

NoAW project



Innovative approaches to turn agricultural waste into ecological and economic assets

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1 Document Info

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1.3 Dissemination level

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CI Classified, as referred to Commission Decision 2001/844/EC	
CO Confidential, only for members of the consortium (including the Commission Services)	

2 Summary

<p>Background</p>	<p>The NoAW project aims to develop methods for cross-sectorial implementation of valorisation of agro wastes, which requires cooperation between the different stakeholders in the agro-food value chain.</p> <p>Previous reports within the project have revealed the main technical, legal, business and behavioural barriers and have given insight on the users' needs for support on the same. Project report D5.1 provided a listing of business concepts on the efficient use of agro-resources, presented a factsheet per business concept together with the key learning and concluded a summary of the key learnings. Report D5.2 described the chosen methodologies for identification and evaluation of innovation strategies opportunities. Report D5.3 identified and characterised different business strategies and models and evaluated potential markets for three selected NoAW products identified by the consortium as the more relevant for a market study.</p> <p>While these reports are not available to the general public, the feedback of various users therein have given insight on what triggers industries to develop sustainable industrial ecology solutions in manure, straw and vine waste utilisation and what barriers are present in taking the full advantage of the eco incentives.</p>
<p>Objectives</p>	<p>The objective of this report is to give recommendations to the policy makers on the types of policy measures that can significantly boost industrial ecology development in the involved agricultural chains. On the input side, special focus is offered to the potential utilisation of manure, straw and wine waste, while on the output side to bioenergy, biofuels and, most importantly to the various bio-polymers explored in other work packages of the project.</p>
<p>Methods</p>	<p>Environmental problems are systemic and thus require a system approach to prevent or solve them by offering a more sustainable alternative. The approach has been based on the results so far concluded in NoAW like stakeholder interviews and feedback from KESP members.</p> <p>The analysis methodology relied on exploring the triggers from a range of case studies. The identified key factors have been systemised in a SWOT analysis and grouped by origin into success and failure factors. The number of these cases is contributing with a representative number of examples to identify legislative and market instruments to tackle the main barriers per sector.</p> <p>Measures which are primarily feasible at policy maker level, have been explored along six aspects, considering the impact and effectiveness of the current policy measures and incentives, market response, obstacles that businesses meet and that particularly require reconsidering current policy measures.</p>

<p>Results & implications</p>	<p>Stakeholders along the value chain must profit from the circular business model. This requires a new type of policy: rather than separate subsidy programs, taxes, charges and fees, the policy makers must create favourable complex systems which influence the behaviour of all actors of the value chain.</p> <p>Successful policy tools also internalise negative externalities. If the utilisation of ecological resources or the harm caused to the environment becomes an explicit cost for the firms, their reactions will be optimal and predictable.</p> <p>Policy measures targeting territorial sustainability must consider regionality, acting at regional level in territories which are suitable for the production of abundant quantities of biomass, by-products or waste. An effective incentive can be created upon these criteria, if it has been well designed, calculated and verified.</p> <p>Effective policy tools result in reduction of the end consumer price of biobased products, by reducing production cost by subsidies, promoting better organisation of the value chain, higher level of coordination among the stakeholders, information exchange, supporting innovation and through direct effect on prices.</p> <p>Implementing a circular economy requires changes at system level, and active involvement of all actors within the value chains. The consumer attitude and market acceptability of bio-based products is high and the positive public image of bio-based product is likely to become the main driver of the future market uptake.</p> <p>The business model canvas examples have been prepared and presented for 3 key valorization routes within the NoAW project scope: PHA/PHBV for the replacement of PE in packaging applications, Biocomposites and Advisory service on biotechnology for farmers on innovative waste valorization technologies.</p>
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3 Introduction

Turning waste into resources is one of the key elements of a circular economy and “near-zero-waste-society”. The objective of the NoAW H2020 project is to enhance the progress towards the concept and to promote the application of circular economy through the application of an early eco-design approach, considering the opportunities for converting agricultural waste, by-products into eco-efficient, bio-based products with direct benefits for environment, economy and society. For the purpose of this project, “agricultural wastes, by-products and co-products” are defined as plant or animal residues that are not (or not further processed into) food or feed and create additional environmental and economic issues in the farming and primary processing sectors.

Agricultural by-product is a huge pool of untapped biomass resources currently mainly representing undesirable economic and environmental burdens, which are amplified by regional specialisation of either crop or animal production. According to Eurostat (Eurostat, 2020), in 2016 20.5 million tonnes of waste within the EU was generated by agriculture, forestry and fishing. Detailed data sets showed that between 2004 and 2016 the generated amount of the same waste decreased from 131 kilograms/capita to 41 kilograms/capita in the EU (Eurostat, 2020). That reduction can be explained by the fact that agro-waste is convertible into sustainable bio-products such as biomaterials, bio-molecules, bio-fertilizers and bio-energy. These conversions increase resource efficiency generally and help to protect biodiversity and ensure global food security and can be considered as true resources for decoupling economic growth and human well-being from (primary, e.g. fossil) resources use.

However, there are still some major challenges in waste management, preventing effective use of resources and waste valorisation (Gontard, et al., 2018). The NoAW project has identified five key challenges for ensuring sustainable agricultural by-products utilisations. Through a wide trans-disciplinary approach with regards to the scientific, technological, socio-economic and environmental aspects, eco-efficient conversion routes and smart agricultural residues management strategies are being proposed devoid of an increase in known side-effects.

Approaches have been built for determining optimal agro-wastes management strategies at appropriate regional scale, covering environmental, economic and safety issues. The chosen waste-resource recovery technology was the anaerobic digestion (AD), with the objectives of better performance, safe use of digestate as renewable soil fertilizer and advanced cascading conversion of its residue stream into more valuable end-products such as bio-polymers. Eco-efficient conversion routes before the AD process have been investigated, to extract high value bio-active molecules, polymer building blocks, and inert fillers as well as upgrade routes for the post-AD streams into biofuels, soil amendment, functional monomer and bio-polymer products.

A very complex set of criteria across multiple dimensions apply to all parties of the value chain, starting with the generators of agro-wastes to the end user of either added value product – including challenges on raw material supply, quality and regulatory requirements, process yield and the market conditions of the product, all affecting the profitability of the given processing step, hence the drive to endeavour into the activity. Previous studies have explored the perception of stakeholders on the sustainability of the agricultural waste management practices and factors influencing the uptake of innovative solutions, investing into and operating the technologies. Based on the findings of the report on multi-stakeholders’ perspectives of sustainable agro-waste management (D1.5), the roles and motivations of the main players in agri-food chains for their current practices, needs and

expectations have been translated into requests to regulatory and incentive measures. Involved parties include farmers, associations, processors, converters, end-users, consumers and waste managers in the value chain, and targeting primarily the legislators and the policy makers but also services and consulting companies among the enablers and regulators of the business environment. The purpose of this document is to give policy recommendations on business and marketing concepts for industrial ecology on the types of measures that can significantly boost industrial ecology development in the involved agricultural chains. On the input side, special focus is offered to the potential utilisation of manure, straw and wine waste, while on the output side to bioenergy, biofuels and, most importantly, to the various bio-polymers explored in other work packages of the project.

4 Results

Industrial ecology is the study of the physical, chemical, and biological interactions and interrelationships both within and between industrial and ecological systems. In a holistic view, Industrial ecology also involves identifying and implementing strategies for industrial systems to more closely design, construct and upkeep sustainable, ecological ecosystems.

One goal of industrial ecology is to change the linear nature of the industrial system, where raw materials are used and products, by-products, and wastes are produced, to a cyclical system where the wastes and by-products are reused as energy or raw materials for another production process.

In this report, in line with the context and goals of the NoAW project, Industrial ecology will be defined as “Cascade of cross-sectorial agro-waste valorization with a bioeconomy approach”.

Cross-chain valorisation of agro by-products is specifically challenging due to the heterogeneity of resources, the changes in volumes over time and regions and the variety of conversion and end-uses sectors. The economic value of a chain’s principal product is still driving most business decision-making. There is a low awareness of valorisation opportunities in alternative sectors and also to challenging in terms of consumer (in)acceptability of agricultural residue-based products. This kind of new distributions of materials, energy and information flows are at the heart of industrial ecology and circular economy strategies.

Environmental problems are systemic and thus require a system approach to recognise, identify and prevent or solve them by offering a more sustainable alternative. Market mechanisms alone will not provide an appropriate amount of eco-initiative, eco-innovation and eco-investment at the right time; chiefly because environmental benefits may not be properly valued by markets and consumers. On one hand, adequate business models are needed to create a setting where all parties involved perceive a “win-win” situation. On the other hand, markets and consumers shall be kept motivated to appreciate and accept willingly the resulting products and ideas even at a price premium. Policy intervention is therefore a must.

From a policy perspective, the driver is to support the development the bioeconomy. The influencing potential may include spatial, time, taxation, financial incentive and support scheme etc. factors. To make recommendations for the inferable effective measures to advance industrial ecology, the key motives of various cross-sectorial players has to be well understood.

The analysis methodology was relying on exploring the triggers within a range of case studies conducted in the previous tasks within the project. The identified key factors have been systemised in a SWOT analysis and grouped by origin into success and failure factors. The number of these cases is contributing with a representative number of examples to identify legislative and market instruments to tackle the main barriers per sector.

Measures which are primarily feasible at policy maker level, have been explored along six aspects(Materials, Applicability, Scope, Range, Co-operation and Horizon), considering the impact and effectiveness of the current policy measures and incentives, market response, obstacles that businesses meet and that particularly require reconsidering current policy measures. Recommendations are made for adapted policy measures to head towards more sustainable solutions or industrial ecology concepts that function in practice.

4.1 Analysis methodology to the recommendations on effective measures for industrial ecology

A systematic approach was followed to evaluate existing results so far concluded in NoAW and in other relevant projects and publications. The following steps were identified to conclude in recommendations on the effectiveness of measures for industrial ecology business and cluster development in agricultural chains with special focus on the potential utilisation of manure, straw and wine waste.

The procedure used for carrying out the analysis and the implementation for recommendations

1. Collecting information
2. Analysing triggers
3. Analysing success and failure factors
4. Developing business concepts based on triggers
5. Analysing incentives and policy measures
6. Recommendations on effectiveness of measures
7. Policy recommendations

Key steps for the methodology are explained below with details of the analysis available in the Annex.

4.1.1 Sources of information

Information from NoAW reports, other relevant projects and publications on existing eco incentives and policy measures was collected from (1) the relevant papers in scientific journals analysing this field, (2) existing bioenergy and biofuels incentives in more (primarily European) countries, (3) Existing policies in EU and in country levels, or regional levels and (4) by analysing the approach of policy measures in other areas.

4.1.2 Industry triggers to develop industrial ecology solutions in manure, straw and wine waste utilisation

By analysing case studies and factsheets from NoAW D5.1, triggers that affect industries to develop industrial ecology solutions in manure, straw and wine waste utilisation, have been identified on its effect of scale size, effects of clustering on industrial ecology solutions and on the impacts of logistics concerning seasonality.

Key triggers and objectives of the analysed initiatives (listed by priorities) are:

1. Market need & opportunity
2. Technical development
3. Valorization of by-products, recycling wastes
4. Avoiding or reducing pollution
5. Environmental awareness and need for sustainable development
6. Legislation and incentives
7. Need to cooperate to increase effectiveness
8. Additional income generation
9. Energetical independence

Case examples for the above nine triggers are in detail in 8.1 Annex 1 - Examples of industry triggers to develop industrial ecology solutions in manure, straw and wine waste utilisation.

4.1.3 Success and failure factors

SWOT analysis

Based on the learnings from the case studies and factsheets from NoAW D5.1, a SWOT analysis was made and the major factors identified and grouped into the below sub-categories:

<p style="text-align: center;">Strengths</p> <ul style="list-style-type: none"> • Technology • CO₂, GHG reduction • Collaboration • Raw materials availability • Marketing and business • Sustainability and awareness 	<p style="text-align: center;">Weaknesses</p> <ul style="list-style-type: none"> • Financial and economic • Scaling-up
<p style="text-align: center;">Opportunities</p> <ul style="list-style-type: none"> • Geographical aspects • Collaboration • Technology, logistics, savings through technological development • Raw materials availability • Incentives • R&D efforts • Environmental awareness of clients 	<p style="text-align: center;">Threats</p> <ul style="list-style-type: none"> • Competition on the market • Technological aspects • Geographical aspects • Financial and economic aspects • Low acceptance of product

Key factor grouping by origin

Success and failure factors of case study factsheets (NoAW D5.1) were organised according to External factors; Internal-Contextual conditions and Space for Innovation as follows:

Triggers	External		Contextual		Space for Innovation	
	Success factors	Failure factors	Success factors	Failure factors	Success factors	Failure factors
	<ul style="list-style-type: none"> • Incentives • R&D possibilities • Environmental awareness of clients • Availability of raw materials 	<ul style="list-style-type: none"> • Competition on the market • Technological aspects (external) • Financial & economic aspects • Low acceptance 	<ul style="list-style-type: none"> • Technology • CO₂, GHG reduction • Collaboration (existing) • Raw materials availability (internally) • Marketing and business • Sustainability and environmental awareness 	<ul style="list-style-type: none"> • Financial & economic aspects • Scaling risks 	<ul style="list-style-type: none"> • Geographical aspects • Collaboration opportunities • Technology, logistics, savings through technological developments 	<ul style="list-style-type: none"> • Geographical aspects

Results of analysing success and failure factors based on the triggers

Generally, it can be observed that the presence of several contextual success factors and space to innovate success factors is important. When the implementation of eco-initiatives is triggered by a **market need** or opportunity, several contextual success factors could be perceived, however space to innovate and external success factors were also found, and some external failure factors were observed. Market opportunity also includes the Marketing and CSR elements as contextual success factors.

In case of **technical development** success factors of “space to innovate” were the most important aspects, but contextual success factors were also significant. Some external success and failure factors could be also found.

For the **valorization of by-products**, recycling wastes geographical aspects, space to innovate are quite important.

When **avoiding or reducing pollution** is the trigger than the case is very similar to technological development, success factors of space to innovate were the most important aspects, but contextual success factors were also significant.

Environmental awareness and need for sustainable development triggered many eco-initiatives and in case of them contextual success factors are extremely important and many of them could be observed which shows us that they have to be strong internally. On the other hand, in one case study several external failure factors were also perceived. Proven technology, cooperation with science and local collaborations are important aspects.

Fiscal incentives are very helpful and can be observed in many case studies, but results show that many other aspects must be met in order to create a viable ecology business. On the other hand, when **legislation and incentives** were the main triggers, then multiple kind of factors appeared, and many external failure factors could be observed. The change in legislation and the dependency on public subsidies was found as external risks.

The need to **cooperate** to increase effectiveness increased the significance of space to innovate and external success factors, like geographical proximity of different kind of actors, clustering. Optimal logistic model and high efficiency infrastructures, shared grids and industrial symbiosis to reduce production costs were important contextual success factors.

In case of the willingness of **additional income generation** the space to innovate was less important than in case of other triggers, however this purpose as the most important trigger was observed only in one case. Contextual success factors, the technology and as external factor, the availability of by-product raw material were the most significant.

The willingness of becoming **energetically independent** triggered two initiatives and almost all types of factors were observed, but external success factors were the most significant. Co-operation with local businesses for by-products, selling energy produced by biogas to households, incentives were important, and there is a space to innovate for more small biogas plants.

The trigger of **CSR, green marketing** is considered within the trigger of avoiding or reducing pollution, however it could be also considered within market need & opportunity.

Success and failure factors of eco-initiatives were arranged by triggers are in detail in 8.1 Annex 1 - Examples of industry triggers to develop industrial ecology solutions in manure, straw and wine waste utilisation.

4.1.4 Developing business concepts based on triggers

After analysing triggers three characteristic triggers were selected to build business concepts by business model canvas around them.

Selected triggers:

1. Avoiding or reducing pollution
2. Environmental awareness and need for sustainable development
3. Market need & opportunity

According to NoAW MS24 Milestone (2019) PHBV/PHA and biocomposites were selected for further evaluation and market analysis. The reason why these were selected in WP 5.4 are as two of the three cases to build Business models are based on the previously analysed triggers.

Case 1 – PHA/PHBV for the replacement of PE in packaging applications

- Triggers:
- Reducing environmental impact of containers and packaging
 - Environmental awareness
 - Market need & opportunity

Case 2 – Biocomposites

- Triggers:
- Market need: biocomposites can be used as automotive interior components and sports equipment as lighter materials;
 - Avoiding or reducing pollution,
 - Environmental awareness and need for sustainable development

Case 3 – Advisory service on biotechnology for farmers on innovative waste valorization technologies

- Triggers:
- Avoiding or reducing pollution: reducing environmental impact of farms.
 - Environmental awareness.
 - Market need for valorizing waste, saving waste management costs and producing energy.

The Business model canvas has been prepared for the following nine criteria:

1. Value Propositions (VP)
2. Customer Segments (CS)
3. Channels (CH)
4. Customer Relationships (CR)
5. Key Resources (KR)
6. Key Activities (KA)
7. Key partnership (KP)
8. Revenue Streams (RS)
9. Cost Structure (C\$)

The Business model canvas sheets for each analysed cases are in 8.1 Annex 1 - Examples of industry triggers to develop industrial ecology solutions in manure, straw and wine waste utilisation.

4.2 The role of the EU and national governments and regional authorities in support of a sustainable circular bio-economy

A comprehensive list of documents published in the EU law directory EUR-Lex, the database of the Official Journals of the European Union is summarised in Annex 8.5 of this deliverable including relevant expected policy options and further amendments planned on existing measures.

4.2.1 Overview of the applicable EU legislation to Anaerobic Digestion plants

Legislation at EU-level is binding for all member states. While EU-regulations are legal acts that come into force in all member states simultaneously, EU directives need to be implemented by each member state into their national legislation. Within the scope of this report, the focus is on legislation on the EU-level due to the binding character for all member states, whereas the implementation into national laws might differ slightly between the member states, e.g. with regards to the time of enforcement in case of different transitional periods.

A comprehensive list of the European legislation on Directives and partly also of norms targeting the conversion path of agricultural residues into bio-based products has been compiled in D1.5. As NoAW puts anaerobic digestion (AD) into the centre of the treatment of agricultural residues, AD related legislation is predominantly being discussed. Anaerobic digestion usually yields a digestate that is used as fertilizer in agriculture and hence fertilizer-related legislation has to be considered. Furthermore, the EU-Eco-regulation (Council Regulation (EC) No 834/2007 on organic production and labelling of organic products) plays a role, since the agricultural residues generated might also originate in organic agriculture, and digestate from an AD-plant treating such residues might be returned to organic farms.

Regulation (EC) No 2003/2003 relating on **fertilisers** aims at removing trade barriers between member states for mineral fertilisers and thus creating an internal fertiliser market. It lays down rules on the identification, traceability and labelling of EC fertilisers to ensure quality and composition compliance. This regulation has been very successful in creating an internal fertiliser market for harmonised products, due to its focus on mineral fertilisers, however, it only covers about 50% of all fertilisers and excludes all fertilisers and fertilising products made from organic materials (e.g. livestock manures, organic wastes, agricultural by-products). Organic materials offer the opportunity for sourcing nutrients like phosphate and nitrogen locally and thus contribute not only to better waste and nutrient management, but also to reducing dependency from external sources, to reduce greenhouse gas emissions and to strengthen the circular economy.

Within the Circular Economy Package, the Commission presented a draft proposal for a new Fertiliser Products Regulation in COM 2016/157/EC in 2016. Along with this are amendments in Regulations (EC) No. 1069/2009 and (EC) No 1107/2009. In Annex I the draft proposal lists seven Product Function Categories which specify the purpose of each end-product, and Annex 2 defines Component Material Categories to categorise input materials for those end-products listed. Each material category is subject to specific process requirements and control mechanisms. Only fertiliser products consisting solely of component materials complying to the requirements defined in Annex II

can become a CE market fertiliser. For NoAW this regulation is relevant with respect to further processing of the digestate and its conversion into biochar, which is a separate Component Material Category in the draft proposal.

Directive 2010/75/EU on **industrial emissions** aims at lowering emissions from industrial production on the environment (e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency) and human health through an integrated approach. Important aspect for reaching these goals is the clustering of industrial activities according to their contamination potential and the obligation of using Best Available Technology. For the NoAW project this directive is highly relevant since it not only concerns anaerobic digestion plants treating livestock manures, but also the production of plastics.

Regulation (EC) No 1069/2009 lays down health rules for **animal by-products** (ABP) and derived products not intended for human consumption, providing rules for the collection, transport, storage, processing and use or disposal for each of the defined 3 by-product categories. Category 3 deals with waste and by-products from slaughterhouses, catering waste, food of animal origin no longer fit for human consumption. This regulation also specifies hygienic requirements for any plant treating ABP for technical products, i.e. composting plants or anaerobic digestion (biogas) plants. In addition, Regulation (EU) No 142/2011 specifies technical details, for example for material that serves as feedstock for biogas plants. For NoAW the animal by-product regulations are relevant, because they define if and how livestock manure needs to be handled when used in a biogas plant. Often hygiene treatment is required, if manure coming from several farms is treated in one biogas plant and the digestate is returned as fertiliser to the farms or agricultural lands, to exclude cross-farm transmission of animal diseases.

Wastes and By Products utilisations have different levels of legislation: European, national, regional and, in some activities of municipal waste. Waste European regulation and by products on wine production are concerned by the Directive 2008/98/CE amended by Directive 2018/852. The Directive lays down some basic waste management principles, also introduces the "polluter pays principle" and the "extended producer responsibility" and includes two new recycling and recovery targets to be achieved by 2020: the relevant one is the 50% preparing for re-use and recycling of certain waste materials from households and other origins similar to households. It sets the basic concepts, definitions and explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products. The Directive clarifies when substances or objects resulting from a production process not primarily aimed at producing such substances or objects are by-products and not waste. If the use of a by-product is allowed under an environmental licence or general environmental rules, this can be used by Member States as a tool to decide that no overall adverse environmental or human health impacts are expected to occur.

Directive 2008/98 also defines the **biowaste** as the biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants. Excluded are the faecal matter, straw and other natural non-hazardous agricultural or forestry material used in farming, forestry or biomass for energy.

4.2.2 Review of the other related EU and national global drivers and initiatives towards the circular economy

Over the past 50 years, global production and consumption of plastics have increased more than 20 times over, going from 15 million tonnes in 1964 to 311 million tonnes in 2014, and according to estimates, it will double again over the next 20 years.

In December 2015, the Commission adopted an EU Action Plan for a circular economy. In 2017, the Commission confirmed it would focus on plastics production and use, and work towards the goal of ensuring that all plastic packaging is recyclable by 2030.

The EU Action Plan for a circular economy identified plastics as a key priority and committed to 'prepare a strategy addressing the challenges posed by plastics throughout the value chain and taking into account their entire life-cycle'. It is the first Europe-wide strategy on plastics and is part of the transition towards a more circular economy. The strategy sets out a strong business case for transforming the way products are designed, produced, used, and recycled in the EU while creating new investment opportunities and jobs. The goal is to protect the environment from plastic pollution whilst fostering growth and innovation.

The European Plastics Strategy

Building upon previous efforts to tackle the escalating problem of plastic pollution, in January 2018 the EU adopted the European Strategy for Plastics in a Circular Economy. The Strategy aims to protect the environment and citizens from plastic pollution and to demonstrate the business case for transforming the way that products are designed, produced, used and recycled.

Under the new plans, all plastic packaging on the EU market will be recyclable by 2030, the consumption of single-use plastics will be reduced and the intentional use of microplastics will be restricted. The strategy highlights the main commitments for action at EU level but also emphasises the important role of businesses, together with national and regional authorities, and citizens. The Strategy presents a "vision for a smart, innovative and sustainable plastics industry, that brings growth and jobs to Europe and helps cut EU greenhouse gas emissions and dependence on imported fossil fuels".

Specifically, under the new strategy, the EU has evaluated the risks and current measures and defined actions on 3 key areas with the aim of:

- Improving the economics and quality of plastics recycling by design for recyclability, boosting demand for recycled plastic and initiate better and more harmonised separate collection and sorting;
- Curbing plastic waste and littering: Preventing plastic waste in our environment (regulate Single use plastics, further restrict Over-packaging and Plastic waste from sea-based sources including shipping, fishing and aquaculture products and increase the collection and re-use of Agricultural plastics, in particular soiled plastic films) Establishing a clear regulatory framework for biodegradable plastics, addressing the concern of Oxo-degradable plastics and of Micro-plastics;
- Driving investment and innovation towards circular solutions: Support the necessary investments, maximise the impact of new rules on Extended Producers Responsibility (EPR)

while and supporting the development of economic incentives to reward the most sustainable design choices, introduce Deposit return schemes (DRS), nurture Innovation for more circularity and define Specific actions to diversify the feedstock.

Of particular relevance to the NoAW project are the quality and contaminant issues associated with post-consumer recycled plastics. In food-contact applications (e.g. beverage bottles), the objective remains to prioritise high food safety standards, while also providing a clear and reliable framework for investment and innovation in circular economy solutions. The Commission will also assess whether safe use of other recycled plastic materials could be envisaged, for instance through better characterisation of contaminants.

Another relevant aspect are the arguments to what extent bio-based are effectively the more sustainable alternative. It not only depends on their origin from renewable materials and their carbon balance, but also on other aspects such as land use, water use, eutrophication and potential toxicity impacts, e.g. due to pesticides. It was also recognised that labelling consumer plastics as biodegradable without indicating the conditions under which it will biodegrade (e.g. industrial or home composting) may also deliver the wrong message as it might lead to think that in some cases it is acceptable for plastics being designed to be littered. The Commission will therefore propose harmonised rules for defining and labelling compostable and biodegradable plastics.

The Single Use Plastics Directive

In line with measures already envisaged under the EU Plastics Strategy, the main objective for Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment is the prevention and reduction of plastic marine litter from single use plastic items and fishing gear containing plastic by addressing the identified gaps in the existing actions and legislation, and further reinforcing the EU's systemic approach to this issue. This Directive converges to a circular economy by supporting innovative solutions for new business models, multi-use alternatives and alternative single use products. This systemic change and material substitution also promotes bio-based alternatives and an innovative bioeconomy, bringing new opportunities for businesses and improving consumer convenience. Following this Directive, new legislative measures are to be expected and biodegradable applications are expected to be better supported. For the NoAW project this Directive is highly relevant because it highlights the need of new, innovative solutions. One of the main focuses of the NoAW project is the production of poly-hydroxy-alkanoates (PHA), precursors of the biodegradable plastics based on agro-waste such as livestock manure and crops silages, which is fully in line with this new Directive.

The Single Use Plastics Directive establishes an EU-wide ban of several single-use plastic item categories by 2021 and introduces the Extended Producer Responsibility (EPR) schemes to covering the costs of collection, transport, and treatment of litter as well as of awareness-raising measures. On the implementation at the national level, the provisions laid down under the SUP Directive must be strengthened. The main issues that Member States should pay attention to during the transposition phase include the reduction of the consumption of food containers and cups for beverages, taking into account the durability, re-usability, recyclability and the presence of hazardous substances by taking a life-cycle approach. While the SUP Directive does not establish an EU-wide target, it requires Members States to achieve an ambitious and sustained reduction of those products.

However, where market restrictions are imposed, there are no exceptions defined for bio-based or compostable products, and the shift should focus on promoting reusable alternatives rather than to another single-use material.

Re-use or recycling is not always feasible. Plastics from various application cannot be recycled, like fertiliser coatings and soil covering plastic sheets in agriculture. These largely end as microplastics in the environment. Biodegradable plastics (that degrade under natural conditions) are thus essential to eliminate this kind of microplastics pollution.

4.2.3 Material production vs Electricity generation

Less relevant in the context is any legislation related to the energy sector, such as the Renewable Energy Directive. It has an interface to this project but attracts a smaller nevertheless key group of stakeholders. As the biogas generation for electricity grid feed option directly competes with the extraction of intermediates that could also be converted into polymer building blocks, local subsidy policies have an impact on economic viability. For an AD-plant operator, any alternative source of income from innovative end-products needs at least be able to compensate the losses from lower electricity sales. In the near future this might change due to changing support mechanisms and decreasing feed-in tariffs for electricity in particular.

4.2.4 Communication standards

The main international guideline for “green claims” is the ISO 14020 series on “Environmental labels and declarations”. Three different types of environmental labels and declarations are detailed: ISO 14021 covers self-declared environmental claims, ISO 14024 the environmental labelling and ISO 14025 the environmental declarations. Also relevant is ISO 14063 on “Environmental management – Environmental communication”, on setting up communication procedures in companies and contains general guidance on the basics of environmental communication.

European standards EN 16848 “Bio-based products – Requirements for Business to Business communication of characteristics using a Data Sheet” and EN 16935 “Biobased products - Requirements for Business-to-Consumer communication and claims” provide guidance on the communication of bio-based products.

4.3 Legislative and market instruments useful to tackle the main barriers identified per sector (Bioplastics, Biogas, Biofuel)

The progress towards a bio-based economy is slower than expected by its proponents. Previous studies have explored the perception of stakeholders on the sustainability of the agricultural waste management practices and factors influencing the uptake of innovative solutions, investing into and operating the technologies. The general barriers that hinder the efficient utilisation of bio-based resources available for the processes within the NoAW project's scope have been explored. Findings of the report on multi-stakeholders' perspectives of sustainable agro-waste management (D1.5) have revealed the difficulties, needs and expectations of involved parties, including farmers, associations, processors, converters, end-users, consumers and waste managers in the value chain, To develop a better understanding of the issues in the bioeconomy these are listed below with the aim of accelerating deployment and commercialisation and to provide a solid foundation for the policy recommendations.

4.3.1 Barriers in utilising eco incentives

This research and previous studies have identified several barriers which hinder the development of the concept of circular economy and especially some utilisation ways which are rather new and not totally accepted by the market or the stakeholders of the value chain. This section shows the main barriers ranked by their importance. Many of the barriers are due to market failure, ecological conditions and challenges, attitude toward the new concept, lack of knowledge or low level of cooperation. Most of these can be handled by policy tools as will be presented in the next section.

- The production cost of biobased products compared to fossil-based processes still is too high, there is not enough motivation to switch to biomass utilisation (Bio-based products, 2017).
- As economies of scale is crucial for all type of biomass utilisation (bioenergy, chemicals, materials and production of other products), the critical mass of the available raw material is the most important factor for the profitable operation (Skovsraad & Jacobsen, 2015).
- Several factors hinder the continuous, cost-effective supply of raw materials (Intelligent Energy Europe, 2009):
 - The access to cost-efficient feedstock is limited. Costs of feedstock are generally higher in Europe because of higher labour and operating costs, climatic conditions and regulations.
 - Seasonal fluctuations and weather dependence are important challenges, as the amount and quality of biomass available at cost-competitive levels for industrial purposes fluctuate significantly. In drought years the supply is limited, several utilisation ways compete for straw and the prices increase even to stimulate exporting.
 - Biomass in general is constrained for industry purposes: Covering food and feed demand remains the first priority of biomass supply; straw is also needed in animal husbandry for bedding; manure and biomass utilisation as soil nutrients is higher in the hierarchy of circular economy in order to improve nitrogen, phosphorous, organic matter in soils and microelements balance.

- Collection, storage and distribution of biomass are still underdeveloped. Cross-chain valorisation of agro by-products is specifically challenging due to the heterogeneity of resources, the changes in volumes over time and regions and the variety of conversion and end-uses sectors. By-product streams are mostly bulky; transport significantly impacts costs. Spatial clustering of different production chains is considered one critical way for making such valorisations feasible, even though far from obvious. Feedstock quality is changing, and difficulties persist in the proper collection, storage and transport of biomass. All these factors increase the price of the raw material and reduce the profitability of the new type utilization methods.
- Continuous supply of biomass needs perfect organisation and/or cooperation vertically and/or horizontally along the chain, but this is underdeveloped at the moment.
- Infrastructure and routes for mobilisation of waste and residues are currently lacking across much of Europe
- There is a lack of industrial capacities of biomass utilisation for chemicals, materials and products in some member countries (Bioways, 2017), this is why transport of the raw materials or new investments of biobased utilisation forms are needed. This increases the cost of this type of utilisation.
- There are several existing incentives to utilise the biomass for bioenergy purposes (Probiogas, 2007), while no similar incentives are available for biomass utilisation for chemicals, materials or products.
- Usage of fossil-based fertilisers is still cheaper and easier for conventional farms. Multinational agricultural input supplier companies offer combined inputs (seeds, fertilizers, plant protection chemicals) and free extension services for farmers, it is difficult to compete with them. Usage of manure is expensive due to high transportation costs and the required machinery costs due to the landfill directive which aims to reduce green house gas emissions.
- While, according to a recent (Eurobarometer, 2020) survey, 94% of citizens in all EU Member States say that protecting the environment is important to them, the consumers are also more price sensitive in member countries at lower income levels, which limits the demand for new type of products (Eurobarometer, 2019). The most important factors for Europeans when buying food are where the food comes from (53%), cost (51%), food safety (50%) and taste (49%), ethics and beliefs (e.g. considerations of animal welfare, environmental concerns or religion) rank lowest in importance (19%). In 12 of the 28 Member States, cost was identified most frequently among factors influencing the choice of food. This is a challenge but it can be handled with proper segmentation of the potential market and targeted communication tools toward the consumers.
- Due to uncertainties, limited demand and high costs the access to finance is an issue. Venture capital¹ investments are needed to establish new capacities, and this further increases the costs as – though it can be risky for investors who put up funds – the potential for above-average returns must remain an attractive payoff.
- There is a general lack of knowledge about how much of these wastes can be utilised and at what prices, in particular without adversely impacting upon other markets.

¹ Venture capital is a form of private equity and a type of financing that investors provide to start-up companies and risky or small businesses that are believed to have long-term growth. Venture capital generally comes from well-off investors, investment banks and any other financial institutions.

- Coherent and harmonised policy concept is still missing. If all sectors must fulfil sustainability criteria for biomass, while only some sectors receive incentives, the other sectors will suffer from additional hurdles (Ecorys, 2012).
- SMEs are particularly conscious of administrative burden – this is a significant burden for SMEs in time, capacity and resources.
- Improvement of Corporate culture and training of individuals is crucial to change. (Rebelo, Santos, & Silva, 2016) concluded that a proactive approach and commitment to cleaner production, supported by an integrated management system brings relevant savings for organizations as well as providing value to the relevant interested parties. Environment conscious management should be an overall attitude within the firms, which thinking is not restricted to leaders but must also be adapted for the purchasing, production, HR, sales, marketing and CSR activities. Such company attitude is still not common in every member country.
- There is no clear labelling to differentiate bioplastics, bio-based plastics and biodegradable plastics, this confuses the potential consumers (European Bioplastics, 2018).
- There is currently no international standard specifying the conditions for the home composting of biodegradable plastics. However, there are several national standards, the French standard NF T 51-800 and the Australian norm AS 5810.
- Similarly, there is no standard providing clear pass/fail criteria for the degradation of plastics in sea water, only standards that outline test methods: like OECD 306 and ISO 16221. However, these standards are only guidelines without clear requirements for conditions and timeframes.

4.3.2 Incentives and policy measures to boost industrial ecology development in the involved agricultural chains

As it was presented before, in the sectors which use biomass as raw material (bioenergy, chemicals, materials or products production) the scale of economy is a very important factor for profitable operation. For this reason, the well organised supply system of the raw materials is crucial. The vertical and horizontal cooperation is necessary for linking the raw material suppliers and producers. This section aims to present the policy instruments which encourage the stakeholders' coordination along the agricultural chain:

- In the EU-15² countries some sectors are very well organised, e.g. milk, cereals or beef / pork / poultry sectors, providing even vertically integrated systems, however, in some member countries especially in EU-10³ countries, the cooperation level is still low (EU Commission - Producer organisations, 2014). In the EU-10 region, encouragement of vertical and horizontal cooperation along the agricultural chain is the most important step to organise the raw material supply and to create the long-term circular economy concept which assumes smooth cooperation along the value chain.

² The 15 pre-2004 EU Member States: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, the United Kingdom

³ The 10 countries that joined the EU in 2004: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

- As homogeneity is lacking among the stakeholders and as there are not enough drivers for the supply chain to organise itself, stimulating and supporting the formal or informal vertical cooperation in the valorization of by-products, is crucial (Sorrento, Russo, & Cacchiarelli, 2016).
- Digitalisation advancing, establish a platform for feedstock suppliers, logistic partners, consumers to optimise the use of the raw materials stimulates the better coordination.
- Encouragement of investments of innovative technologies along the agricultural chain is important.
- Development of logistics conditions, capacities in order to improve the cost-effective transport of raw materials. When planning the supply routes for e.g. a biogas plant, the obvious question will be the magnitude of traffic, the impact of vehicles transporting bulky and (potentially) malodorous feedstock on existing roads through populated areas. Logistics may involve road infrastructure development such as shorter routes with appropriate load rating for the expected traffic. For example, dirt roads may require upgrading to accept freight traffic hence avoiding public roads and not discouraging the hauliers with longer transport times and higher vehicle wear on poor quality roads not designed for the increased traffic.
- Approaching farmer associations and discussing how to best implement modern technology and today's knowledge into practice helps them to connect to circular economy (Thomas, Riley, & Spees, 2020) Producer organisations (POs) and associations of producer organisations (APOs) already offer several benefits to farmers (European Commission, 2019) including production planning, adapting to demand; concentration of products; and placing of products on the market. These activities can bring economic, technical and social or human benefits to their members which may be extended to get subsidies in agriculture schools, secondary training, as part of the extension services.
- Education and consultation services, demonstration programs for stakeholders improve the knowledge and attitude toward modern solutions, circular economy. Existing such initiatives address Young Farmers as Circles of a Circular Economy: (CIHEAM), American Farm School (InterregEurope), Innovative Smart Farming services supporting Circular Economy in Agriculture (LifeGaiaSense).

Related topics on circular economy may include:

- how to differentiate waste and identify valorizable by-product streams
- on possible cascading steps in the flow of their products and by-products
- favoured practices (e.g. composting instead of burning, dumping or landfilling)
- industrial bio-reactors (such as biogas), advantages over traditional manure handling
- cooperation with service providers (investors, technology providers, consultants)
- Supporting research activities in the field of technology, environment protection, economy is a useful tool for designing sustainable solutions for better recycling biowastes.
- Education and communication initiatives to reduce reluctance from recycling stakeholders fearing higher costs.
- Regulatory policy is effective if it is coordinated within governments, and among the governments of different member countries, with regular dialogue and stakeholder consultation as a formalised part of the process.

4.3.3 How clustering makes easier to utilise eco incentives

Clustering is a higher level of cooperation, where greater integration of the value chain is being achieved through vertical relationships that improve product flow, coordinate financing and payments, and reinforce communication (FAO, 2010). This form of coordination is an ideal way to connect small-scale farms and larger firms to a value network which fulfil the requirements of circular economy. This is why it is important to boost the development of these.

- In Slovenia the comparison of environmental practices between large and small companies reveals that large companies more than small ones demonstrate a much greater environmental commitment. Among the motives for environmental strategies top management's commitment and the expected competitive advantage seem to be more important in large companies than in small ones (Čater, Prašnikar, & Čater, 2009). The behaviour of Hungarian food processing firms regarding food loss (Dudás & Kürthy, 2019) was concluded by two well-differentiated clusters based on the awareness of the Hungarian firms toward reducing or better utilization of food loss. "Large, conscious firms" kept records on food losses and used several methods with the aim of reducing it. A significant share of "Incentive small firms" could not even estimate the amount of their losses and the management disregarded the problem. Other researches (Nemcsicsné Zsóka, 2007) also underlined that built-in "regulators" (e.g. EMS, environmental management systems like ISO 14 000, regular monitoring of environmental impacts, etc.) ensure the recognition of environmental problems and the follow-up of environmental efforts, as well as establishing some solid environmental foundations in organisational culture (OECD & EIRIS, 2007). As EMS or other environment monitoring systems are usually used by larger companies, these firms tend to be more proactive – due to their investment and capital needs they tend to take care to manage their environmental performance and reputation to ensure access to funding and the protection of their reputation, while SMEs have a more reactive attitude to economic incentives for improved environmental performance– because of this they are most often targeted by grants and soft loans (Ecorys, 2012). Linkage, close cooperation between them stimulate the best way the steady development of the concept of circular economy.
- Power of reputational driver varies by company size, this is linked to the market that a firm serves, larger firms are typically more responsive, particularly to national and international rankings, SMEs can be less responsive but can also be driven by local and regional reputation and incentives such as awards. Supply chain links can reduce the difference between firms based on size, as firms apply pressures on each other.
- Agricultural cooperatives are usually created within a specific production sector (cereals, wine, fruits etc) (Copa-Cogeca, 2014). Their production generates predictable waste and by-product flows. Alone, one member may not bear the financial capacities to invest in a valorisation infrastructure, neither to gather a sufficient amount of by-products for making a valorisation pathway viable. However, a union of farmers in form of a cooperative is able to reach the critical size and to collect sufficient amounts of by-products. For economic, regulatory or environmental reasons, co-operatives are interested in valorising their by-products.
- An agropark is a spatial cluster of agro-functions and related economic activities. It brings together natural resources-based production and processing along industrial principles. (Wageningen University & Research Centre, 2008) The cycles for water, minerals and gaseous compounds are skilfully closed and the use of fossil energy is minimised, particularly via waste and by-product processing. An agropark aims to cluster companies in the direct environment of

each other; this allows benefitting from joint waste management, natural resources usage and logistics. An agropark is based on the same principles as industrial symbiosis concepts, but it is in general dedicated to circular bio-based systems.

4.3.4 Prerequisites and supporting actions necessary for companies and clusters to enhance the utilisation of eco incentives

This section introduces those actions which motivate the companies for better connection to the ecosystems, intensify their innovation willingness and make recycling more attractive:

- Supporting application of increased knowledge and modern technology in agriculture and the related processing sectors.
- Encouraging the harmonization of the company aims with the circular economy concept and with the waste system.
- Creating a well-established logistical chain for raw material collection and intermediate storage.
- Building policy coherence through regular and strategic international cooperation and by exploiting synergies between countries and regions, taking into account existing mechanisms.
- Adjustments in public procurement procedures to favour and support the development of bio-based products.
- Development of common standards for labelling requirements to raise consumer awareness.

4.3.5 Most effective eco incentives

In order to establish a long-term, effective incentive policy, it is important to analyse which tools are most popular and, in contrast, which instruments are proved to be less successful. Most of the studies carried out in this field stress that stable and predictable policy environment, clear targets are indispensable conditions for an effective incentive policy. Other findings are detailed below:

- Remuneration is effective if it is long-term, predictable and appropriate in order to change attitudes and behaviour of stakeholders. Factors in the success of reputational incentives include accessibility to SMEs, simplicity, comparability, transparency, inclusiveness and they being well communicated
- It is useful to communicate regularly with stakeholders in order to identify the most important barriers. Minimisation of non-financial, non-necessary regulatory barriers is a cheap but very effective tool. On the other hand, reconciliation with other fields to reduce or abolish the regulatory barriers is important to be convinced if it is possible and do not harm.
- Agricultural subsidies, especially those connected directly to products and production influence greatly the decisions of farmers and thus distorts production and trade (OECD, 2019). Agriculture and farming is principally a long-term activity by nature, but commodity farmers are subsidy-driven and choose production of such goods which are most supported in CAP. Subsidies, grants, soft loans for investments are simple tools, but firms remain quite a short-term thinking. Most decisions are made on the basis of short-term paybacks and rates of return. These criteria make it difficult for decisions in favour of investments for improved environmental performance, which rather deliver benefits over the medium-long term. For example, stakeholders prefer

improvement of their profitability, effectiveness, capacity increase etc. and, in many cases, use the subsidies for these purposes on behalf of circular economy development. Financial incentives have a crucial role to play in overcoming this barrier (Ecorys, 2012).

- Cooperation among the stakeholders is crucial, but subsidies for fostering cooperation are useless if other drivers had stronger effects (ie. tax system, bad experiences of former cooperation etc.) (EU Commission - Producer organisations, 2014)
- Internalisation of negative externalities may be a useful incentive if the cost of contra-indicated utilisation of biomass can be exactly determined, but it is a challenge due to lack of information of exact costs of negative externalities (DeNyse, 2000)⁴.
- Reduced charges, taxes with some conditions are effective if the fulfilment of the conditions are well controlled.
- Mandatory quotas, utilisation methodologies, technologies increase the cost of production, these tools are effective combined with support which covers the extra cost
- Voluntary sector schemes are popular but not always effective – these are often introduced to head-off mandatory regulation. Although voluntary schemes can be successful in some contexts, this is often related to national culture, i.e. they are more successful in consensus-oriented cultures such as The Netherlands. Voluntary schemes can be ineffective if there is no follow-up or checking by others.
- Important design considerations for tax-based incentives include the use of revenues and disproportionate effects on some firms. It is important to consider and prioritise recycling revenues from taxes back to the sector, potentially with a focus on rewarding the better performing;
- Reputational incentives have proliferated in recent years – these are present at all levels and in many sectors. Part of the reason for this is that they are flexible, can be introduced at low cost and provide a way for firms, most often voluntarily, to project a positive internal and external image;
- Time-limited, tapering quotas (on usage share of fossil energy, amount of waste etc.) designed for the whole economy is a good long-term target. If used predictably, as part of a middle-term (up to 5-8 years) plan or a long-term (typically over 10 years) strategy, it has the potential to shape the behaviour of multi-player process and value chains; also allowing them to work out harmonised co-operation schemes and investment plans together. Continuous communication of the achievements, with specific targeted messages through the value chain is rewarding in maintaining the effort.

⁴ Internalisation of negative externalities: Externalities are a common problem associated with our interaction with the biosphere. The price one pays for a product does not include the environmental costs to create the product. We depend on the market to regulate our production and consumption – to value the goods and services at the true price to society. The market fails us when it comes to the environment and other common property resources because of the issue of externalities. This can be solved with several methods (subsidies, regulations, prohibitions, taxes etc.), but most of these have limitations. According to economists the best way the internalisation of the externalities which means that the cost of negative externalities should be built into the other costs. The main challenge is the exact determination of the level of the costs and the way of implementation.

4.3.6 How incentives and policy measures can be changed and improved to help companies and clusters utilising them

Regulation and subsidies remain important drivers of environmental behaviour for many firms and sectors, but their effectiveness can be further enhanced with well-designed incentives. Combining regulations with incentives helps to achieve a positive cycle of improvement. Effectiveness of existing policy tools moves within wide limits, there are several ways to improve them:

- The continuous controlling and measurement of the effectiveness of different policy instruments is useful and an incentive both for stakeholders and policy makers. If some of the tools are proven ineffective, modification is needed. Successful results are to be communicated openly towards the stakeholders, taxpayers, consumers, governmental and non-governmental organizations.
- Transparent and action orientated incentives are more effective—it is important that they require positive, measurable and controllable action by the organisations concerned, in order to avoid the risk of 'greenwash'.
- Appropriately verified needs and targets are easier fulfilled. Impacts on firms' profitability and competitiveness are important.
- Identification and removal of administrative burdens on research and industry, to enable innovation through non-discriminatory, market-based incentives to improve spreading modern technology.
- Transparency in terms of lobbying and a stronger involvement of impartial experts to reduce one-sided influences on policy making.
- Economic and reputational incentives are the most effective elements in an incentive mix.
- Although administrative incentives have a role, this appears to be limited, as a result of their implicit association with relatively complex regulatory regimes.
- Economic incentives can be successfully employed at all levels - by their nature they are most often deployed at a national level, though EU and sub-national approaches can also be successful. EU funding already plays an important role in economic incentives, but there is further potential – the European Commission funds a number of programmes, such as FP7, LIFE+, INTERREG and others, that inter-alia support companies in increasing efficiencies and improving their environmental performance. Making this link to improved environmental performance more explicit could be used to make further use of these funds. Modulated incentives are needed and more effective – significant variation between sectors, firms, Member States, markets, clients and other factors means that the application of individual incentives has to be carefully considered depending on targeted companies and targeted behaviour change.

4.3.7 The role of consumers in generating demand for bio-based products

The role of consumers is a very important factor as they can create a sound demand for the biobased products, but there are also many challenges to convince them to switch to these. Almost nine in ten (89%) of Europeans are worried about the impact of plastic products on the environment and a similar proportion (88%) are worried about the environmental impact of microplastics (Eurobarometer, 2020). According to (Klein, Emberger-Klein, Menrad, Möhring, & Blesin, 2019) there has been little research on the consumption of bioplastic products and consumers' choice behaviour for bioplastics. Detailed market researches are needed to determine the possible market segments which are ready to buy these products even with a price premium and marketing strategies

for bioplastic products could focus on interested consumer groups and illustrate their properties and functions to those groups.

The most effective actions are the following:

- Raising consumer awareness on bio-economy (e.g. bioplastics, bio-based plastics and biodegradable plastics) is the base. Consumer awareness is raised in a number of steps and by different means. Adequate information is the first step (on the targets, policies, labels). Media campaigns are useful for Generation X, influencers are effective for Generation Y, and for the future consumers (children) the new mentality are well adapted by up-to-date information in education materials.
- The purchase intention for bioplastic products measured is moderate at about 56% even in a environment conscious and well-being country such as Germany (Klein, Emberger-Klein, Menrad, Möhring, & Blesin, 2019). Present consumer awareness is very different across the different member states (Eurobarometer, 2019). In countries with low standard of living, the consumers are usually highly price sensitive. In this case the segmentation of the consumer market is important.
- Taxation benefits are seen as an important policy tool in the promotion of bioplastics in a range of applications. Adaptation of lowered VAT of biobased products reduce the consumer prices and thus increases even their consumption. The Lead Market Initiative For Europe (European Commission, 2009) sought to provide a production tax credit for bioplastics with the intention to encourage investment, production, and adoption of these materials in a developing market (European Commission, 2010); for example, in Italy biodegradable mulch films were subject to a 16% reduction in VAT compared to conventional films (Valpak Consulting Consortium for DEFRA, 2010).
- Consumer facing sectors where some organisations would be expected to react well to credible, yet simple, reputational incentives that the public can use to differentiate their products. However, some companies will only seek to differentiate on price, so there may well be a need for compulsory schemes and a continued major role for regulation.
- Adequate labelling to inform customers of types of bio-based plastics and end-of-life processing such as suitability for home or industrial composting e.g. Seedling logo (European Bioplastics, 2016). Over the last 20 years, several studies have been written on the impact of eco-labelling on access to markets in developed countries, with the role of consumers (IISD, 2003) (OECD, 2003) (UNEP, 2005) (AEAT, 2004). The Blue Angel, a successful eco-label has been used in Germany since 1978, nevertheless it became soon clear from survey data, that in general households' willingness to pay higher prices for an environmentally friendly product is unlikely to be strongly pronounced. A case study (Hemmelskamp & Brockmann, 1997) of a product labelled with the Blue Angel indicated that an environmental label can support a product's market penetration effectively, even if this is accompanied by rising prices and there was a scope for demand expansion at an even higher price level, provided the individual consumer can expect a personal positive advantage by utilizing the labelled product. Examples of consumer information devices is given in Annex 6 – Pictures of bioplastics specific labels.

4.4 Recommendations and options for policy makers

As discussed among the main barriers, market instruments and mechanisms alone are insufficient to provide an appropriate amount of eco-initiative, eco-innovation and eco-investment; in particular, if considering fundamental changes to be made in the industrial ecology attitude of consumers and business in the European Union as a whole. Policy intervention is therefore a must.

In the following sections, recommendations are made on six aspects where legislative and policy measures may be made. These six aspects include:

1. Materials – from resources to marketable products, recyclable products back to resources
2. Applicability – from individual businesses to circular business models
3. Scope – from life cycle assessments of single products in chains towards territorial sustainability analysis
4. Range – from political measures on individual sectors to cross-sectors
5. Co-operation – from financial incentives at product-technology level to clustered support and integral cost-benefits scenarios
6. Horizon – from consumer perceptions of single end-products towards an appreciation for the environmental context of product manufacturing.

The structure in which these aspects are discussed comprises of these four steps:

- A. Current policy measures and incentives – to efficiently utilise spare resources (including waste, co- and by-products)
- B. Response of the sector/market – the activities of businesses to seize opportunities
- C. Bottlenecks – obstacles that businesses meet when trying to implement circular economy solutions, and that particularly require reconsidering current policy measures
- D. Recommendations for adapted policy measures – to head towards more sustainable solutions or industrial ecology concepts that function in practice

4.4.1 Materials: closing the loop from resources to product through recycling

Current policy measures and incentives

Applicable regulation:

Regulation on EU fertilising products – (EU) 2019/1009

Sustainable land use, soil fertility management, recycling of organic and inorganic materials

Waste Directive 2008/98/EC Article 5 (1) includes a definition of by-products. The basis of the conditions laid down measures may be adopted to determine the criteria to be met for specific substances or objects to be regarded as a by-product and not as waste.

List of waste Decision 2000/532/EC establishes the classification system for wastes, including a distinction between hazardous and non-hazardous wastes. The List of Waste (LoW) serves as a common encoding of waste characteristics in a broad variety of purposes like classification of hazardous wastes. Assignment of waste codes (02 01 Primary production wastes) has a major impact on the transport of waste, installation permits (which are usually granted for the processing of specific waste codes), decisions about recyclability of the waste or as a basis for waste statistics.

Communication on waste and by-products COM (2007) 59 aims to explain the definition of waste set down in Article 1 of the Waste Framework Directive, as interpreted by the European Court of Justice, in order to ensure that the Directive is properly implemented. In EU waste law, notions such as by-product or secondary raw material have no legal meaning – materials are simply waste or not. In business vocabulary, these may be identified as by-products, co-products, intermediate products, non-core products or sub-products. Industrial production processes are often complex and can generate several different materials with different economic values, environmental impacts and waste/non-waste statuses. In the food and drink sector, a clear distinction between waste and product is crucial to the economic exploitation of the material concerned.

Shipments of waste Regulation (EC) No 1013/2006 specifies under which conditions waste can be shipped between countries. Establishes procedures and control regimes for the shipment of waste, depending on the origin, destination and route of the shipment, the type of waste shipped and the type of treatment to be applied to the waste at its destination. According to Article 13, although the supervision and control of shipments of waste within a Member State is a matter for that Member State, national systems concerning shipments of waste should take account of the need for coherence with the Community system in order to ensure a high level of protection of the environment and human health.

Landfill Directive 1999/31/EC - in respect of the technical characteristics of landfills, this, for those landfills to which Directive 96/61/EC is applicable, the relevant technical requirements in order to elaborate in concrete terms the general requirements of that Directive. Article 16 measures should be taken to reduce the production of methane gas from landfills, inter alia, in order to reduce global warming, through the reduction of the landfill of biodegradable waste and the requirements to introduce landfill gas control. As per Article 17, the measures taken to reduce the landfill of biodegradable waste should also aim at encouraging the separate collection of biodegradable waste, sorting in general, recovery and recycling. This directive, by more strictly regulating to transport wastes to landfill, incentives alternative utilization routes of biomass materials and better processed organic fertilisers.

Incentive policy examples:

- Reduced charges, fees in case of meeting some environmental requirements;
- Reduced taxes in case of meeting some environmental requirements;
- Investment subsidies for establishment new technologies;
- Voluntary coupled support for producing some agricultural raw materials suitable for bioenergy production;

- Increased price of green energy for producers;
- Price levies, product fees on recyclable and non-recyclable products;
- Free selective waste collection for the consumers;
- Prohibition of usage some type of plastic products.

Sector response

The related regulations lay down the new definition of by-products, wastes, create new rules of shipping waste among countries and introduce limitations for landfill use in order to reduce the emission which increase the share of harmful greenhouse gases. These conditions draw up minimal requirements for agricultural production and producers of biowastes.

The effect of the incentive policy is still moderate in some sectors, too. In case of those sectors and products which are entitled for subsidies the production of bio-based goods increased but thinking and action in a system is still missing. For example, in some member countries where there are incentives for biomass production, biogas production, establishment of biogas plants, green energy etc., these solutions became very popular among agricultural firms and pricing firms, but these activities were created separately in space and time, the value chain does not work properly in every case and companies tend to quit their activity if the subsidy is modified or abolished.

Identified bottlenecks

In those countries where the incentives are limited in time, many companies finish their operation due to the lack of profitability after the initial period; such investment subsidies are wasted.

For example, in Hungary the biomethane sector is considered a niche segment in the field of renewable energy. It received no support recently and has barely any market, with less than 5% of the total estimated capacity for biomethane utilised. In 2015, only two upgraded biomethane plants were operating throughout the country (European Commission, 2017, p. 127). The reason is, there is no defined cap of feed-in quantities and the eligibility period for the feed-in tariff is calculated on the individual basis. This might lead to the uncertainty with regards to the investment planning. In general, the Feed-in Tariff scheme sets not enough incentives to invest into the installation of biogas plants. All these resulted in the closure of several biogas plants except the ones combining heat and electricity. This activity usually is not profitable with market prices (2015 figures: 99.5 €/MWh, the lowest in the EU, vs Germany 237.3 €/MWh), and higher prices must be paid by the Government or the market.

The demand in most cases is limited, consumers and users look out for favourable prices. Only those plants and activities are able to operate which have the economy of scale, use large quantities of biomass and/or the suppliers have to pay fees for processing their wastes. Either the higher prices should be guaranteed longer or only well designed, profitable plants with thoroughly vetted technical and business plans should be supported in the future.

The last solution – passing the cost on the biowaste producers – is contra-productive: biowaste can be transported to landfill if it is too expensive to valorize it as bioenergy, compost, or other bio-based products. A well organised value chain can operate only in that case if all stakeholders have received fair price for their product which made their operation profitable.

Recommendations to adapted policy measures

Economic sustainability is a key factor in long-term operating circular systems. All the stakeholders along the value chain must profit from the circular business model. This requires a new type of policy: instead of separate subsidy programs, taxes, charges and fees, the policy makers must create a favourable complex system which influences the behaviour of all the actors along the value chain.

This type of incentive system must be well designed and calculated. Before designing information, collection is important among the potential beneficiaries exploring their needs and hindering factors.

Another recommendation is concerning the definition and vocabulary used for the processed material streams – the current definition in COM (2007) 59 for waste, by-products and co-product is hardly applicable for renewable materials and does not consider upgrading processes like in NoAW.

4.4.2 Applicability from individual businesses to circular business models

Current policy measures and incentives

Applicable regulation:

Use of animal by-products and derived products as a fuel in combustion plants Commission Regulation (EU) No 592/2014 lays down implementing measures for the public and animal health rules for animal by-products and derived products laid down in Regulation (EC) No. 1069/2009. Detailed provisions concern the disposal and use of animal by-products and derived products. Further the Regulation sets out measures concerning certain samples and items exempt from veterinary checks at border inspection posts as provided for in article 16(1)(e) and (f) of Directive 97/78/EC.

Industrial Emissions Directive 2010/75/EU integrated pollution prevention and control. To control industrial emissions, the EU has developed a general framework based on integrated permitting. This means the permits must take account of a plant's complete environmental performance to avoid pollution being shifted from one medium – such as air, water and land – to another. Priority should be given to preventing pollution by intervening at source and ensuring prudent use and management of natural resources. In order to ensure the prevention and control of pollution, each installation should operate only if it holds a permit.

Promotion of the use of energy from renewable sources Directive 2009/28/EC sets out sustainability criteria with which biofuels and bioliquids need to comply in order to be counted towards the target in that Directive and to qualify for inclusion in public support schemes.

Incentive policies:

- Companies with certified environment management system are controlled less frequently;
- Reduced waste fees, taxes for companies with certified environment management system;

- 100% interest free loan for SMEs to invest into new energy efficiency technologies;
- Grant scheme that provides subsidy for SMEs to invest in the recommended resource efficient technologies;
- Subsidy for establishment of new technologies suitable for biobased production, bioenergy production;
- Increased price for green energy.

Sector response

Current regulations are limited to laying down measures of proper usage of animal by-products, to creating emission limitations of industrial emissions and definition of energy from renewable sources. These rules create the frame of bioenergy production and stimulate the emission reduction of industrial firms.

Firms perceive regulation and legal requirements as major drivers of their improved environmental performance. The administrative burden of compliance can be high in terms of time and/or money allocated. These costs seem to affect small companies the most. Administrative incentives should be relatively more important to SMEs as proportionally administration is a larger burden to them than to large companies and they have less resources available to dedicate to it.

Investment subsidies, soft loans are also very attractive tools, but as these are mainly available in an application system, the cost of this support form is high both for the evaluators and the companies as the preparation of an application is also an administrative burden.

Again, these incentives promote circular economy in an isolated way, the continuous, cost effective raw material supply, sound demand for the end product is not proved – though the presented applications usually contain a business plan with these contents, its realization is unsure.

Identified bottlenecks

The stability of the business environment is an important factor that determines companies' decisions regarding investments for sake of environmental performance improvement. An unstable business environment would be one with high variability in taxes and interest rates, and also accompanying regulations.

Despite increased environmental awareness and increased consumer pressure for environmentally friendly products, the primary determinant of a consumer's purchase decision is the product price (Eurobarometer, 2019). Therefore, for producers, uncertainty about the market acceptance of new products can hinder the uptake of new measures or investment in higher environmental performance.

There is asymmetric information between the environmental solution providers (the EU eco-industries) and the client businesses. This market failure mode is prominent for SMEs.

Continuous supply of cost-effective raw materials is also an issue in case of biomass processing. The agricultural producers are usually small-scale, with different production methods. Purchasing the required quantity of raw materials with unified quality is always a challenge for processors especially if the weather, or other market issue changes the conditions.

In case of increased price for the end product (for example green energy) the producer may remain dependent of the support.

Recommendations to adapted policy measures

The incentive policy must take into account the existing burdens of creating a well-organised value chain which provide fair prices for all the stakeholders in the chain. The incentives must have an answer for both bottlenecks: the proper supply system and the sound market for the end-products.

The following factors stimulate this:

- External conditions solved, for example adequate logistic system, long-term predictable economical and taxing policy;
- Industrial investments incited only in case of well-operating supply system and existing long-term contract with the suppliers, at the same time the production of the raw material is also supported;
- The market development, creating sound demand is crucial;
- Costs/benefits evaluation (including third party verification) with special regard to key costs and other risks is extremely important;
- Setting appropriate benchmarks or targets by market segment or geographical region; sector or sub-sector;
- The incentive tool designed especially for different firm sizes; or environmental risk/impact.
- There is need for lighter requirements in case of SMEs – as lower administrative burdens are seen as particularly rewarding.

4.4.3 Assessment scope: from single products towards territorial sustainability analysis

Current policy measures and incentives

Applicable regulation:

Waste Directive 2008/98/EC defines general waste management requirements, such as environmental and human health protection during waste treatment and priority for waste recycling. It also contains specific bio-waste related elements (new recycling targets for household waste, which can include bio-waste) and a mechanism allowing setting quality criteria for compost (end-of-waste criteria)

Waste Directive 2008/98/EC, Article 22(3) regulates Bio-waste Member States shall take measures, as appropriate, and in accordance with Articles 4 and 13, to encourage:(a) the separate collection of bio-waste with a view to the composting and digestion of bio-waste;(b) the treatment of bio-waste in a way that fulfils a high level of environmental protection;(c) the use of environmentally safe materials produced from bio-waste. The Commission shall carry out an assessment on the management of bio-waste with a view to submitting a proposal if appropriate. The assessment shall examine the opportunity of setting minimum requirements for bio-waste management and quality criteria for

compost and digestate from bio-waste, in order to guarantee a high level of protection for human health and the environment.

Communication on waste and by-products COM (2007) 59 is scope of the distinction between waste and non-waste in a production process context. It is not relevant to other waste such as municipal waste or other similar waste streams, or to consumption residues. It does not deal with the issue of when a product may become a waste, or when a waste ceases to be a waste. It does not deal with waste that is excluded from the scope of the Waste Framework Directive

Renewable Energy Directive (RED – 2018/2001/EU Directive on the promotion of the use of energy from renewable sources)

Right priorities for bio-polymer conversion use of biomass rather than fuel conversion and energy use. A similar policy on bio-based materials and products, in particular for those with agriculture, feed and food use

Sewage Sludge Directive 86/278/EEC regulates the use of sewage sludge in agriculture in such a way as to prevent harmful effects on soil, vegetation, animals and man, while encouraging its correct use.

Sewage Sludge Directive 86/278/EEC Article 6: sludge shall be treated before being used in agriculture. Member States may nevertheless authorize, under conditions to be laid down by them, the use of untreated sludge if it is injected or worked into the soil.

Health rules for composting and biogas plants which treat animal by-products. Regulation (EC) No 1069/2009, Article 20 lays down the procedure for authorization of an alternative method of use or disposal of animal by-products or derived products may be initiated either by the Commission or, following an application, by a Member State or by an interested party, which may represent several interested parties.

Promotion of the use of energy from renewable sources Directive 2009/28/EC Directive 2009/28/EC, Article 17 lays down the sustainability criteria for biofuels and bioliquids are (a) measuring compliance with the requirements of this Directive concerning national targets; (b) measuring compliance with renewable energy obligations; (c) eligibility for financial support for the Article 18 the Directive requires the verification of compliance with the sustainability criteria for biofuels and bioliquids consumption of biofuels and bioliquids.

Incentive policy examples:

- Agreement between local government and SMEs whereby companies receive preferential treatment (reduced costs) if they can commit to environmental performance;
- Tax on waste sent to landfill, charged by tonne. Systemic annual increase in taxation on an environmentally harmful company behaviour i.e. waste generation.

- REMAKE: an EU funded programme provides vouchers to companies for free consultancy support to businesses to investigate their operations and how resource efficiency can be increased. Life Cycle Analysis (LCA) of production processes analyses where improvements can be made.

Sector response

Regulation: Life cycle assessment can be found sporadically in the current regulation, but as a concept it is present in the regulations and directives for example: proper waste management, waste hierarchy, preferred utilisation ways. Exact LCA is usually missed, only the favourable targets are laid down.

Incentive policies are scarce in this field.

LCA is mainly still a scientific tool, only large firms invest money into investigating the LCA for their own products or services as part of their CSR (Corporate Social Responsibility) Programme. While proper LCA can be prepared with accurate input data, the data collection is the greatest challenge during this analysis.

Wider concepts as sustainable production chain within a specific territory is still missing, though real energy saving and recycling can be achieved easier if the production is sustainable both environmentally and economically, within a determined geographical area.

On the other hand, most of the firms seek raw material supply from a limited distance due to the logistics cost, also to save the quality of the raw material or due to its perishability. This greatly depends on the type of raw material. Bio-based processing typically requires low-value agricultural products or by-products, such as plant residuals, straw and manure. Owing to their low value, the transport cost is more critical, so it is important to optimise the supply chain for economic reasons, there is no need for special incentive if the process is otherwise profitable.

Identified bottlenecks

Continuous supply of biomass can be limited for several reasons. Unfavourable weather, utilisation of the biomass in a higher way according to the waste hierarchy (for example feed, littering in animal production, soil nutrient, etc.), too fragmented agricultural producers.

The other end of the value chain is also a critical point: it is unsure whether the end-product can be marketed within a given area as only special segments of the consumers are aware of the importance of sustainability currently.

Recommendations to adapted policy measures

Policy measures targeting territorial sustainability must consider regionality more than any other policy tools: instead of EU, at member state level, and instead of country, at regional level.

Territorial sustainable systems cannot be achieved in every geographical area, only in those territories which are suitable for production of large quantities of biomass, or near to large animal farms or food processor companies with enough wastes for profitable bio-based processing. It is crucial to create proper network plans.

If the ecological and economic conditions are given, the willingness of the potential stakeholder must be evaluated. The effective incentive can be created based upon these criteria, if it has been well designed, calculated and verified.

4.4.4 Range: from individual sectors to cross-sectors

Current policy measures and incentives

Applicable regulation:

Single Use Plastics (SUP) Directive – (EU) 2019/904

Bio-based products are for a large part still more expensive than conventional products. Reasons lie with the early developmental stage and small market volumes of the bio-based sector, but also with the low price of conventional products, not considering their environmental impact. The burden on pollution is still a great political challenge.

Waste Directive 2008/98/EC defines key concepts such as waste, recovery and disposal and puts in place the essential requirements for the management of waste, notably an obligation for an establishment or undertaking carrying out waste management operations to have a permit or to be registered and an obligation for the Member States to draw up waste management plans. It also establishes major principles such as an obligation to handle waste in a way that does not have a negative impact on the environment or human health, an encouragement to apply the waste hierarchy and, in accordance with the polluter-pays principle, a requirement that the costs of disposing of waste must be borne by the holder of waste, by previous holders or by the producers of the product from which the waste came.

Landfill Directive 1999/31/EC with a view to meeting the requirements of Directive 75/442/EEC, by way of stringent operational and technical requirements on the waste and landfills, to provide for measures, procedures and guidance to prevent or reduce as far as possible negative effects on the environment, in particular the pollution of surface water, groundwater, soil and air, and on the global environment, including the greenhouse effect, as well as any resulting risk to human health, from landfilling of waste, during the whole life-cycle of the landfill.

Health rules as regards animal by-products and derived products Regulation (EC) No 1069/2009 lays down that new technologies have widened the possible use of animal by-products or derived products to a large number of productive sectors, in particular for the generation of energy.

Bio-plastics certification requirement EN 13432 certification requirements have to be met by bioplastics (EN 13432:2000 Packaging, EN 14995:2006 Plastics).

European top-level strategies supporting bioplastics:

- Europe 2020 / Innovation Union
- Lead Markets Initiative for Bio-based Products
- Resource Efficiency Strategy

- Key Enabling Technologies
- P7 & Horizon 2020
- Bioeconomy Strategy
- Circular Economy Package

EU plastic standards and the Society of the Plastics Industry in the United States classify bioplastics in category 7 as “Other” without further details. A compostable labelling scheme has nonetheless been developed by European Bioplastics for all compostable EN 13432 compliant packaging materials. Certification ensures that the product can be industrially composted and that not only the plastic but also all other components of the product are compostable, e.g. colours, labels, glues and – in case of packaging products – residues of the content.

Certification links harmonised standards and self-declared or independent third-party environmental claims and labels such as the compostability label ‘Seedling’ logo. Environmental claims and labelling has been standardised in ISO 14021:2016 Environmental labels and declarations — Self-declared environmental claims (ISO 14021, 2016)

Promotion of the use of energy from renewable sources Directive 2009/28/EC sets out in the light of the positions taken by the European Parliament, the Council and the Commission, it is appropriate to establish mandatory national targets consistent with a 20 % share of energy from renewable sources and a 10 % share of energy from renewable sources in transport in Community energy consumption by 2020. In order to reach the targets Member States may, inter alia, apply the following measures: (a) support schemes;(b) measures of cooperation between different Member States and with third countries for achieving their national overall targets. The main purpose of mandatory national targets is to provide certainty for investors and to encourage continuous development of technologies which generate energy from all types of renewable sources.

Directive 2009/28/EC Article 4 lays down each Member State shall adopt a national renewable energy action plan.

Directive 2009/28/EC Article 6 lays down Member States may agree on and may make arrangements for the statistical transfer of a specified amount of energy from renewable sources from one Member State to another Member State.

Directive 2009/28/EC Article 7 lays down Two or more Member States may cooperate on all types of joint projects relating to the production of electricity, heating or cooling from renewable energy sources.

Directive 2009/28/EC Article 9 lays down one or more Member States may cooperate with one or more third countries on all types of joint projects regarding the production of electricity from renewable energy sources. Such cooperation may involve private operators.

Directive 2009/28/EC Article 11 lays down two or more Member States may decide, on a voluntary basis, to join or partly coordinate their national support schemes. In such cases, a certain amount of energy from renewable sources produced in the territory of one participating Member State may count towards the national overall target of another participating Member State.

Directive 2009/28/EC Article 13 lays down Administrative procedures, regulations and codes in the case of biomass, Member States shall promote conversion technologies that achieve a conversion efficiency of at least 85 % for residential and commercial applications and at least 70 % for industrial applications.

Calculation of land carbon stocks Decision C(2010) 3751 Guidelines for the purpose of Annex V to Directive 2009/28/EC. Annex V to Directive 2009/28/EC sets out the method for calculating greenhouse gas impacts and contains rules for the calculation of annualized emissions of carbon stock change from land use changes. The guidelines annexed to this Decision establish rules for the calculation of land carbon stocks, completing the rules laid down in the Annex.

Incentive policy examples:

- Voluntary coupled support⁵ for production of energy plants (European Commission, 2019);
- Investment grants, interest rate subsidies for establishment of biobased processing facilities;
- Tax and fee allowances;
- Increased procurement price for green energy;
- Setting medium- and long-term goals regarding the share of renewable energy, quantity of not utilised wastes etc.
- Products fees or prohibition of use some plastic products;
- Green procurement standards for firms for public tenders;
- Drivers from transport companies save up to 30% on fuel, thereby reducing the CO₂ emissions by taking eco-driving test. Insurance premiums correspondingly decrease.

Market response

There are several examples both for regulation and incentive policy regarding single sectors or product types.

Incentives and regulations were prominent towards renewable energy use, reduction of harmful gas emission and in the last 10 years toward suppression of plastic products. These policy tools usually concentrated on single targets, single sectors and the system conception was missed.

The reaction of the market actors was positive, but the single targets created other problems which had to be solved by new regulations. For example, the incentives for renewable energy created large scale bioethanol plants using maize or other food and feed crops as raw material, increasing the prices of these commodities. The RED Directive tried to suppress this type of energy production, but still there exist first-generation bioethanol production plants.

Promotion and certification of bio-plastics is useful and meets with the increasing awareness of the consumers, but these products attract a price premium precluding significant market penetration.

Identified bottlenecks

Individual sector incentives are attractive for the stakeholders, but simple requirements evoke simple reactions. Supporting single sectors does not take into account the difficult environmental and economical interrelationships.

⁵ EU countries may continue to link (couple) a limited amount of income support payments to certain sectors or products

The market actors seek profit or benefits (consumers) and consider the available resources (both natural and financial) in order to optimise their situation. If the cross-sector concept is missing, the supported activities may create negative externalities.

Recommendations to adapted policy measures

Rather than supporting one special target or sector, the incentive tools are to switch to a wider concept. The motivation of companies and other actors is cost reduction or profit maximalisation, in case of environmental investments too.

Successful policy tools internalise all the negative externalities. If the utilisation of ecological resources or the harm caused to the environment becomes an explicit cost for the firms, their reactions will be optimal and predictable.

Desired policy instruments are sector-neutral and boost cooperation among different sectors.

Information exchange, supporting innovation, knowledge transfer are also useful “soft” policy tools.

4.4.5 Co-operation: from product-technology level to clustered support

Current policy measures and incentives

Applicable regulation:

Waste Directive 2008/98/EC, Article 29(5) calls upon the Commission to create a system for sharing information on best practice regarding waste prevention and to develop guidelines in order to assist the Member States in the preparation of their waste prevention programs.

Packaging and packaging waste Directive 94/62/EC has a dual purpose: (1) encouraging all the Member states to engage in waste prevention and promote the reuse of packaging waste; and (2) coordinate and harmonise all the initiatives in this context so as to ensure the flow of trade is unimpeded in the European Union and prevent anti-competitive practices. The best means of preventing the creation of packaging waste is to reduce the overall volume of packaging.

Directive 94/62/EC lays down from an environmental point of view recycling should be regarded as an important part of recovery with a particular view to reducing the consumption of energy and of primary raw material and the final disposal of waste. Energy recovery is one effective means of packaging waste recovery. The Directive also defines Organic recycling including the preferred anaerobic treatment in NoAW, the biodegradable parts of packaging waste, which produces stabilized organic residues or methane. Landfill shall not be considered a form of organic recycling.

Promotion of the use of energy from renewable sources Directive 2009/28/EC, Article 23 lays down The Commission shall monitor the origin of biofuels and bioliquids consumed in the Community and the impact of their production, including impact as a result of displacement, on land use in the Community and the main third countries of supply. Directive 2009/28/EC Annex I. The national overall targets for the share of energy from renewable sources in gross final consumption of energy

in 2020. It contains of Member States' share of energy from renewable sources in gross final consumption of energy 2005 (0-32.6%) and target for share of energy from renewable sources in gross final consumption of energy 2020 (11 to 49%).

Quality of petrol and diesel fuels Directive (EU) 2015/1513 amending Directive 2009/28/EC. One of the key laws to reduce the risk of indirect land use change and to prepare the transition towards advanced biofuels. Pursuant to Article 3(4) of Directive 2009/28/EC of the European Parliament and of the Council, (3) each Member State is to ensure that the share of energy from renewable sources in all forms of transport in 2020 is at least 10 % of the final consumption of energy in transport in that Member State. The blending of biofuels is one of the methods available for Member States to meet this target and is expected to be the main contributor. Where pasture or agricultural land previously destined for food and feed markets is diverted to biofuel production, the non-fuel demand will still need to be satisfied either through intensification of current production or by bringing non-agricultural land into production elsewhere. In order to ensure the long-term competitiveness of bio-based industrial sectors, and in line with the Commission Communication of 13 February 2012 entitled 'Innovating for Sustainable growth: A Bioeconomy for Europe' and the Commission Communication of 20 September 2011 entitled 'Roadmap to a Resource Efficient Europe', promoting integrated and diversified biorefineries across Europe, enhanced incentives under Directive 2009/28/EC should be set in a way that gives preference to the use of biomass feedstocks that do not have a high economic value for uses other than biofuels.

Incentive policy examples:

- Investment grants, interest rate subsidies for establishment of biobased processing facilities;
- Tax and fee allowance;
- Increased procurement price for green energy;
- Setting medium- and long-term goals regarding the share of renewable energy, quantity of not utilised wastes etc;
- Products fees or prohibition of use some plastic products;
- Green procurement standards for firms for public tenders;
- National Industrial Symbiosis Network (NISP, in the UK): an industrial symbiosis initiative which brings together traditionally separate industries and organisations from all business sectors (International Synergies, 2005) with the aim of improving cross industry resource efficiency and sustainability; involving the physical exchange of materials, energy, water and/or by products together with the shared use of assets, logistics and expertise.

Market response

There are several examples of regulations and incentive policy tools driving special products or technologies, but special programs for creating integrated clusters are very rare or only under organisation. Examples include (SmartAgriHubs, 2019), (EIP-Agri, 2016), (Crop Diversification Cluster, 2018).

The policy instruments targeting special products and technologies attract individual firms and the circulating economy concept is not fulfilled.

Identified bottlenecks

Vertical and horizontal cooperation is a widespread solution among the market actors to reduce their transaction costs and optimize their operation. Nevertheless, in some member states the cooperation level is still low due to the attitude of the stakeholders and the special tax system which drives them to remain individual actors in the market. The existing EU supports for POs and Producer Groups were not able to change this tendency either.

The rate of organisation is very heterogeneous among the Member States: it has risen to over 80% only in the Netherlands, Belgium and Ireland. In particular, in the case of The Netherlands the rate of organisation is over 100% because of transnational POs. On the other extreme, it does not reach 15% in most new Member States, Portugal, Greece and Finland (EU Parliament, 2011). Different factors may limit the development of POs in some regions or even entire Member States. They include historically linked sociological patterns as lack of mutual trust, systematic suspicion and the temptation of taking advantage of the efforts done by others without paying the price (free rider behaviour). Grey economy may be also a further key reason for not joining POs: not paying taxes (in particular VAT) make that non organised farmers obtain higher profit (under grey economy) than the ones belonging to POs which are obliged to respect the legal framework. In addition, many producers sell exclusively in local or regional markets or through direct sales and therefore are less concerned by the benefits that the POs could bring them.

Another possible obstacle to the development of POs is represented by the complexity of the procedures for obtaining recognition as a PO, for having an operational programme approved and, subsequently, for having access to the public financial aids. This complexity can discourage small producers who do not have the necessary competences or consider that the advantages of adhering to the regime are lower than the administrative costs associated.

A further factor that reduces the attractiveness of POs may be the perception by producers that there are very high risks of losing the public financial aids, which can put the survival of a PO at jeopardy. Thus, respect of recognition criteria, especially minimum number of members, democratic control, placing of products on the market and outsourcing, is critical for a PO to maintain its recognition (EU Commission - Producer organisations, 2014).

Building clusters means a stronger cooperation among the stakeholders. In most member countries, the market actors will recognise the advantages of this type of unions, but in some other countries it will be challenging to convince them.

Recommendations to adapted policy measures

Clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, and associated institutions in a particular field that are present in a region. Clusters arise because they increase productivity. The development and upgrading of clusters is an important agenda for governments, companies, and other institutions. Cluster development initiatives are also an important new direction in economic policy, building on earlier efforts in macroeconomic stabilisation, privatisation, market opening, and reducing the costs of doing business.

Clusters have more important role in sustainable production and circular economy. The territorial connection is expected to reduce transportation and transaction costs and reduce environmental pollution. The broader cooperation makes it easier to turn positive and negative environmental impacts into costs and to ensure profitable operation for all the actors of the clusters.

Creating effective policy tools presumes a new approach. As the circular economy concerns not only agriculture but also the industry and energy sectors, a co-operation of policy makers in the different fields must be working towards designing effective incentive instruments.

Apart from direct incentives such as grants, interest subsidies, favourable loans, tax and fee allowances, the incentives shall encourage cooperation. The policy tools must be attractive enough to exceed the economic benefits of remaining an individual actor. This can be achieved by financial benefits but also by raising awareness, knowledge and information sharing about the advantages of such a cooperation. Well-balanced relationships among the stakeholders is important, the system have to provide security for this. The flow of information along the value chain must be smooth, this can be ensured by adequate regulations.

4.4.6 Horizon: consumer appreciation towards the environmental context of manufacturing

Current policy measures and incentives

Applicable regulation:

ERP (Extended Producer Responsibility) concept in the Single Use Plastics (SUP) Directive – (EU) 2019/904

Low consumer awareness on the concept of bioeconomy, understanding and mindful selection of bio-based products. Information on bio-based products is not easily accessible for consumers

Regulation on the EU Ecolabel – (EC) 66/2010

Information on bio-based products is not easily accessible for consumers. Confusion exists in terms of nomenclature and various certification systems worldwide. Ecolabel Regulation (EC) 66/2010 lays down rules for the establishment and application of the voluntary European Union Ecolabel scheme, which applies to any goods or services which are supplied for distribution, consumption or use on the European Community market. These provisions regulate the award of the EU Ecolabel and terms and conditions of its use. Article 5 provides for the setting up of the European Union Ecolabelling Board (EUEB).

Organic production Regulation (EC) 834/2007 lays down rules for the principles, aims and overarching rules of organic production. Foods may be labelled "organic" only if they fulfil the EU-regulation 834/2007 on standards for production and processing organic food. In non-organic foods, any ingredients which meet organic standards can be listed as organic. To ensure credibility, the code number of the certifying organisation must be provided.

Promotion of the use of energy from renewable sources Directive 2009/28/EC, Article 14 lays down Information and training (1) Member States shall ensure that information on support measures is made available to all relevant actors, such as consumers, builders, installers, architects, and suppliers of heating, cooling and electricity equipment and systems and of vehicles compatible with the use of energy from renewable sources.

According to Directive 2009/28/EC Article 14 Information and training (6) Member States, with the participation of local and regional authorities, shall develop suitable information, awareness-raising, guidance or training programs in order to inform citizens of the benefits and practicalities of developing and using energy from renewable sources.

Labelling and standard product information of the consumption of energy and other resources Directive 2010/30/EU sets out a framework for the harmonization of national measures on end-user information, particularly by means of labelling and standard product information, on the consumption of energy and where relevant of other essential resources during use, and supplementary information concerning energy-related products, with a view to allowing end-users to choose more efficient products. Directive 2010/30/EU sets out a framework for the responsibilities of Member States, suppliers and dealers. According to Directive 2010/30/EU Article 15, Member States shall lay down the rules on penalties applicable to infringements of the national provisions adopted pursuant to this Directive and its delegated acts, including unauthorised use of the label, and take the necessary measures to ensure that they are implemented. The penalties provided for shall be effective, proportionate and dissuasive.

Incentive policy examples:

- Acknowledged bio-based (and biodegradable, if applicable) product labels;
- Reputation lists (lists of firms which meet environmental, sustainability requirements);
- Consumer awareness campaigns.

Market response

The perception of consumer is a crucial point of successful circular economy. Currently the regulation and incentive policies concentrate on labelling and promotion of different products or production methods (for example organic production), but the concept of the sustainability of the whole production chain is lacking. Findings (Russo, Confente, Scarpi, & Hazen, 2019) regarding consumers' demographics show that perceptions of and reactions to bio-based products are not affected by gender but are affected by age and past purchases. Specifically, older consumers display higher willingness-to-pay, and those who already purchased eco-products had higher intentions to purchase and switch to bio-based products, regardless of the number of times they purchased eco-products in the past.

The purchase intention for bioplastic products measured for all German citizens is moderate at about 56%. In contrast, about 95% of the consumers with product experience intend to buy bioplastic products (Klein, Emberger-Klein, Menrad, Möhring, & Blesin, 2019).

The awareness of the consumers differs largely in countries and even within the countries, and there is a strong relationship between the standard of living and the perception toward environment protection (Eurobarometer, 2019), (Eurobarometer, 2020). This can be explained by the fact that the consumers are in different levels of the environmental consciousness.

However, increasing awareness can be detected among the consumers toward sustainability, but the price of the products is still the dominant decision factor during purchasing, this is why the promotion programs have limited effects.

(Cai & Aguilar, 2013) found that consumers pay higher premiums for frequently purchased products than for less frequently purchased ones. The basic price category could affect the size of the surplus consumers are willing to pay for sustainable products in general.

(Kainz, 2016) found that consumers have a basic interest in biopolymer products, but as they are not part of everyday consumer behaviour biopolymers seem somewhat meaningless and rather far away from consumers. The experimental auction method (which is a new method to measure the real readiness to pay instead of questionnaires usually overestimating it) showed that even with the information that was provided, consumers find it difficult to evaluate the benefits and values of biopolymers. In addition, biopolymers might not meet consumers' expectations of a sustainable, climate-friendly, environmentally friendly material.

A study (Galarraga Gallastegui, 2002) states the market impact of labelled goods depends on the level of environmental awareness and the consumer demand for green goods. Labelling is an effective tool if the environmental advantages are well communicated, simply understandable and the label is easily recognised.

Identified bottlenecks

Consumer behavioural intentions such as willingness-to-pay for, buy and switch to bio-based product was investigated (Russo, Confente, Scarpi, & Hazen, 2019) whether it depends upon the degree to which consumers are involved in the product itself; to what extent personal values affect their purchase intention and willingness-to-pay for bio-based products and how consumer demographics and previous purchasing experiences affect one's intention to purchase or switch to bio-based products.

Interest in bio-based plastic seems to correlate with preference for organic food (Scherer, Emberger-Klein, & Menrad, 2018). Due to the higher prices of the sustainable products and production methods only limited part of the consumers buys them, except the product offer higher quality which has direct effect on health.

Positive consumer trends can reverse in times of negative economic growth the outlook for the same. Consumer perception can change under new circumstances. The risk of Covid-19 for instance has placed the health protection far atop of the environmental issues, like making the extensive use of single use items and food packaging an overwhelming advantage and almost exclusive decision feature during shopping (New Food, 2020). This pandemic highlighted the vulnerability of awareness campaigns if higher prices cannot be solved.

On the other hand, consumers became more health-minded, switched to on-line shopping (EFMP, 2020) and avoided more food waste (Deloitte, 2020).

Recommendations to adapted policy measures

Biogas and compost are consolidated and easy-to-use materials for PHA-based bioplastics according to findings (Russo, Confente, Scarpi, & Hazen, 2019) and send a clear message to governments and regulatory bodies that consumers are generally willing to participate in circular economy initiatives seeking to replace traditional plastic by transforming waste into a new raw material suitable for bio-based products.

The most important and most effective policy tool is that reduce the end consumer price of biobased products. This can be achieved by reducing the cost of production by subsidies, better organisation of the value chain, higher level of coordination among the stakeholders, information exchange, supporting innovation and last, but not least by direct effect on prices, for example lower VAT, government procurement than re-allocation of the products with lower prices, administrative price limits or income tax reduction in case of buying bio-based products.

However, a starting point from policy-makers in setting standards for the end-of-life-usage of bioplastics will be necessary to eliminate confusion for consumers and waste management companies likewise. Life-cycle assessments need to support these standards and substitution of conventional plastic products to assure a wise substitution and resource management.

4.5 Business and marketing concepts for industrial ecology

The major challenge of implementing a circular economy is that it requires a change at a system level, and an involvement of all actors within the value chains (suppliers, manufacturers, retailers, consumers), hence a new view on business strategies (NoAW D5.3 Report , 2019). At an enterprise level, innovative business models are needed that replace existing ones or offer new market opportunities for new products (Ellen McArthur Foundation, 2013). Teece (2010) emphasises that “technological innovation by itself does not automatically guarantee business or economic success - far from it”.

Firstly, adequate business models are needed to create a setting where all parties involved perceive a “win-win” situation. Secondly, markets and consumers shall be kept motivated to appreciate and accept willingly the resulting products and ideas even at a price premium.

Policy intervention is therefore a must. The previous section has discussed and given recommendations for adapted policy measures to head towards more sustainable solutions or industrial ecology concepts that function in practice. If the policy measures are not seen by the potential users as real incentives, which provide tangible or at least perceivable benefits for them, the spending on funding and support will be considered as useless. Such benefits can include exploitable knowledge for new products, processes, services, systems and markets; systematic approach to support decisions and approach potential markets; new knowledge towards a more substantiated and long-term vision thinking; and assurance for better planning decisions.

Another key ingredient is a sound and functioning business model. In its very basic and broad definition, a business model describes how a firm does business (Magretta, 2002). Often, the business model structure is analysed according to the largely recognised Business Model Canvas (Osterwalder, Pigneur, & Clark, 2010). It consists of nine building blocks, where the value proposition - defined as the value proposed by an enterprise to solve customers’ problems and satisfy their needs - is central and linked to three business domains: (1) infrastructure, i.e. the key activities, partners and resources as strategic components, (2) customers, i.e. the customer relationships, the customer segments and channels as market components, and (3) financial components, i.e. the cost structure and revenue streams (NoAW D5.3 Report , 2019).

Example business concepts have been presented in Section 4.1.4, “Developing business concepts based on triggers” and the Business model canvas sheets for each analysed cases included in Section 8.1 Annex 1 - Examples of industry triggers to develop industrial ecology solutions in manure, straw and wine waste utilisation.

4.5.1 Recommendations on the marketing strategy

Marketing is focusing the activities, products and services of the organisation on serving the needs and expectations of the customers, consumers at a higher level than the competitors can offer and on achieving this at a profitable level. It facilitates the exchange of the products and services between the organisation and its client, which results in added value for both parties. Marketing includes the identification of the needs and expectations of the clients and predicts their foreseeable needs and allocates the necessary resources for meeting them.

Following this logic, the following main steps should be applied during the development of the marketing strategy (CampdenBRI Hungary & Sebök, 2011):

- Analysis of the needs of the different users' groups: market segments, geography, age groups or distribution channels;
- Establishing the marketing objectives;
- Defining the marketing strategy;
- Design and implementation of the marketing activities and the necessary resources;
- Review and evaluation of the marketing activities, their results and impact;
- Implementation of corrective actions (adjustments) as necessary.

Market segments

Consumers have positive environmental associations with bio-based products. In principle, the market acceptability of bio-based products is high (Sijtsema, et al., 2016) and the positive public image of bio-based products are to become a main driver of the future market uptake. The consumer perception as green products clearly represents an opportunity for the marketing of bio-based products. More than 60% of the population are interested in bioplastic products in Germany (Scherer, Emberger-Klein, & Menrad, 2018). Marketing strategies for bioplastic products could focus on interested consumer groups and illustrate their properties and functions to those groups.

However, the awareness of bio-based products among potential buyers is still low, the lack of public awareness being an important market barrier. Many consumers are unfamiliar with the term "bio-based", and the lack of understanding hides the benefits and hinders rapid and wide adoption. Quick take-up market segments are hence the B2B customers (converters) and other professional users well aware of the terms and benefits.

An example within the context of the NoAW project, valorisation route: PHA production (building block for biodegradable biobased polymers), the envisioned market segments for the final PHA/PHBV based polymers are biocomposites producers and producers of agriculture mulch films.

Geography

A key finding is that drivers of the market for bio-based products and hence the importance of information on related items differ distinctly across countries (Eurobarometer, 2019). The promotion of local supply chains and the independence from fossil sources plays a particularly important role in driving the B2B market in France, whereas in Italy end-of-life considerations are particularly important (Open-BIO, 2015). Overall, these findings indicate that national trends play a role in driving markets for bio-based products. These country-level differences should be taken into consideration when formulating messages to different user groups at European level.

Another factor is the availability of raw material resources; in case of PHA production, the upgraded biogas. This context (density of biodigesters and average power of the biodigesters) is particularly favourable in Germany followed by Italy, Austria and France (NoAW D6.3, report expected 2020).

Age groups or distribution channels

Green and innovation-oriented public procurement schemes represent potential entry points for the promotion of bio-based products when demonstrably contributing to relevant environmental benefits (carbon balance, greenhouse gas impacts and recyclability). In general, the share of organizations that engage in practices of green public procurement is higher than the share of organizations involved in innovation-oriented procurement practices (Open-BIO, 2015).

Another distribution channel model is for B2B customers (converters) and other professional users. In case of the NoAW PHA bio-polymers, the preferred distribution channel is from a centralised PHA concentration plant to the “niche” market segments, like polymer producers for specific applications in agriculture and packaging.

4.5.2 Developing the marketing objectives towards the operational marketing policy

In its simplest form the marketing mix deals with the aspects of the product and product choice policy (Product), the price policy (Price), the product distribution policy (Place) and the communication policy for preparing the market (Promotion).

The key messages below are confirmed by the learnings from the case studies and factsheets from NoAW D5.1

Product related drivers

- The reliance on bio-based products brings important strategic benefits for businesses, such as the positioning as an innovative and technologically advanced company, the diversification of supply chains, and the safeguarding against oil price increases.
- Strategic considerations, indicated by the perceived importance of savings in carbon emissions and compliance with environmental regulation are drivers of the future market.
- New bio-based products, such as plastics and chemicals, seem to face significantly more barriers than well-known bio-based products, such as wood-based materials. Biodegradability or compostability plays a particular role as a market driver for a number of bio-based plastics.
- Examples of Product related attributes relevant to the NoAW project include:
 - Biomass source and origin – percentage of bio-based carbon content, percentage of bio-based content. Choice and reference to the relevant standard measuring the biobased carbon content in materials or products using the ¹⁴C method (EU: EN 16640 or CEN/TS 16137, International: ISO 16620-2, US: ASTM 6866).
For the PHA/PHBV biopolymers for the replacement of PE in packaging applications, derived from upgraded biogas, the biobased carbon content is 100%.
 - Additives – claims on the presence or absence of specific additives like inert fillers, adhesives, dyes, printing inks, anti-blocking agent or similar compounds. In particular, the bio-based source of the NoAW epoxy prepolymer compared to petrol-based source avoids the use of BPA (bisphenol-A) and the use of bio-based epoxy is in accordance with the legislation evolution as there is a push for safer materials by the general public. Lignocellulosic fillers produced from vine solid residues are expected to reduce the final

cost of the PHBV material according to the filler content and also alter the properties of the final product.

- Product life cycle properties - considered to cover relevant information, also with relation to durability (in the use phase), re-usability and end-of-life options like recyclability or the choice and reference to the relevant Biodegradable (e.g. CEN/TR 15822), Home (NF T51-800) or Industrially compostable (EN 13432/EN 14995) standards.
- Application and additional value/functionality of the product – like advantages vs fossil-based alternatives.

Price related drivers

- High production costs and volatile feedstock prices are considered to be among the most important barriers for bio-based products. The acceptance of bio-based products thus critically depends on the offering of extra values in addition to the technical performance also provided by comparable fossil-based products. The realization of price premiums is a precondition for bio-based value chains.
- Premium prices do exist for certain products and higher prices are paid in the value chains of different bio-based chemicals, polymers, and plastics (Carus & al, 2014). In this study, the term 'GreenPremium price' is defined as: "The additional price a market actor is willing to pay for the additional emotional performance and/or the strategic performance of the intermediate or end product the buyer expects to get when choosing the bio-based alternative compared to the price of the conventional counterpart with the same technical performance". This means that the GreenPremium price is not paid for better technical performance of the bio-based product, but rather for the additional performance beyond the technical performance.
- Price premiums for bio-based products in the B2B market are expected to be based on strategic considerations rather than environmental reasons. Accordingly, most of the premium prices found in the market are paid for bio-based intermediates and polymers (Carus & al, 2014).
- Price is often mentioned as a barrier by consumers (Open-BIO, 2015). If the price of labelled products is higher compared to regular products, it is important to make clear to consumers what the benefits are for consumers themselves (durability, convenience, feel good). The willingness of consumers to pay a price premium for a better environmental performance is an important market driver. However, with wider adoption this may taper off in the future, individual buyers change behaviour and remain interested in personal benefits of bio-based products – such as convenience, looks and functionality – and less willing to pay a green premium. Improved economies of scale of manufacturing may later counterbalance this.
- A pricing strategy that is differentiated in time and is adjusted based on the balance of demand and supply may permit an initial high price with an exclusivity promise in the beginning and blend into the mainstream price as the unique offering diminishes.
- Introducing Transition obligations like the Renewable Transport Fuels Obligation⁶. Biopolymers share many similarities with Biofuels which have still generally higher cost price than the fossil-derived alternatives, but EU countries have committed to have at least 10% of their transport fuels come from renewable sources by 2020. These experiences show that

⁶ RTFO – a long term mechanism requiring transport fuel suppliers to ensure a set percentage of their sales are from a renewable source. Non-complying suppliers will pay a penalty. Backed by tradable offset certificates - Renewable Transport Fuel Certificates (RTFCs), the Obligation programme aligns with the EU Directive 2003/30/EC on the promotion of biofuels and renewable transport fuels.

biobased solutions, although more expensive than fossils, can be successful when implemented as obligation. Such approach, also represented by the plastic ban, can be introduced for other applications as well.

- Policy actors may enable such a pricing strategy by leveraging:
 - On Public procurement policies to provide support in the initial period to generate demand;
 - Introducing a transition obligation scheme similar to the RTFO. Legislative elements for this are already present (see Section 4.2.2 Review of the other related EU and national global drivers and initiatives towards the circular economy) and the NoAW project has shown that technically it is possible to replace fossil-based and/or non-biodegradable plastics in certain applications like PHA/PHBV fertilizer coatings and food packaging.
 - Establishing periodical targets for the penetration of bio-based versus fossil-based materials and use legislative and taxation instruments to promote or throttle supply.

Place (distribution channel) related drivers

- When designing European strategies to promote bio-based products, market particularities have to be considered as important differences exist between markets for bio-based products across Member States. Consumer awareness and perception of bio-based products differ significantly across countries. For instance, consumers in Italy, the Czech Republic and Slovenia associate bio-based products more often with health and safety issues than consumers in Denmark and the Netherlands. In order to strengthen the position of bio-based products, it is recommended to take consumers' perceptions and unfamiliarity seriously into account in developing communication strategies for bio-based products. The approach should be context specific and as concrete and comprehensive as possible (Open-BIO, 2015).
- Regional differences exist in the income levels (e.g. Scandinavia vs Central Eastern Europe or the Mediterranean) that restricts the demand for these new type products.
- Therefore a policy, crossing product use, geography and distribution channels is necessary. For the NoAW project's output biomaterials, elements of such policy includes:
 - Shortlisting, prioritising and selection of product use channels in need of a bio-based and/or biodegradable alternative. Again, the current European legislative framework in particular *The European Green Deal* (COM/2019/640 final, 2019) is extremely favourable and provides a long-term vision and commitment towards a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050. All NoAW products (PHA, epoxy prepolymer and fibres-based biocomposites) are well in line with these initiatives and offer sustainable solutions in many market segments.
 - Distribution channels – unless for niche applications, the current customer needs towards PHBV and PHBV composites highly depend on the application and the sector that is being addressed. Conventional polymers are “criteria qualifiers”, this means that they dictate the needs towards the biopolymer alternatives; properties of the substitute need to be as close as possible to the properties of the conventional product (NoAW D5.3). Similarly, the “critical mass” for a biopolymer like PHBV to be successful on the market is in the magnitude of one thousand ton annually and per processor and this practically pre-empts the entry of another party to the market. A marketing policy should encourage supply contracts with a variety of customers and actively seek for applications on a wide range. On the legislative side, this effort is assisted by goal of making the economy more market- and service-oriented and expanding the role of private and foreign investment.

On the other hand, as biopolymers gain market share, certain EU competition law measures may need specific interpretation. The Treaty of Lisbon in general prohibits anti-competitive agreements including price fixing but also establishes exemptions, if the collusion is for distributional or technological innovation, gives consumers a "fair share" of the benefit and does not include unreasonable restraints that risk eliminating competition anywhere. In here, term "distributional or technological innovation" should be understood in its broadest sense to permit entry of new markets, players, products and applications.

- Market entry and gain – NoAW D5.3 has identified a range of possible uses for bio-based PHA/PHBV, epoxy and PHBV composites ranging from agriculture through automotive and office stationery right into delicate cosmetics, food packaging and biomedical applications. These all require different properties for example biodegradability is crucial for marine and agro use while not a property wanted in others since recycling is seen as the cheaper and more sustainable option. Further research should be conducted to substantiate the potential ecological benefits of PHBV and PHBV composite by performing a comprehensive ecological evaluation of the products. Marketing efforts therefore shall concentrate on defining unique Value Propositions (see Section 4.1.4 Developing business concepts based on triggers and 8.4 Annex 4 - Business model canvas examples). To further explore new and potential uses, policy measures should also encourage R&D activities for applied research as well as product/process development activities.
- Information needs may differ across Member States. Ongoing policy and standardization processes at the EU level will have to take these country-specific trends into consideration; for instance, it may be necessary to address country-specific issues in the development of labels to meet national perceptions, priorities or trends.

Promotion (communication) related drivers

- There is an overall very positive consumer perception and buying intention towards bio-based products. The positive image of bio-based products and their ability to ensure stronger independence from fossil-based resources are expected to become the most important drivers of market acceptance.
- To successfully introduce the NoAW products into the market, communication of PHBV and PHBV composites to B2B customers is a crucial success factor. Detailed specifications and performance characteristics of the PHBV and PHBV composites are required focusing on the products' strengths e.g. the ecological benefits to better differentiate them from fossil-based applications available on the market. This is essential to perceive the benefits of the NoAW products to accept the higher prices compared to market available fossil-based applications.
- On the consumer side, public awareness can be raised in a number of steps and by different means. Some studies suggest that younger consumers could be more sensitive to green issues than older consumers and more likely to purchase eco-friendly products, having grown up in a time period where environmental issues have been a more central topic (Russo, Confente, Scarpi, & Hazen, 2019). Media campaigns are useful for Generation X, influencers are effective for Generation Y, and for the future consumers (children) the new mentality are well adapted by up-to-date information in education materials.
- The use of graphical devices (e.g. Annex 6 – Pictures of bioplastics specific labels) helps consumers to orientate. Ideally, such labels should address additional environmental criteria and feedstock sustainability related issues.

4.6 Time frame and enablers for successful implementation

The *European Green Deal* (COM/2019/640 final, 2019) launched a concerted strategy for a climate-neutral, resource-efficient and competitive economy. The European Commission has adopted a new *Circular Economy Action Plan* (COM/2020/98 final, 2020) - one of the main blocks of the European Green Deal, Europe's new agenda for sustainable growth. A sustainable bioeconomy is the renewable segment of the circular economy. Investments, innovation, developing strategies and implementing systemic changes that cut across different sectors as agriculture, forestry, fisheries, aquaculture, food, bio-based industry. The circular economy action plan prioritises the reduction and reuse of materials before recycling them and supports the sustainable and circular bio-based sector through the implementation of the *Bioeconomy Action Plan* (COM/2018/673 final, 2018). The Commission will aim at ensuring the sustainability of renewable bio-based materials, through actions aiding the Bioeconomy Strategy and Action Plan.

Bioenergy, currently the EU's largest renewable energy source, is expected to remain a key component of the energy mix in 2030 and contribute to meet the EU renewable energy targets of 20% in 2020 and of at least 32% in 2030. A stronger bio-based sector can accelerate the substitution of non-renewable resources in line with the EU's commitments under the Paris Agreement.

4.6.1 Enablers for the short-term (up to 3 years) implementation

Digital technology and data access

Data, combined with digital infrastructure (cloud, server farms, high-speed networks) and artificial intelligence solutions facilitate evidence-based decisions and expand the capacity to understand and tackle environmental challenges are important factors. The following actions are crucial:

- Creating the hardware conditions for digital technologies (such as artificial intelligence, 5G, cloud and edge computing for tracking);
- Ensuring that investors, businesses, farmers and consumers are able to access data, by expanding data networks;
- The *European data space for smart circular applications* (COM/2020/66 final, 2020) will provide information for applications and services such as product passports, resource mapping and consumer information.

Infrastructure and production conditions

The construction and expansion of basic infrastructure and incentives are needed for the acceptance of technology:

- Supporting the modernization of existing infrastructures and facilities;
- Addressing the issue of energy storage in biogas production;
- Supporting the development of external conditions, such as an appropriate logistics system;
- Supporting the production of raw materials for biogas and bioplastics production;

- Incenting continuous supply for biogas plants with a sufficient quantity and quality of raw material, suitable for biogas production;
- Increasing the capacity of biogas plants;
- Supporting further growth in the number of biogas plants;
- Assisting the delivery of biogas to a central treatment plant;
- Cost/benefit assessment by companies (including third party control), with particular reference to key costs and other risks.

Firm sizes

Incentives need to be supplied for companies of different sizes or environmental risks impacts. Lighter requirements are needed in the case of SMEs, for example:

- Reducing the administrative burden of compliance for SMEs;
- Reducing of SME regulations, standards, and labels formalities due to their limited financial and human resources.

Consumers

Consumers need to be provided with relevant and reliable product information:

- Involving consumer in processes such as designing harmonized symbols for key waste streams;
- Introducing reputation lists for consumers (list of companies that meet environmental and sustainability requirements);
- Supporting of consumers' awareness campaigns;
- Providing free selective waste collection for the consumers;
- Generating demand (consumer pull) through the social media;
- Raising consumer awareness of the environmental benefits of bioplastics;
- Encouraging more efficient and economical use of biogas among consumers.

4.6.2 Enablers for the medium term (2-5 years) implementation

Standardization

- Strengthening the role of standardization based on the on-going assessment of existing standardization work at national, European and international levels.

Certification

- Supporting the industry-led reporting and certification system, and enabling the implementation of industrial symbiosis;
- Reducing waste fees, taxes for companies with a certified environment management system.

Verification

- Promoting the uptake of green technologies through a system of solid verification by registering the *EU Environmental Technology Verification* (EU ETV, 2020) scheme as an EU certification mark;
- Setting appropriate benchmarks or targets by MS or geographical region, by sector or sub-sector.

Intellectual property

- Ensuring the institution of intellectual property in the circular economy and the emergence of new business models.

Collaboration

- Supporting vertical and horizontal cooperation through financial benefits, by raising awareness, knowledge and sharing information about the benefits of such forms of cooperation;
- Encouraging the promotion of circular industrial cooperation between SMEs under the new *SME Strategy* (COM/2020/103 final, 2020);
- Enabling sectoral integration;
- Promoting re-use and encourage industrial symbiosis, when a by-product of one sector is used as a raw material by another sector;
- Supporting experiments and cross-sectoral and interdisciplinary work;
- Supporting cooperation between small biogas plants

4.6.3 Enablers for the long term (over 5 years) implementation

Innovation

- Supporting the introduction of large-scale innovative projects;
- Promoting circular innovations, new technologies, sustainable solutions;
- Supporting the introduction of innovative technologies in biogas- and bioplastic production process;
- Supporting bio-based innovations, including agriculture, to develop new chemicals, products, processes and value chains in bio-based markets in rural and coastal areas, with the involvement and enhanced benefits of primary producers;
- Encouraging the application of best practices in the biogas- and bioplastic production process;
- Improving the usage of the produced biogas;
- Development of technological and legal possibilities for injecting bio-methane into the natural gas network;
- Encouraging the use of new biogas and bioplastic production technologies.

Investment

- Providing investment support for the creation of new technologies;
- Providing interest-free loans to SMEs to invest in new energy efficiency technologies;
- Developing a support system for SMEs investing in resource-efficient technologies.
- Supporting industrial investments that have long-term contracts with suppliers, thereby developing a well-functioning supply system;
- Supporting the construction of biogas plants;
- Ensuring the continuous use of energy and fermentation residues;
- Supporting the production of bioplastics by raw material production and transformation processes, through investments in land and machinery.

Market development

- Stimulating the development of lead markets for climate neutral and circular products, in the EU and beyond;
- Making the EU's energy supply secure and affordable for consumers and businesses;
- Increasing the price of green energy for producers;
- Increasing the number of biogas plants to expand sustainable and job-creating economic activities;
- Creating a complex system that influences the behaviour of all actors in the value chain, instead of separating support programs, taxes, levies, fees, policy makers;
- Optimising the supply chain due to economic reasons;
- Providing the right incentives for sustainable behaviour by producers, users and consumers;
- Boosting private investments;
- Development of energy security, environmental protection, return on investment, technology, energy efficiency, energy pricing concepts;
- Enhancing the competitiveness of bioplastic finished material.

Economic incentives

Economic incentives are the most important and most effective policy tool that reduces consumer prices of biobased products. This can be achieved by reducing the cost of production by subsidies, better organisation of the value chain, higher level of coordination among the stakeholders, information exchange, supporting innovation and by direct effect on prices, for example lower VAT, government procurement, re-allocation of the products with lower prices, administrative price limits or income tax reduction in case of buying bio-based products.

- Encouraging the broader application of well-designed economic instruments, such as environmental taxation, including landfill and incineration taxes, and enable Member States to use value added tax (VAT) to promote circular economy activities that target final consumers
- Introducing a broad-based tax reforms, removing subsidies for fossil fuels, shifting the tax burden from labour to pollution, and taking social considerations into account;

- Reducing charges, fees in case of meeting environmental requirements;
- Applying long-term, predictable economical and taxing policy;
- Establishing agreements between local the government and SMEs whereby companies receive preferential treatment (reduced costs) if they can commit to environmental performance;
- Increasing taxation annually for environmentally harmful company behaviour (e.g. waste generation);
- Considering policy measures for territorial sustainability regional policy rather than other policy instruments: at Member State level instead of at EU level and at regional level instead of at country level;
- Establishing investment grants, interest rate subsidies for establishment of biobased processing facilities;
- Setting medium- and long-term goals regarding the share of renewable energy and amount of not utilized waste;
- Imposing product charges or banning the use of certain plastic products;
- Requiring green procurement standards for companies in public procurement procedures;
- Promoting the bio-plastics to increase consumer awareness.

Research and education

- Supporting the research and innovation efforts needed circular bio-based sectors;
- Promoting collaboration among higher education institutions, research organisations and companies;
- Developing knowledge, skills and attitudes on climate change and sustainable development.

5 Conclusions

Economic sustainability is a key factor in long-term operating circular systems. All stakeholders along the value chain must profit from the circular business model. This requires a new type of policy: rather than separate subsidy programs, taxes, charges and fees, the policy makers must create favourable complex systems which influence the behaviour of all actors of the value chain. Successful policy tools internalise all the negative externalities. If the utilisation of ecological resources or the harm caused to the environment becomes an explicit cost for economic actors, their reactions will be optimal and predictable.

The incentive policy must take into account the existing burdens of creating a well-organised value chain which providing fair prices for all stakeholders in the chain. Vertical and horizontal co-operation is a widespread solution among the market actors to reduce their transaction costs and optimize their operation, nevertheless, in some member states the cooperation level is still low due to the attitude of the stakeholders and the special tax system which drives them to remain individual actors in the market.

Policy measures targeting territorial sustainability must consider regionality more than any other policy tools: instead of the whole EU, at member state level, and instead of a country, at regional level. Territorial sustainable systems cannot be achieved in every geographical area, only in those territories which are suitable for production of suitable quantities of biomass, or near to animal farms or food processor companies with sufficient and constant supply of organic matter for profitable bio-based processing. It is crucial to create proper network plans. If the ecological and economic conditions are given, the willingness of potential stakeholder must be encouraged and evaluated. An effective incentive is to be created upon these criteria, if it has been well designed, calculated and verified.

The future development of the market for bio-based products needs a stable and long-term political support. Uncertainty about future regulation and unsupportive regulatory environment are indicated as barriers for bio-based products. Effective policy tools are those that reduce the end consumer price of biobased products. This is achieved by reducing the cost of production by subsidies, better organisation of the value chain, higher level of coordination among the stakeholders, information exchange, supporting innovation and equally importantly, by direct effect on prices – for example lower VAT, government procurement and re-allocation of the products with lower prices, administrative price limits or tax reduction for companies committed to bio-based products. Subventions must address investment risks and poor return on investment during the first growth period. Such measures are effective in the first stage of the roll-out and ramp-up process, before the scale effects will lower production costs. On the long term, a pricing strategy that is differentiated in time and is adjusted based on the balance of demand and supply is likely to permit the long-term, sustainable income generation and further investments.

In order to capitalize on the positive public image as a key driver of the market acceptance of bio-based products and in order to receive green premium prices, the industry needs to embrace the high expectations of consumers regarding sustainability performance and complement marketing strategies with communication about additional sustainability criteria. The terms used in market communication to describe bio-based raw materials or products should be considered carefully in each particular context, especially in end consumer markets.

Promoting the market for bio-based products means to raise the awareness among consumers and to develop the public image further by demonstrating the related environmental advantages. This is best achieved by stressing the contribution to a circular economy and by systematic comparison of the existing fossil products with the competing bio-based alternatives. National or regional preferences, priorities or trends may be studied and consumer segment specific message and channel be considered to deliver a targeted message. Companies may also be able to justify the premium price by highlighting product attributes and functionalities on top of environmental advantages.

Implementing a circular economy requires changes at system level, and active involvement of all actors within the value chains, from feedstock suppliers to consumers (and vice versa, hence circular). Consumers have positive environmental associations with bio-based products, the market acceptability of bio-based products is high and the positive public image of bio-based product is expected to become a main driver of the future market uptake. At enterprise level, innovative business models are needed that replace existing ones or offer new market opportunities for new products. Business model canvas examples have been prepared and presented for 3 key valorization routes within the NoAW project scope: PHA/PHBV for the replacement of PE in packaging applications, Biocomposites and Advisory service on biotechnology for farmers on innovative waste valorization technologies.

These examples of the introduction of biopolymers into the consumer markets also show that efforts on the side of policy makers, agriculture, industry as well as business support services are necessary to adequately inform consumers and to involve them into the development and implementation of the circular bio-economy.

6 Partners involved in the work

Organisations:

CBHU: Campden BRI Magyarország Nonprofit Korlátolt Felelősségű Társaság, Hungary

DLO-FBR: Stichting Dienst Landbouwkundig Onderzoek

INRAE: Institut National de Recherche en Agriculture, Alimentation et Environnement, France

SOFIES: SOFIES, Switzerland

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In memoriam of our late colleague, dr. Szilvia Joó (Campden BRI Hungary).

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7 FAIR Data management

The datasets below are publicly available in the INRAE NoAW dataverse:

Annex 2 "SWOT analysis of case studies"

<https://doi.org/10.15454/Y3RPE3>

Annex 3 "Results of analysing success and failure factors based on the triggers"

<https://doi.org/10.15454/48IFBQ>

Annex 4 "Business model canvas examples"

<https://doi.org/10.15454/AHKBTQ>

8 Annexes

8.1 Annex 1 - Examples of industry triggers to develop industrial ecology solutions in manure, straw and wine waste utilisation

8.1.1 Market need & opportunity

1. **Anticipating the market needs** for bio sourced aromatic and looking for competitiveness. **Developing a new technology and process** to produce aromatic chemicals and renewable fuels at a competitive price (versus petro-based aromatic and fuels). Development of a new process to produce aromatic from cellulosic biomass. (Anellotech, USA)
2. **Need to replace a significant share of fossil-based polyesters**, such as polyethylene terephthalate (PET), and packaging materials like glass and metal **with 100% bio-based furanics polyesters**. (PEference, Europe)
3. **Growing need for proteins to feed animals** world-wide, environmental awareness of the co-funders, co-founders fully aware of the challenges of the animal food industry. TV program on “insects, the proteins of the future”. The objective is to nourish animals in Europe with proteins from insects, as an alternative to proteins from transgenic soya and fish meal. (Entomeal, Switzerland)
4. **Producing** cellulosic ethanol from biomass as **an alternative** to petroleum. To avoid competing with food supply, we develop the second-generation process in which agricultural residues are applied as the feedstock instead of grain crops. (FEG FENC, Taiwan)
5. The company makes barbecue briquettes out of recycled “olive cake”, which is a **by-product** of the fabrication of olive oil. They use a process that was originally developed in Greece to heat the limestone to paint and protect houses. (Oliobric, Germany)
6. A company's **customers** in the footwear and consumer electronics industries are constantly looking for new solutions to **reduce their CO₂ footprint**, and bio-based Thermoplastics polyurethane is one such solution. Aim is to bring these modern materials to the market. TPU closes the gap between rubber and hard thermoplastic which is used in many industries. (Convestro, Germany)
7. **Promote the development of a bioeconomy model** based on the efficient use of renewable resources and on the regeneration of local areas. (Novamont, Italy)

8.1.2 Technical development

1. **Technological development in a company for a cost-effective process** for the production of sugar as raw material. The new reference plant is based on a new technology that has been developed by the company and the process aims for a cost-effective process for the production of high-purity glucose from non-food biomass such as forestry residue, pulp or agricultural by-products. Glucose is suitable for both catalytic and fermentation processes for the production of a new and growing generation of sustainable materials. (Avantium, Netherlands)
2. Revision of a refrigerating plant: **as installer, the company has a duty of advice. It is important to follow the technical evolutions and to recommend the best solution**. The innovation and the environmental protection is „in their genes”. Objective: increased resource efficiency and better process control with an environmentally friendly alternative to fossil based heater. (DuPont, USA)

3. **Willingness to bring the patented Inbicon technology** for cellulosic ethanol production from a pre-commercial level **to a commercial level**, including demonstration of the whole value chain. (KACELLE, Denmark)
4. **A discovery can be used for medical applications:** Debridase extracted from pineapple stems can be applied as enzymatic debridement of serious burns, diabetic foot ulcers and venous legs ulcers. (Challenge Bioproducts, Taiwan)
5. The two municipalities took the initiative to establish MECBioHeat&Power when drawing up **plans for district heating**. Supply the two main towns as well as a number of smaller surrounding communities with district heating. (Maabjerg Energy Center, Denmark)

8.1.3 Valorization of by-products, recycling wastes

1. **Valorization of einkorn husk and rice husk** at the same time in a region, and a meeting between einkorn husk and rice husk actors led to their cooperation. (Association Bâtir-en-balles, France)
2. **Farming cooperation, vast agricultural area, huge biobased feedstock, vertical integration, high willingness to collaborate to innovate.** Objective: Value creation through non-food applications. (Biorefinery Bazancourt-Pomacle, France)
3. **Regional manure surplus; local availability of emitted CO₂ and heat; financial incentives** for bio-energy. Objectives: valorization of residual biomass and heat through mutual exchange between different companies. (Biopark Terneuzen, Netherlands)
4. The Local Colours project is based on **recycling vegetable remnants** from the food industry. Every month, tons of fruit and vegetable peelings with potentially fantastic dyeing properties are sorted and then thrown away to make bio-ethanol. Local Colours reuses the residues coming from regional farms, processing factories and restaurants. The project aims to improve **eco-friendly colours** in the competitive textile industrial chain. (Local Colours, Switzerland)
5. **Willingness to be energetically independent.** (Farm Georges Martin, Switzerland) **Valorize the manure** produced on the farm: **be self-sufficient** and supply other households. (Farm Georges Martin, Switzerland)

8.1.4 Avoiding or reducing pollution

1. **Avoiding pollution:** Conventional fire extinguisher contain PFOS (Perfluoro octane Sulfonate), which is harmful for humans and for the environment. Taking into account the damage they provoke to health and environment; conventional fire extinguisher brings high recovery costs. The objective was to find new effective fire extinguishing agents, which are biodegradable and not toxic. (NEF fire extinguisher, Taiwan)
2. **Aware of the pollution occurring in the region**, so representatives of the involved municipalities decided to work together to find ways of **producing renewable energy** on their territory. Objectives: **To valorise industrial by-products and sewage sludge into gas** for vehicles which fuel is more effective than classic fuels in terms of air and noise pollution. Producing a fuel which doesn't emit any fine particles and reduces the emission of greenhouse gas and the sound pollution in comparison with a diesel vehicle. (Clean fuel, France)
3. **Reduction of air pollution:** A technology incorporates the by-products of agricultural residues and waste of rice straw into recycled PET filaments. These by-products would otherwise be burned or buried and lead to greater pollution (current situation). (FENC, Taiwan)

4. World-wide **need for more efficient and reliable drying technologies** in agro-food sectors, in order to **tackle economic and environmental challenges** (need for on-time and on-site energy, need to reduce smoke emissions during the drying process, need to enhance soils). (Pyrolysis technology, Switzerland and Vietnam)
5. **Reducing carbon footprint** of a product. Green marketing. (FENC, Taiwan)

8.1.5 Environmental awareness and need for sustainable development

1. The founding companies aspired to **further develop their business, but in a more eco-sustainable way** than stand-alone. Objective: developing the companies' primary activity + creating added value of the side streams in a joint installation. (New Mixed Farm, Netherlands)
2. A company was originally focused on the development of functional textiles. Recognizing the **impact of rapid climate change** on the survival of the human race and to uphold the philosophy that we must all do our part to **protect our only planet**, Singtex has invested hundreds of millions of dollars over recent years to establish a pioneering R&D center and precision environmentally dyeing center." Objective: increased added value and branding via the development of eco-friendly functional textiles, via a partial substitution of fossil-based components for increased textile functions. (Singtex S.Cafe technology, Taiwan)
3. A company's **customers** in the footwear and consumer electronics industries are constantly looking for new solutions to **reduce their CO₂ footprint**, and bio-based Thermoplastics polyurethane is one such solution. Aim is to bring these modern materials to the market. TPU closes the gap between rubber and hard thermoplastic which is used in many industries. (Convestro, Germany)
4. The Local Colours project is based on **recycling vegetable remnants** from the food industry. Every month, tons of fruit and vegetable peelings with potentially fantastic dyeing properties are sorted and then thrown away to make bio-ethanol. Local Colours reuses the residues coming from regional farms, processing factories and restaurants. The project aims to improve **eco-friendly colours** in the competitive textile industrial chain. (Local Colours, Switzerland)
5. **Committed and environmentally conscious majors** get inspired after a visit in Sweden. Aim is to achieve ambitious climate goals. (The Magic Factory, Norway)

8.1.6 Legislation and incentives

1. **EU bans** rendered animal proteins from the feed chain costs for the treatment of Animal By-Products increased considerably. (BiogasPlant Grossfurtner, Austria) Objectives: Realization of Grossfurtner abattoirs integrated biogas plant. The first biogas plant worldwide, which exclusively uses slaughterhouse waste as substrate for biogas production. The aim of the project was the improvement of the economic and ecological performance of this abattoir. Two cost intensive areas in the company are the energy costs (natural gas, electricity) and the disposal costs for the slaughterhouse waste. By using the slaughterhouse waste as substrate for biogas production Grossfurtner can reduce the disposal costs and can cover approximately 33% of their electricity demand and 75% of their heat demand with renewable energies. (BiogasPlant Grossfurtner, Austria)
2. **Law** that obliges winemakers to deliver their waste for distillation. Valorization of grape marc for distillation as a response to legal obligation. (Union of cooperatives Grap'Sud, France)

3. **Favourable conditions for renewable energy production** in the Renewable Energy Sources Acts 2000&2004. **Additional income generation** for the farm through renewable energy production. (Energiehof Weitenau, Germany)

8.1.7 Need to cooperate to increase effectiveness

1. **Clustering companies** in the direct environment of other companies they could **benefit from in terms of waste management, natural resources and logistics**. At the beginning the focus was on logistics. During the planning process energy and water became more and more important. (Agriport A7, Netherlands)
2. **Create a cooperation** between the cereal and the eco-construction sectors. (Association Bâtir-en-balles, France)
3. **Inform and train people in using by-products** of cereals (rice, einkorn, spelt, buckwheat, barley). (Association Bâtir-en-balles, France)
4. **Need to reach a critical mass for this bioeconomy “emerging” sector. Need to organize the value chains and de-risk investments**. (BBI, Europe) Objectives: To develop sustainable and competitive biobased industries in Europe, based on advanced bio refineries that source their biomass sustainably by (1) demonstrating new technologies using European biomasses: new chemical building blocks, new materials, and new consumer products from European biomass; (2) developing new business models integrating economic actors along the value chains; (3) setting-up flagship bio refinery plants deploying technologies& business models. (BBI, Europe)

8.1.8 Additional income generation

1. **Limitations to expand the farm** because of nutrient application from pig slurry on land. **Additional income generation** for the farm through renewable energy production, Nutrient recovery and export to other regions / sectors. (Agro Energie Hohenlohe, Germany)
2. **Favourable conditions for renewable energy production** in the Renewable Energy Sources Acts 2000&2004. **Additional income generation** for the farm through renewable energy production. (Energiehof Weitenau, Germany)

8.1.9 Energetical independence

1. **Willingness to be energetically independent**. (Farm Georges Martin, Switzerland)
2. **Valorize the manure** produced on the farm: **be self-sufficient** and supply other households. (Farm Georges Martin, Switzerland)

8.1.10 CSR, Green marketing

1. **CSR, branding** and greener products. **Green marketing** (FENC, Taiwan)
2. **Reducing carbon footprint** of a product. Green marketing. (FENC, Taiwan)
3. **Strong sustainability vision**. Attractive partner for large brands using synthetic fibers and willing to develop greener products. Strong strategy regarding certifications of Green Products. (FENC, Taiwan)

8.2 Annex 2 - SWOT analysis of case studies

8.2.1 Strengths

Technology

- Development of an open technological platform for industrial scaling-up of biotechnology processes (Case Bio-refinery Bazancourt Pomacle)
- High efficiency infrastructures, local smart-grids and driven Industrial Symbiosis to reduce production costs in an Agro-industrial Park (Case Agriport A7)
- Anaerobic digestion is a proven technology (Case Agro feed in Hohenlohe)
- Feed-in tariff for electricity coming from anaerobic digestion (case Agro Energie Hohenlohe)
- Protect innovative products with a patent makes them more stable and interesting for investors (Case Oliobric)
- Replacing toxic components with natural non-toxic products can significantly reduce some hidden costs like the recovery costs of fire extinguishers (Case NEF fire extinguisher)
- Innovation capacities & product portfolio extension (Case Grap'Sud)
- Optimization of logistics costs (Case Grap'Sud)
- Technology transfer: robust and low-cost solution designed to be implemented in developing and transition countries. Design that fits with the needs of the targeted countries (case pyrolysis)
- The bio-sourced alternatives solve issues that are not solved by the fossil-based products (case Singtex, Taiwan, DuPont Tate & Lyle)
- Well accepted processes (focus on emission reduction CH₄ mitigation and water protection, energy and material recovery from pig manure) in the local context (case Agro Energie Hohenlohe)
- Very clean kind of fuel produced (Biogas Pays Rochois)
- No seasonality (case Agro Energie Hohenlohe)
- Big potential to generate bio- sourced PET, plastic present in many packaging (Anellotech, USA)
- Strong technology transfer strategy (Challenge Bioproduct)
- Excelled achievement in test and effects (NEF fire extinguisher)
- Boost local food production (The Magic Factory)
- Pellet can reach a burning temperature of 1000°C (Oliobric)
- A large organic vegetable producer is almost energetically neutral due to energy synergies between their biogas production plant using vegetables co-products as substrate, their greenhouse and their freezing facility (Case Westhof)

CO₂, GHG reduction

- Combining the treatment of households' waste with bioethanol and biogas plants to reuse most by-products and to lower CO₂ emissions (Case Maabjerg)
- Hundreds of thousands of CO₂ equivalents saved per year (case Novamont)
- Well accepted processes (focus on emission reduction CH₄ mitigation and water protection, energy and material recovery from pig manure) in the local context (case Agro Energie Hohenlohe)
- A large organic vegetable producer is almost energetically neutral due to energy synergies between their biogas production plant using vegetables co-products as substrate, their greenhouse and their freezing facility (Case Westhof)

Collaboration

- Collaboration between private companies and local municipalities (Case Magic factory)
- 3 different companies in charge of the 3 steps in the biogas (Case Magic factory)
- Successful collaboration between a German company and farmers in Greece (case Oliobric)
- Successful public-private partnership (Case Biogas Pays Rochois, Case Maabjerg)
- Partnership along the overall new Value Chain from the start; solution-oriented partnership between a green building block developer and a high tech material producer; A partnership of strengths to answer to the market demand (Case Covestro)
- Joint venture designed to develop strategic innovations (Case Dupont Tate & Lyle)
- Build an existing cluster (case Bâtir-en-balles)
- Strong open to the world promotion strategy and strong public and private cooperation (Foundation F. de Bohan, case Biorefinery Pomacle Bazancourt)
- Geographical proximity of 3 ecosystems: industries, applied R&D and academia (Case Bio-refinery Bazancourt Pomacle)
- Strong public support in the long run (Case Bio-refinery Bazancourt Pomacle)
- Development and industrialization require different skills (Challenge Bioproduct)
- Large network of commercial partners worldwide (Challenge Bioproduct)
- Support local agriculture (Maabjerg Energy Center BioHeat&Power)

Raw materials availability

- Huge quantity of feedstock available, high storage capacity (Case Bio- refinery Bazancourt Pomacle, Biorefinery Bazancourt- Pomacle)
- Buying olive production by-products to local farmers avoids throwing tons of co-products in the sea (Vase Oliobric)
- Regional nutrient surplus, export needed (case Agro Energie Hohenlohe)

Marketing and business

- Traceability, high quality standards and fair agriculture attract clients even if the products are a bit higher than conventional ones (Case Westhof)
- Testing all the assumptions of the business model foreseen; Staying connected to economic realities (Case Entomeal)
- Global strategy in the niche market of functional textiles (Case Singtex, Taiwan)
- A vertical integration enables a strong IP and labeling strategy; this enables to build up a strong brand, facilitating cross-industry cooperation and further innovation (Case Singtey, Taiwan)
- Transparency and traceability for an ethical and ecological production is appreciated and an important marketing argument (Case LocalColours)
- Certificates (NEF fire extinguisher)
- Pro-active promotion of the project to obtain a permission to produce and public support (Case Entomeal)

Sustainability and awareness

- Designing for sustainability from the start (Case entomeal)
- Pro-active citizen awareness raising (Case entomal)
- High motivation (case Bâtir-en-balles)

8.2.2 Weaknesses

Financial and economic aspects

- High dependency to large investment (case AgriportA7)
- Need to reach a critical mass for the bio-economy “emerging” sector. Need to organize the value chains and de-risk investments (BBI Case)
- High dependency to fossil-based energy; AgriportA7 acknowledges the risk and plans to be fully independent of fossil-based energy in the future (case AgriportA7)
- High competition with petro-based technologies that are produced at lower costs (case Novamont, Case PEFerence)
- Fiscal incentives are critical for economic feasibility (Case New Mixed Farm)
- Public financial support is critical (Case Grap’Sud)
- Public financial support is difficult to get (Case Bâtir-en-balles)
- Initial purchase costs are high, but recovery costs are non-existent (NEF fire extinguisher)

Scaling

- Technology has never been tested on a large scale (Biogas Pays Rochois)
- Working with fresh by-products requires an efficient logistic (case LocalColours); but scaling-up might result into not enough (fresh) by-products available in nearby surroundings (case Grap’Sud)

8.2.3 Opportunities

Geographical aspects

- Available space to grow in the future (Case AgriportA7)
- Geographical proximity of actors of the primary sector (growers) and actors of the secondary sector (Case AgriportA7)
- Development of local areas by using old industrial sites that are decommissioned (case Novamont)
- Economic promotion of local areas through the creation of new industries, products and jobs (Case Novamont)
- Region as “agricultural development area”, creation of conditions for business development; giving room for economic development under the condition that the processing is sustainable (case New Mixed Farm)
- Creation of jobs in rural areas while developing technological know-how (Case PEFerence)
- Locality (Biopark Temeuzen)

Collaboration

- Driven top-down strategy to benefit from efficient Industrial Symbiosis (Case AgriportA7)
- Vertical integration via existing agro-food actors in search of value creation through non-food applications (Case Bio-refinery Bazancourt Pomacle)

- Combining a variety of energy and supply tasks in a unified system concept to optimize synergies between individual elements by making efficient use of the energy flows between the individual plants (Case Maabjerg)
- Development of Bio-CCP (Carbon Capture Products) in the region (Case Magic factory)
- Strong and long-lasting Public-Private partnership at regional level, with a clustered and topical competitiveness approach combined with an Eco-industrial park approach leading to advanced industrial symbiosis (Case Bio-refinery Bazancourt Pomacle)
- Economies of scale in a cluster or an agro-industrial park (Case Bio-refinery Bazancourt Pomacle, case AgriportA7, case New Mixed Farm)
- A non-profit principle leading to maximum hedging for investors, creditors and heat customers (Case Maabjerg)
- Large strategic Public-Private Partnership between the EU and the Bio-based Industries Consortium (BBI Case)
- Setting-up a large facility/cluster can only happen when local governments, citizens, entrepreneurs and NGOs are involved (Case AgriportA7)
- Building an initiative on existing clusters (case Bâtir-en-balles)
- Going from R&D innovation to markets: building a long-term collaboration between the project holder, R&D experts and potential clients (markets) in order to reach a complete effective, economic and commercially viable process (Case Anellotech)
- To scale-up and commercialize a new marketable technology or process: identify and partner with existing multi-national and eco-innovative actors in the same field (Case FENC BioPET, Case FENC Bio-Polyster)
- Including clients in the project management (Case Inbicon)

Technology, logistics, saving through technological developments

- Optimal logistic model in and out (Case AgriportA7)
- Strategic innovation to anticipate and lead the post fossil-based economy (Case PEFerence)
- Use manure as a substitute for process water Case Magic factory)
- Implant plants such as refineries next to wastewater-treatment plants to reduce energy and water consumption through resource exchange (Case Inbicon)
- Innovative technology allowing new processes (Biogas Pays Rochois)
- The construction cost of small biogas plants can be reduced a lot by self-building (Case George Martin)
- Using slaughterhouse by-product as substrate for biogas production vs the disposal costs and can cover a large part of electricity and heat demand (Case Biogas Plant Grossfurtner)
- Keeping process cost-effectiveness in mind when developing new processes; Designing the all process to reach the highest technical efficiency and thus the highest possible economic performance (Case FENC Bio-Polyster, Case FENC Cellulistic Ethanol)
- Winning prizes/awards facilitates promotion (Case Westhof, Biogas Plant Grossfurtner)
- Development of a new technology (MinFree) improve the competitiveness (Anellotech, USA)
- Designing alternative processes that are more than pure alternative; for instance processes that are bio-based but also source of energy-savings or increased production capacity (Case Dupont Tate & Lyle)

- Valorization of all the new process co-products in order to be economically and environmentally optimal (Case pyrolysis)
- Designing new products that are drop-in replacements enabling full utilisation of existing logistics infrastructure without blending limitations (Case FENC Bio- Polyester)

Raw material availability

- Use of local biomass resources based on long-term contracts for high security of supply (Case PEference)
- Available local agro by-products (case Agro Energie Hohenlohe)
- Using local industrial by-products and sewage sludge (Biogas Pays Rochois)
- Possibility of valorizing all by-products when involving other local businesses (Case George Martin);
- Possibility to use slaughterhouse by-product as substrate for biogas production (case Biogas Plant Grossfurtner)

Incentives

- Financial support of the European Union (Case PEference)
- Getting national and international prizes (Case Maabjerg)
- Selling the energy produced by a small biogas plant to neighbouring households (Case George Martin)
- Operational and cost optimization via shared infrastructure (Wood to chemicals, Pilot Plant, Avantium, Netherlands)
- The biogas branch is supported by the states (Switzerland and EU) and the current strategy wants to support the use of alternative energies (Case George Martin)
- Public financial support is critical (Case Grap' Sup)
- Received several national and international prizes (Maabjerg EnergyCenter)

R&D

- Co-investment in R&D and demonstration plants (BBI Case)
- Strategic Innovation and Research Program to anticipate and lead the post fossil-based economy (BBI Case)
- Going from R&D innovation to markets: building a long-term collaboration between the project holder, R&D experts and potential clients (markets) in order to reach a complete effective, economic and commercially viable process (Case Anellotech)
- Going from R&D innovation to markets: having a network of strategic partners ready to invest in the next phases. i.e industrialization (Anellotech Case)

Environmental awareness of clients

- Targeting the market of conscious clients (Case LocalColours)
- Textile industry growing market of conscious client (case Local Colours)
- Consumers and communities are always more interested in ecological products (case Bâtir-en-balles)

8.2.4 Threats

Competition on the market

- Difficult to be competitive with bio-based products in a context of “too cheap” fossil-based energies (Case PEFerence)
- Entering an existing market with a new product is challenging (case Bâtir-en-balles);
- Difficult to open a market for pellets from digestate as single plant operator (Case Agro Energie Hohenlohe);
- Strong consortium from a financial perspective, but difficult to be competitive with bio-based products in a context of “too cheap” fossil energies. (BBL case)
- Increasing competition with concentration of competitors and lack of raw materials to the legal change and reduction of surface (Grap' Sud)
- There is competition between different sectors for the same agricultural by-products (Case Bâtir-en-balles);
- Large sensitivity to biomass prices (Biopark Temeuzen)
- Producing barbecue briquettes from olive oil by-products is more expensive than regular wood briquettes (Case Oliobric);

Technological aspects

- Seasonality alters the availability of by-products; thus, stocks must be carefully planned (Case Local Colours)
- Outputs (etc: fertilizer) quality varies (Case Agro Energie Hohenlohe)
- The industrialisation process is a critical phase (case Entomeal)
- Getting food security/safety approvals is time consuming; it should be considered carefully in the project design and development (case Dupont Tate & Lyle)

Geographical aspects

- Sufficient space (at least one hectare) is needed to set up a small biogas plant (Case George Martin)
- Far away from the farmers, today farmers are not benefiting from the added value generated via the by-products (Case Grap' Sud)

Financial and economic aspects

- Public financial support is difficult to get (Case Bâtir-en-balles)
- Change in legislation is a risk (case Grap'Sud);
- Dependency on public subsidies (case Grap'Sud)
- Bio-based structural elements are much more expensive to produce compared to those that are mass-produced (Case Bâtir-en-balles);
- Development independent from investors (Biopark Temeuzen)
- The biogas branch relies on subsidies to be profitable (Case George Martin)
- Future remuneration of electricity (power) coming from anaerobic digestion (case Agro Energie Hohenlohe);

Low acceptance

- Resistance from NGOs (Case New Mixed Farm)
- Odour emission needs to be considered when designing the concept of a biogas plant (Case Biogas Plant Grossfurtner)
- Clients do not trust a new kind of fuel (Biogas Pays Rochois)
- Contractors do not know and therefore do not trust an innovative partner in spite of good results (Case Bâtir-en-balles)
- Biogas plants are sometimes not “wanted” in the landscape (Case George Martin)
- Public entities have high quality standards (Biogas Pays Rochois)

8.3 Annex 3 - Results of analysing success and failure factors based on the triggers

Triggers involved in the analysis of success and failure factors, on the External, Contextual and Innovation aspects include:

1. Market need & opportunity
2. Technical development
3. Valorization of by-products, recycling wastes
4. Avoiding or reducing pollution
5. Environmental awareness and need for sustainable development
6. Legislation and incentives
7. Need to cooperate to increase effectiveness
8. Additional income generation
9. Energetical independence

8.3.1 Trigger: Market need & opportunity

Triggers	External		Contextual		Space to innovate	
	Success factors	Failure factors	Success factors	Failure factors	Success factors	Failure factors
Market need & opportunity		Producing barbecue briquettes from olive oil by-products is more expensive than regular wood briquettes (Case Oliobric)	Protect innovative products with a patent makes them more stable and interesting for investors (Case Oliobric)			
			Pellet can reach a burning temperature of 1000 centigrades (Oliobric)			
			Successful collaboration between a German company and farmers in Greece (case Oliobric)			
			Buying olive production by-products to local farmers avoids throwing tons of co-products in the sea (case Oliobric)			Economic promotion of local areas through the creation of new industries, products and jobs (Case Novamont)
	Financial support of the European Union (Case PEference)		Hundreds of thousands of CO ₂ equivalents saved per year (case Novamont)			Development of local areas by using old industrial sites that are decommissioned (case Novamont)
	Use of local biomass resources based on long-term contracts for high security of supply (Case PEference)	Difficult to be competitive with bio-based products in a context of "too cheap" fossil-based energies (Case PEference)	Strategic innovation to anticipate and lead the post fossil-based economy (Case PEference)	High competition with petro-based technologies that are produced at lower costs (Case PEference)		Creation of jobs in rural areas while developing technological know-how (Case PEference)
	The industrialisation process is a critical phase (case Entomeal)	Testing all the assumptions of the business model foreseen; Staying connected to economic realities (Case Entomeal)				
		Pro-active promotion of the project to obtain a permission to produce and public support (Case Entomeal)				
		Designing for sustainability from the start (Case Entomeal)				
		Pro-active citizen awareness raising (Case Entomeal)				
Going from R&D innovation to markets: building a long-term collaboration between the project holder, R&D experts and potential clients (markets) in order to reach a complete effective, economic and commercially viable process (Case Anellotech)		Development of a new technology (MinFree) improve the competitiveness (Anellotech, USA)				
Going from R&D innovation to markets: having a network of strategic partners ready to invest in the next phases. i.e industrialization (Anellotech Case)		Big potential to generate bio- sourced PET, plastic present in many packaging (Anellotech, USA)				

8.3.2 Trigger: Technical development

Triggers	External		Contextual		Space to innovate	
	Success factors	Failure factors	Success factors	Failure factors	Success factors	Failure factors
Technical development	Operational and cost optimization via shared infrastructure (Wood to chemicals, Pilot Plant, Avantium, Netherlands)		Strong technology transfer strategy (Challenge Bioproduct)		Implant plants such as refineries next to wastewater-treatment plants to reduce energy and water consumption through resource exchange (Inbicon)	
			Development and industrialization require different skills (Challenge Bioproduct)		Including clients in the project management (Inbicon)	
		Getting food security/safety approvals is time consuming; it should be considered carefully in the project design and development (DuPont Tate & Lyle)	Large network of commercial partners worldwide (Challenge Bioproduct)			
			Joint venture designed to develop strategic innovations (DuPont Tate & Lyle)		Designing alternative processes that are more than pure alternative; for instance, processes that are bio-based but also source of energy-savings or increased production capacity (DuPont Tate & Lyle)	
	Receives several national and international prizes (Maabjerg Energy Center BioHeat&Power)		Combining the treatment of households' waste with bioethanol and biogas plants to reuse most by-products and to lower CO ₂ emissions (Maabjerg)		Combining a variety of energy and supply tasks in a unified system concept to optimize synergies between individual elements by making efficient use of the energy flows between the individual plants	
	Getting national and international prizes (Maabjerg)		Successful public-private partnership (Maabjerg)		Support local agriculture (Maabjerg Energy Center BioHeat&Power)	

8.3.3 Trigger: Valorization of by-products, recycling wastes

Triggers	External		Contextual		Space to innovate	
	Success factors	Failure factors	Success factors	Failure factors	Success factors	Failure factors
Valorization of by-products, recycling wastes	Strong public support in the long run (Case Bio-refinery Bazancourt Pomacle)		Development of an open technological platform for industrial scaling-up of biotechnology processes (Case Bio-refinery Bazancourt Pomacle)		Geographical proximity of 3 ecosystems: industries, applied R&D and academia (Biorefinery Bazancourt Pomacle)	
			Strong open to the world promotion strategy and strong public and private cooperation (Foundation F. de Bohan, case Biorefinery Pomacle Bazancourt)		Vertical integration via existing agro-food actors in search of value creation through non-food applications (Biorefinery Bazancourt Pomacle)	
			Huge quantity of feedstock available, high storage capacity (Biorefinery Bazancourt- Pomacle)		Economies of scale in a cluster or an agro-industrial park (Biorefinery Bazancourt Pomacle)	
		Development independent from investors (Biopark Temeuzen)			Strong and long-lasting Public-Private partnership at regional level, Eco-industrial park approach leading to advanced industrial symbiosis (Biorefinery Bazancourt Pomacle)	
		Large sensitivity to biomass prices (Biopark Temeuzen)				Locality (Biopark Temeuzen)

8.3.4 Trigger: Avoiding or reducing pollution

Triggers	External		Contextual		Space to innovate	
	Success factors	Failure factors	Success factors	Failure factors	Success factors	Failure factors
Avoiding or reducing pollution			Technology transfer: robust and low-cost solution designed to be implemented in developing and transition countries. Design that fits with the needs of the targeted countries (Case pyrolysis)		Valorization of all the new process co-products in order to be economically and environmentally optimal (Case pyrolysis)	
	To scale-up and commercialize a new marketable technology or process: identify and partner with existing multi-national and eco-innovative actors in the same field (Case FENC Bio-Polyester)		<p>Exceeded achievement in test and effects (NEF fire extinguisher)</p> <p>Certificates (NEF fire extinguisher)</p> <p>Replacing toxic components with natural non toxic products can significantly reduce some hidden costs like the recovery costs of fire extinguishers (Case NEF fire extinguisher)</p>	Initial purchase costs are high, but recovery costs are non-existent (NEF fire extinguisher)		Designing new products that are drop-in replacements enabling full utilisation of existing logistics infrastructure without blending limitations (Case FENC Bio-Polyester)
			Keeping process cost-effectiveness in mind when developing new processes; Designing the all process to reach the highest technical efficiency and thus the highest possible economic performance (Case FENC Bio-Polyester, Case FENC Cellulistic Ethanol)			

8.3.5 Trigger: Environmental awareness and need for sustainable development

Triggers	External		Contextual		Space to innovate	
	Success factors	Failure factors	Success factors	Failure factors	Success factors	Failure factors
Environmental awareness and need for sustainable development	Region has formal destination of agro-development area Fiscal incentives on bio-energy Founding parties developed BioEnergyUnit	Became more decisive after some founding parties dropped out. Resistance from NGOs	Proven technologies for producing a valuable product (organic fertilizer) Economies of scale in a cluster Manure waste in a considerable amount that can be valorized Residual heat is used in farm level. Founding parties developed BioEnergyUnit Cooperation with science: support on selection of technologies and synergies. (New Mixed Farm)		R&D and regional development organizations both support sustainable initiatives	Dependence on fiscal incentives
	Boost local food production (The Magic Factory)		The bio-sourced alternatives solve issues that are not solved by the fossil-based products (Singtex, Taiwan, DuPont Tate) Global strategy in the niche market of functional textiles (Singtex, Taiwan) A vertical integration enables a strong IP and labelling strategy; this enables to build up a strong brand, facilitating cross-industry cooperation and further innovation (Singtex, Taiwan)			
	Consumers, communities are more interested in ecological products	Entering an existing market with a new product is challenging Public financial support is difficult to get Bio-based structural elements are much more expensive to produce compared to mass-produced Contractors do not know and therefore do not trust an innovative batir despite good results	Collaboration between private companies and local municipalities Offers storage for bio residuals Committed, inspired and environmentally conscious majors triggered the implementation (The Magic Factory) 3 different companies in charge of the 3 steps in the biogas (The Magic factory)		Development of Bio-CCP (Carbon Capture Products) in the region	
	Textil industry growing market of conscious client (Local Colours)	Competition between different sectors for the same agricultural by-products	Build an existing cluster High motivation about sustainability and awareness (Batir en balles)		Building an initiative on existing clusters	
	Targeting the market of conscious clients (Local Colours)	Seasonality alters the availability of by-products; thus, stocks must be carefully planned (Local Colours)	Transparency and traceability for an ethical and ecological production is appreciated and an important marketing argument (Local Colours)	Working with fresh by-products requires an efficient logistic (Local Colours)		

8.3.6 Trigger: Legislation and incentives

Triggers	External		Contextual		Space to innovate	
	Success factors	Failure factors	Success factors	Failure factors	Success factors	Failure factors
Legislation and incentives	Public financial support is critical (Case Grap'Sud)	Change in legislation is a risk (case Grap'Sud);	Innovation capacities & product portfolio extension (Case Grap'Sud)	Risk: Public financial support is critical (Case Grap'Sud)		Far away from the farmers, today farmers are not benefiting from the added value generated via the by-products (Case Grap' Sud)
		Dependency on public subsidies (case Grap'Sud)	Optimization of logistics costs (Case Grap'Sud)	Scaling-up might result into not enough (fresh) by-products available in nearby surroundings (case Grap'Sud)		
		Increasing competition with concentration of competitors and lack of raw materials (Grap' Sud)				
	Using local industrial by-products and sewage sludge (Biogas Pays Rochois)	Clients do not trust a new kind of fuel (Biogas Pays Rochois)	Very clean kind of fuel produced (Biogas Pays Rochois)	Technology has never been tested on a large scale (Biogas Pays Rochois)	Innovative technology allowing new processes (Biogas Pays Rochois)	
		Public entities have high quality standards (Biogas Pays Rochois)	Successful public-private partnership (Case Biogas Pays Rochois)			
Possibility to use slaughterhouse by-product as substrate for biogas production (case Biogas Plant Grossfurtner)	Odor emission needs to be considered when designing the concept of a biogas plant (Case Biogas Plant Grossfurtner)	Winning prizes/awards facilitates promotion (Case Westhof, Biogas Plant Grossfurtner)			Using slaughterhouse byproduct as substrate for biogas production vs the disposal costs and can cover a large part of electricity and heat demand (Case Biogas Plant Grossfurtner)	

8.3.7 Trigger: Need to cooperate to increase effectiveness

Triggers	External		Contextual		Space to innovate	
	Success factors	Failure factors	Success factors	Failure factors	Success factors	Failure factors
Need to cooperate to increase effectiveness	Setting-up a large facility/cluster can only happen when local governments, citizens, entrepreneurs and NGOs are involved (Case AgriportA7)		High efficiency infrastructures, local smart-grids and driven Industrial Symbiosis to reduce production costs in an Agro-industrial Park (Case Agriport A7) (Case Agriport A7)	High dependency to fossil-based energy; AgriportA7 acknowledges the risk and plans to be fully independent of fossil-based energy in the future (case AgriportA7)	Available space to grow in the future (Case AgriportA7)	
	Geographical proximity of actors of the primary sector (growers) and actors of the secondary sector (Case AgriportA7)		Optimal logistic model in and out (Case AgriportA7)	High dependency to large investment (case AgriportA7)	Economies of scale in a cluster or an agro-industrial park (Case AgriportA7)	
			Driven top-down strategy to benefit from efficient Industrial Symbiosis (Case AgriportA7)			
	Co-investment in R&D and demonstration plants (BBI Case)	Difficult to be competitive with bio-based products in a context of "too cheap" fossil energies. (BBI case)	Strong consortium from a financial perspective (BBI case)	Need to reach a critical mass for the bio-economy "emerging" sector. Need to organize the value chains and de-risk investments (BBI Case)	Large strategic Public-Private Partnership between the EU and the Bio-based Industries Consortium (BBI Case)	
	Strategic Innovation and Research Program to anticipate and lead the post fossil-based economy (BBI Case)					

8.3.8 Trigger: Additional income generation

Triggers	External		Contextual		Space to innovate	
	Success factors	Failure factors	Success factors	Failure factors	Success factors	Failure factors
Additional income generation	Available local agro by-products (case Agro Energie Hohenlohe)	Difficult to open a market for pellets from digestate as single plant operator (Case Agro Energie Hohenlohe)	Anaerobic digestion is a proven technology (Case Agro feed in Hohenlohe)	Outputs (etc: fertilizer) quality varies (Case Agro Energie Hohenlohe)		
	No seasonality (case Agro Energie Hohenlohe)	Future remuneration of electricity (power) coming from anaerobic digestion (case Agro Energie Hohenlohe)	Well accepted processes (focus on emission reduction CH ₄ mitigation and water protection, energy and material recovery from pig manure) in the local context (case Agro Energie Hohenlohe)			
			Feed-in tariff for electricity coming from anaerobic digestion (case Agro Energie Hohenlohe) Regional nutrient surplus, export needed (case Agro Energie Hohenlohe)			

8.3.9 Trigger: Energetical independence

Triggers	External		Contextual		Space to innovate	
	Success factors	Failure factors	Success factors	Failure factors	Success factors	Failure factors
To be energetically independent	<p>Possibility of valorizing all by-products when involving other local businesses (George Martin)</p> <p>The biogas branch is supported by the states (Switzerland and EU) and the current strategy wants to support the use of alternative energies (George Martin)</p>	<p>The biogas branch relies on subsidies to be profitable (George Martin)</p> <p>Biogas plants are sometimes not "wanted" in the landscape (George Martin)</p>			<p>The construction cost of small biogas plants can be reduced a lot by self-building (George Martin)</p>	<p>Sufficient space (at least one hectare) is needed to set up a small biogas plant (George Martin)</p>
			<p>A large organic vegetable producer is almost energetically neutral due to energy synergies between their biogas production plant using vegetables co-products as substrate, in their greenhouse and freezing facility (Westhof)</p> <p>Traceability, high quality standards and fair agriculture attract clients even if the products are a bit higher than conventional ones (Westhof)</p>			

8.4 Annex 4 - Business model canvas examples

8.4.1 Case 1 – PHA/PHBV for the replacement of PE in packaging applications

<p>7. Key partnership (KP)</p> <ul style="list-style-type: none"> • Farmers with proper agro-wastes. • Customers, the users of PHA/PHBV plastics • Universities and research institutes • Partner laboratories if needed 	<p>6. Key Activities (KA)</p> <ul style="list-style-type: none"> • Producing PHA/PHBV pellets from agro-waste. • Logistics, collecting and transportation of agro-waste to the production site • Quality control of the raw material • Quality control of the product • Pre-treatment, storage • Keeping contacts with customer segments • Marketing and selling activities 	<p>1. Value Propositions (VP)</p> <ul style="list-style-type: none"> • Biodegradable plastic for packaging with similar properties to PE. • PHA/PHBV granulates have similar properties to PE granulates, so it can be adjusted into PE molding equipments using some adjustments. No need to change machinery. • Reducing environmental impact of containers and packaging. Environmental awareness. (Triggers) 	<p>4. Customer Relationships (CR)</p> <ul style="list-style-type: none"> • Personal assistance • Long-term relationships with customers 	<p>2. Customer Segments (CS)</p> <ul style="list-style-type: none"> • Food processing factories • Container producers • Packaging producers
<p>9. Cost Structure (C\$)</p> <ul style="list-style-type: none"> • Technology investment is a major cost • Logistics of collecting and transporting agro-wastes • Production costs (materials, energy, etc.) • Staff costs • Marketing costs 		<p>3. Channels (CH)</p> <ul style="list-style-type: none"> • Own sales network. Only B2B sales. • Personal contact • Online channels • Attending conferences, exhibitions, workshops <p>8. Revenue Streams (RS)</p> <ul style="list-style-type: none"> • Selling PHA/PHBV granulates for producing packaging purpose • Consultancy for customers 		

8.4.2 Case 2 – Biocomposites

<p>7. Key partnership (KP)</p> <ul style="list-style-type: none"> • Farmers with proper agro-wastes. • Customers, the users of biocomposites plastics • Universities and research institutes • Partner laboratories if needed 	<p>6. Key Activities (KA)</p> <ul style="list-style-type: none"> • Production of biocomposites • Logistics, collecting and transportation of agro-waste to the production site • Quality control of the raw material • Quality control of the product • Pre-treatment, storage • Keeping contacts with customer segments • Marketing and selling activities <p>5. Key Resources (KR)</p> <ul style="list-style-type: none"> • Knowledge, well-educated employees, competent workforce in the field • Agro-waste • Equipment • Modern technology production 	<p>1. Value Propositions (VP)</p> <ul style="list-style-type: none"> • automotive interior components made of renewable biocomposites • sports equipment made of renewable biocomposites • more sustainable production for producers (environmental awareness) • avoiding or reducing pollution by changing composite materials • targeting environmental conscious end-users 	<p>4. Customer Relationships (CR)</p> <ul style="list-style-type: none"> • Personal assistance • Long-term relationships with customers <p>3. Channels (CH)</p> <ul style="list-style-type: none"> • Own sales network. Only B2B sales. • Personal contact • Attending conferences, exhibitions, workshops 	<p>2. Customer Segments (CS)</p> <ul style="list-style-type: none"> • sport equipment producers • automotive sector, factories
<p>9. Cost Structure (C\$)</p> <ul style="list-style-type: none"> • Technology investment is a major cost • Logistics of collecting and transporting agro-wastes • Production costs (materials, energy, etc.) • Staff costs • Marketing costs 		<p>8. Revenue Streams (RS)</p> <ul style="list-style-type: none"> • Selling biocomposites 		

8.4.3 Case 3 – Advisory service on biotechnology for farmers on innovative waste valorization technologies

7. Key partnership (KP) <ul style="list-style-type: none"> • Farmers with proper agro-wastes. • Universities and research institutes • Partner laboratories for analysing agro-waste composition and quality 	6. Key Activities (KA) <ul style="list-style-type: none"> • Consultancy • Engineering the chosen technologies • Analysing agro-waste composition and quality, laboratory work and evaluation of the results • Keeping up-to-date with literature and biotechnology development • Keeping contacts with farmers • Keeping contacts with research institutes • Marketing activities 	1. Value Propositions (VP) <ul style="list-style-type: none"> • Advisory service for farmers on innovative waste valorization technologies • Valorizing waste and saving waste management costs for farmers • Cheap energy production possibilities for farmers • Other benefits based on the selected biotechnology • Reducing environmental impact of farming 	4. Customer Relationships (CR) <ul style="list-style-type: none"> • Personal assistance • Long-term relationships with customers 	2. Customer Segments (CS) <ul style="list-style-type: none"> • Farmers • Food processors
	5. Key Resources (KR) <ul style="list-style-type: none"> • Knowledge, well-educated employees, competent workforce in the field • Laboratory equipment • Engineering softwares if needed • Decision support tool 		3. Channels (CH) <ul style="list-style-type: none"> • Own sales network. Only B2B sales. • Personal contact • Online channels • Attending conferences, exhibitions, workshops 	
9. Cost Structure (C\$) <ul style="list-style-type: none"> • Staff costs • Marketing costs • Travelling costs • Laboratory costs 			8. Revenue Streams (RS) <ul style="list-style-type: none"> • Consultancy for farmers 	

8.5 Annex 5 - Applicable EU policy documents

Document title	Publication date
Nitrates Directive – 91/676/EEC	December 1991
Landfill Directive – 1999/31/EC	April 1999
Regulation on shipments of waste – (EC) 1013/2006	June 2006
Waste Framework Directive – 2008/98/EC	November 2008
Regulation on the EU Ecolabel – (EC) 66/2010	November 2009
European Commission – Taking bio-based from promise to market. Measures to promote the market introduction of innovative bio-based products	November 2009
Industrial Emissions Directive 2010/75/EU	November 2010
A Roadmap for moving to a competitive low carbon economy in 2050 (COM(2011)112 final)	March 2011
Roadmap to a Resource Efficient Europe (COM(2011)571)	September 2011
Innovating for Sustainable Growth: A Bioeconomy for Europe, DG for Research and Innovation, EC	February 2012
2030 Climate & Energy framework (COM/2014/015final)	October 2014
Lightweight plastic carrier bags Directive – 94/62/EC	April 2015
Circular Economy Action Plan COM (2015) 614	December 2015
A global view of bio-based industries: benchmarking and monitoring their economic importance and future developments, JRC Technical Report	February 2016
JRC Science for Policy Report. Bioeconomy Report 2016.	May 2017
Study on Access-to-finance conditions for Investments in Bio-Based Industries and the Blue Economy – European Investment Bank	June 2017
EPR in the EU Plastics Strategy and the Circular Economy: A focus on plastic packaging (IEEP Report)	November 2017
A European Strategy for Plastics in a circular economy COM(2018) 28	January 2018
Communication on a monitoring framework for a circular economy COM(2018) 28	January 2018
Commission action plan on financing sustainable growth COM(2018) 97 final	March 2018
OECD Meeting Policy Challenges for a Sustainable Bioeconomy	April 2018
Directive on packaging and packaging waste – Directive (EU) 2018/852	May 2018
Directive on organic production and labelling of organic products – (EC) 834/2007	May 2018
Guidance on Innovation Procurement – COM(2018) 3051	May 2018
Proposal for a Single Use Plastics Directive – COM(2018) 340	May 2018
A European Strategy for plastics in the circular economy. Local and regional dimension	June 2018

A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment. Updated Bioeconomy Strategy – COM (2018) 673/2 & SWD (2018) 431	October 2018
Communication on A Clean Planet for all – COM(2018) 773	November 2018
OECD – Realising the circular Bioeconomy	November 2018
Legal Limits on Single-Use Plastics and Microplastics: A Global Review of National Laws and Regulations (UNEP)	December 2018
Directive on the promotion of the use of energy from renewable sources – 2018/2001/EU	December 2018
EMAS regulation – (EU) 2018/2026	December 2018
EC – Reflection Paper – Towards a Sustainable Europe by 2030	January 2019
Report on Implementation of Circular Economy Action Plan – COM(2019) 90 and SWD(2019) 91	March 2019
Commission Staff Working Document on Sustainable Products in a Circular Economy – SWD(2019) 92	March 2019
Regulation on EU fertilising products – (EU) 2019/1009	June 2019
Single Use Plastics (SUP) Directive – (EU) 2019/904	June 2019
New Plastics Economy Global Commitment Report (UNEP)	June 2019
OECD – Policy approaches to incentivise sustainable plastic design	July 2019
The European Green Deal – COM(2019) 640	December 2019
Sharing Europes Digital Future COM(2020) 67	February 2020
EU New Circular Economy Action Plan	March 2020
European climate law – achieving climate neutrality 2050	expected May 2020
Sustainable food – ‘farm to fork’ strategy	expected 2020
Revision of all relevant climate-related policy following the review of Emissions Trading System Directive; Effort Sharing Regulation; Land use, land use change and forestry Regulation; Energy Efficiency Directive; Renewable Energy Directive;	expected 2021
Review of the Industrial Emissions Directive, including the integration of circular economy practices in upcoming Best Available Techniques reference documents	expected 2021
Review to reinforce the essential requirements for packaging and reduce (over)packaging and packaging waste	expected 2021
Restriction of intentionally added microplastics and measures on unintentional release of microplastics	expected 2021
Policy framework for bio-based plastics and biodegradable or compostable plastics	expected 2021

8.6 Annex 6 – Pictures of bioplastics specific labels

Bio-based plastics	<p>BioPreferred label (USDA, 2018) Issuer: United States Department of Agriculture Method: ASTM 6866</p>	
	<p>DIN Geprüft Bio-based certification (TÜVRheinland, 2016) Issuer: TÜVRheinland Standard: CEN/TS 16137 and ISO 16620, percentage of bio-based carbon content using the ¹⁴C method.</p>	
	<p>NEN bio-based content (NEN, 2016) Issuer: Netherlands Standardization Institute (NEN) Standard: EN 16785-1</p>	
Industrially compostable	<p>OK biobased (TÜVAustria, 2016) Issuer: TÜV Austria (formerly: Vinçotte) Standard: EN 16137 (percentage of renewable raw materials, % Bio-based)</p>	
	<p>Seedling (European Bioplastics, 2016) Trademark holder: European Bioplastics Standard: EN 13432/EN 14995</p>	
Home compost	<p>TÜV - DIN Geprüft and OK compost (Industrially) Issuer: TÜV Standard: EN 13432</p>	
	<p>TÜV - DIN Geprüft and OK compost (Home) Issuer: TÜV Standard (DIN Geprüft): NF T51-800 Standard (OK compost): not referenced</p>	
Biodegradable	<p>TÜV - DIN Geprüft (soil only) and OK biodegradable Issuer: TÜV Standard (DIN Geprüft): CEN/TR 15822 Standard (OK compost): not referenced</p>	

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