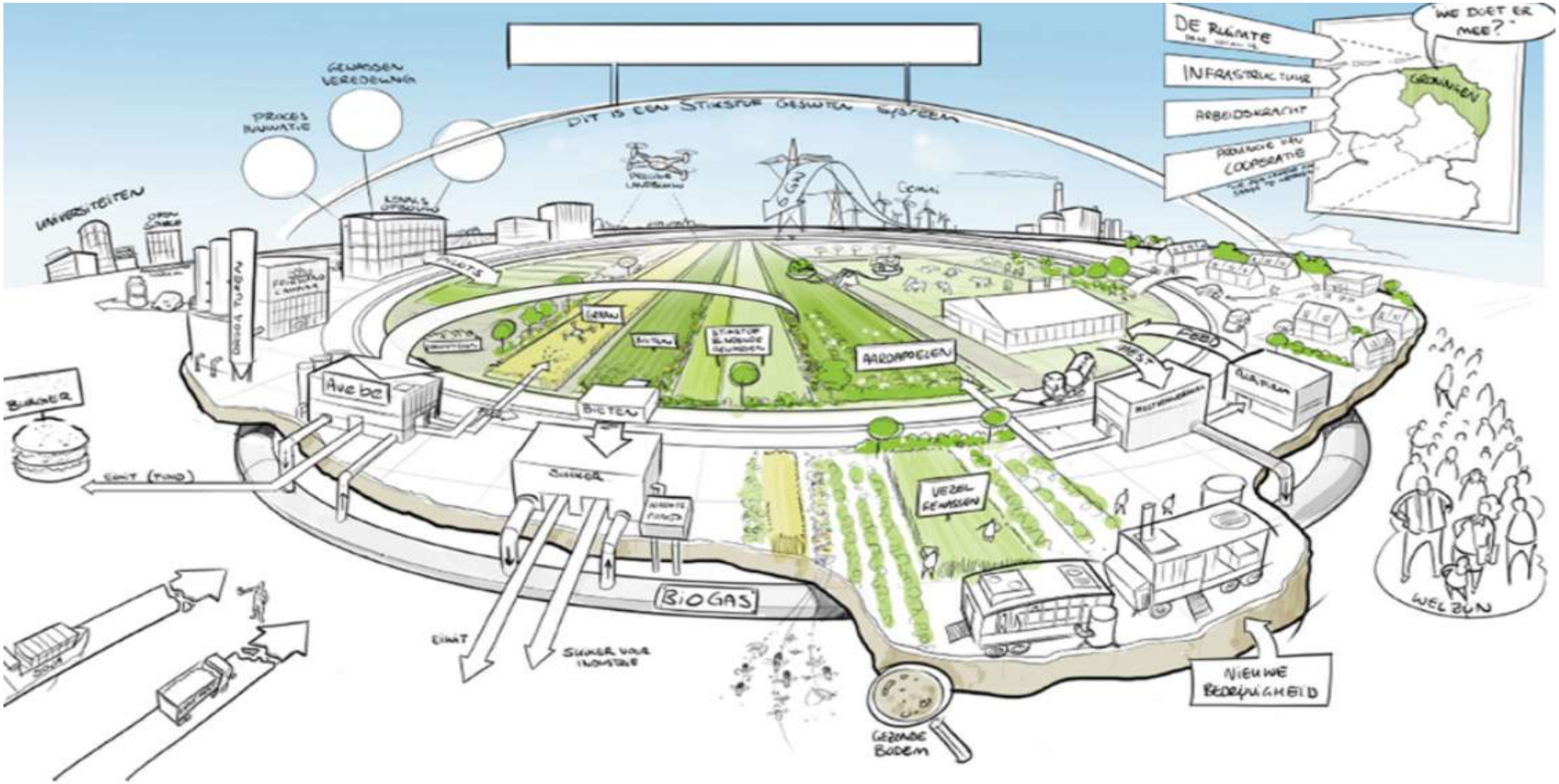
National protein strategy

- in 2018 the aim was 100 000 ha plant proteins
- in 2021 this aim was regarded far too ambitious
- 80 000 tonnes of beet proteins are degraded to NH3 and nitrate /year
- 950 000ha of grassland is not regarded as plant protein source for this strategy

- A recent book of 575 pages devoted to OUR FUTURE PROTEINS Ddoes not even mention grass biorefineries in Denmark, Austria, Switzerland, the Netherlands.



FASCINATING GRONINGEN COMBINING 4 LARGE COOPERATIVES IN PROTEIN DEVELOPMENTS



functional proteins from

Benefits of Solanic®

- Free from allergen labeling
- Perfectly fit a vegetarian and vegan lifestyle
- More sustainable than animal proteins
- Exceptional soluble
- Superior emulsifying, foaming and gelling properties

Avebe

Products Innovation Sustainability About us Members Contact

abel binder for pased meat

s provide all the required ctionality, like gelation and for manufacturers seeking animal proteins or E-number nethylcellulose: in burgers and c® replaces egg albumen, to give ng and bite. In vegan 'sausages' to give a stable emulsion and a

Cosun protein applications from Fava and beet leaf

Our applications with Tendra® Fava Bean Protein Isolate

Milestone for Rubisco Foods: EFSA gives positive verdict on food safety of protein concentrate from water lentils

RAALTE, 18 April 2023 At Rubisco Foods, we were already convinced. Now it has also been officially confirmed that the protein concentrate that Rubisco Foods extracts from water lentils (duckweed) is food-safe. The EFSA (European Food Safety Authority) confirms this, having conducted thorough research.

18 april 2023

Home The Team What is it? Sustainable News Blog
Get in touch Careers EN | NL

ENOUGH

delicious. nutritious. sustainable.

10 000 ton mycoprotein
In 2023 together with Cargill

Talk to us

GOOD FOR THE PLANET TOO...

99% Less Water
98% Less Land
95% Less CO2e
THAN RED MEAT

SAY GOODBYE TO OVERFISHING...

Salmon

SAY HELLO TO FUNGI FOOD! BECAUSE ONE WORLD has to be ENOUGH

Conclusions

- Biorefining of grass will increase animal protein production per ha by 50% while milk quantity and quality stays equal,
- Biorefinery improves NUE threefold if combined with legumes and ammonia stripping offering conditions to stay within our Planetary boundaries
- Biorefinery of leaves will substitute all soy and undesired mineral imports into EU
- Biorefinery will lead to increased rural employability and increased agricultural incomes
- Biorefinery of green leafs in Africa will contribute to food security also during dry periods.

Johan Sanders - johan@grassa.nl - www.grassa.nl