Bio-based strategies and roadmaps for enhanced rural and regional development in the EU

Small-scale technology options for regional bioeconomies

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Felix Colmorgen, Cosette Khawaja

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Responsible author(s):	Felix Colmorgen, Cosette Khawaja (WIP)
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EXECUTIVE SUMMARY

This report provides an overview of technology options, which are considered good practice examples when it comes to facilitating the transition to a regional bio-based economy, looking at the five Open Innovation Platform (OIP) regions covered in BE-Rural and beyond. The five OIP regions are Stara Zagora (Bulgaria), Vidzeme and Kurzeme (Latvia), Strumica (North Macedonia), Szczecin Lagoon and Vistula Lagoon (Poland) and Covasna (Romania). Inspired by their bioeconomy potentials, a set of small-scale technology options and good practices was compiled and discussed with representatives from the OIP regions. A selection procedure intended to reduce the pool of different technologies and good practices to a final set of 16, which this report presents in a factsheet format. The factsheets include general background information, technological and economic descriptions, the motivation behind the technology, as well as an outline of the environmental and socioeconomic impacts. Furthermore, advantages and disadvantages of small-scale technology options compared to larger and more complex systems, such as large-scale biorefineries, are discussed.

The overview of technology options presented in this report focusses on small-scale technologies that are considered suitable for the development of regional and rural bioeconomies. A definition of suitable technologies was drawn up taking into account the overall scope of BE-Rural. The feedstocks considered are originating mainly from the agricultural, forestry, fishery and waster sectors. The diversity of this set of technology options reflects the nature of the growing bioeconomy – in the context of BE-Rural's OIP regions and beyond. Since there is no single blueprint for developing and implementing the bioeconomy, this overview aims to inspire stakeholders in the aforementioned sectors.

BE-Rural collaborates with the Horizon 2020 project Power4Bio (https://power4bio.eu/), which also assesses technology options and business models for regional and local bio-based economies. A joint guidance document will summarise the relevant outputs of the two projects and provide concrete recommendations for policy-makers regarding the application of bio-based technology options and business models in specific regional contexts. The present report will contribute to this joint output. For further complementary information from the Power4Bio project, we encourage the reader to visit: https://power4bio.eu/project-material.

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Abbreviations

Ca	Calcium
CH_4	Methane
CHP	Combined heat and power
Cl	Chlorine
CO_2	Carbon dioxide
dm	Dry matter
EC	European Commission
EU	European Union
Fe	Iron
GHG	Greenhouse gas
GJ	Gigajoule
GWP	Global warming potential
HP	Horsepower
IBC	Intermediate Bulk Containers
kWh	Kilowatt hour
Mg	Magnesium
MWh	Megawatt hour
N	Nitrogen
R&D	Research and development
S	Sulfur
SDGs	Sustainable Development Goals
SME	Small and medium-sized enterprises
TRL	Technology Readiness Level
VOC	Volatile organic compounds
WP	Work package

1 Introduction

The BE-Rural project aims at supporting the development of sustainable bioeconomy strategies, roadmaps and business models in selected regions across Europe. The bioeconomy thrives for nearly one decade now, depending on the specific context often initialized by science, politics or the call from the European Commission for smart specialization strategies. Thus, the strategies for implementing the bioeconomy can vary considerably regarding their geographical scope, content and focus as well as sectors and potentials addressed.

Since, as of today, many valuable resources and potentials remain unexploited, the aim of this report is to give an overview of existing small- and pilot-scale technologies which can help realizing and valorizing the potential of regional and local bio-based economies. This compilation of technologies and good practices aims to match with region-specific potentials and feedstocks. The considered feedstocks originate from the agricultural, forestry, fishery and waste sectors. Consequently, some of the selected technology options and good practice examples may be more suitable for some regions than for others. Since this report is supposed to provide relevant inputs for the subsequent project activities, it functions as source of information for BE-Rural's OIPs and their stakeholders in the field of the bio-based economy.

The OIP regions are rural areas in five different Eastern and Southeastern European countries: Stara Zagora (Bulgaria), Vidzeme and Kurzeme (Latvia), Strumica (North Macedonia), Szczecin Lagoon and Vistula Lagoon (Poland) and Covasna (Romania). The regions differ concerning the type and status of bioeconomy-related strategies, the addressed bioeconomy sectors and resource potentials. Looking at the unexploited resources in the OIP regions and in many other regions across Europe, the technology options presented in this report may help reducing Europe-wide imbalances regarding the development status of regional bioeconomies (Ronzon and M'Barek, 2018).

After outlining the methodology which has been applied for the selection of technology options, the report presents a selection of 16 different technologies and good practices in a factsheet format. In a final section, a short comparative assessment of small- and large-scale biorefineries is carried out. Here, references to previously presented technology options are made whenever possible and useful.

The 16 technology options and good practice examples aim to address not only the stakeholders from the OIP regions, but also other interested parties. The selected examples demonstrate the wide spectrum of technology options, which have already proven their market maturity or potential and may shape the future of specific sectors in a regional bioeconomy context. Rather than serving as a tailor-made guideline for the OIP regions, the overview is supposed serve as an inspiration for stakeholders who are interested in the development of regional and rural bioeconomies.

2 Methodology for the selection of technology options

As mentioned above, the focus of this report lies on small- and pilot-scale technologies and good practices. Taking into account the overall scope of the project and in order to limit the broad field of biorefining technologies, small-scale technology options are defined as follows:

(1) socially, ecologically and economically beneficial,
(2) (re-) using local raw material and feedstocks,
(3) simple, less expensive and easy to replicate,
(4) increasing employment and creating new income streams in rural areas,
(5) mostly producing partly pure and intermediate products (Bruins and Sanders, 2012).

However, it is important to stress that the different technology options vary in their coverage of the five principles as defined above.

The principal method used for the analysis presented in this report was desk research that was undertaken to identify technology options and good practices in the following sectors: agriculture, forestry, fishery and waste management. To this extent, open source documents, websites and relevant literature sources were reviewed. For the selection of technology options, different criteria including availability of raw material, replicability and the suitability for the addressed sectors on a regional level were considered. After generating a broadly diversified overview, BE-Rural's OIP facilitators were consulted to limit the range to a set of 16 technology options and good practices. Involving the OIP facilitators in the selection process was essential in terms of paying attention to region-specific conditions and interests for compiling the final set of suitable technology options and good practices. That screening and selection process was realized in two consultation rounds via e-mail in which the OIP facilitators could select those technology options, which seemed most suitable with regard to their region's bioeconomy potentials. Since there was a remarkable interest in some traditional biorefining technologies (e.g. pelletizing, anaerobic digestion), this report will cover a few of them as well. Nevertheless, the focus of the review was on new, innovative technologies and good practices.

For each of the selected technology options, a general factsheet guideline was then compiled and pre-filled, whereby the level of information and focus of each factsheet varied, depending on data availability. The factsheets included general background information, technological and economic descriptions (whenever accessible), the motivation behind the technology as well as an outline of the environmental and socioeconomic impacts. The latter is of importance, since one of BE-Rural's main objectives is to support the development of regional bioeconomy strategies and roadmaps that promote a sustainable use of natural resources. Thus, the environmental and socioeconomic effects of the selected technology options are evaluated in each of the 16 cases. The investigation of environmental and socioeconomic impacts is complex and partly multi-layered as shown by Hasenheit et al. (2016) in the context of the BioSTEP project[1]. Due to this complexity and data limitations, this report only covers a limited set of key environmental and/or socioeconomic impacts for each technology option.

The pre-filled factsheets were sent to the respective technology contact persons, who were asked to deliver relevant and missing information for the selected technology options and to validate the data that was collected during the desk research. WIP was responsible for 13 technology options, IPE covered three additional technology options. The response rate among the contact persons was high. They collaborated actively by providing new information and validating the pre-filled content. Sensitive economic and technical data were kept confidential in several cases.

[1] Promoting Stakeholder Engagement and Public Awareness for a Participative Governance of the European Bioeconomy (BioSTEP), see www.bio-step.eu

3 Overview of small-scale technology options and good practices

In this section, a uniform template for the presentation of each technology option is followed, although there are, as mentioned before, some differences in the focus, content, level of detail and extent of each factsheet compiled. Since the technology options and best practices are dominantly private sector activities, there is no further note on the type of intervention in the general information of the factsheet, except it differs. The same applies for the TRL, which is prevalently 9. In the case the TRL differs, it is mentioned.

The chapter is divided into the sectors agriculture, forestry, fishery and waste management, which are addressed in the BE-Rural project. Nevertheless, one must note that some of the technology options described below are suitable for more sectors. This is mentioned within the general information of each factsheet.

3.1 Agriculture

3.1.1 Disposable tableware and packaging

Figure 1: BIO-LUTIONS factory in India (BIO-LUTIONS [1] 2019).

Company

BIO-LUTIONS

Product

Packaging and disposables

Since

2014 (R&D), 2018 (start of serial production)

Sectors

Agriculture, packaging industry

Technology

BIO-LUTIONS provide a technology which enables them to produce disposable tableware and packaging from renewable raw materials like plant and crop residues. The process transforms previously unused crop residues into innovative and valuable products. So, the patented technology, developed by BIO-LUTIONS and Zelfo, can be described as an up-cycling procedure that can be applied worldwide. The plant fibers are broken down and blended into a cohesive pulp, which is conducted into a water tank. A mechanic rake is moving the humid mixture which is very similar to the one in the paper industry. Afterwards, the mass runs to the squeezing machine where the products are formed and pressed under high temperatures. There is no need for use of chemicals during the whole process. The process water is cleaned and recycled several times until it is disposed by using it for irrigation (BIO-LUTIONS [2] 2019, Bioökonomie.de n.d.).

Figure 2: Section of BIO-LUTIONS' production line (BIO-LUTIONS [2] 2019).

Feedstock

Various types of crop residues (4.000 – 4.500 tons/year dm)

Product

Disposable tableware and packaging (3.500 – 4.000 tons/year finished products)

Figure 3: Banana stems as a raw material source in India (BIO-LUTIONS [2] 2019).

Figure 4: Current product range of disposables (BIO-LUTIONS [2] 2019).

Initial idea

The idea of BIO-LUTIONS was to develop an innovative and resource efficient technology which can use even the shortest fibers from numerous agricultural residues to produce valuable products worldwide. By extending the life cycle of these unused crop residuals they also aim to create a decentralized production network with local production units and regionalized distribution of the local raw material used. Beside adding value in the regions and strengthening the circular economy, they want to raise awareness on the issue of plastic waste, offer sustainable and affordable solutions and eliminate non-sustainable disposables (BIO-LUTIONS [2] 2019).

Economic description

Investment costs: EUR 3 million (rented building)

Operational costs: depending on the local labor costs of each country

Return of investment: turnover of EUR 4.5 million in sales / profit about 20 % on average (BIO-LUTIONS [1] 2019).

Impact

Environmental impact

Simplified logistics and the integration of regional raw material suppliers lead to limited CO_2 emissions. Furthermore, the process water is not contaminated with chemicals, why it can be used for irrigation afterwards. The products of BIO-LUTIONS are compostable and biodegradable (BIO-LUTIONS [2] 2019).

Socioeconomic impact

By focusing on local unused crop residues from surrounding agriculture, BIO-LUTIONS creates additional income streams for numerous local famers and safes transportation costs at the same time. Since there is no need for specialists to operate the machines, newly created positions are available for everyone. The manufactured products can meet local demand (Bioökonomie.de n.d., KfW n.d.).

The way forward

BIO-LUTIONS is planning to expand by building a new production plant. Since this technology can deal with several feedstocks, it has great potential for application worldwide. The company offers a solution for reducing the consumption of fossil-based disposables, which will gain in importance.

List of references

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BIO-LUTIONS [2] (2019): Renaturing the world of materials. https://www.BIO-LUTIONS.com/ (accessed 18.09.2019).

Bioökonomie.de (n.d.): Turning waste into packaging "gold". https://biooekonomie.de/en/forscherprofil/turning-waste-packaging-gold (accessed 18.09.2019).

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3.1.2 A sustainable microfibrilated cellulose material

Figure 5: Curran® CV5000 Granules (CelluComp Ltd 2019).

Company

CelluComp Ltd

Product

Microfibrilated Cellulose (Curran®)

Since

2014

Sectors

Agriculture, cosmetic and pharma industry, construction industry, food industry

TRL

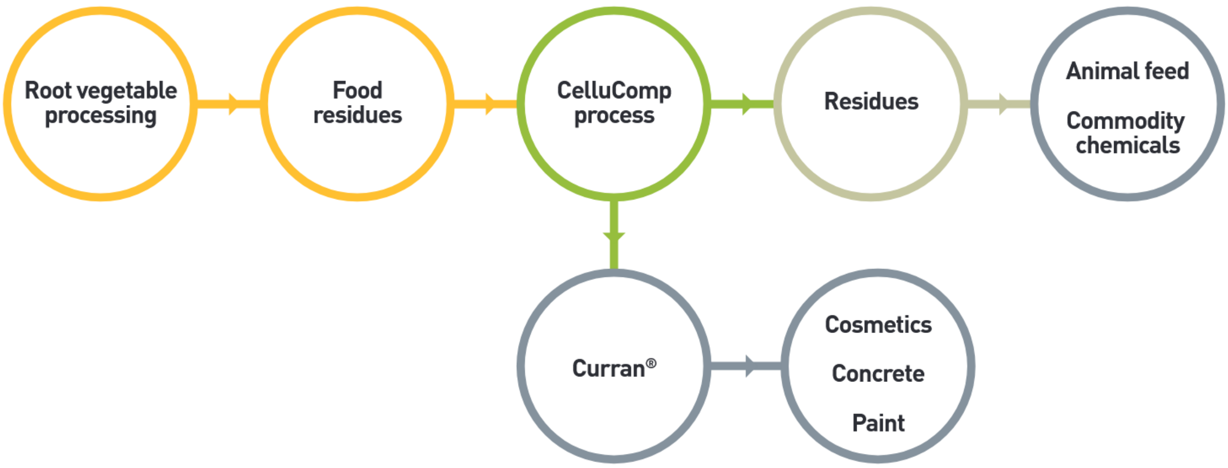
8-9

Technology

CelluComp developed a technology to produce sustainable alternatives to petroleum-based composites. Through the patented green chemistry processes, nano fibers from vegetables are extracted and combined with high-tech resins. This tough and durable mixture can be molded and heated to create a strong microfibrilated cellulose material with competitive mechanical and rheological properties (Curran® in form of granulate with approximately 20 % solid matter and 80 % water). Finally, Curran® can be applied as additive in numerous applications as granule or in a more diluted form (Curran® slurry with approximately 2 % solid matter). Moreover, Curran® is available as a powder (CelluComp Ltd 2019, Ecologic Institute 2018).

Water-based reactions at low temperatures and pressures maximize the energy efficiency of the manufacturing process. By using nanocellulose fibers of root vegetables (currently primarily from sugar beet pulp and carrot fibers), CelluComp valorizes waste streams from the food processing industry. CelluComp is currently doing research on developing further products, like animal feed or commodity chemicals, from their processing leftovers (see Figure 6) (Zero Waste Scotland n.d.).

Figure 6: Overview of the CelluComp value chain (Zero Waste Scotland n.d.).



Feedstock

Nanocellulose fibers from root vegetables

Figure 7: Raw material for the CelluComp process: carrots and sugar beet root (BCF 2018).

Product

Microfibrilated Cellulose (Curran®) (currently 400–500 tons/year on a small scale)

Figure 8: Application possibilities for Curran® (CelluComp Ltd 2019).

Economic description

CelluComp Ltd is operating the first plant of its kind in Europe on a small scale. The company aims to turn profitable once the commercial size plant will be built (EUR 22.6 million) in 2021. Currently Curran® is sold in units of 15 kg (3-4 EUR/kg) (Ecologic Institute 2018).

Impact

Environmental impact

Curran® is produced 100 % from renewable feedstock. CelluComp extracts nano fibers from vegetables and leaves behind the carbohydrates and proteins which can be used to produce commodity chemicals, energy or animal feed. Since the technology works with water-based reactions at low temperatures and pressures, the process is characterized by a lower energy consumption com-pared to e.g. other paint thickeners. Additionally, less chemicals are used unlike during the production of other cellulose ethers (CelluComp Ltd 2019, Ecologic Institute 2018).

Socioeconomic impact

CelluComp is using biological resources that are currently underused. By using these feedstocks within their process, they increase its economic value by an estimated factor of 50 (Zero Waste Scotland n.d.).

The way forward

CelluComp demonstrates an innovative and profitable use for underused biomass and has the potential to offer further products based on its own processing residues. Economic value is exploited and added and at the same time, the circular approach is strengthened. Since Curran® does not emit any VOCs, more and more companies are attracted as they search for more sustainable technologies, products and a way to reduce the dependence on fossil-based materials.

List of references

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Zero Waste Scotland (n.d.): Case Study CelluComp. https://www.zerowastescotland.org.uk/sites/default/files/2870%20ZWS%20Bio%20Economy%20Cellucomp%20Case%20Study%20AW%20FINAL%20HI%20RES_0.pdf (accessed 19.09.2019).

3.1.3 Greener plastics from hemp

Figure 9: A molded product and injection molding granulates (Trifilon [1] n.d.).

Company

Trifilon AB

Product

Biocomposite BioLite^{TM}

Since

2015

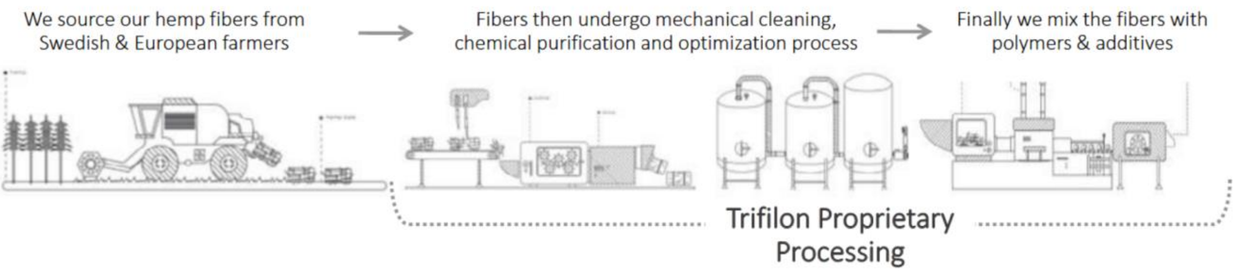
Sectors

Agriculture, plastics and packaging industry

Technology

Trifilon developed a process to create a biocomposite that has similar features like their conventional, petroleum-based counterparts. For the production, two types of feedstock are needed. On the one hand natural fibers like hemp or flax fibers, which can be provided by surrounding or European framers, are required. On the other hand, thermoplastic polymers like polypropylene are used. Since the outcome of this process is a blended product and not free from fossil-based ingredients, it must be considered as a greener plastic, not as a bioplastic, even though recycled plastics are involved, too. The natural fibers undergo a mechanical cleaning, a chemical purification and an optimization process (see Figure 10), before they are mixed with the polypropylenes and some additives. The outcome is the biocomposite BioLite^{TM} in granulate form with different ratios of polypropylenes and natural fibers. BioLite^{TM} AP21 consists of 10 % natural fibers and 90 % polypropylene and BioLite^{TM} AP23 consists of 30 % natural fibers and 70 % polypropylene. The different ratios result in different product properties like bio-content, stiffness and weight. The latter can be even better than competing fossil-based compounds (30 % stiffer and 10-25 % lighter). Finally, both types of granulate can be fed to conventional injection moulding units (Ecologic Institute 2018, Trifilon [1] n.d.).

Figure 10: Illustration of the production stages of BioLite^{TM} (Ecologic Institute 2018).



Feedstock

Natural fibers from hemp and flax, thermoplastic polymers like polypropylene

(0.3 kg of hemp fiber required for 1 kg of BioLite^{TM} AP23)

Figure 11: Hemp fibers (Trifilon [1] n.d.).

Product

BioLite^{TM} AP21 and AP23

Figure 12: BioLite^{TM} samples in different colors (Trifilon [2] n.d.).

Initial idea

The idea of the project was to reduce the reliance on fossil fuels, which are still determining numerous sectors today and posing the risk of environmental damages. Trifilon wants to provide a more sustainable solution unlike many large-scale producers of plastics. Therefore, they involve European farmers who can provide the natural ingredients for the greener granulates for injection molding. Thus, non-renewable feedstocks like petroleum derivatives, glass fiber, or chalk will be partly replaced by plants which absorb carbon without losing essential properties like lightweight, stiffness and impact resistance (Ecologic Institute 2018, Trifilon [1] n.d.).

Economic description

The investment costs amount to EUR 1.5 million. The break-even is expected after one business year (Ecologic Institute 2018).

Impact

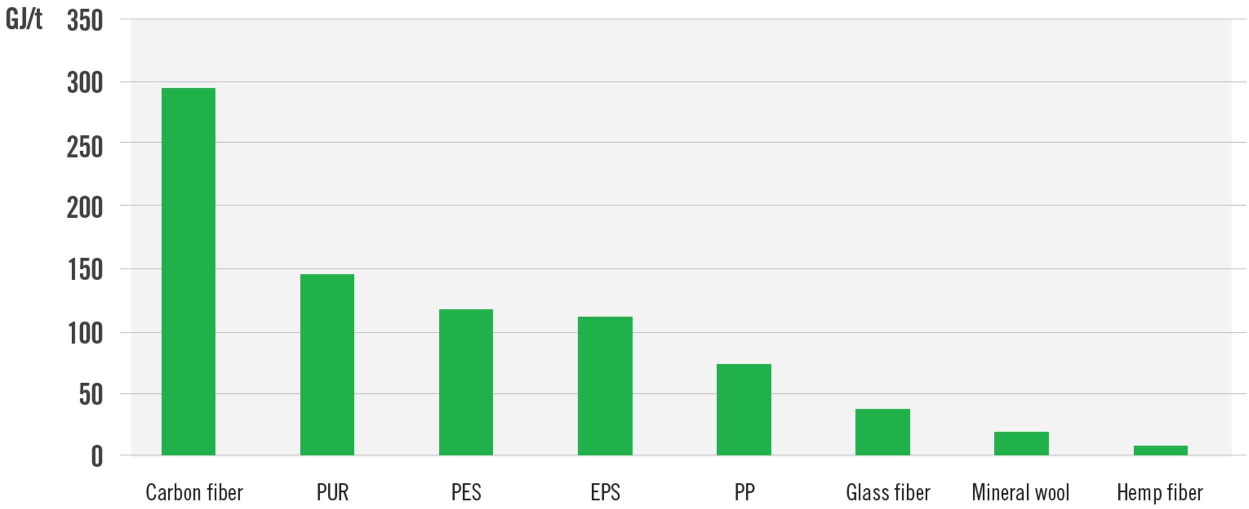
Environmental impact

Since BioLite^{TM} is produced with different ratios of renewable feedstock and polypropylene, the CO_2 footprint varies between the different products. Regarding the renewable part of BioLite^{TM} one can notice that hemp is a rapidly growing plant with a particularly high sequestration potential (hemp can store more carbon dioxide than its weight) (Ecologic Institute 2018). Moreover, hemp is rather undemanding regarding pesticides and herbicides, why it has a very low environmental impact during its growth. Pursuant to Trifilon, the utilized hemp does not compete with food crops (Ecologic Institute 2018). On the fossil-based part of BioLite^{TM} one must differentiate between virgin polypropylene and recycled polypropylene, be-cause the CO_2 footprint varies significantly. In case the polypropylene is recycled, the savings of CO_2-eq/kg are even higher and the impact on carbon emissions can turn positive. A standard product made with BioLite^{TM} AP21 (AP23) reduces the carbon footprint by 30 % (54 %) compared to a product made from virgin polypropylene (Jacobsson 2019).

Socioeconomic impact

Trifilon focuses on local hemp and flux resources. Thus, they create new income streams for the surrounding farmers. In the special case of flax, they plan to use the local flax fibers from the production of flax oil which are not used yet, remaining as residues. By adding value to these leftovers, new income streams for farmers and flax oil producers can be generated (Trifilon [1] n.d.).

Figure 13: Material energy needs in GJ/t (Jacobsson 2019).



The way forward

Trifilon AB provides a solution to the plastic waste problem, that is relevant worldwide. BioLite™ can help to substitute common petroleum-based plastic, e.g. PP, in various applications across several markets (automotive market, consumer goods etc.). Since BioLite™ is a resource- and energy-efficient solution, it has the potential to attract companies that attach importance to sustainability and resource efficiency. Next steps would be to further reduce the share of petroleum-based plastics and to focus only on recycled plastics.

List of references

Ecologic Institute (2018): Bio-based products - from idea to market. https://www.ecologic.eu/sites/files/publication/2018/3513-bio-based-products-15-success-stories.pdf (accessed 19.09.2019).

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Trifilon [2] (n.d.): Show your fibers.

Trifilon [3] (n.d.): The first step.

3.1.4 A mobile green biorefining concept

Figure 14: GRASSA! mobile unit (Biorefineries Blog n.d.).

Company

GRASSA!

Product

Whey, protein concentrate, food and feed additives, fertilizer

Since

n.d.

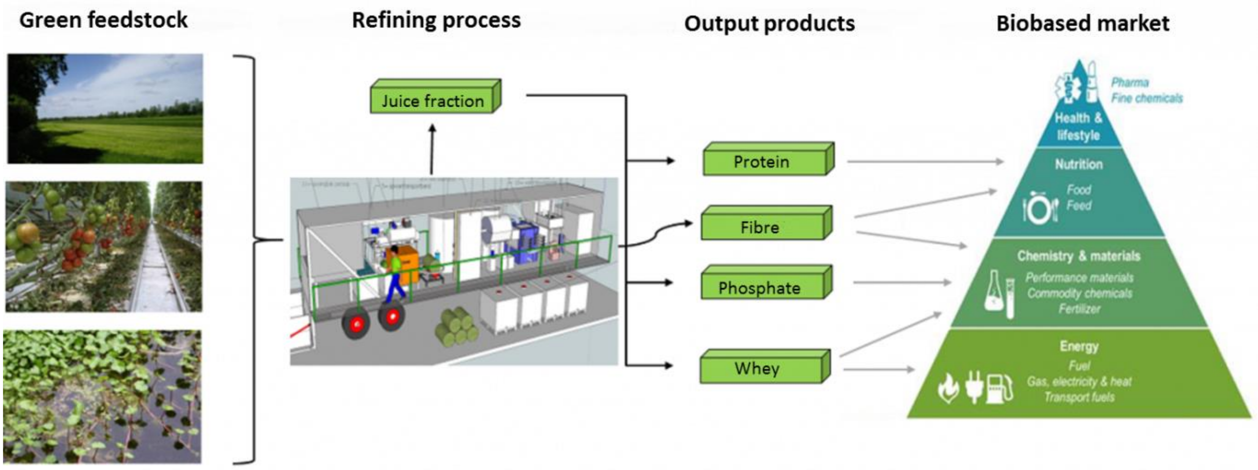
Sectors

Agriculture, communities

Technology

GRASSA! developed a patented mobile biorefining concept, which separates grass and other green biomass in several high value products like protein fodder, grass fibers, phosphate and whey. The feedstock can be obtained from different sources, which is different to many other green biorefinery concepts. The plant is capable of processing fresh mowed grass, residues from greenhouses or water plants. Precondition for a successful operation of the mobile concept is the fast transfer of the used feedstock into the process. For the recovery of protein from the fresh biomass, a time slot of only 2–4 hours after harvesting exists (Wagener 2017). The fresh green biomass, coming from local producers, is fed into the process through a hydraulic feeder (for bringing the biomass onto this feeder a fork lifter is used). Then, the biomass passes a refiner and a mechanical press to separate the liquid fraction of the biomass from the solid one. The protein in the liquid fraction is recovered by coagulation after heating up the grass juice to temperatures around 50 °C and above with a heat exchanger (the heat, a byproduct of the diesel generator that powers the mobile unit, is applied by steam injection). Subsequently, the coagulated protein is isolated from the liquid fraction by centrifugation. The outcome is the coagulated protein together with other solids like cellulose, cell membranes and chlorophyll. The process water still contains valuable substances and is collected in several IBCs. After sedimentation of the solid parts of the process water, the substrate is recovered and used as additive for nutrient rich fodder (Paping et al. 2014).

Figure 15: GRASSA! - Overview of the process and possible use of products (GRASSA! 2017).



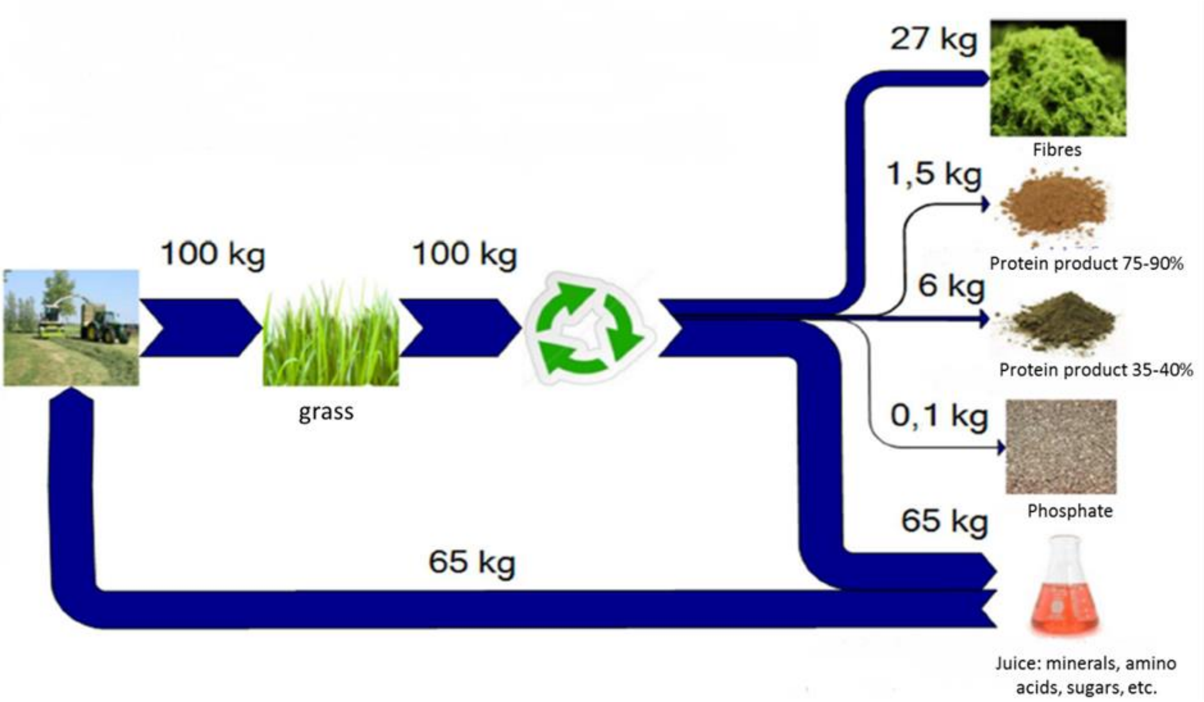
Feedstock

Fresh green biomass like grass, crop residues, water plants (capacity of 2 t/h)

Product

Protein rich whey, protein concentrate, food and feed additives, fertilizer

Figure 16: GRASSA! – Mass balance (fibers EUR 80/t dm, protein product 35-40 % EUR 133/t, protein product 75-90 % EUR 372/t, phosphate EUR 9/t) (van Doorn et al. 2014).



Initial idea

Since the European agriculture is protein-inefficient, contributes crucially to the emissions of greenhouse gases and is dependent on feed and fertilizer imports, the idea of GRASSA! was to counteract those challenges by offering an innovative and mobile biorefining technology. Thus, GRASSA! helps to change the role of farmers in the bioeconomy, from suppliers of biomass to producers of finished products and intermediates. This results automatically in a diversified local food and feed production and consumption as well as in a reduction of the ecological footprint (GRASSA! 2017).

Economic description

The investment costs range from EUR 500.000 to 600.000 per mobile plant. The operational costs and the return of investment may differ since the prize of (bio-) diesel for the generator, the salary, the feedstock costs and the output prices can vary. Additionally, the period in which fresh green biomass is available can differ (Ball 2018, van Doorn et al. 2014).

Impact

Environmental impact

The technology offered by GRASSA! reduces the phosphate and ammonia surplus (optimization of phosphate levels in the feed) as well as the greenhouse gas emissions of CO_2 and CH_4 (less imports of feed and fertilizer, and reduced ammonia from manure) (GRASSA! 2018 [1]). Furthermore, the technology relieves agricultural land, which is currently used to produce products like feed or fertilizer, that can be produced more efficiently by GRASSA!. That means e.g. soy imports from overseas can be reduced which helps protecting the local resources and ecosystems (GRASSA! 2017).

Socioeconomic impact

According to GRASSA!, this technology helps to strengthen the position and independence of famers today and in a future bioeconomy. That means framers will be more self-sufficient by purchasing less feed and fertilizer, their income will be diversified, and more robust and unused plant and crop residues will be valorized by extending value chains. Furthermore, no mechanical specialists are needed to run the GRASSA! mobile biorefinery (GRASSA! 2018 [1]).

The way forward

GRASSA! offers a marketable, mobile, flexible and affordable technology with a high replication potential. These properties result in a worldwide applicability, a diversification of income streams and a reduction of import dependencies. At the same time, it is important to note that the running period is strongly depended on the local growth period.

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van Doorn W., et al. (2014): Meer waarde halen uit gras en gewas. http://grassa.nl/wp-content/uploads/2014/09/Bijlagen-rapport_Evaluatie-rapport-Demonstratie-project-Bioraffinage-De-Peel-presentatie-1-5.pdf (accessed 21.04.2017).

Wagener M., Director from GRASSA! (2017): Telephone interview on GRASSA!.

3.1.5 Ecologic insulating materials

Figure 17: Roof insulation with sheep wool (FNR 2016).

Company

Daemwool Naturdämmstoffe GmbH & Co KG

Product

Sustainable insulating material

Since

n.d.

Sectors

Agriculture, textile industry, construction industry

Technology

The starting material is raw wool with a high contamination level of up to 50 % (sweat, skin scales, soil and plant remains and wool grease). Therefore, the wool is gently washed with soda and soap at 60 °C and degreased. Additionally, the pH value is adjusted, and the wool is treated with moth repellents. Now the wool consists of approx. 97 % protein (keratin fibers) (FNR n.d.). The treated wool is pressed in bales to transport them to the production site, where the bales are opened again to fed the wool to the carding machine. The carding machine produces a primary fleece which gets accumulated until it reaches the necessary weight. To generate the desired raw density, the fleece is compressed either mechanically by needling or thermally by solidifying with synthetic fibers in an oven. Finally, the insulating material is cut to size with a cutting machine. Leftovers are recycled. Since the wool fibers are not exposed to highly intensive UV radiation or constant moisture, chemical decomposition won't occur. Further characteristics of the flame-retarding and self-cleaning insulation wool are the natural ability of air conditioning and absorbing pollutants, the easy handling as well as its energy-saving potential and environmental friendliness (Daemwool n.d., FNR 2016, FNR n.d.).

Figure 18: Section of Daemwool's production line (Daemwool n.d.).

Input

Sheep wool, cleaned and treated with moth repellents

Product

Environmental insulating material (thermal and sound insulation) for building insulation

Figure 19: Sheep wool in bags (Energieheld n.d.).

Figure 20: Sheep wool fleece (Daemwool n.d.).

Initial idea

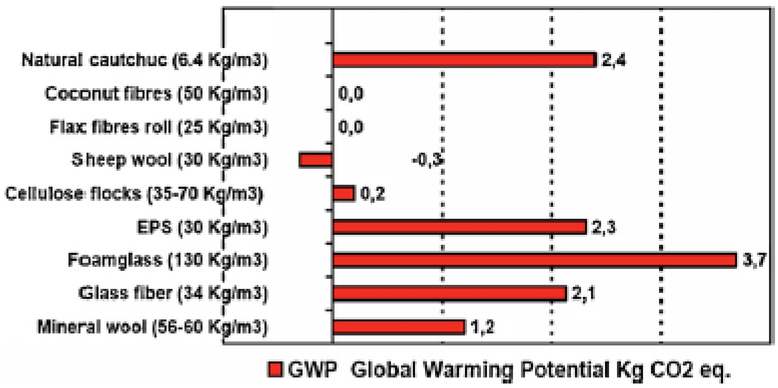
Coming from the field of textile manufacturing with a long family tradition, the idea behind Daemwool's production of ecofriendly sheep wool insulating material was to use and valorize local and existing sheep wool resources that have been unexplored for a long time. In this case, unexplored resources stand for disposed or burnt sheep wool that couldn't be sold (Daemwool n.d.).

Impact

Environmental impact

Daemwool valorizes unused sheep wool resources and thus extends their life cycles. Sheep wool can be produced without much energy input, just like the production of the insulating material. After a few years of production, energy savings accrue which leads to a reduction of CO_2 emissions. Compared to the primary energy requirement of mineral wool, sheep wool insulation materials safe 130 kg CO_2/m^3. Furthermore, the GWP of sheep wool is negative (see Figure 21). Discarded sheep wool can still be used as fertilizer (Daemwool n.d.).

Figure 21: Global Warming Potential of different insulating materials (Daemwool n.d.).



Socioeconomic impact

By valorizing untapped sheep wool resources, Daemwool extends and diversifies the value chain of sheep wool (leftovers). Thus, new income streams for local farmers and sheep breeders' associations in the surrounding regions are created (Daemwool n.d.).

The way forward

Daemwool show how to widen the product range of a renewable raw material that was underused for a long time. Their sheep wool-based insulation material can be seen as a competitive and sustainable alternative to other insulating materials.

List of references

Daemwool (n.d.): Daemwool. https://www.daemwool.at/de/daemstoff.html (accessed 08.09.2019).

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FNR (2016): MARKTÜBERSICHT - Dämmstoffe aus nachwachsenden Rohstoffen. http://www.fnr.de/fileadmin/allgemein/pdf/broschueren/Broschuere_Daemmstoffe_2016_web.pdf (accessed 08.09.2019).

FNR (n.d.): Schafwolle. https://baustoffe.fnr.de/daemmstoffe/materialien/schafwolle/ (accessed 08.09.2019).

3.1.6 Turning medicinal mineral water into a gluten-free functional drink

Figure 22: Gluten-free functional drink (FIBRO+) (IPE 2019).

Company

WEGA Invest SRL

Product

Gluten-free functional medicinal mineral water (FIBRO+)

Type of intervention

R&D&I activity

Since

2012

Sectors

Food & beverage industry

TRL

8

Technology

Within the scope of Interreg Europe the first gluten-free fibers enriched natural medicinal mineral water was investigated (Interreg Europe n.d.). The rather simple technology was developed by a cooperation of members of the Agrofood Regional Cluster in Romania. The product consists of Valcele medicinal mineral water, which is rich in Fe, Ca, Mg and several natural ingredients like aroma, fructose, natural colorants, soluble, gluten-free and prebiotic food fibers (Inulin). All ingredients are mixed at a controlled temperature regime. For preservation and packaging, the bending process is followed by pasteurization at 70 °C for 10 minutes. To manufacture the product with the required properties, several test series were needed (IPE 2019).

Feedstock

Valcele medicinal mineral water, aroma, fructose, natural colorants, soluble, gluten-free and prebiotic food fibers (Inulin)

Product

Gluten-free functional medicinal mineral water in bottles of 0.3 l

The annual production of ca. 450 l requires 48 kg of biomass in powder form (IPE 2019).

Initial idea

The project was launched as an innovation voucher for productive and innovative SMEs to come with new products on the national market. The idea itself emerged from two needs. First, the human body's undersupply of fiber should be addressed in terms of a healthy lifestyle and balanced diet. Second, patients suffering from celiac disease were targeted, since this product can counteract low absorption rates of nutrients and minerals caused by a too fast digestive transit. By consuming this product, enriched with fibers and minerals, the digestive transit slows down which leads to absorption rates of nutrients and minerals from the food (Interreg Europe n.d., IPE 2019).

Economic description

The investment costs within in the project are approximately EUR 15.000. Up-scaling to a small-scale factory with a capacity of 500.000 bottles per month would require investment costs ranging from EUR 800.000 – 1.000.000 from scratch. One bottle of gluten-free functional medicinal mineral water costs EUR 0.40 which leads to monthly sales of EUR 200.000 (IPE 2019).

Impact

Environmental impact

The environmental impact of a small-scale factory described in the economic description cannot be assessed neither positive nor negative at this level of development (IPE 2019).

Socioeconomic impact

First, the outcome of the technology is a gluten-free fiber enriched natural medicinal mineral water which has several medical benefits like increased mineral uptake or disease prevention. A small-scale factory would generate 10 – 15 jobs as well as a new income source. In the Romanian case, local businesses are supported by e.g. falling back on local mineral water producers (IPE 2019).

The way forward

Since the awareness of high-quality food and beverages will further increase, the demand for safe beverages like the gluten-free functional medicinal mineral water has the potential to be integrated in a constantly growing market. The technology described here is ready-to-use and can be upscaled with relatively low financial effort to supply the local demand. The exploitation of international markets can be hard regarding legislative barriers, marketing and a higher competition compared to local distribution (IPE 2019).

List of references

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Interreg Europe (n.d.): Europe first gluten-free fibers enriched natural mineral water. https://www.interregeurope.eu/policylearning/good-practices/item/1120/europe-first-gluten-free-fibres-enriched-natural-mineral-water/ (accessed 13.08.2019).

3.2 Forestry

3.2.1 Sustainable textile fibers from wood

Figure 23: Section of Spinnova's production line (Spinnova 2019).

Company

Spinnova Ltd

Product

Continuous filament or staple fiber

Since

2015

Sectors

Forestry, textile industry

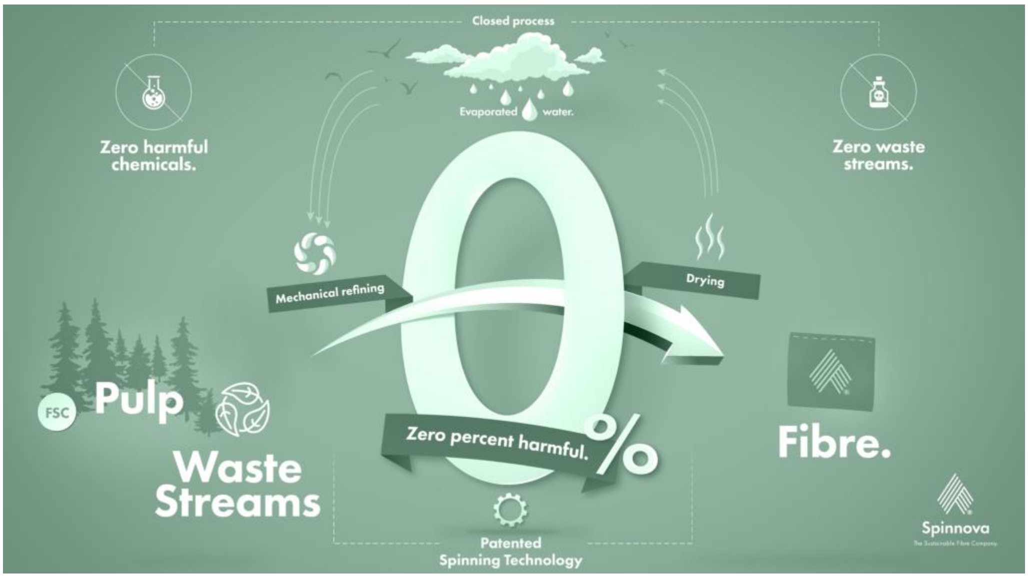
TRL

8-9

Technology

Spinnova developed a technology that allows them to turn wood fibers into yarn without using harmful chemicals. The whole process is built upon a mechanical treatment of the pulp, fiber suspension flows and rheology. Spinnova produces fiber out of micro fibrillated cellulose (made of FSC certified wood or waste streams) which can be described as a pasty mass of tiny wood fibers (Spinnova 2019, Spinnova n.d.). This finely ground pulp mass then flows through a nozzle, where the fibers rotate and align with the flow, creating a strong, elastic fiber network. Using the patented spinning technology, the fiber is spun and dried. The outcome of this process is a fluffy but solid wool-like material, suitable for spinning into yarn and to use for textile production. The only by-product of the process is evaporated water, which is lead back into the process (see Figure 24). The produced yarns are unexpectedly fire retardant, antimicrobial, warm as lamb wool and naturally biodegradable. This opens several interesting applications apart from the textile industry (Material District 2018, Spinnova 2019).

Figure 24: Simplified depiction of the Spinnova process (Spinnova n.d.).



Feedstock

Micro fibrillated cellulose from FSC certified wood, agricultural waste (stubble)

Product

Continuous filament or staple fiber

Figure 25: Micro fibrillated cellulose mixed in water (Spinnova n.d.).

Figure 26: Spinnova's sustainable filament fibers (Spinnova 2019).

Initial idea

Spinnova wants to fill the cellulose gap by offering a sustainable technology to produce eco-friendly cellulose-based textiles. Their overall objective is a more sustainable textile industry, where sustainable cellulose-based materials are a competitively and preferred option for brands in terms of cost efficiency and environmental friendliness. The clothes should be affordable for the mainstream (Spinnova n.d.).

Impact

Environmental impact

The fiber produced by Spinnova is particularly sustainable, both from a raw material and a manufacturing point of view (Spinnova n.d.). It can replace a variety of less ecological fibers such as cotton, viscose or even polyester. The wood for the micro fibrillated cellulose comes from FSC certified nurseries, a resource which is rather undemanding regarding water consumption and tendering. Spinnova's manufacturing process is highly water efficient and produces no side or waste streams. Compared to cotton production, Spinnova uses 99 % less water during the production of their bio-degradable fibers. In total, Spinnova's business meets five of the United Nations' 17 SDG's for 2030 directly (Spinnova n.d.).

Socioeconomic impact

Spinnova developed a scalable technology, which can be set up anywhere in the world, preferably next to the raw material source and e.g. textile industry supply chains. Thus, Spinnova found a way to create new, extended value chains and jobs (Spinnova 2019).

The way forward

This technology can be seen as an example on how to adjust the textile and the forest industry in terms of sustainability. Supported by the growth of conscious consuming, Spinnova can be a credible competitor on the future textile market. Currently, the company is using wood pulp from sustainably managed nurseries and agricultural waste-based cellulose and is also researching on other cellulosic waste streams.

List of references

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3.2.2 The containerized pyrolysis unit

Figure 27: Pyrogreen® 600 – the containerized pyrolysis unit with and without casing (Biogreen [1] 2019).

Company

ETIA Biogreen

Product

Pyrolysis oil, syngas, biochar, heat, wood vinegar

Since

1989

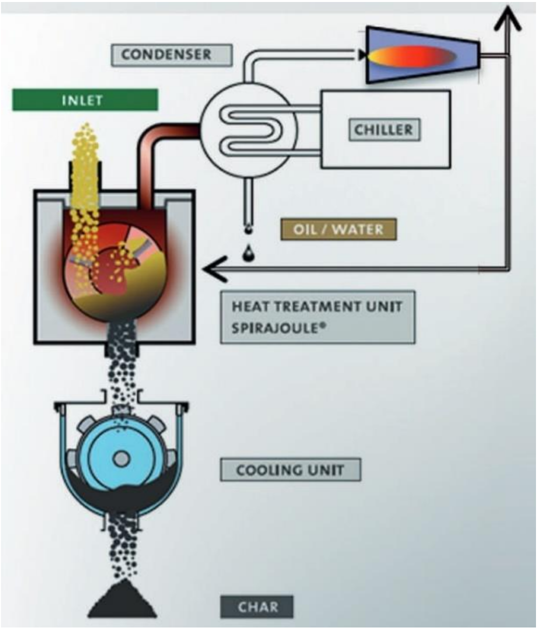
Sectors

Agriculture, agroindustry, forestry, municipalities, waste industry

Technology

Pyrolysis is the thermal decomposition of materials at high temperatures in an inert environment. The treatment leads to the formation of new molecules and is irreversible. The exclusion of oxygen during the treatment provokes high energy contents in the products received, that often have a more superior character than the original residue. The decisive factor is the chosen temperature of the pyrolysis, that determines the composition and yield of the products (pyrolysis oil, syngas and char). Pyrolysis is a commonly used treatment for organic materials (Biogreen [1] 2019).

Figure 28: Biogreen's patented technology (Biogreen n.d.).



Biogreen® offers a continuous process based on the Spirajoule® technology, an exclusive process for thermal treatment. The centerpiece of the process is a hollow shaft screw conveyor that is heated by a low voltage current. The screw, made from electrically conductive material, is connected to an electricity power supply. The passage of electronic current through the conductor (screw) generates heat, which is a result of Joule heating (also known as Ohmic heating or resistive heating). The temperature of the screw is maintained due to the joule effect and precisely controlled by the regulation of the screw temperature setting. The product that enters the pyrolysis chamber is conveyed and remains in the continuous contact with the heater while it is being transferred. So, the particles of the feedstock are heated in a uniform manner while passing through the reactor. The residence time of treated material is regulated by the setting of the screw rotation speed. The conditions of the treatment are continuously monitored and can be adapted by each operator individually (Biogreen [2] 2019).

Biogreen® is an extremely versatile system that offers a wide range of possibilities for conversion of biomass and waste into valuable materials and energy. Figure 27 shows the containerized processing unit Pyrogreen® 600, which converts biomass (wood, crops and forest residues) into high-value products. This ready to use technology is suitable for fast, temporary applications and easy to be shipped or stored, without taking much space (Biogreen [1] 2019, Biogreen [2] 2019).

Feedstock

Biomass (wood, crop), dried sewage sludge, carbon-based materials (up to 16 tons/day of feedstock, 10-20 % moisture, particle size less than 20 mm)

Product

Pyrolysis oil (8 tons/day), **syngas** (9 MWh/day to be used as heat for drying or to be converted into energy), **biochar** (4,8 tons/day to be used as solid fuel, soil amendment, fertilizer, water retention material), **heat, wood vinegar**

Initial idea

The objective of the Biogreen technology is to turn different resources and feedstocks like waste and biomass into value-added products and energy. The pyrolysis process aims to support different stakeholders in valorizing, recycling and recovering of resources by providing a versatile and easy to implement solution that is suitable for local deployment.

Thanks to the adjustable operating conditions in Biogreen pyrolysis units, the technology offers the ability to engineer the products according to the demand and to produce different types of biochar, bio-coals, bio-coke, and solid fuels (Biogreen [2] 2019).

Economic description

ETIA configures the equipment according to the specific project demand. Capital costs, operational expenses and return on investment are linked to the individual business case and operational model (Biogreen [2] 2019).

Impact

Environmental impact

Biogreen offers a fossil-free pyrolysis process that allows to convert various feedstocks into bio-based products and renewable energy. By not emitting carbon, replacing petroleum-based products and thus sequestrating carbon, Biogreen contributes to the decarbonization of industries. Furthermore, Biogreen offers environmental-supporting products with e.g. the potential of soil restoration (Biogreen [2] 2019).

Socioeconomic impact

Pyrogreen® is a technology, that is suitable for a decentralized utilization on a small scale, since it does not require interferences in local infrastructure or adjustments of legislation. The technology can create new income streams and value-added products (Biogreen [2] 2019).

The way forward

ETIA is specialized in converting biomass residues and waste into bio-based products, chemicals and renewable energy. The circular economy has been a key motivating factor for the growth of the company. In order to address the environmental challenges, ETIA has created a large portfolio of solutions adapted for small and industrial scale applications. Growing demand for technologies that support the decarbonization of various industries may increase the importance of the companies’ solutions.

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Biogreen [1] (2019): Think sustainable. http://www.biogreen-energy.com/ (accessed 14.09.2019).

Biogreen [2] (2019): Mail traffic.

3.2.3 Biomaterials from organic and agroforestry residues and mycelium

Figure 29: Forestry pots and containers (Spawnfoam 2019).

Company

Spawnfoam

Product

Forestry pots and containers, construction boards, ornamental vases

Type of intervention

Private sector activity (co-financed and funded by several projects)

Since

2017

Sectors

Forest industry, agroindustry

Technology

Spawnfoam developed a process, which enables them to produce an innovative biocomposite material made of fungi, organic additives and biomass from the surrounding agroindustry and forestry. The chopped and blended biomass used is the raw material base for the process. The key of Spawnfoam is the application of mycelium, which works as a bonding agent to cohere the biomass particles. Finally, the composite material can be pressed and molded in different shapes, depending on the desired product (EC 2018, Government Europa 2018, Spawnfoam 2019).

Feedstock

By-products and residues from agriculture and forestry, mycelium

Product

Biodegradable pots, packaging and filling materials, construction materials (sound, thermal and vibration absorbance)

Figure 30: Wood processing residues (BioEnergy Consult 2019).

Figure 31: Construction boards (Spawnfoam 2019).

Initial idea

The general idea of Spawnfoam emerged in 2013 with a clear objective: changing the paradigm of production and consumption of fossil-based composites and materials, such as plastics, by providing an innovative and competitive alternative of organic and biodegradable origin. Spawnfoam aims to contribute decisively to increase the planet's sustainability, to improve resource efficiency and, consequently, to facilitate the transition to a circular economy (Spawnfoam 2019).

Impact

Environmental impact

Spawnfoam offers a 100 % biodegradable product, implementing the "cradle to cradle" approach. Since the biocomposites have the potential to replace petroleum-based products, they reduce the dependence on fossil fuels and GHG emissions. Thus, Spawnfoam helps reducing the ecological footprint and contributes actively to decarbonization. The biocomposites are just as effective and efficient as their fossil-based counterparts but completely harmless to the environment and even beneficial. For instance, their plant pots are environmentally friendly, customizable, easy to use and increase the plant survival in forestation projects and tree nurseries. The plants or trees are planted in the soil with the pot, into which natural fertilizers can be incorporated to boost the success of the transplant. This can be an important issue regarding reforestation as a climate mitigation measure (Government Europa 2018, Spawnfoam 2019).

Socioeconomic impact

Sticking to the idea of sustainable economic growth, Spawnfoam aims to create new economic models that facilitate generating wealth and employment in the scope of the circular economy (European Commission [1] 2018).

The way forward

Spawnfoam creates environmentally friendly and renewable alternatives for petroleum-based plastics. Their biodegradable materials can be used in multiple contexts which shows the broad field of applications renewable resources can be used for. Such companies can contribute to disseminate and demonstrate the importance and versatility of renewable products. Spawnfoam already has a wide reach, since it was funded by the EU.

List of references

BioEnergy Consult (2019): Biomass from Wood Processing Industries. https://www.bioenergyconsult.com/tag/wood-processing-residues/ (accessed 10.08.2019).

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3.2.4 Small-scale pelletizing units

Figure 32: Small pellet plant with a capacity of 50-1100kg/h (GEMCO Energy n.d.).

Company

GEMCO, abc Machinery, AMISY, etc.

Product

Pellets (feed and fuel)

Since

n.d.

Sectors

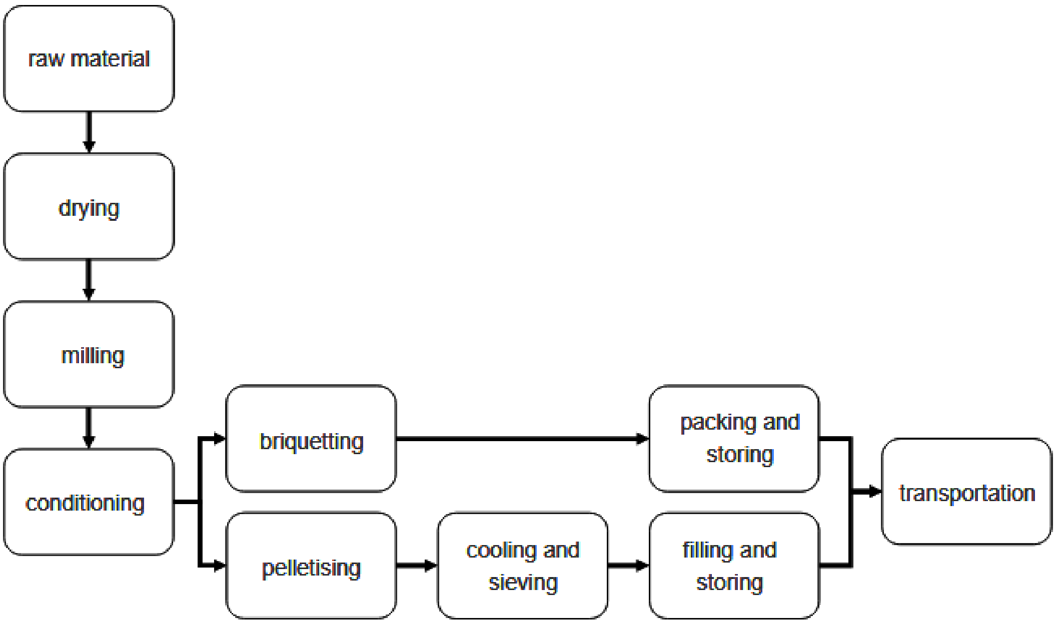
Forestry, agriculture

Technology

Pelletizing, a pressure agglomeration process, can be used to improve the mechanical and physical properties of solid biofuels. The compacting process leads to the formation of lager fuel particles with reduced surface area. The technology is often used to homogenize the mechanical properties, increase the density and improve the transportation and handling properties.

Prerequisites for the pelletizing process are the deformability and the proper moisture content of the used biomass. Depending on the feedstock, a water content of 10-15 % is needed to achieve the required physical fuel properties. Usually feedstocks like straw and grass do not need to be dried, in contrast to other raw materials. Small-scale pellet plants either have a batch perforated-floor technology using heated air or a band conveyor using exhaust gas or heated air for drying. In a next step, the biomass needs to be grinded, which can be realized with various mill types. The chosen mill type has a direct influence on the mechanical durability of the produced pellets (DBFZ 2012).

Figure 33: Production process of pellets and briquettes (DBFZ 2012).



Before pelletizing, the raw material is conditioned by influencing the water content, adding binders, additives or other raw materials as well as by pre-heating and steam addition. Binders like maize gravel, maize starch and rye flour can increase the stability of the pellets. Additives such as lime, dolomite and talcum powder can also be added to improve the combustion properties of the biomass through increasing the ash melting temperature. The right ratio of biomass, additives and binders is important to achieve the highest possible mechanical durability. Furthermore, the control of the concentrations of N, S and Cl in the raw material mix can help to keep the emissions during combustion as small as possible (DBFZ 2012).

Finally, the eponymous process takes place, during which the mixed materials are uniformly and continuously fed into the pellet mill to form pellets. The pressure agglomeration takes place by applying external forces to the conditioned mixture. The most common pelletizing technologies used are pellet mills with flat dies and ring dies (depending on the raw material used and the desired product). Subsequently, the pellets are screened and discharged into a cooling unit to reduce the pellet's temperature and prepare them for packaging (DBFZ 2012).

Feedstock

Several biomass feedstocks like wood waste, saw dust, crop residues, crops, etc.

Product

Pellets as animal and livestock feed, organic fertilizer, biofuel

Figure 34: Pile of saw dust for pellet production (GEMCO Energy n.d.).

Figure 35: Pellets - ready to use (GEMCO Energy n.d.).

Processing capacities

The processing capacities of the considered small-scale pelletizing plants can vary from 50 kg/h to 3.000 kg/h.

Economic description

The investment costs of a small-scale pellet unit depend on the size and the installed equipment. To estimate the operational costs of such a plant, the local feedstock costs, salaries and electricity prices must be considered.

Impact

Environmental impact

Pellet exports from large-scale pellet plants can have a negative environmental impact regarding pellet production, logistics and the raw material used (Dart and Milman 2018, Magelli et al. 2009). No valid sources for the impact of small-scale pellet plants could be found. But one can suspect, that since small-scale pellet plants, described in this section, mainly use waste and residues as raw materials to meet local demand, the emissions during the value chain are significantly lower.

Socioeconomic impact

The socio-economic impacts of the whole supply chain may be important at local level (IEA Bioenergy 2019). Valorizing untapped raw materials like wood waste or saw dust may result in new income streams and an increased independence for local small-scale farmers and households from fuel purchases.

The way forward

Small-scale pellet plants offer an opportunity to turn a wide range of (waste) raw material into valuable products that can be used for different purposes. As long as they are produced and sold locally, SME's and households can profit from the pellet production without harming the environment.

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3.2.5 Mobile wood chipping unit

Figure 36: Mobile wood chipping unit (Erpék Ind 2019).

Company

Erpék Ind SRL

Product

Wood chips

Since

2015

Sectors

Forestry, wood industry, agriculture, municipalities

Technology

Erpék Ind offers a mobile wood chipping unit which can be fed with wood based raw material from forest industry, agriculture and municipalities. The woodchipper is mounted on a trailer chassis why it is highly flexible and suitable for different surfaces. Since the woodchipper is driven by an integrated 60 HP diesel engine, it can work autonomously without any external power. The feeding of the chipper is done manually, and the unit is basically designed for branches from orchards, forest residuals, Christmas trees from urban areas, branches from urban parks and so on. In one hour, up to 15 m^3 of chipped biomass can be produced. The volume of the raw materials can be reduced to 25 % whereby the transport and logistic process of wood materials becomes simpler and cheaper. The performance of the machine depends strongly on the quality, size and type of input material, as well as on the labor force involved in the wood chipping process (IPE 2019).

Feedstock

Woody biomass like branches from orchards, vineyards and urban parks, forest residues, etc.

Product

Wood chips

Figure 37: Green cuttings from orchards ready to be picked up (Bioeconomy BW 2016).

Figure 38: Wood chips (Chemistry World 2018).

Initial idea

Since a lot of woody biomass from different sectors remained un- or even underused in Covasna County, Erpék Ind developed a small and mobile wood chipping unit for Romanian stakeholders at an affordable price. Originally this unit was a spin-off from Erpék Ind's small and medium size boilers which required biomass that was identified in wood chips in this case (IPE 2019).

Economic description

The woodchipper requires only a small investment of about EUR 17.000 (including trailer chassis, Kubota diesel engine, chipper, hydraulic engine, pump and pipes). The operational costs depend on influence factors like fuel costs, labor force and maintenance. The payback can be reached after running 900 h (IPE 2019).

Impact

Environmental impact

Sustainably produced (including harvesting) wood chips have the potential to reduce fossil carbon emissions. Wood chips are an alternative to fossil fuels regarding thermal energy production for households and industry. Moreover, the burning of wood chips is typically performed in a controlled environment, which leads to less greenhouse gas emissions compared to uncontrolled on-site burning. Since the raw materials of wood chips are widely spread, wood chips can be produced and consumed locally in many cases, which leads e.g. to a reduction of transportation emissions (IPE 2019).

Socioeconomic impact

Wood chipping can help to valorize un- and underused raw materials and thus create new jobs and income streams in the fields of harvesting, manufacturing, logistics, etc. (IPE 2019). Moreover, the costs per MWh are significantly lower for wood chips than for heating oil and natural gas (C.A.R.M.E.N. e.V. 2019).

The way forward

Since wood chipping is a very simple technology with a high replication potential, it is suitable for various locations including rural areas. New income streams can be implemented easily with relatively low investment costs. Moreover, wood chips cover a wide field of application (solid fuel, wood pulp production, mulch, etc.) (FNR n.d.) what makes them particularly useful for rural areas.

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3.3 Fishery

3.3.1 A mobile fish waste processing unit

Figure 39: Mobile Sealab at customer's site (SINTEF 2018).

Company

SINTEF

Product

Animal feed, Omega-3 fish oil, protein hydrolysates

Since

n.d.

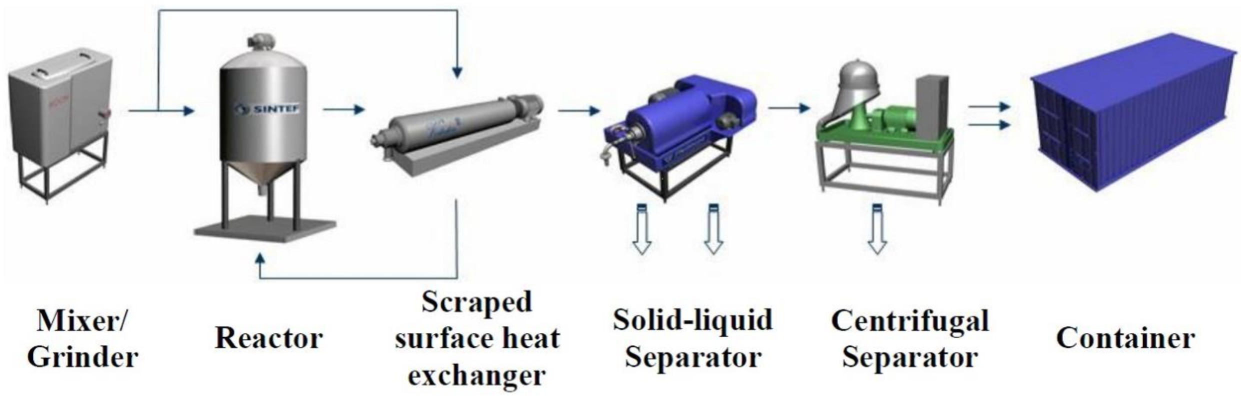
Sectors

Fishery industry

Technology

The Mobile Sealab contains a small, but complete, factory facility for the recovery of oil, protein-rich fractions, and other nutrients from waste raw materials, produced by the fishery industry. SINTEF's mobile customized facility enables customers, in cooperation with SINTEF, to develop new products and value streams as well as to optimize existing processes for a wide range of raw materials. In this way, SINTEF fills the gap between lab scale tests and production and full industrial facilities. Screen testing of enzymes and antioxidants can also be done. Currently, fish backbones, offal and off-cuts from fillet production are processed to make low-quality animal feed, even though it is possible to produce food quality Omega-3 fish oil and protein hydrolysates from the same raw materials. To preserve the potential and quality of the feedstock used, it is important to process the raw material when it is completely fresh. SINTEF's mobile processing unit can fulfill these requirements since it can be dispatched to production locations as a result of its high level of mobility (SINTEF 2016, 2018).

Figure 40: Example of process setup in SINTEF's Mobile Sealab (SINTEF 2016).



Feedstock

Fish processing residues, fish waste, low value fish

Product

Animal feed, Omega-3 fish oil, protein hydrolysates

Figure 41: Fish processing residues are a valuable resource for further applications (SINTEF n.d.).

Figure 42: Heads from salmon, cod and herring can be used to produce fish oil and powdery protein hydrolysates (SINTEF n.d.).

Variation in processing capacity

The capacity will vary depending on the chosen product and type of process used. For heat treatment the capacity is 500-1.000 kg/h and for one batch hydrolysis it is 400 kg/4-6 h (SINTEF 2016).

Initial idea

The idea of SINTEFF was to develop a mobile customized processing unit and laboratory that helps to investigate potential applications of numerous raw materials and process designs on small scale. Therefore, the processing units can be customized regarding the feedstock and the desired output. In this way, the customer can identify value streams that might be worth to invest in or not (SINTEF 2016, 2018).

Environmental impact

The environmental impact can be neglected at this phase of processing, but it is gaining importance when it comes to commercialized processing units.

Socioeconomic impact

Since the Mobile Sealab from SINTEF is doing research on valorizing fish waste and fish processing residues, it helps to investigate and develop new income streams from renewable resources for interested customers (SINTEF 2016).

The way forward

SINTEF provides a technology which helps to sound different ways of processing fish waste from an investor or interested party perspective. After running a project using Mobile Sealab, SINTEF and the customer will have more information on what kind of process should be used for various feedstocks, what parameters and capacities each process should have and what kind of product and quality can be expected from the process. Against this background, SINTEF offers an opportunity to develop future businesses based on renewable fish resources, without taking big financial risks.

List of references

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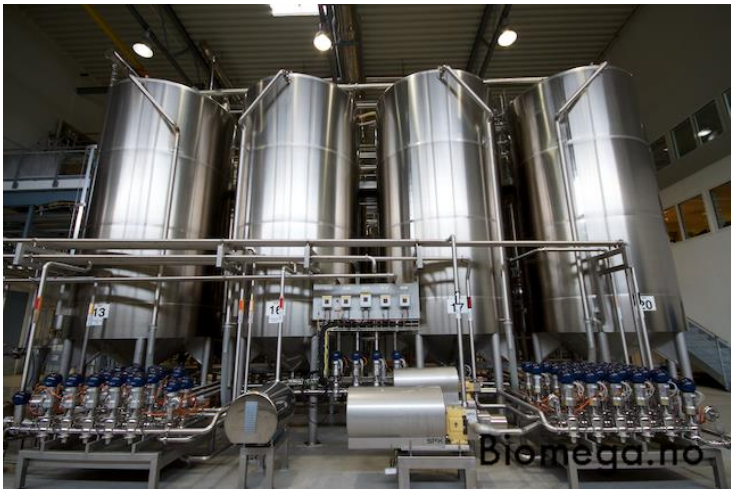
3.3.2 Food and feed from fish processing residues

Figure 43: A section of Biomega's patented process (Biomega 2019).



Company

Biomega

Product

Fish oil, peptides, minerals and proteins for food and feed

Since

n.d.

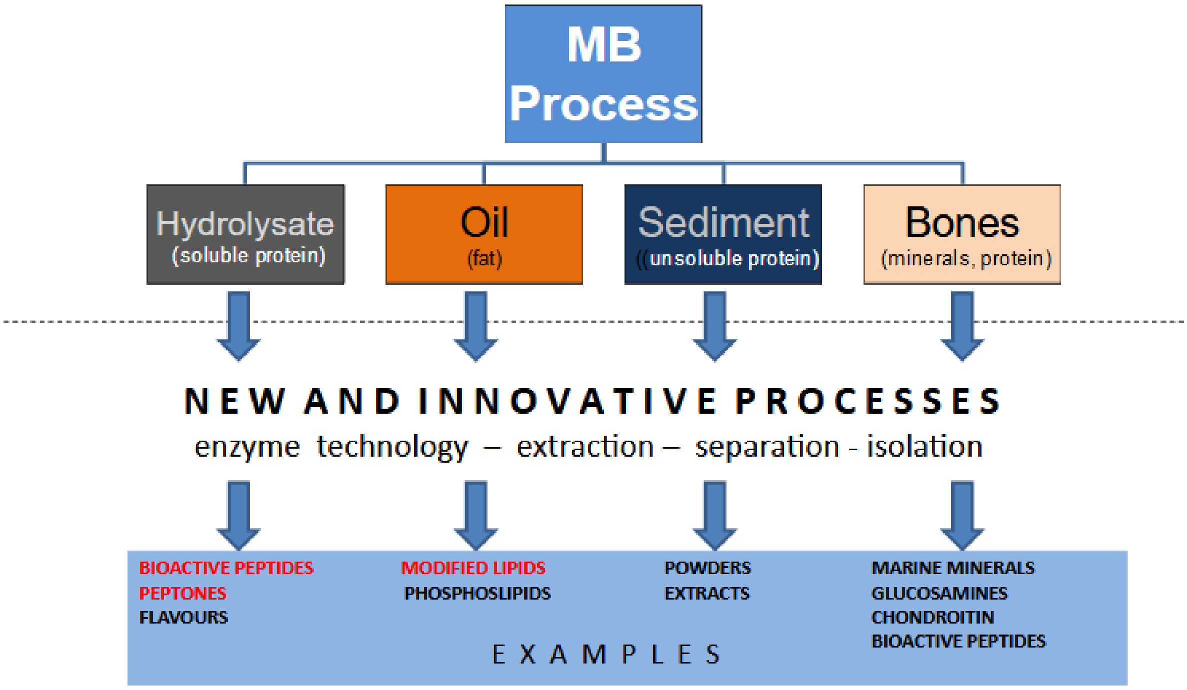
Sectors

Fishery industry

Technology

Biomega offers a solution to valorize fish processing residues and subsequently saves them from being dumped into the sea or costly disposed. The patented process uses only natural enzymes to predigest proteins, based on the model of the human and mammal digestion systems. The fish processing residues (every part of the fish except of the fillet) must be processed within a maximum of two days after slaughter. Advanced separation techniques ensure the gentle separation of the nutritional components. Biomegas technology approach serves to preserve more nutrients like proteins and minerals than during chemical processes. The outcome of their process consists of soluble and non-soluble proteins, oils and minerals. The raw material is kept refrigerated during the whole production to allow the end products to be certified for human consumption (Biomega 2019, Sandens n.d.).

Figure 44: Biomega's marine bioproduct process (Sandens n.d.).



Feedstock

Fish processing residues (every part of the fish except of the fillet) (capacity of 36.000 t/year)

Figure 45: Slaughter waste and trimmings from the fish processing industry (Eurofish Magazine n.d.).

Product

Fish oil, peptides, minerals and proteins for food and feed (capsules, powder and liquid)

Figure 46: pet food ingredient products: Salmeal® Active, Salmigo® Protect and Salmoil® Pet (Biomega 2019).

Initial idea

Biomega was founded as a production and research company aiming to develop solutions for the valorization of fresh raw materials of marine origin which were left unexploited for a long time. They focus on optimizing the use of the provided raw material, search for innovative solutions and therefore spent a minimum 8 % of company revenue on R&D every year. Nowadays they have unique expertise in purifying active components from marine by-products (Biomega 2019, Nordic Council of Ministers 2017).

Economic description

A plant using the patented technology of Biomega with a capacity of 10.000 tons/year would require an approximate investment of EUR 3.6 million (Ramírez 2007). The production costs are dependent on the raw materials used, local salaries and energy costs.

Impact

Environmental impact

Biomega does not use any chemicals during the treatment of fish waste resources, their storage or transport. Their energy sourcing is based on clean hydro power and natural gas condensate. The latter is a by-product from oil & gas production. Biomega is among a few companies using this as an energy source. Usually, the gas condensate is incinerated at the oil and gas refineries (Biomega 2019).

Socioeconomic impact

Bio using fish processing residues, Biomega reduces the slaughterhouses' waste disposal expense-es and meanwhile provides them with a new revenue stream. From a health perspective, the pre-digested proteins facilitate bioactive effects such as increased immune system stimulation, heart benefits, and improved intestinal health (Biomega 2019, Nordic Council of Ministers 2017).

The way forward

Biomega commands a biorefining process which is patented worldwide. The company holds a food grade approval for several products what sets them apart from others. Sticking to their guiding principle, relying on research and innovation, they have the potential to expand their product range as well as their processing technologies. Regarding the trend of worldwide fish consumption, especially from aquacultures (Our World in Data 2017), there will be huge fish waste and residue resources to be explored soon, where Biomega can take over a facilitating role.

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Nordic Council of Ministers (2017): Nordic Bioeconomy - 25 cases for sustainable change. https://norden.diva-portal.org/smash/get/diva2:1065456/FULLTEXT01.pdf (accessed 05.08.2019).

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3.4 Waste management

3.4.1 High protein level drink from milk waste

Figure 47: High protein level drink from milk waste (IPE 2019)

Company

MEOTIS

Product

High protein level drink (FRUCTOZER)

Type of intervention

R&D&I activity

Since

2012

Sectors

Agriculture, dairy industry, sports nutrition

TRL

5

Technology

SC Meotis SRL and IBA - National Institute of Research and Development for Food Bioresources, both members of the Agrofood Regional Cluster, found a way to valorize the dairy waste by using it for a new developed high protein level drink (Interreg Europe n.d.). The product consists of whey, aroma, amino-acids, fruit juice, fructose, and natural colorants, which are all agitated mechanically. Before arriving at the optimal composition of ingredients, which was preferred by various test persons, 35 recipes have been tested. For that, a sensory analysis was conducted that included color, texture, taste, and aroma. To guarantee an optimal product with good storage and preservation properties, the mixture is pasteurized and homogenized (IPE 2019).

Feedstock

Dairy residues (whey waste), aroma, amino-acids, fruit juice, fructose and natural colorants

Product

Protein-rich drink for active persons in bottles of 0,3l.

One batch provides 51 l (170 bottles of 0,3 l).

The price of one bottle is around EUR 0,70.

Initial idea

The project was launched as an innovation-fostering programme for productive and innovative SMEs to develop new and innovative products for local and regional markets. Since waste from the dairy industry was identified as an underused resource pool, the project aimed to valorize it as a beverage with recovery, rehydration and muscle development properties (IPE 2019).

Economic description

There is no need for investment in the technology since the high-level protein beverages can be produced with the existing equipment that is already used for the milk processing: pasteurizer, homogenizer, and bottling machine (IPE 2019).

Impact

Environmental impact

The high biochemical oxygen demand of whey poses a major disposal and pollution problem for the dairy industry. Whey has the potential to harm the environment as a water and soil pollutant. Using this by-product from dairy processing helps to solve the problem in a sustainable manner, both from an environmental and an economic point of view (Marwaha, Kennedy 1988).

Socioeconomic impact

High protein level drinks from milk waste can help to diversify the product range of beverages of local dairy producers and related SMEs and thus diversify income streams. Moreover, local demand can be satisfied (IPE 2019).

The way forward

Turning whey into a valuable product has several aforementioned advantages like generating new income streams and reducing environmental risks coming from whey disposals. Nevertheless, the patented technology needs to be developed further in terms of the range of fruit aromas, supporting marketing strategies and larger technological capacities and product quantities (IPE 2019).

List of references

Interreg Europe (n.d.): High protein level drink for the sportsman as a solution for milk waste in the dairy industry. https://www.interregeurope.eu/policylearning/good-practices/item/1121/high-protein-level-drink-for-the-sportsman-as-a-solution-for-milk-waste-in-the-dairy-industry/ (accessed 13.08.2019).

IPE (2019): Mail traffic.

Marwaha S. S., Kennedy J. F. (1988): Whey—pollution problem and potential utilization. In: International Journal of Food Science + Technology, Volume 23, Issue 4.

3.4.2 Efficient membrane-covered composting

Figure 48: Membrane-covered compost heap (UTV AG 2019).

Company

UTV AG

Product

Compost

Since

1996

Sectors

Agriculture, forestry, municipalities

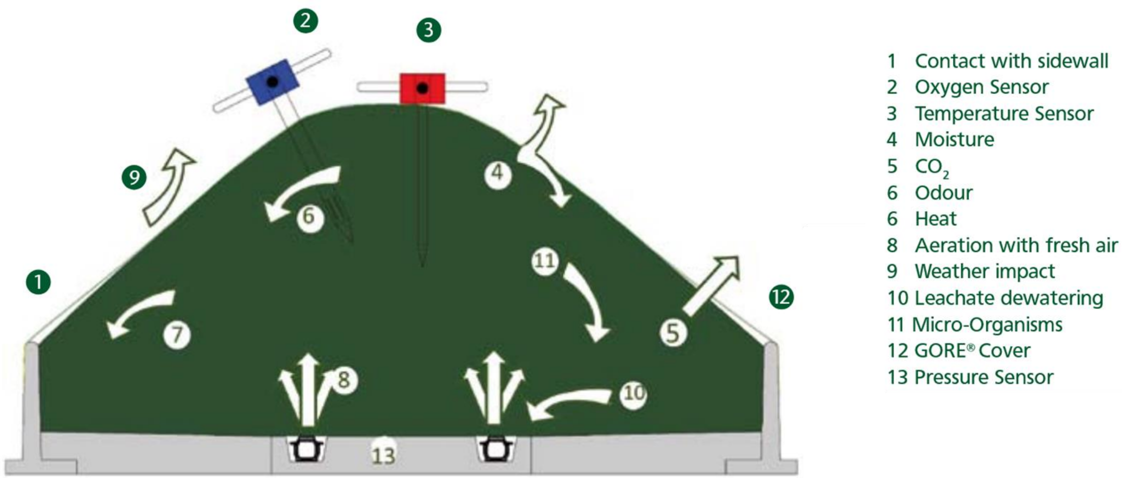
Technology

Composting is a process in which microorganisms, naturally present in organic matter and soil, decompose organic matter. In order to break down the organic matter into smaller particles the microorganisms require basic nutrients, oxygen and water. Organic matter is recycled naturally without human management, but since this process is under human control the end-product is called compost. Furthermore, the regulation and optimization of the composting process have a decisive influence on the time in which the composting takes place as well as on the quality of the compost (Chen et al. 2011).

With the GORE® Cover, UTV AG offers a retrofittable, cost efficient and flexible technology which suits for different types of waste. Within the membrane-covered heap (see Figure 48) the organic matter is decomposed in a pressure-aerated and oxygen-controlled environment, which is computer monitored. The optimized aeration and supply of oxygen through the fans and ventilation pipes result in an intensified decomposition in eight weeks. The end-product is a high-quality compost. Advantages of this technology are the short planning and installation (maximum three months), its mobility, its low construction and operating costs (compared to concrete installations) and the easy handling (trained staff necessary) (UTV AG [1] n.d.).

Moreover, UTV provides a mechanical-biological treatment of wastes (MBT), which helps to reduce the volume of mixed municipal solid waste to be landfilled by 70 %. The investment and treatment costs are considerably lower compared to enclosed MBT plant or waste incineration (UTV AG [2] n.d.).

Figure 49: UTV's composting system with a membrane-covered heap (UTV AG [1] n.d.).



Feedstock

1.000 to 1.000.000 tons/year of green waste, bio waste, food residues, residual waste (UTV AG 2019)

Product

High-quality compost

Initial idea

The idea behind the project was to offer an expandable and retrofittable, cost efficient and flexible technology which suits for different waste types. This technology helps to produce humus for soils by recycling organic waste and safes land by proper waste treatment and storage technologies. Since the volume and duration of organic waste streams are difficult to predict in the long run, UTV wants to offer a flexible technology that is cost efficient and easy to replicate (UTV AG [2] n.d.).

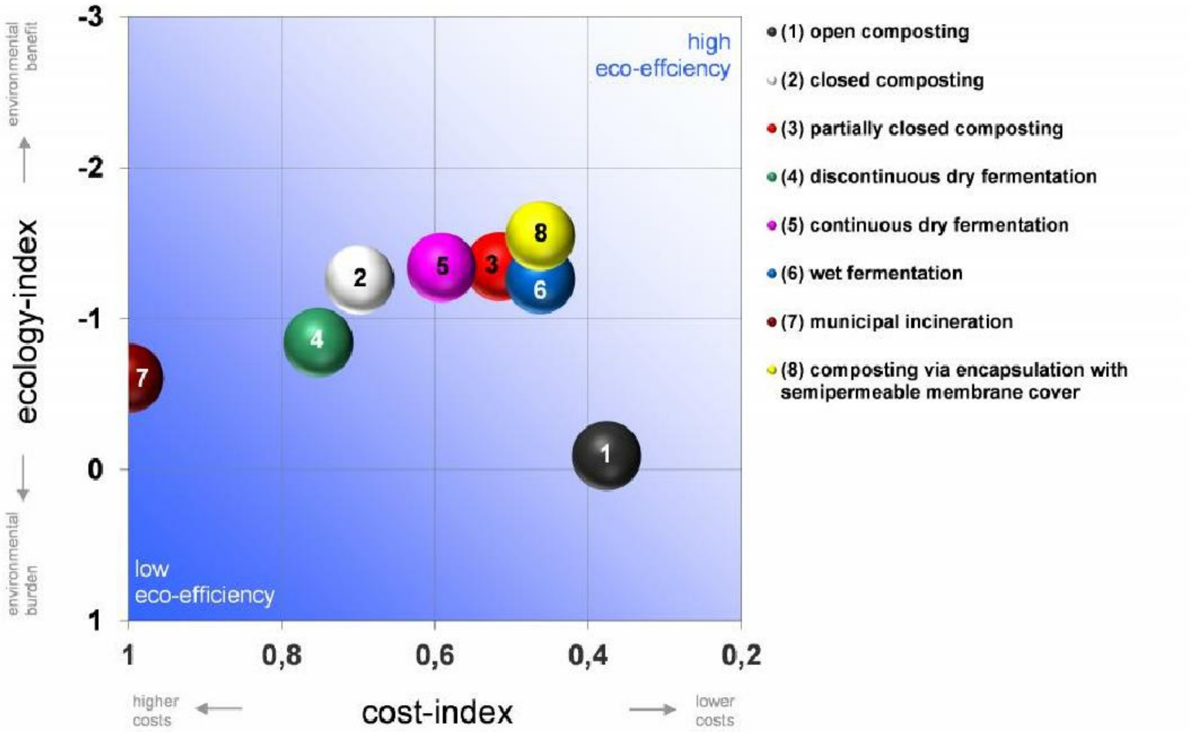
Economic description

The investment costs vary depending on the input material, the density of the input material and the product which should be achieved after the biological treatment. The electrical consumption of the system is estimated to be approximately 2 kWh/t input material (UTV AG 2019).

Impact

Figure 50 shows the results of a comparison regarding ecoefficiency of the treatment via encapsulation with semipermeable membrane cover with alternative treatment processes. Various parameters, like e.g. GWP, acidification, terrestrial eutrophication, resource conservation and eco and human toxicity, were considered. Composting via encapsulation with semipermeable membrane cover has lower electricity requirements as well as a higher emission retention potential regarding methane, nitrous oxide and ammonia flows (UTV AG [1] n.d.).

Figure 50: Ecoefficiency portfolio of different biomaterial treatment methods (ecology index < 0 means environmental burden; ecology index > 0 means environmental benefit; costs index: Scaling of the process-specific costs at the maximum value) (UTV AG [1] n.d.).



The way forward

The GORE® Cover from UTV AG is a retrofittable, cost efficient and flexible technology that suits for different feedstock types. The highly replicable technology can deal with different amounts of raw material since it can be adapted in scale, why it is suitable for a wide range of target groups, especially because waste and residues will be a persisting issue.

List of references

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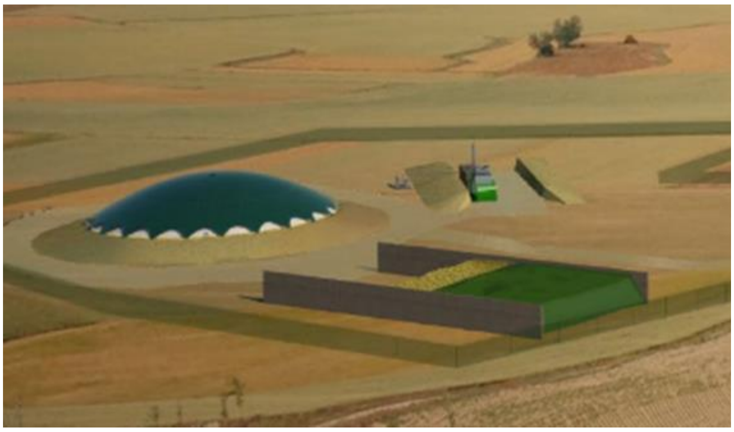
UTV AG (2019): Mail traffic.

UTV AG [1] (n.d.): Let’s make compost. *https://www.kompostanlagen.de/wp-content/uploads/2015/04/UTV-Magazin_2015_de_en.pdf* (accessed 20.09.2019).

UTV AG [2] (n.d.): Let’s make compost *https://www.kompostanlagen.de/* (accessed 20.09.2019).

3.4.3 Anaerobic digestion on a small scale

Figure 51: The ADbag from Demetra (Demetra Ltd. n.d.).



Company

Demetra Ltd

Product

Biogas, fertilizer

Sectors

Agriculture, municipalities

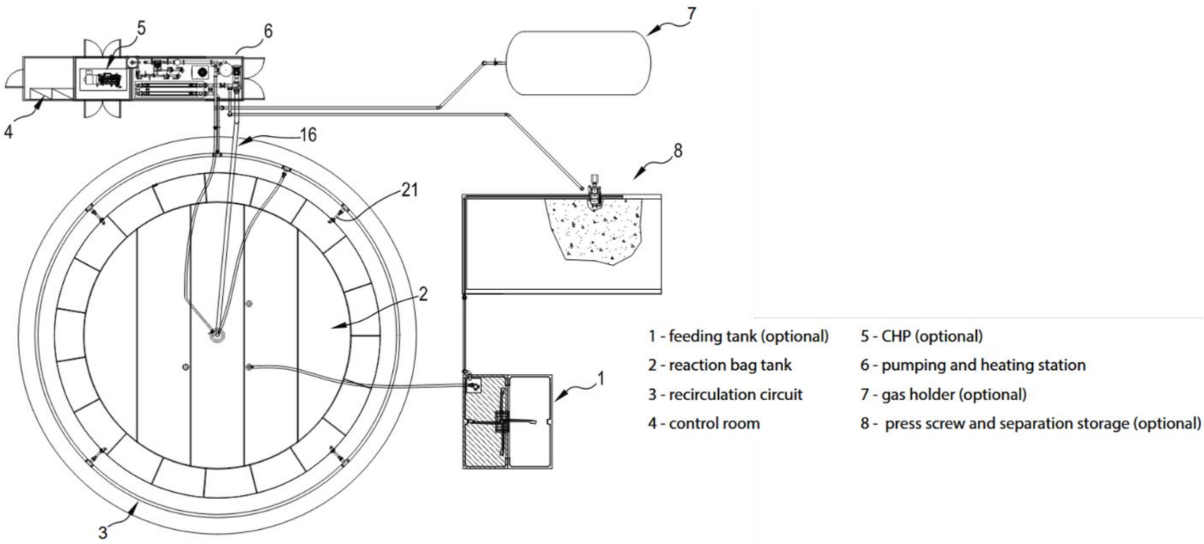
Technology

Anaerobic digestion is a biochemical process by which anaerobic microorganisms break down complex organic material in the absence of oxygen. In a biogas installation, the outcomes of the anaerobic digestion process are the biogas on the one and the digestate on the other hand (Al Seadi et al. 2008).

The Demetra ADbag is an example, that uses this process to convert different feedstocks to biogas and natural fertilizer. The Demetra ADbag consists of a plasticized fabric bag which works as reaction tank and a technical container which regulates the recirculation, the feeding and the heating of the digester. Depending on the energy type the client wants to retrieve, the ADbag can be supplied with or without the CHP (see Figure 52). The sludge within the reaction tank is agitated by the recirculation system to provide the perfect mixing of the feedstock and thus, to maximize the production of biogas. The entire process is monitored, and the automatized system can be controlled by onsite operators and remotely via an internet connection (Demetra Ltd 2016, n.d.).

The bag tank is partially embedded in the soil and the excavated material is used to build the shoulders all around the bag. The bag gets unpacked at the center of the excavation before connecting it to the pipes in order to complete the circulation system. The storage pits for the digestate, the feeding tank and the screed for the container can be assembled on site from pre-casted concrete elements. The ADbag is available with a diameter of 12 m (ADbag12), 15 m (ADbag15) or 18 m (ADbag18) (Demetra Ltd 2016, n.d.).

Figure 52: Technical set-up of the Demetra ADbag (Demetra Ltd. n.d.).



Feedstock

Agricultural residues, agroindustrial waste, organic fraction of municipal solid waste

Product

Biogas, natural fertilizer

Table 1: Calculated values for the purpose of the comparison between different feedstocks and their outcome in an ADbag18 (Demetra Ltd. n.d.).

Adbag 18m		FEEDSTOCK	Cow Slurry (10% TS)	Organic waste (23% TS)	Sludge from Water Treatment (6% TS)	Sludge from Distillery (10% TS)	Slaughter house waste (15% TS)	Grass (16% TS)
Feedstock quantities		tons/day	19	12	25	*25*	13	11
		tons/year	6,935	4,380	9,125	*9,125*	4,745	4,015
Gas production		Biogas (Scm/h)	28	67	19	*42*	54	29
		CH4 (Scm/year)	124,000	320,000	88,000	*195,000*	257,000	126,000
Digestate production		Solid (tons/year)	876	1,059	767	*1314*	329	1,241
		Liquid (tons/year)	5,771	2,665	8,279	*7,483*	3,873	2,446
Biogas exploitation	CHP	Electrical (kW)	50	130	36	*80*	105	52
		Thermal (kW)	71	186	51	*114*	150	74
	Boiler	Thermal (kW)	127	325	90	*176*	257	128

Initial idea

The motivation behind the Demetra ADbag was to design and provide a smart environmental-friendly plant with a reduced carbon footprint. It is easy and quick in installation (less than 20 workdays), handling and maintenance and at the same time there are no reduced yields in biogas production compared to a standard installation. The goal was to offer an inexpensive biogas plant, which

1) is suitable for small-scale farms and food processors with limited supply of residues and waste and

2) can be rapidly deployed (Demetra Ltd 2016, n.d.).

Environmental impact

When it comes to the impact of biogas on climate change, methane emissions are one of the main issues since it can be released during incomplete combustion and poorly managed biomass and biogas storage. Furthermore, the efficiency of CHP and the exploitation of the thermal energy need to be enhanced to improve the global warming reduction potential (Paolini et al. 2018). If the whole process works properly in a controlled environment, anaerobic digestion results in the reduction of emission of greenhouse gases since the biogas can replace fossil fuel in energy production (Farm Energy 2019).

Socioeconomic impact

The socioeconomic impact of biogas and bioenergy production strongly depends on local circumstances like subsidy programs, energy prices etc. Nevertheless, anaerobic digestion plants have the potential to create new income streams for local farmers, mainly from biogas and fertilizer production. The latter is much more compatible for arable land (C.A.R.M.E.N. 2008).

The way forward

Demetra ADbag is a technology that can be applied quickly on different scales why it has the potential to reach several target groups. Thus, organic waste coming from agroindustrial supply chains and municipalities can be valorized and turned into value-added products like energy or fertilizer.

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Farm Energy (2019): https://farm-energy.extension.org/environmental-benefits-of-anaerobic-digestion/ (19.09.2019).

Paolini V., Petracchini F., Segreto M., Tomassetti L., Nour Naja, Angelo Cecinato (2018): Environmental impact of biogas: A short review of current knowledge, Journal of Environmental Science and Health, Part A, 53:10, 899-906.

4 Comparative assessment of small- and large-scale technology options

The scale of a biorefinery is always linked to advantages and disadvantages. This becomes even clearer as one compares small- and large scale biorefineries. Large-scale biorefineries almost always benefit from economies of scale. However, there exist a few important advantages for small-scale biorefineries, too, which are shortly outlined in the following.

When it comes to advantages of small-scale biorefineries, the most mentioned one is the reduction of transportation and logistics costs, which can be a major part of processing costs. Although some logistics are needed in all cases, small-scale decentralized biorefineries can reduce these costs significantly since they can process raw materials near to the source. Dispersed liquid waste streams, like liquid manure or domestic wastewater, should not be transported at all, but can be used for local small-scale biogas production (e.g. Demetra ADbag). Furthermore, local small-scale pre-processing can be beneficial for small- and large-scale biorefineries, since unwanted amounts of water and minerals stay on the farms and thus, transportation costs of the raw material for large-scale biorefineries decrease (e.g. dried and pyrolyzed raw material). Fractions like water, residual organic matter and minerals can be reused on the fields (e.g. nitrogen, phosphate and potassium as fertilizer). The produced heat and CO_2 can also be reused during the biorefining processes (Bruins and Sanders, 2012; Serna et al., 2017). BIO-LUTIONS and GRASSA! can be named here as examples, which demonstrate the reuse of several by-products.

The local decentralized (pre-) processing may also create new income streams within rural areas. Facilities with simple and less expensive technologies have the potential to increase rural employment (Bruins and Sanders, 2012). Thus, small-scale biorefineries have the potential to promote the economic, social and technical growth in rural areas by valorizing the raw material on site (Serna et al., 2017). Moreover, local products are more and more appreciated above the ones produced on large-scale since they are associated with a higher degree of sustainability. These products are sold for higher and more constant prices, from which small-scale biorefineries could profit as well as the raw material suppliers (Bruins and Sanders, 2012).

Seasonality and storage (time) are major limiting factors regarding efficient processing of agricultural products. Consequently, there are two options to deal with these limiting factors. First, small-scale biorefineries can produce intermediates that are stored and sold to large factories little by little during the year. Second, small-scale biorefineries can react quickly on the seasonality and location of renewable raw material due to their mobile and flexible design (Bruins and Sanders, 2012). This gains in importance when the perishable raw material needs to be processed shortly after harvesting (e.g. GRASSA!).

Finally, it is easier for small-scale biorefineries to attract investors for new technologies since investor risks as well as the investment costs are usually lower, compared to large-scale biorefineries. Thus, faster innovations are possible and due to their higher flexibility, processes can be adapted quicker to changing circumstances. Even for large-scale biorefineries it is beneficial to invest in small-scale technologies due to learning effects and smaller investment risks (Bruins and Sanders, 2012). With the mobile Sealab, SINTEF offers a small-scale facility to research in biorefining processes at low investment risks and costs.

The major advantage of large-scale biorefineries is the major disadvantage of small-scale facilities at the same time: large-scale factories benefit from economies of scale due to lower costs for raw material (buying in bulk), advertising, administration, infrastructure, storage and buildings. Moreover, they can afford expensive skilled operational personnel (Bruins and Sanders, 2012). Thus, upscaling results in a decrease of costs per unit since the fixed costs for utilities, employees etc. are divided into more output units (Serna et al., 2017).

5 Conclusions

The technology options that have been summarised and analysed in this report show the wide range of technology options that are available for the development of regional bioeconomies. The diversity of the considered feedstocks and products hints at the huge potential small-scale technology options have when it comes to facilitating the transition to a regional bioeconomy. However, at the same time, many resources remain unexploited and new technologies need to be invented, further developed or commercialized. Nevertheless, the 16 technology options provide an idea of what the shift toward a regional bioeconomy can look like in practice. Even though this set of technology options covers the bioeconomy potentials of the OIP regions to varying degrees, stakeholders participating in BE-Rural's OIPs may see possible uses of feedstocks and fitting technologies in the context of their regional bioeconomies. This overview can be a starting point for further investigation in feedstocks, technologies and the involvement of further relevant actors. A multi-stakeholder approach can be beneficial in terms of the creation of synergies, reduction of trade-offs and sharing of information and experiences, thereby helping regions, SMEs and the producers and consumers of biomass and bio-based products to develop and implement regional bioeconomy strategies and roadmaps in a sustainable and participatory manner.

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