WaysTUP!

VALUE CHAINS FOR DISRUPTIVE TRANSFORMATION OF URBAN BIOWASTE INTO BIOBASED PRODUCTS IN THE CITY CONTEXT

D6.1: Market Outlook Report

WP6 – New business & marketing concepts along the entire value chain from urban biowaste

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Executive summary

This deliverable is a direct outcome of **Task 6.1 Analysis of market outlook**, a task implemented in the context of **WP6 New business concepts along the entire urban biowaste value chains**. Task 6.1 is focused on the development of a complete view of the entire urban biowaste value chain **focusing on a detailed market analysis, which is implemented in the context of this deliverable.**

At the first part of the Deliverable, the **overall concept and methodological approach** is presented and analysed. **The methodology is strongly related with the aims and the objectives of the deliverable**, and it is a drafted in such a way that it serves the overall concept if the work elaborated. Both **Secondary (Desk research) methods**, as well as **Primary (questionnaires)** research methods were utilised in order to safeguard the deliverable's methodological integrity.

A presentation of the **Project Pilots** takes place in the next part of the deliverable in order to get a **brief but comprehensive view** of all the issues that are relevant with the core od the deliverable, since **the bulk of the research is focused on the Pilot solutions.** A **Market Overview** focusing on the **Trends in European Industry** follows, providing insights on the current situation in the European Industry and the future of it, **identifying and analysing where and how industries are transforming themselves** and where **new specialization patterns give rise to the emergence or renewal of industries**. Trend analysis is crucial for companies as it helps them quickly **adapt to the market changes** and **stay ahead of competitors**. It has to be pointed out, that for each chapter of the deliverable, **an estimation on the impact of COVID-19 is also presented.**

The next part of the report is focused on **EU Circular Economy/Bioeconomy** by exploring **EU Policies** in the Bio-economy area as well as **national and local policies**. Furthermore, the **Social, Economic and Environmental Impacts** of the bioeconomy is explored, while **Future Opportunities and Developments** in the Bioeconomy are identified, together with the examination of a number of **technical barriers** that could hinder the adoption of circular economy solutions, always of course with a focus on the WaysTUP! Pilot Solutions.

The **Market Breakup by geographic areas** (countries) that follows, incorporates the geographic segmentation **by countries where the WaysTUP! Pilots are taking place**. By taking a closer look into the current **economic, political and technological situation within these counties**, we have chance for a deeper look into specific issues of interest focusing on geographical characteristics. More specifically, we examine the **United Kingdom, Spain, the Czech Republic, Italy and Greece.**

The geographical analysis is followed by the **Market Breakup by technology type**. This section is dedicated to the **technological processes** that will be implemented within WaysTUP! Project (fermentation, extraction, larval breeding, and slow pyrolysis). Each of these processes will enable the production of targeted end product, therefore it is crucial to understand **how these processes work, what they entail, how they can be applicated for different purposes and what their major products are.** In order to identify different factors and possibilities on the market that can have an impact on the final realization of Pilots' business solutions, **potential markets of the primary products that come as a result of technical processes are explored.**

A **Market Breakup by end products** is the next section of the deliverable, focusing on **end products that will come as results of technological processes applied within WaysTUP! Pilots**. The aim of this chapter is to **identify characteristics of these end products**, **their applications in different industries** and also to **analyse the markets of each relevant industry** where the final transactions will take place in a value chain. For all the end-products, **a definition is provided, as well as Product/application insights, a Market analysis and the relevant conclusions.**

The following part of the report consists of the **Market Breakup by end users/industry**. This chapter is dedicated **to plastic, food and feed, chemical and biofuel industries, as well as biofertilizer market.** These markets are key drivers of the future WaysTUP! Pilots' value chain growth and development. The aim of this chapter is to inform WaysTUP! Pilots' supply chain actors about the current and future trends of each market in order to help them to compete in the marketplace.

A **Competitive Landscape initial analysis** follows, whereas potential competitors and their relative position at a particular market are examined. So, an **initial scanning of competitive landscape** is taking place by identifying who are **the most prominent players on the Pilots' potential markets**, that are actually **Pilots' future competitors**, and also by **understanding main attributes of competitors' market strategies, vital strengths of their products, as well as their current weaknesses.** By knowing this information, Pilots will be able to brainstorm about what could be their **potential advantages** in **comparison to their future competitors**, as well as what characteristics of their businesses should be improved.

The last part of the report include an examination and analysis of the p**otential opportunities within geographical areas of pilots' interest.** At this point, it is very important to focus on **finding the right position for every Pilot on the EU market** and look for **opportunities to expand to other geographical areas and markets**. In order to see the full potential of their end products, develop strong business structures and reach sustainable income and production, Pilot stakeholders are strongly advised to **consider following current industry trends** regarding **cross-sectoral and cross-industry collaboration**, including smart specialization as a starting point.

1. Introduction

This deliverable is a direct outcome of **Task 6.1 Analysis of market outlook**, a task implemented in the context of **WP6 New business concepts along the entire urban biowaste value chains**. Task 6.1 is focused on the development of a complete view of the entire urban biowaste value chain **focusing on a detailed market analysis, which is implemented in the context of this deliverable.** Overall, the scope of the market outlook is focused on the **market drivers and barriers to entry for technologies and end-products** stemming from the **Project's Pilots**, taking into account **economic, scientific/technological, political and organizational factors** for **different geographic areas, technological solutions, end-products and user groups**. Moreover, the deliverable is taking into account the **economic models for the Pilot solutions**, including the value of the solutions to each stakeholder group, while it initially identifies **potential markets** for deployment of Pilot solutions beyond the pilot stage, including identification of potential early adopters.

Overall, the **Market Outlook Report** examines **the bulk of the external environment** on which the outcomes of the **WaysTUP! Pilots** (end-products, technologies) are expected to be **launched and exploited** (both scientifically and commercially). The **findings of this Report will be utilised** as a **valuable input for the elaboration of the next steps towards the implementation of WP6**. More specifically, the analysis of the external environment will guide us towards the **conceptualisation and generation of new Business Models implemented around the Pilots** (Task 6.2 Development and setup of innovative business models and marketing strategies for valorising urban biowaste / D.6.2. Business Models Analysis), while it will also provide **valuable feedback for the elaboration of D6.3, Individual business and marketing strategies** for Project Partners participating at the pilots.

2. Methodology

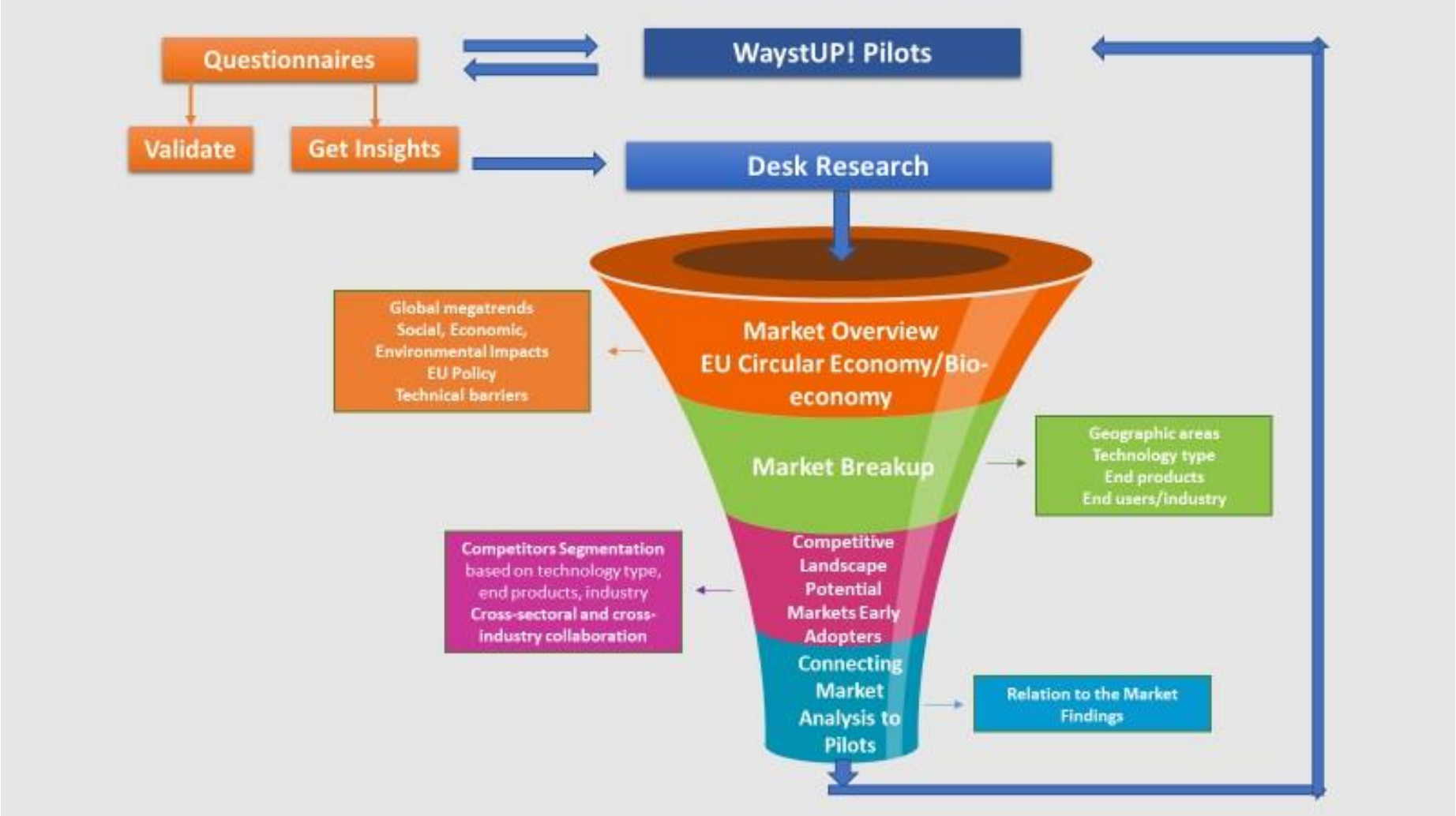
In order to successfully implement the deliverable and taking under consideration the **immense amount of data and information** needed to be **investigated, gathered, analysed and presented**, a robust **research methodology** had to be planned and elaborated. Against this background, **a combination of both secondary and primary research methods** where utilised in order to achieve optimal research results.

More specifically, the **primary research method** used, involved the elaboration and distribution of **questionnaires,** addressed to the WaysTUP! Project Partners that are participating in the projects' Pilots. The questionnaires included **open-ended questions** providing insights on the current situation, as well as the Pilots' interests for a plethora of issues relevant to this deliverable (more detailed information about the scope and structure of the questionnaires will follow). Overall, the questionnaires provided valuable feedback which **guided parts of the deliverable** in order to be relevant to the **pilot's needs and requirements**.

In terms of **secondary research (or desk research),** a huge number of available resources where utilised (more detailed information will follow). All the information was examined in a **critical manner**, while the report strived to **connect all the findings with issues relevant to the project needs**, and more specifically to the **needs of the pilots**. The **basic pillars** of the secondary research include a general Market Overview and an overview of the EU Circular Economy/Bio-economy, a detailed Market Breakup (Geographic areas, Technology type, End products, End users/industry), an analysis of the Competitive Landscape, a Cross-sectoral and cross-industry collaboration analysis together with information on Potential Early Adopters, and of course the connection of the overall Market Findings to the WaysTUP! Pilots.

It has to be pointed out that before the initiation of writing this report, **all contributing organisations discussed and agreed upon the Table of Contents.** Based on this discussion, all contributing partners, took over specific parts of this deliverable, based **both in their background and expertise**, as well as **based on their geographical location** (e.g. Greek partners provided information about Greece, Spanish about Spain and so on).

In the following chapters, **we present the overall methodological approach** of this report in a detailed and comprehensive manner, while this Methodological Approach is also **diagrammatically presented** in the Figure below**:**


Questionnaires
Validate
Get Insights
WaystUP! Pilots
Desk Research
Global megatrends
Social, Economic,
Environmental Impacts
EU Policy
Technical barriers
Market Overview
EU Circular Economy/Bio-economy
Market Breakup
Geographic areas
Technology type
End products
End users/industry
Competitors Segmentation
based on technology type,
end products, industry
Cross-sectoral and cross-industry collaboration
Competitive Landscape
Potential Markets Early Adopters
Connecting Market Analysis to Pilots
Relation to the Market Findings

2.1 Secondary Research - Methodology and Techniques

The Market Outlook Report **relies mainly on secondary research (or Desk research), with analysis and synthesis of existing reports, studies and other available market data**. The desk research took under consideration and examined a plethora of **different sources of information**.

Desk research **is not only about collecting data** but also **to review previous research findings** to gain a broad understanding of the field. Overall, desk research is very effective and can be conducted in starting phase of market research as it is quite quick while most of the basic information could be easily fetched which can be used as benchmark in the research process.

In the context of this Deliverable, we used the following Desk Research Methods and Resources:

i. Internal Desk Research:

Internal desk research can be treated as the most reasonable starting point of research. Much Information could be generated internally within any organisation. In this context, **internal information** considering all the relevant scope of the deliverable where sought internally by the participating organisations that were expected to provide input on the context of the deliverable.

ii. External Desk Research:

External Desk Research involves research done outside the organisational boundaries and collecting relevant information. Some of the external resources used are described below:

- Previous research
- Government reports
- Official statistics
- Various Web information
- Historical data
- Encyclopedias
- Journal articles

- Research analysis
- Dissertations
- Works of criticism and interpretation
- Financial sources such as profit and loss statements balance sheets, inventory records, sales records and etc.

Secondary Research issues encountered:

In order to safeguard the integrity of the secondary research results, we had to take under consideration the **main potential problems** that could be encountered in the context of the research and are summarised below:

- Information may be outdated, therefore inaccurate.
- The data may be biased, and it is hard to know if the information was collected is accurate.
- The data was not relevant to the original context.

In order to **minimise the risk stemming from biased findings of the desk research**, we followed a structured methodological approach which is presented at the following table:

Step	Stage	Description
1	Identify Major Resources	Identify the most popular secondary resources for finding relevant information based on the criteria set out by the research scope (e.g. Market Information Geographical Information etc)
2	Validate Major Resources	Compare the initial findings (from major resources) with other secondary resources. In that way we are able to validate that the information coming from our major sources is accurate
3	Internal Cross Check	Check the resources Internally between the members of the consortium (review process)
4	Organization and Clean-up of Data	• Organize all data collected per country, per sector

		• Standardise results • Ensure all data and information is unified • Clear duplicated data
5	Involve Project Partners	Different parts of the deliverable where elaborated by different contributors/project partners based on their expertise as well as based on their geographical positioning

2.2 Primary Research / Questionnaires

In order to obtain better insights related to the deliverable's research scope and objectives, primary research methods were also utilised. More specifically, **questionnaires** where preferred since they provide the research flexibility required based on the scope of the deliverable.

Advantages of using questionnaires:

- Easy to conduct and surely, large amounts of information can be obtained from a large number of respondents. Questionnaires are also cost-effective when the research aim to target a large population.
- Broad coverage. Local, national, and international respondents can be easily reached by questionnaires..
- Responses received are frank and anonymous. Unlike interviews, questionnaires are good for sensitive & ego-related questions, as well as IPR sensitive questions.
- Carrying out research with questionnaires is less time consuming and respondents can fill in questionnaires at a convenient time as well.

Disadvantages of questionnaires:

The main disadvantages of using questionnaires: and how these disadvantages were overcome are presented below:

- **Problem:** No clarification for ambiguous questions.
- **Solution:** All the questions included in the questionnaire where straightforward and easy to understand. Besides this, explanatory texts where provide for each question

(where needed), while at the same time a member of the team was available to reply to any question and provide further clarifications if necessary.

- **Problem:** Inadequate motivation to respond. Unattractive style and format of questionnaires may also put some respondents off.
- **Solution:** The questionnaire design was straightforward and very easy to follow. Moreover, some basic questions where pre-filled for each Pilot. In terms of motivation: The scope of the questionnaire was explained in detailed to the respondents (Pilots) in the context of WP6 Project Meeting (online).

- **Problem:** Some questions may be poorly worded, while some others may be very direct. Many researchers also argue that questionnaires lack validity as they yield information without explanation.
- **Solution:** All the questions included in the questionnaire where straightforward and easy to understand. Besides this, explanatory texts where provide for each question (where needed), while at the same time a member of the team was available to reply to any question and provide further clarifications if necessary.

- **Problem:** Low response rate as questionnaires may not simply be suitable for some respondents.
- **Solution:** The responders where only Project Partners (Pilots), so a 100% response rate was achieved.

Types of questions and Scope of the Questionnaire:

Different types of questions to obtain a variety of information. Therefore, questions may be open-ended and close-ended. Likewise, questions may be structured and unstructured.

In the context of elaborating Deliverable 6.1 Market Outlook Report, we drafted a short questionnaire. The purpose of this questionnaire is to get your feedback in order for the Deliverable to be as relevant as possible to the Pilots and their participants.

Basic instructions:

- In each part of the questionnaire, we already had indicated the organization that needs to provide the reply (the organisation short name is in brackets). So, every organisation referred in the questionnaire must reply one or more questions. In case there are more than one organisation included in a question, all of them should provide an answer. Each organisation should fill in the questionnaire separately
- Some questions are there in order to verify that the status of the Pilot in terms of processing technologies, feedstock and end-products are the same with the initial planning (proposal stage).

- In case there are questions that any organisation does not wish to reply due to confidentiality issues, there was the possibility to state that this is “confidential information”
- In case there are questions that any organisation cannot reply for any other reason (there was the possibility to state “Information not available”.

Questionnaire Design:

The design of the questionnaire can be found at ANNEX 1.

2.3 Next Steps

Besides the contents, scope and approach of the current deliverable, there is a number of **next steps** that are expected to **enhance the usability of the deliverable** towards to the various stakeholders that is directed to, but most importantly towards the main stakeholders, which are **WaysTUP! Pilots**.

Against this background, there **is a number of complementary next steps** will be implemented in order to safeguard the **further utilization of the deliverable**.

Step 1 – Dedicated Workshop:

A dedicated workshop will be implemented, which will be directed to the **WaysTUP! Pilots.** In the context of this Workshop, we will be able to present the findings of this deliverable to the Pilots but also to the whole project consortium. Therefore, on the one hand we will able to present the most important findings in a more targeted and interactive manner, while on the other hand we will be able to get valuable feedback for specific issues.

Step 2 – Deliverable Summary: We will develop a summary of this deliverable, thus serving a two-fold purpose:

Communication and Dissemination Purposes: The summary can serve as a very useful communication and dissemination tool for the project (the length of the deliverable is too big to distribute externally for such purposes).

Handiness for external readers: The summary will facilitate readers (which might not be interested in many details) to have a summarised but also very clear picture of the findings of the deliverable.

3. WaysTUP! Pilots

WaysTUP! Partners (Pilots) have led or participated in ongoing or completed EU-funded and national research projects related to waste management, biomass conversion, and biorefinery applications, which led them to develop knowledge and networks that will definitely be beneficial for project implementation.

Each Pilot was asked to **complete a questionnaire** and share the most important information regarding specific challenges and problems within their value-chains, competition, and potential obstacles on the market. **Their answers were thoroughly examined and used as very important inputs for further research.**

In the following table (Table #) the pilots that will be demonstrated through the project are illustrated.

	Pilot 1	Pilot 2	Pilot 3	Pilot 4 (A&B)	Pilot 5	Pilot 6	Pilot 7
Name:	Food & Feed	Coffee Oil	Insect Protein	Bioplastics	Biosolvents	PERSEO	Biochar
Place:	Valencia (Spain)	London (UK)	Alicante (Spain)	Prague (Czech)	Athens (Greece)	L´Alcúdia (Spain)	Chania, (Crete Greece)
Owner:	SAV	BIO-BEAN	UA	NFG	NTUA	IMECAL	TUC
Type of feedstock:	Meet waste; Fish waste; Coffee waste	Coffee waste	Source separated biowaste	Used cooking oils and coffee oil	Source separated biowaste	Cellulosic rejection streams MSW/ WWTP	Sewage sludge
Feedstock provider:	SAV	BIO-BEAN	SAV	NFG, BIO-BEAN	SUST	AMB	TUC
Process:	Fermentation	Extraction	Larval breeding	Fermentation	Non-isothermal simultaneous saccharification and fermentation after mild drying	Simultaneous saccharification and fermentation after acid hydrolysis	Slow pyrolysis
Process partner:	BIOPOLIS	BIO-BEAN	UA	NFG, AIMPLAS, NVMT	NTUA	IMECAL	NTUA
End-product:	Functional ingredients; gelatine and active peptides; flavours, polyphenols, carotenoids	Coffee-oil	Insect protein (protein insect flour)	Monomers and PHAs; and long chain dicarboxylic acid to bioplastics for packaging	Biosolvents (i.e. bio-ethanol, bio-butanol)	Bioethanol / Biosolvents etthylactate	Biochar
End-product partner(s):	BIOPOLIS	BIO-BEAN	UA	NFG, AIMPLAS, NVMT	NTUA	IMECAL	TUC
Capacity:	5 tonnes/week	5 kg/day Coffee Oil	0.25 tonnes per week of homogenised feedstock	Pilot4a: 15 kg/one operational cycle Pilot4B: 1ton/Batch	50 kg dried biowaste/operational cycle	25 tonnes / day	600-800 kg biochar/month
TRL final:	7	7	7	7	7	7	7

Table 1 Summary characteristics of WaysTUP! Pilots

3.1 PILOT 1: Food & Feed

PILOT 1 will be located in **Valencia (Spain)**, in SAV facilities located in Paiporta (Valencia). **Feedstock** will be **meat by-products** such as blood, bones, meat trimmings, skin, fatty tissues, horns, hoofs, feet, skull, and viscera, among others; **fish by-products** consisting of head, tails, skin, entrails, fins, and frames, and **spent coffee grounds** provided by SAV. The pilot will have a capacity of **5 2,000 tpy of waste treated.**

Spent Coffee Grains will be utilized for the extraction of flavors, polyphenols, and oils. Carotenoids will be obtained by fermentation. Production of functional ingredients from animal by-products i.e. active peptides and enzymes for tendering.

Food and Feed pilot will also focus on **the extraction of gelatin and active peptides**. A series of interventions towards behavior change of citizens for their participation in the collection of urban bio-waste will be implemented, led by VAL and supported by local user communities. Local stakeholders will be involved, through links with relevant social innovation activities that are in place.

3.2 PILOT 2: Coffee Oil

PILOT 2 will be located in **Alconbury, Cambridgeshire (UK)**. **Feedstock** will be s**pent coffee grounds**, provided by BIO-BEAN which is the first company in the world to industrialize the process of recycling Spent Coffee Grounds (SCG) into advanced biofuels. PILOT 2 **end-product will be coffee oil** which will be also used as feedstock for synthesis of long-chain dicarboxylic acids and PHAs which will ultimately be used to produce **biodegradable bio-plastics** in PILOT 4A and potential use in many other chemical processes. Currently bio-bean are extracting coffee oil at a lab-scale using a variety of technologies, including **conventional solvent extraction** (SE) and **supercritical fluid extraction** (SFE). PILOT 2 will scale-up **SFE technology** that is already in place at a laboratory scale from BIO-BEAN. PILOT 2 capacity will be **5 kg/day Coffee Oil**. The unit will consist of extraction and collection chambers. The latter of which will contain various extracted coffee oils. Moreover, auxiliary equipment such as heat exchangers, chillers, solvent recovery systems, solvent storage systems, and material handling systems will be required.

Examination of the questionnaire Pilot 2 provided gave important insights regarding **the main challenges** they are facing - **legislative framework and market prices.** Since the coffee oil market is not saturated at all and Pilot 2 is providing a unique end-product (biomass from the coffee ground), there are **no direct competitors on the market.** In terms of competition, Veolia is the only major waste management company that can be considered.

The main advantage of the Pilot is The first-mover advantage - they have already secured a large feedstock in supply from Costa and Nestle and we are able to process it and turn it into biomass. Currently, Pilot 2 is the **only company that can process coffee at this scale**.

3.3 PILOT 3: Insect Protein

PILOT 3 will be located in **Alicante (Spain)** in the Alicante Science Park (ASP). Currently, the pilot plant has a surface of 90m2. **Feedstock** material will be **meat by-products** such as blood, meat trimmings, skin, fatty tissues, bones, feet, and viscera, among others; **fish by-products** consisting of head, tails, skin, entrails, fins, and frames, containing mainly proteins, fats, and minerals; and **spent coffee grounds** provided by SAV. **Source separated biowaste** will be also used as feedstock. It will have **a capacity of 0.25 tpw of homogenized feedstock**. In Pilot 3 the artificial rearing of the **Black Soldier Fly Hermetia illucens** will take place. The specific type of fly grows in a wide range of organic substrates. Furthermore, blowflies, **Calliphoridae** will grow on the feedstock of animal origin. Both types of flies **can work simultaneously** improving the final result. **The massive production of larval biomass** will be performed based on in-house know-how developed by UA through bio-digesters for growing of larvae and automated harvesting systems. The feedstock, to be used as larval feeding media, will be pre-treated appropriately to **maximize the capacity of the pilot.**

Examination of the questionnaire the Pilot 3 implied that **the main challenge with larval biomass** is to **introduce it as a new ingredient** of the animal feed and to standardize the product and **take the production to a full industrial scale.** There are other companies on the market, that rear insect as animal feed or human food in Europe, as *Ynsect* (France), *Protix* (Netherlands), *Hipromine* (Poland) or *Hermetia Baruth* (Germany). These companies can be viewed **as direct competitors** to Pilot 3, but Pilots' greatest **advantages** about competition are definitely the development of **their know-how** and **efficiency of industrial production.**

3.4 PILOT 4: Bioplastics

PILOT 4.A is located in **Prague (Czech Republic)**. **Feedstock** for PILOT 4A will be **used cooking oil** (UCO) from restaurants and canteens (NFG) and **coffee oils** (BIO-BEAN). NFG technology is the first one which is converting UCO for PHA production which will be then converted to bioplastics for packaging. **PILOT 4.B** is located in **Terni (Italy)**. **Feedstock** for PILOT 4B will be UCO from restaurants and canteens (NFG) for IcDCA production through fermentation starting from the selected UCO and **based on an enhanced microorganism with low biological risk** (BSL1) and improved performances. The fermentation will be performed in

batch mode in **Piana Di Monte Verna Pilot Plant (Italy)** by employing a genetically modified microorganism (Candida strain, biosafety level 1) able to convert fatty acids into lcDCA by NVMT. Then using lcDCA **bioplastic production will be implemented.** The obtained lcDCA will be used in the formulation of **biodegradable and compostable polyesters** using the first Novamont **pilot facilities in Novara (50 Kg/h)** and for the further upscale at TRL7. NVMT will leverage the industrial facilities owned by NVMT in Terni in the batch process **(up to 10,000 tonnes/year).** Within the project, NVMNT will demonstrate at TRL7 in a relevant industrial environment the **formulation of biobased and biodegradable polyesters** based on long-chain dicarboxylic acids with **enhanced properties** compared to already produced biopolyesters. Reactive extrusion with other organic and inorganic additives will be evaluated by NVMT to **further enhance the thermal and physical characteristics of the targeted materials** towards its application into the secondary packaging.

As stated in the questionnaire, a great **challenge** for Pilot 4 is linked to the necessity to create a **clear and stable legislative framework**, an essential element to encourage investment. The diffusion of **high-quality standards** for circular and bio-based products is **still not sufficient and demand support measures** that allow innovative and sustainable products to compete with existing ones need to be implemented. The **lack of homogeneity of the authorization approach** regarding End Of Waste criteria is another important challenge to face in the future (which is essential to utilize biowaste as secondary raw material for new biobased products). **Customer education** in the field of organic cosmetics is also highlighted as an obstacle and it is imperative to deal with **social awareness** in this field. Working to raise awareness of the general public, a path is being built towards **solving the problem of accepting higher prices** for green and sustainable products. **The biggest competitors** in the bioplastics market are Technologic centers such as *Itene*, *Gaiker,* or *Aitiip*, at the national level, and *Fraunhofer* or *TNO* at the international level. But, **Pilot 4's main market advantages** are years and years of experience in bioplastics for different sectors in the value chain, possession of the pilot plant equipment to modify the materials and process them to obtain samples or prototypes. Knowledge of materials characterization, properties, and the best end of life (recycled, composted), together with the emphasis on quality research and development, marketing, and a worldwide network of contacts, puts Pilot 4 in a great starting position.

3.5 PILOT 5: Biowaste Biosolvents

PILOT 5 will be located in **Athens (Greece)**. The pilot for the biochemical conversion of separately collected household food waste to ethanol is currently located at the premises of NTUA. It is a **pre-existing installation** developed in the framework of the LIFE WASTE2BIO

project (LIFE11 ENV/GR/000949). **Feedstock** material will be **source-separated biowaste** from households. SUST will be responsible for the provision of feedstock material.

The reactor consists of two interconnecting horizontal cylindrical chambers of 200 L, with a rotating shaft for the mixing of the material. **The temperature** is controlled by an external steam/water jacket. **pH can also be controlled** by the addition of the necessary chemicals. The operation of the pilot plant is fully controlled through PLC. Currently, the plant has **a capacity of treating 50kg of dried biowaste** (10% H2O)/cycle and is able to produce **190 liters of ethanol/tn dry waste** (or 38 liters of ethanol/tn wet waste 80% H2O). For the purposes of the WaysTUP project, the same prototype plant will be used, **after upgrading for the production of bio-solvents.** PILOT 5 system will move to a TRL of 7 at the end of the project. A series of interventions towards **behavior change of citizens** for their participation in the collection of urban bio-waste will be implemented, led by HSNP and supported by SUST and local user communities. **Local stakeholders** will be involved, through links with relevant social innovation activities that are in place.

As **the biggest challenges** about the Pilots' market, **the efficiency** of the process in terms of end product yield, **the economic viability** of the biorefinery approach, and **end product characteristics in relation to market demand** are stated in the questionnaire. Also, as a common potential risk, legal and regulatory barriers related to biowaste volarization were suggested again. Considering the bioeconomy trend, it is easy to conclude that biosolvent **market is not saturated** at all, and competitors are few on the market. **Main competition** are still the companies that produce fossil fuel-based solvents, and they are dictating the market prices. A big **advantage** for the Pilot, which will ensure a strong market position and profitability of production, is the **use of bio-waste as a resource to produce added-value products** that can substitute fossil-based products.

3.6 PILOT 6: PERSEO Bioethanol® semi-industrial plant

PILOT 6 is located in **L'Alcudia (Valencia, Spain**), in the biotechnological demonstration plant of **IMECAL (PERSEO Bioethanol® plant)**. **Feedstock** material will be cellulosic rejection streams from waste and wastewater treatment plants from the Barcelona Metropolitan Area for the production of bioethanol. The plant has a capacity to **process 25 tonnes/day of feedstock**.

IMECAL together with the partner **CIEMAT** has developed this biotechnological patented technology (European Patent EPO 2112226, USA Patent 8399228 B2 and international PCT WIPO 099038) **to produce second-generation bioethanol from the organic fraction of MSW** (PERSEO Bioethanol ®). PERSEO Bioethanol® semi-industrial plant consists of: the

pretreatment unit, the fermentation unit, the solid-liquid separation unit, the distillation unit, the end-product storage unit, effluents treatment unit, and the control system. Parts of **produced ethanol** will be further upgraded **to produce ethyl lactate** via a reactive distillation pilot by **TBWR**.

A series of interventions **towards behavior change** of citizens for their participation in the collection of urban biowaste will be implemented, led by **AMB** and supported by local user communities. **Local stakeholders** will be involved, through links with relevant social innovation activities that are in place. A launch event will be organized, and there will be a presence in third party events.

The questionnaire was jointly completed by Pilot 3 partners (IMECAL, CIEMAT, TBWR, AMB), giving the overall insight into market problems they are facing in their countries. As a common challenge, the pricing pressure of conventional (petrol-based) solvents is very present, since the Pilots' purpose is not commercial. The goal is to reduce rejection to zero waste and move towards less hazardous solvents like ethanol and ethyl lactate. Biobased bisolvents are competing with the general solvent market, with key advantages such as the production of high-value "green" product lines, continuously available feedstock, current process/technology development stage, and own patented process.

3.7 PILOT 7: Biochar

PILOT 7 will be located at **Chania (Crete, Greece)** at the premises of the Technical University of Crete Campus. **Feedstock** material will be **sewage sludge provided by the Municipal Enterprise for Water and Sewage (DEYAX)**. In addition, **wood chips and pruning** will be used as bulking agents that will be combined with the **dewatered sludge** before they enter the biochar unit. Excess heat and gas emissions produced by the biochar unit will be recirculated to the drying unit which will be equipped with an **air pollution treatment unit** (Venturi scrubber). The end products will be **the biochar** and **the off-gas concentrate** (**Pirolenhoso**).

Prototype Biochar Production:

The prototype will be installed in an **ISOBOX** and it will include: (i) the drying unit; (ii) the furnace for the production of biochar for the demonstration activities; (iii) an air pollution treatment unit that will be a simple and efficient off-gas cleaning system, similar to a Venturi scrubber. Gases will enter the system which will **contain water** from the lower part and exit the system from the top. This operation will enable the **clean-up of the off-gases** and thus a **zero-emission operation**. Off-gases from the furnace will be used to dry "fresh" raw materials to the required degree. **The air pollution** system will produce a concentrate that will be rich in nutrients and micro-nutrients that are called **Pirolenheso**. This concentrate if diluted 1/100

can be **used for nutrient addition to plants together with irrigation**. On the other hand, the end product of pyrolysis will be biochar which **can be used as soil-improving and fertilizer material in agriculture.**

TUC has a campus with a 3 km2 brush land area and a certain section for installing various innovative technologies demos. The size of the prototype is designed to be capable of

producing the necessary amount of biochar required for this project. The prototype is planned to be constructed **during the first 6 months of the project,** allowing for the following 6 months the production of the required quantity of biochar at least **for the first year field experiments.** It is believed that during each batch operation of the prototype **15-20 kg of biochar can be produced**, so considering two production cycles per day, it is estimated that **30-40 kg of biochar will be produced daily (600-800 kg biochar/month).**

The questionnaire examination showed that the end product (Biochar) will be distributed to agriculture manufacturers and farmers, as end-users. The main **challenge** will be to e**ducate the market** about biochar's great potential in many industries and **raise awareness** about the importance of **sustainable and eco-friendly production.** Since the Pilot will be producing biochar from the sewage sludge, it is easy to present feedstock sustainability and constant availability on the market. This is also the main **competitive advantage** of the Pilot, together with **a clean production** process and **zero-emission operation.**

4. Market Overview-Trends in European Industry

In order to understand current situation in the European Industry and the future of it, it is very important to identify and analyze where and how industries are transforming themselves and where new specialization patterns give rise to the emergence or renewal of industries. Trend analysis is crucial for companies as it helps them quickly adapt to the market changes and stay ahead of competitors. Furthermore, trend analysis helps businesses forecast the market potential for a product or service.

Ten emerging industries identified by European Cluster Observatory[1] are listed below:

Figure 1 Ten emerging industries identified by European Cluster Observatory

*Source: **https://ec.europa.eu/growth/content/trends-european-clusters-results-2019-european-panorama-trends-and-priority-sectors-reports_en***

WaysTUP! Pilots will provide innovative solutions that will be applied in most of these emerging industries. Therefore, it is important to investigate major trends that affect these industries because megatrend analysis allows businesses to build a long-term strategy that is proactive, rather than reactive, and will help Pilots good market entry strategy, but will also ensure they have a plan to remain relevant moving forward.

Our aim is to enable Pilots to better anticipate market developments and lead both incremental and disruptive change for their industries. In order to achieve that, we need to do a comprehensive megatrend analysis. This type of analysis can and should be leveraged as a key input to innovating all areas of Pilots' businesses, including both internal and external changes.

[1] https://ec.europa.eu/growth/industry/policy/cluster/observatory_en

4.1 Global megatrends and their impact on emerging industries

The future development of emerging industries is shaped by a certain number of global megatrends, defined as sustained forces on a global and macroeconomic level that influence the developments of business, environment, economy, society, cultures and citizens' lives on a local and global scale.[2]

Since we've found out that Circular Economy, which is the central theme of WaysTUP! project, is one of the main global megatrends, we continued our research to identify which emerging industries are affected the most by this megatrend. These are: Mobility Technologies, Environmental industries, Digital industries, Advanced Packaging, Blue Growth industries, Logistical Services and Biopharmaceuticals. Four of listed industries are considered to be possible end-industries for WaysTUP! Pilots solutions - Environmental industries, Advanced Packaging, Logistical Services and Biopharmaceuticals.

Moreover, we explored how Green and Circular Economy megatrend affects businesses worldwide and what kind of disruptions it brings. On the other hand, we also investigated other global megatrends that affect emerging industries, most of which are relevant for WaysTUP! Pilots, in order to prepare Pilots for the current and the upcoming market situation within these industries.

According to European Cluster and Industrial Transformation Trends Report there are **ten megatrends** that should be investigated in detail. They are related to different factors and these are:

1. diffusion of new disruptive technologies and
2. demographic, socio-political, environmental and economic shifts.

Figure 2 shows the overall impact of each megatrend on each emerging industry: the larger the bubble, the larger the expected impact of the selected megatrends for the considered industry. The figure accounts for both positive and negative effects since every megatrend is expected to pose both great challenges and opportunities for industry development.[3]

Related to diffusion of new disruptive technologies

[2] The concept of megatrend emerged in the 1980s, with the seminal work of John Naisbitt, "Megatrends: Ten New Directions Transforming Our Lives" (Naisbitt, 1982).

[3] European Cluster and Industrial Transformation Trends Report

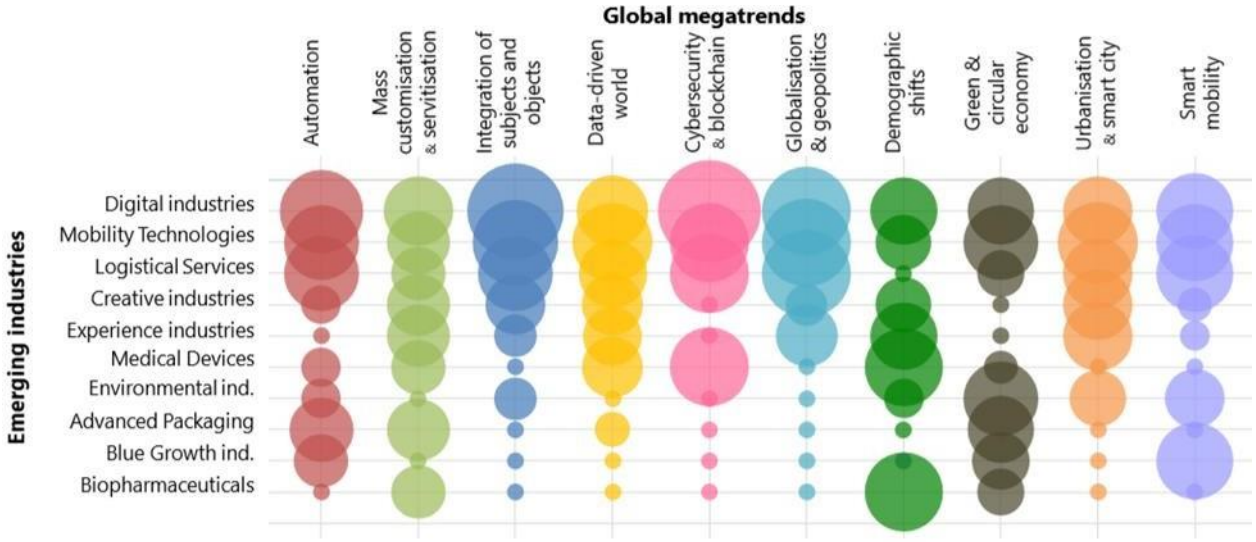


Figure 2 Impact of ten global megatrends on ten emerging industries[4]

Source: EOCIC, 2019c.

The impact of these ten global megatrends on industries is huge. They present major drivers and restraints for emerging industries by affecting the business models and existing value chains, creating incentives or deterrents to the development of new markets, altering employment and productivity and causing shifts in skills requirements.

According to European Cluster and Industrial Transformation Trends Report, impact of global megatrends can be analyzed by the intensity of the impact and also, by the number of emerging industries that are expected to be affected.

As we can see, industries are more or less affected by particular megatrends. Digital industries, Mobility Technologies and Logistical Services are impacted the most by all the identified global megatrends. Global megatrends and emerging industries which are expected to be affected the most (given respectively) are shown in the table below.

Global megatrends	Emerging industries
Automation	Digital industries Mobility Technologies Logistical Services Advanced Packaging Blue Growth industries

[4] The full results are displayed in EOCIC, 2019c.

Masscustomisation & servitisation	Digital industries Mobility Technologies Creative industries Experience industries Advanced Packaging Logistical Services Medical Device Biopharmaceuticals
Integration of subjects and objects	Digital industries Mobility Technologies Logistical Services Creative industries
Data-driven world	Mobility Technologies Digital industries Logistical Services Medical Device Experience industries Creative industries
Cybersecurity and blockchain	Digital industries Mobility Technologies Logistical Services Medical Devices
Globalisation & geopolitics	Digital industries Mobility Technologies Logistical Services Experience industries
Demographic shifts	Medical Devices Biopharmaceuticals Digital industries Experience industries Creative industries Mobility Technologies
Green & circular economy	Mobility Technologies Environmental industries Digital industries Advanced Packaging Blue Growth industries Logistical Services Biopharmaceuticals
Urbanisation & smart city	Mobility Technologies Digital industries Logistical Services Creative industries

	Experience industries Environmental industries
Smart mobility	Digital industries Mobility Technologies Logistical Services Blue Growth industries Environmental industries

Table 2 Impact of global megatrends by the number of emerging industries that are expected to be affected

Megatrends that are expected to impact the largest number of emerging industries are[5]:

- **mass customisation and servitisation**, which trigger changes in business organisation and creation of new market segments;
- **smart mobility**, which is having disruptive effects on different sectors. The increasing focus on energy efficiency, alternative fuels, shared mobility, automated vehicles and transport systems require changes in business organisation models, skills sets and value chain structure of the emerging industries, which may present at the same time challenges and opportunities for firms, depending on their ability and willingness to embrace change; and
- **green and circular economy**, which determines the greatest challenges across all the industries, particularly regarding changes in business models and transformation of global value chains that will likely become shorter and circular.

4.2 Foresight scenarios and impact assessment

The report "Foresight scenarios of ten global megatrends and their impact on the industry" provides information on how each megatrend is expected to develop in the next decades and how it could impact the industry.

Megatrends have important impacts (both positive and negative) on specific features of the industry structure. In Figure 3, the bar length reflects the number of emerging industries for which the megatrend is having the largest effect in terms of the considered type of impact: the longer the bar, the higher the number of emerging industries (up to 10) that are significantly impacted along a specific dimension .

According to the data, automation have the strongest impact on skills and productivity and business organisation of emerging industries. Mass customisation and servitisation, Data-

[5] European Cluster and Industrial Transformation Trends Report

driven world and Demographic shifts cause new market creation. Compared to other megatrends, urbanisation and smart city impact employment levels of the largest number of industries. On the one hand, employment opportunities may arise in the (smart) mobility, ICT, housing, energy and environmental sectors. On the other hand, the traditional urban transport sectors (buses, taxis and rail) could witness a loss of employment due to large-scale automation and ICT pervasiveness.

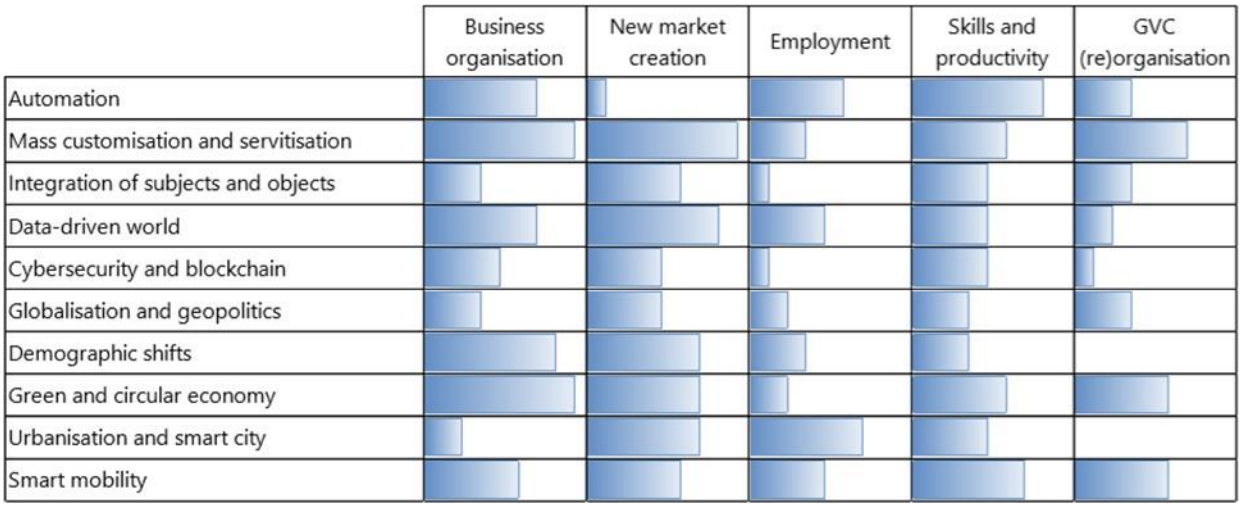


Figure 3 Degree of future impact of global megatrends for different types of impact

Source: EOCIC

First step in analyzing the impact of each megatrend, is to group them according to their relations to Technological, Socio-Political and Environmental and smart economy megatrends, as presented in the table below.

Table 3 List of ten global megatrends

Global megatrend		Definition
Technological megatrends		
	**Automation**	Automation means the use of robotics and "various control systems for operating equipment with minimal or reduced minimal intervention" (RBC, 2014).
	**Mass customisation and servitisation**	Mass customisation means "Developing, producing, marketing and delivering affordable goods and services with enough variety and customisation that nearly everyone finds exactly what they want" (Business Innovation Observatory, 2013). Servitisation is the "innovation of an organisation's capabilities and processes to better create mutual value through a shift from selling products to selling product-service systems" (Baines et al, 2009).
	**Integration of subjects and objects**	It is the process driven by new technologies such as the Internet of Things (IoT), augmented/ virtual reality (AR/VR), and human-machine interactions.
	**Data-driven world**	It includes data analytics techniques and Artificial Intelligence (AI).
	**Cybersecurity and blockchain**	Cybersecurity is the process towards increased "protection of networked information systems" (Department of International Trade, 2018). Blockchain is a "distributed digital ledger technology utilising cryptography and timestamps to provide a permanent record of various types of transactions and interactions" (IHS Markit, 2018). As such, it is considered a possible solution to some cybersecurity and digital trust challenges.
Socio-political megatrends		
	**Globalisation and geopolitics**	It covers the prominence and transformation of global trade and the most recent shifts in international powers.
	**Demographic shifts**	It means population growth, migration trends and an ageing society.
Environmental and smart economy megatrends		
	**Green and circular economy**	It is the shift towards an economic system that is internationally competitive while achieving high social and environmental standards. It covers the energy transition processes and the transition from linear to sustainable production models to face resource scarcity.
	**Urbanisation and smart city**	It is the rising share of population living in urban areas and transitioning towards more efficient and smarter cities, thanks to decentralisation, governance shifts and new ICT solutions.
	**Smart mobility**	It is the transition towards new modes of transportation, the transformation of vehicles and the related changes in social norms and business models.

Source: EOCIC, 2019c.

Each type of megatrends is expected to influence previously identified types of impact and that influence is described in the following chapters[6]. Also, foresight scenarios of each of these megatrends are described for the next decades[7].

Technological megatrends

In the following Table, we presented technological megatrends that might be relevant to Circular Economy, as they can provide valuable information on the overall market future course.

Business organization	New markets	Employment	Skills and productivity	Global value chains (re) organization
Data, automation and AI solutions Product personalization AI and new data analytics	Customerisation of products and services IoT devices or users of AR/VR	Automation, data-solutions and AI will have a major impact on employment, destructing and creating an important number of jobs.	Increase in industrial productivity, especially through speed, flexibility and reduction of errors	Greater automation, integration of subjects and objects and data-driven world could favour the reshoring of production to the developed world, which has the capital and skilled labour to unlock its potential

Foresight scenarios of technological megatrends	
2020 - 2030	• Development of digital servitisation • Increased user-friendliness and acceptability of new technologies • Emergence of new markets for personalised products • Greater integration of the customer in design, production and after-sales phases
2030 - 2040	• Mass adoption of technologies favoring flexible production systems (automation, IoT, additive manufacturing) • Progressive reshoring of manufacturing to developed countries • Consolidation of servitisation and mass customization
2040 - 2050	• Generalised use of AI, AR/VR across various industrial domains
After 2050	• New factory models (customer-centred approach, fully digitalised and automated)

Table 4 Technological megatrends and their potential relation to Circular Economy

Socio-political megatrends

In the table below, we summarize socio-political megatrends that could significantly influence Circular Economy, because they include information that show comprehensive future market development.

Business organization	New markets	Employment	Skills and productivity	Global value chains (re) organization
Shifts in business strategies	Increased number of consumers Population ageing	Job losses in some areas because of protectionist measures Migrations Global employment is expected to rise, but with important national differences	Trend of upskilling, especially in developing countries	Increase of the complexification and segmentation of global value chains

Foresight scenarios of socio-political megatrends	
2020 - 2030	• Economic losses due to increased protectionism • Important brain drain and low skilled migrations • Increasing integration of migrants in ageing countries
2030 - 2040	• Fast increase in global population • Erosion of labour cost advantage in developing countries • Increased global competition for skilled workers • Anticipation of labour and skills shortages
2040 - 2050	• High increase in healthcare spending • Labour and skill shortages (partly mitigated by migration and increasing automation) • Gradual slowdown of world population growth
After 2050	• Aging is a global phenomenon • Adaptation of businesses to local conditions (glocalization) • BRICS as first economic powers worldwide

Table 5 Socio-political megatrends and their potential relation to Circular Economy

Environmental and smart-economy megatrends

Following the same approach implemented on other megatrends, table below shows environmental and smart-economy megatrends that might be important from the perspective of Circular Economy.

Business organization	New markets	Employment	Skills and productivity	Global value chains (re) organization
Transition to more sustainable economic models, profoundly affecting design, production processes and business models Smart mobility	New market opportunities Bigger market for smart city and smart mobility solutions	New jobs within sectors related to renewables, waste and water management, air quality and biodiversity etc. Loss of employment in the transport sector	Engineering and management skills Increased competitiveness of companies adopting environmentally friendly technologies Shift towards higher skill requirements (especially regarding ICT) and more specialisation of professionals.	Shorter and circular value chains An urban-centred world
Foresight scenarios of environmental and smart-economy megatrends				
2020 - 2030	• Fast technological progress of energy efficiency and low carbon solutions • Rising demand for energy • Global rise in environmental concerns • Rapid development of automated vehicles • Forerunners of circular economic models in resource-intensive sectors			
2030 - 2040	• Consolidation of environmental regulatory framework worldwide • Creation/upgrade of infrastructures and services in cities • Gradual shift to alternative designs of ships, airplanes and trains			
2040 - 2050	• Significant diffusion of electric vehicles and alternative fuels • Significantly improved intermodality and new business models for global transportation • Major development of new markets for environmental-friendly products			
After 2050	• Significant negative effects of climate change • Consolidated models of integrated smart cities and megacities			

Table 6 Environmental and smart-economy megatrends and their potential relation to Circular Economy

4.3 Conclusions

We studied the megatrends in order to get an insight of the overall market trends for the next 30 years. Megatrend analysis should help WaysTUP! Pilots to build a strong long-term strategy that will support their future growth. In a rapidly changing global environment, megatrend analysis helps businesses better anticipate changes that could have a direct or indirect influence on their development.

Companies need to acknowledge megatrends, and act accordingly. At the very least, they should understand their contribution to relevant trends, as well as how their business is impacted by them, both positively and negatively.

Communicating an understanding of megatrends to stakeholders is also key.[1]

After a comprehensive analysis, we identified circular economy, which is actually directly linked with the scope of the WaysTUP! Project, as one of the major megatrends. Green and circular economy determines the greatest challenges across all the emerging industries, particularly regarding changes in business models and transformation of global value chains that will likely become shorter and circular.

Since companies involved in WaysTUP! project are already on top of circular economy megatrend, the evolving regulatory environment and stakeholder expectations will be a cinch to maneuver. For them, there are different opportunities to gain competitive advantage on the market by adapting to this megatrend most quickly and effectively through:

- Circular product design and production involving: prolonged asset life, reduced obsolescence and greater utility
- New business models, for example:
    - Models that focus on access to services rather than ownership, (such as hiring, renting and leasing)
    - Models in which the business establishes a longer-term relationship with the customer, resulting in:
        - Greater insights into usage patterns
        - New ways to creatively engage with customers
        - Greater customer loyalty and satisfaction
- An ever-increasing focus on reverse cycling, value preservation and reverse logistics infrastructure (waste management, collection and treatment).

Furthermore, we identified a number of technological, socio-political and environmental

[1] Megatrends — Why Do They Matter to Business? - Sustainable Brands

trends that are directly and indirectly related to Circular Economy and the Pilots. These are reflected in a breakthrough of an urban-centred world, data, automation and AI solutions, product personalization, IoT devices or users of AR/VR, new jobs within sectors related to renewables and waste, as well as to the increase in industrial productivity, shifts in business strategies focusing more on developing sustainable economic models, increase of the complexification and segmentation of global value chains etc.

These changes will probably shake things up across all different aspects of company's business model — some in very beneficial ways, and some in quite challenging ways. Therefore, companies involved in WaysTUP! Pilots should pay attention to the following business aspects:

- **Strategy**: If strategy is about defining "what business to pursue," then new technologies are opening up a slew of new opportunities and corresponding considerations. IoT, for example, are giving manufacturers the ability to "sensorify" their existing products, creating "intelligent" new offerings with value-added analytics and software services to go with them. In some cases, these new offerings require a comprehensive rethink of innovation and portfolio strategies. In other cases, they may necessitate fresh go-to-market and even merger and acquisition strategies. But the technologies can accelerate and amplify bigger shifts: manufacturers' moves into service sectors, for instance, or fluid joint ventures with other corporate entities to leverage broad technology platforms for mutual advantage.
- **Customer Engagement**: Breakthrough technologies are already reshaping almost every dimension of companies' interactions with their customers, from sales and marketing to billing and after-sales support. For example, artificial intelligence, applied as machine learning, for instance, can help process volumes of customer-behavior data to identify patterns that enterprises can use to improve customer engagement
- **Operations**: Artificial intelligence, robots, and drones can all improve operational efficiency and provide significant competitive advantage. Also, early adopters of virtual reality and augmented reality are already reaping benefits. For example, Boeing and DHL are using augmented reality to be both faster and more efficient.[2]
- **Compliance**: This is an often-overlooked aspect of the business model. However, new technologies will see many companies scrambling to adapt to — and trying to influence — the resulting regulatory landscapes. The regulators themselves are likely to be in a catch-up mode for a while.

Foresight scenarios of technological megatrends show that we can expect in the future development of new factory models (customer-centred approach, fully digitalised and automated).

[2] Tech breakthroughs megatrend: how to prepare for its impact (pwc.com)

All of these changes will be followed by increasing integration of migrants in ageing countries that will contribute to increased global competition for skilled workers. For many businesses, as well as for companies involved in WaysTUP! Pilots, the primary impact of migrants is providing additional or complementary skills and filling roles with a shortage of applicants.

In many instances the skills and experience migrants possessed were over and above what was required to fill the role. Therefore, having access to migrants allows the business to select the best candidate from a wider talent pool.[3]

In parallel, environmental concerns will rise on a global level and that will result in rapid development of automated vehicles and gradual shift to alternative designs of ships, airplanes and trains.

Circular economy and bio-economy present one important step towards tackling environmental problems. These areas provide sustainable business solutions to the current challenges. WaysTUP! Pilots set up their businesses in line with Circular economy principles. Scope of EU Circular Economy and Bio-economy is elaborated in the next chapter.

[3] The impacts of migrant workers on UK business (publishing.service.gov.uk)

5. EU Circular Economy/Bio-economy

WaysTUP! Project, with its Pilot solutions, aims to improve the sector of EU Circular Economy and Bio-economy. Therefore, it is important to better understand this area and its social, economic and environmental impacts, that refer to:

- economic impact – changing production processes that will lead to changing demand for Bioeconomy-related and non-related products; all together will impact food prices that will change GDP/GNI
- social impact: changing behaviour, state of health, employment and food security
- environmental impact: changing biodiversity, water/soil quality, carbon emissions.

This chapter will contribute to the overall Projects' objectives, as well as to the Pilot solutions. We will explore EU Policies in the Bio-economy area since one of the Projects' objectives is to support the successful incorporation of integrated system innovation approaches aiming at the valorisation of urban biowaste into existing and future local, national and EU-level policies. Furthermore, will contribute to achieving another Projects' objective related to identifying opportunities and barriers for utilisation of urban biowaste sources.

In terms of Pilots solutions, we are able to identify a plethora of factors that might affect several areas relevant to the whole life cycle of the Pilots and stakeholders in connection to the Pilots and the corresponding solutions. Some of the main impact subcategories related to different stakeholder groups such as workers, consumers, local communities, society and other value chain actors, are given below:

- Worker – fair salary, working hours, forced labours, child labour
- Consumer – consumers' health and safety, consumer privacy, feedback mechanism
- Local community – access to material/immaterial resources, delocalization and migration, secure living conditions
- Society – public commitments to sustainability issues, corruption
- Value chain actors – fair competition, promoting social responsibility, supplier relationships.

Bioeconomy is the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based

products, and bioenergy.[8] Bioeconomy already plays a crucial role in the EU and global economy and the achievement of most of the Sustainable Development Goals. In recent years the main focus of European bioeconomy development was on increasing circularity and sustainability in its sectors. Such a trend will have a multiplicator effect on the economy and environment helping to renewal EU industries, transform of European primary production systems, protect the environment, and enhance biodiversity.

5.1 Social, Economic and Environmental Impacts of the bioeconomy

With sustainable development at the forefront of the global agenda and policy priorities, **bioeconomy seems to be at the heart of sustainable economic strategies worldwide**.[9] The European Union's (EU) Bioeconomy Strategy is considered crucial for paving the way towards a more sustainable future, with its five objectives being linked to 14 out of the 17 Sustainable Development Goals (SDGs).[10] Moreover, bioeconomy is identified to be a key factor towards achieving a circular, low carbon economy by the renewed Industrial Policy Strategy, the Circular Economy Action Plan and Accelerating Clean Energy Innovation.[11] Nevertheless, **in order to deliver a sustainable circular bioeconomy the mutual reinforcement of our economic welfare and our environment's health is required**.[12]

A sustainable bioeconomy can contribute to tackling major global challenges such as climate change, land degradation, growing demand for food and energy, and consequently help in achieving global commitments under the 2030 Agenda and the Paris Agreement.[13] Bio-

[8] https://scar-europe.org/images/SCAR-Documents/bioeconomycommunicationstrategy_b5_brochure.pdf#:~:text=On%2013%20February%202012%2C%20the%20European%20Commission%20adopted,indeed%20the%20world%20are%20facing%20already%20today.%205

[9] Sillanpää M., Ncibi C. (2017) Bioeconomy: Multidimensional Impacts and Challenges. In: A Sustainable Bioeconomy. Springer, Cham. https://doi.org/10.1007/978-3-319-55637-6_9

[10] Robert, N., Giuntoli, J., Dos Santos Fernandes De Araujo, R., Avraamides, M., Balzi, E., Barredo Cano, J.I., Baruth, B., Becker, W.E., Borzacchiello, M.T., Bulgheroni, C., Camia, A., Fiore, G., Follador, M., Gurria Albusac, P., La Notte, A., Lusser, M., Marelli, L., M`barek, R., Parisi, C., Philippidis, G., Ronzon, T., Sala, S., Sanchez Lopez, J. and Mubareka, S., Development of a bioeconomy monitoring framework for the European Union: an integrative and collaborative approach, NEW BIOTECHNOLOGY, ISSN 1871-6784 (online), 59, 2020, p. 10-19, JRC119127.

[11] European Commission (EC). (2018a), A Sustainable Bioeconomy for Europe: Strengthening the Connection between Economy, Society and the Environment – Updated Bioeconomy Strategy, European Commission: Brussels, Belgium

[12] European Commission (EC). (2018b), COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment, COM/2018/673 final

[13] ESPON (2019), Territorial Impact Assessment On the Bioeconomy

based products and processes emerging in the bioeconomy context can have various impacts on society, economy, and environment, impacts that can arise throughout the entire value chain of bio-based products.[14] Although several studies have been carried out for assessing the impacts of bioeconomy using mainly quantifiable indicators, a common and widely accepted assessment approach, including clearly identified impacts areas, is not yet established. Given the fact that bioeconomy is an economic model, most of the studies mainly focus on its economic impacts alongside with its environmental impacts, mostly in comparison with fossil-based economy, not addressing respectively its social impacts.

At the economic level, when measuring bioeconomy impacts, the focus is mainly on the gross output (or turnover), value added, investments, exports of bioeconomy goods and employment.[15] According to the European Committee of the Regions[16] , bioeconomy in the EU currently (2019) has an annual turnover value of around EUR 2 trillion and employs over 18 million people, while at the same time it delivers added value of EUR 621 billion, and accounts for 4.2% of the EU's GDP and 76% of employment (agriculture, food and drink manufacturing). Furthermore, according to the work of the European Commission's Joint Research Center[17], it can be extracted as general feature that for 2014 the national bioeconomy turnovers in EU-28 countries mainly relied on two sectors: the manufacture of food, beverages and tobacco (on average 51 % of the bioeconomy turnover) and agriculture (on average 17% of the bioeconomy turnover). Following the above, the European Commission's Update Bioeconomy Strategy[18] highlights the fact that "*The relative contribution of primary sectors to the EU Bioeconomy is significantly lower in terms of value added (33%) than in terms of the number of persons employed (55%).*". In the same report it is stated that this pattern can be also observed at national level, as many EU countries have a

[14] Hasenheit, M., Gerdes, H., Kiresiewa, Z., & Beekman, V. (2016). D2.2: Summary report on the social, economic and environmental impacts of the bioeconomy.

[15] Kuosmanen, T., Kuosmanen, N., El-Meligli, A., Ronzon, T., Gurria, P., Iost, S., M'Barek, R., How Big is the Bioeconomy? Reflections from an economic perspective. EUR 30167EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17858-3, doi:10.2760/144526, JRC120324

[16] ESPON (2019), Territorial Impact Assessment On the Bioeconomy

[17] T. Ronzon, M. Lusser, M. Klinkenberg (ed.), L. Landa, J. Sanchez Lopez (ed.), R. M'Barek, G. Hadjamu (ed.), A. Belward (ed.), A. Camia (ed.), J. Giuntoli, J. Cristobal, C. Parisi, E. Ferrari, L. Marelli, C. Torres de Matos, M. Gomez Barbero, E. Rodriguez Cerezo (2017). Bioeconomy Report 2016. JRC Scientific and Policy Report. EUR 28468 EN

[18] European Commission (EC). (2018a), A Sustainable Bioeconomy for Europe: Strengthening the Connection between Economy, Society and the Environment – Updated Bioeconomy Strategy, European Commission: Brussels, Belgium

low resulting added value compared to the high share of jobs in bioeconomy, mostly because of the predominance of employment in the less productive sectors.[19]

Graphic below shows an overview of the economic impacts.

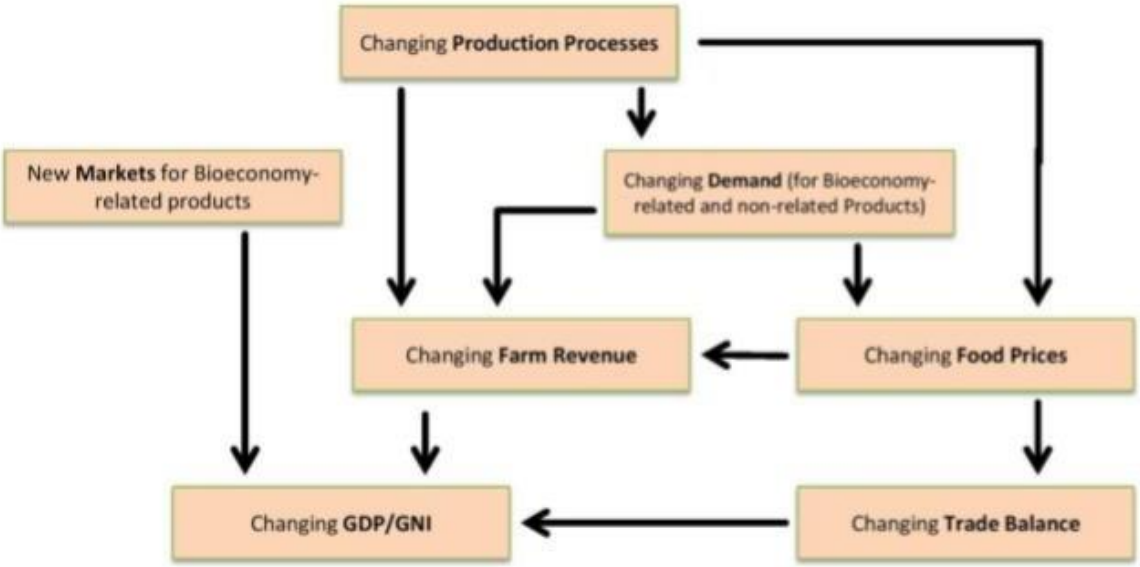


Figure 4 Overview of the economic impacts

Source: http://www.bio-step.eu/fileadmin/BioSTEP/Bio_documents/BioSTEP_D2.2_Impacts_of_the_bioeconomy.pdf

For bioeconomy to go beyond being another economic model and deliver on sustainability, it is emerging that we can measure its impacts on the ecological boundaries of our planet. **Bioeconomy is not only about creating jobs and growth but also about addressing global environmental issues and challenges**.[20] It is necessary that bioeconomy, although being an economic model primarily, is developed to strengthen the decoupling of economic growth and environmental pressures. As mentioned earlier, the impact areas of bioeconomy activities are not strictly defined. Thus, **various environmental impact areas have been identified, with the focus being on greenhouse gas emissions (GHG), land-use change, biodiversity, ecosystem services, water consumption, soil degradation and waste**

[19] European Commission (EC). (2018a), A Sustainable Bioeconomy for Europe: Strengthening the Connection between Economy, Society and the Environment – Updated Bioeconomy Strategy, European Commission: Brussels, Belgium

[20] T. Ronzon, M. Lusser, M. Klinkenberg (ed.), L. Landa, J. Sanchez Lopez (ed.), R. M'Barek, G. Hadjamu (ed.), A. Belward (ed.), A. Camia (ed.), J. Giuntoli, J. Cristobal, C. Parisi, E. Ferrari, L. Marelli, C. Torres de Matos, M. Gomez Barbero, E. Rodriguez Cerezo (2017). Bioeconomy Report 2016. JRC Scientific and Policy Report. EUR 28468 EN

management[21]. Apart from quantifiable indicators, Life Cycle Assessment (LCA) methodology is widely used for evaluating the impacts of bioeconomy activities. Yet, studies using the LCA methodology often follow different assumptions and background data making the results difficult to compare[22]. According to the work of the European Commission's Joint Research Center[23], bio-based products had lower environmental loads than their fossil references regarding the climate change and non-renewable energy consumption impact categories. However, the same study underlies that for the impact categories of acidification, land use and eutrophication, the bio-based products had a lower environmental performance mainly because of the agricultural activities for the biomass production and the decreased efficiency during the production processes.[24] Despite the data and methodology gaps, several environmental benefits can occur through bioeconomy if it is sustainably established.

An overview of environmental impacts of bioeconomy is presented below.

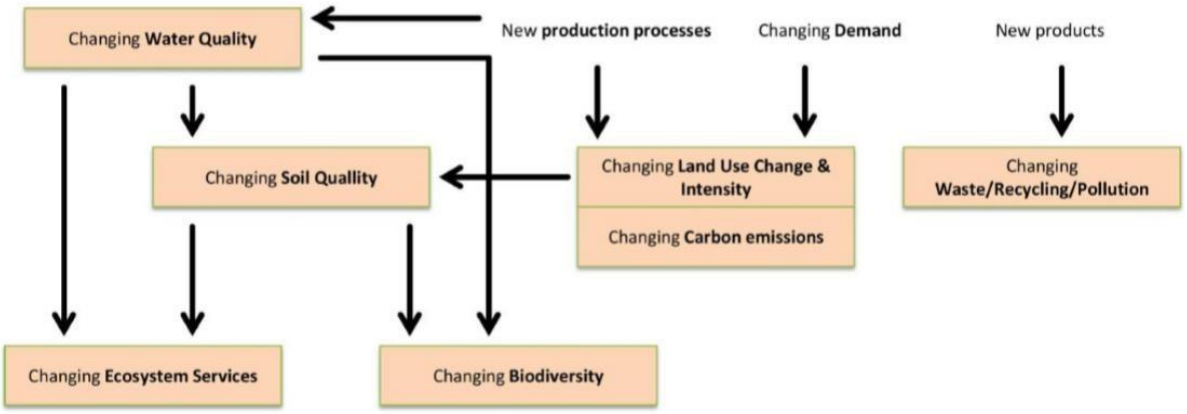


Figure 5 Overview of environmental impacts

Source: http://www.bio-step.eu/fileadmin/BioSTEP/Bio_documents/BioSTEP_D2.2_Impacts_of_the_bioeconomy.pdf

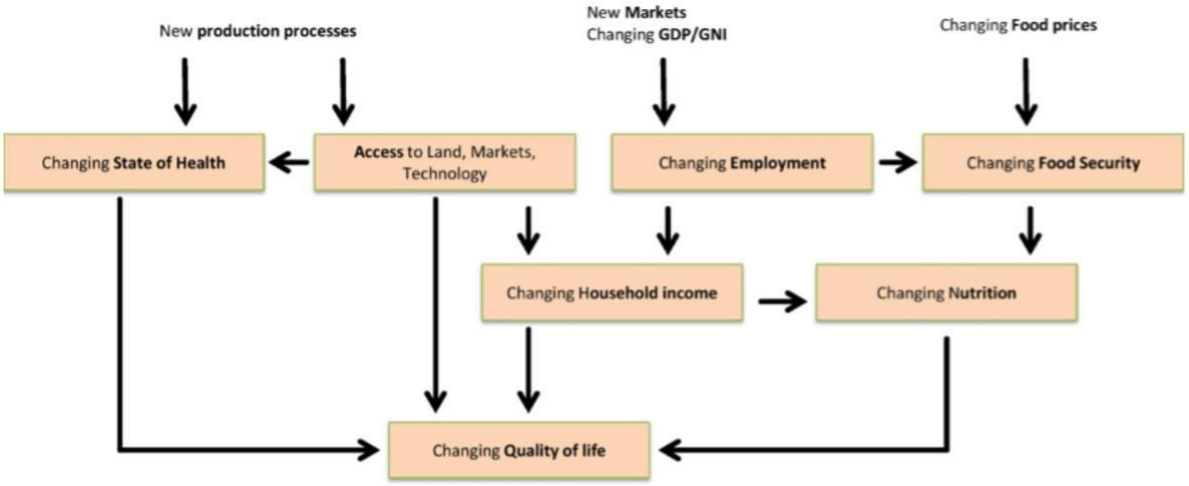
[21] Camia A., Robert N., Jonsson R. , Pilli R. , García-Condado S., López-Lozano R., van der Velde M., Ronzon T., Gurría P., M'Barek R., Tamosiunas S., Fiore G., Araujo R., Hoepffner N., Marelli L., Giuntoli J., Biomass production, supply, uses and flows in the European Union. First results from an integratedassessment, EUR 28993 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN978-92-79-77237-5, doi:10.2760/539520, JRC109869

[22] Cristóbal, J., Matos, C.T., Aurambout, J., Manfredi, S., & Kavalov, B. (2016). Environmental sustainability assessment of bioeconomy value chains. Biomass & Bioenergy, 89, 159-171.

[23] T. Ronzon, M. Lusser, M. Klinkenberg (ed.), L. Landa, J. Sanchez Lopez (ed.), R. M'Barek, G. Hadjamu (ed.), A. Belward (ed.), A. Camia (ed.), J. Giuntoli, J. Cristobal, C. Parisi, E. Ferrari, L. Marelli, C. Torres de Matos, M. Gomez Barbero, E. Rodriguez Cerezo (2017). Bioeconomy Report 2016. JRC Scientific and Policy Report. EUR 28468 EN

[24] T. Ronzon, M. Lusser, M. Klinkenberg (ed.), L. Landa, J. Sanchez Lopez (ed.), R. M'Barek, G. Hadjamu (ed.), A. Belward (ed.), A. Camia (ed.), J. Giuntoli, J. Cristobal, C. Parisi, E. Ferrari, L. Marelli, C. Torres de Matos, M. Gomez Barbero, E. Rodriguez Cerezo (2017). Bioeconomy Report 2016. JRC Scientific and Policy Report. EUR 28468 EN

At the social level, bioeconomy's impacts have not been studied to the same extent as the economic and environmental ones. Social Life Cycle Assessment (S-LCA) has been used to evaluate the societal impacts of bioeconomy, however this methodology is still not mature.
In general, **the main social impact areas attributed to the bioeconomy refer to employment, food security and state of health**. Furthermore, bioeconomy arises several issues such as changing household income, changing prices of commodities related to bioeconomy and access to land, technology and markets, which highly affect people's quality of life[27]. Although bioeconomy is linked with the potential of fostering the repopulation of rural



areas and cleaner cities[28], still major concerns about adverse effects remain. These concerns mainly focus on volatile prices of commodity crops and extensive land use for the production of non-food biomass, underlying that there shouldn't be a competition between food security and biofuels and biomaterials.[29]

Table 6 Overview of social impacts

Source: http://www.bio-step.eu/fileadmin/BioSTEP/Bio_documents/BioSTEP_D2.2_Impacts_of_the_bioeconomy.pdf

[27] Hasenheit, M., Gerdes, H., Kiresiewa, Z., & Beekman, V. (2016). D2.2: Summary report on the social, economic and environmental impacts of the bioeconomy.
[28] ESPON (2019), Territorial Impact Assessment On the Bioeconomy
[29] HLPE, 2013. Biofuels and food security. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome 2013.
[30] Hasenheit, M., Gerdes, H., Kiresiewa, Z., & Beekman, V. (2016). D2.2: Summary report on the social, economic and environmental impacts of the bioeconomy.

In the bioeconomy context, several impacts can be attributed to a product or a process, which are context-specific and affected by different factors[30]. As these impacts can be partly positive and partly negative, identifying the overall impact as positive or negative becomes a challenge[31]. A sustainable bioeconomy should promote the use of renewable resources, lessen environmental impacts and value the natural resources, while aiming at restoring and enhancing ecosystems' functions and biodiversity.[32]

Despite the abundance of available information, considerable data gaps continue to exist hindering the overall assessment of the several bioeconomy impacts.[33] To this end, in addition to impact assessment, one should move a step forward and examine how it can be ensured that the bioeconomy bears social, economic, and environmental opportunities. It seems that there cannot be one specific bioeconomy in Europe, as certain features of national bio-economies have been observed and, as a result, several bioeconomy concepts can be adapted depending to local context.[34] Risks are inherent as we move towards bioeconomy, drawing attention to the fact that if proper policy framework is not established, bioeconomy may serve as an unsound alternative.[35]

[31] Hasenheit, M., Gerdes, H., Kiresiewa, Z., & Beekman, V. (2016). D2.2: Summary report on the social, economic and environmental impacts of the bioeconomy.

[32] European Commission (EC). (2018b), COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment, COM/2018/673 final

[33] European Commission (EC). (2018a), A Sustainable Bioeconomy for Europe: Strengthening the Connection between Economy, Society and the Environment – Updated Bioeconomy Strategy, European Commission: Brussels, Belgium

[34] European Commission (EC). (2018a), A Sustainable Bioeconomy for Europe: Strengthening the Connection between Economy, Society and the Environment – Updated Bioeconomy Strategy, European Commission: Brussels, Belgium

[35] Eickhout B. (2012), A strategy for a bio-based economy, Green New Deal Series, volume 9, Green European Foundation (GEF)

5.2 EU Policy

The purpose of exploring EU Policy regarding Bio-economy is to provide to all Project stakeholders (and especially Pilots) the latest EU policies relevant with the whole life cycle of their activities.

That said, the latest development in this area happened in 2018 when an updated Bioeconomy Strategy was launched by the European Commission (EC) '*A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment*'. This Strategy includes an Action Plan with fourteen (14) measures, based on three (3) main action areas:

- strengthening and scaling up the bio-based sectors by unlocking investments and markets.
- development of local bio-economies throughout Europe
- understanding the ecological boundaries of the bioeconomy.

The updated strategy proposes development and support actions in rural and coastal areas, as well as in remote areas, ensuring a more proportionate distribution of the benefits of a competitive and sustainable bioeconomy between European territories and value chains.

Moreover, we found out that 19 Member States (MS) have a bioeconomy strategy or another similar strategic document in place or are in the process of developing a strategy. These documents are available for each country on the official EC website.

The bioeconomy is a field which interconnects various economic sectors as well as responds and contributes to different EU policies and strategies, such as the Common Agricultural Policy, the Common Fisheries Policy, the Circular Economy Strategy, the Food 2030 approach, the Renewed EU Industrial Policy Strategy, the EU Energy and Climate Union policy and the EU Biodiversity Strategy. Furthermore, it is related to global leading policies such as the Paris Climate Agreement, the Sustainable Development Goals and the Convention on Biological Diversity.

A European Bioeconomy Strategy was first published in 2012, through the Communication document 'Innovating for Sustainable Growth: A Bioeconomy for Europe' [36,37]. The main goal of this Strategy was to promote a more innovative, resource efficient and competitive society that connects food security with the sustainable use of renewable resources for industrial purposes, while ensuring environmental protection.

In **2018** an **updated Bioeconomy Strategy was launched by the European Commission (EC) 'A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment'** [38], which aims at accelerating the deployment of a sustainable European bioeconomy and maximizing its contribution towards the 2030 Agenda and its Sustainable Development Goals (SDGs), as well as the Paris Agreement. It encompasses multiple areas and policies related to the bioeconomy, it establishes links between them, facilitates cohesion and synergies, addresses trade-offs such as the competitive use of biomass, and provides a holistic plan to assist the EU in developing the potential of the bioeconomy and using it to effectively achieve many of its policy objectives. In the Strategy five (5) objectives are defined and more specifically i) ensuring food security, ii) managing natural resources sustainably, iii) reducing dependence on non-renewable resources, iv) mitigating and adapting to climate change and v) creating jobs and maintaining European

[36] European Commission, Directorate-General for Research and Innovation, 'Innovating for Sustainable Growth: A Bioeconomy for Europe', Brussels 2012 Available at file:///C:/Users/%CE%95%CF%85%CE%B3%CE%B5%CE%BD%CE%AF%CE%B1/Desktop/WAYSTUP!/D%206.1/gp_eudor_WEB_KI3212262ENC_002.pdf.en.pdf (Last visited 10/09/2020)

[37] COM(2012)60 European Commission, Innovating for Sustainable Growth: A Bioeconomy for Europe. Available at https://ec.europa.eu/research/bioeconomy/pdf/official-strategy_en.pdf (Last visited 10/09/2020)

[38] European Commission, Directorate-General for Research and Innovation, "A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment. Updated Bioeconomy Strategy", Brussels 2018. Available at https://ec.europa.eu/research/bioeconomy/pdf/ec_bioeconomy_strategy_2018.pdf (Last visited 10/09/2020)

competitiveness. Moreover, the updated Strategy includes an **Action Plan** with fourteen (14) measures, based on **three (3) main action areas**.

The first action area addressed in the Strategy is ***strengthening and scaling up the bio-based sectors by unlocking investments and markets***. In particular, one of the actions included in this area is to intensify the mobilization of public and private stakeholders, in research sector as well as in the demonstration and deployment of bio-based solutions. Moreover, the EU intends to develop a targeted financial instrument - a € 100 million thematic investment platform in the circular bioeconomy in order to reduce the risk of private investment in sustainable solutions. The bio-based sector will be further promoted, by identifying bottlenecks, facilitators and gaps affecting bio-based innovations and providing at the same time optional guidance on their large-scale implementation. Furthermore, the development of standards, which can be used to verify the properties of products will be promoted. Finally, in an effort to contribute to the global challenge of plastic-free oceans the development of substitutes to plastics that are bio-based, recyclable and marine biodegradable will be supported.

In the second action area the key objective is the ***development of local bio-economies throughout Europe***. One of the main actions include the promotion and support of all types of innovation and practices for sustainable food and agriculture systems, sustainable forestry and sustainable organic production through a systemic and horizontal approach linking factors, soils and value chains. In addition, a mechanism to support bio-economy policy in the Member States will be set up under Horizon 2020. The mechanism will support the development of national / regional bioeconomy strategies, including support in remote areas. The systemic nature of the new emerging bioeconomy approaches and the new value chains will require also new training and new skills.

The third action area focuses on ***understanding the ecological boundaries of the bioeconomy***. Main actions will include enhancing the knowledge base and understanding of specific areas of bio-economics. This can be achieved through the collection of more data in order to produce better information and systematic analysis (for example through artificial intelligence) of data and information. Moreover, the status of biodiversity, ecosystem, degraded land areas and land at risk of climate change impacts will also be monitored and the knowledge gained will be used to provide optional guidance on the operation of the bioeconomy within safe ecological limits.

Concluding, the updated strategy proposes development and support actions in rural and coastal areas, as well as in remote areas, ensuring a more proportionate distribution of the benefits of a competitive and sustainable bioeconomy between European territories and

value chains. These actions will ensure that the bioeconomy respects the boundaries of our planet.

According to report of the EC "***Bioeconomy development in EU regions***"[39] some of the EU countries and regions follow a strategic approach to support the bioeconomy and more specifically 19 Member States (MS) have a bioeconomy strategy or another similar strategic document in place or are in the process of developing a strategy. Furthermore, in the regions or countries without an established bioeconomy strategy, the bioeconomy aspect is often embedded in other strategic documents or funding programs. The analysis conducted concludes that 35.7% of the European regions have a low level of bioeconomy maturity, and they have difficulties in exploiting its potential (i.e. jobs, growth, resource efficiency, rural development) on their own.

Regarding bioeconomy related research and innovation (R&I) even within regions and countries there is a wide thematic variation. The "agro-food" sector is the most common within bioeconomy related R&I. Additionally, "bio-based fuel and energy" and "other bio-based industries" are also significant focuses within the bioeconomy. However, numerous thematic sectors are combined in each country or region. As for the value chain's perspective, the "biomass processing and conversion" is the most prominent approach among the European countries and regions. The most frequent specific value chains that have been reported are "bio-energy and fuel from biomass" and/or "food and beverages". (Spatial Foresight 2017)

[39] Spatial Foresight, SWECO, ÖIR, t33, Nordregio, Berman Group, Infyde (2017): Bioeconomy development in EU regions. Mapping of EU Member States'/regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy for 2014-2020

In the following figure, a visualization of the latest available bioeconomy status (Status as of November 2019) in European countries[40] is provided.

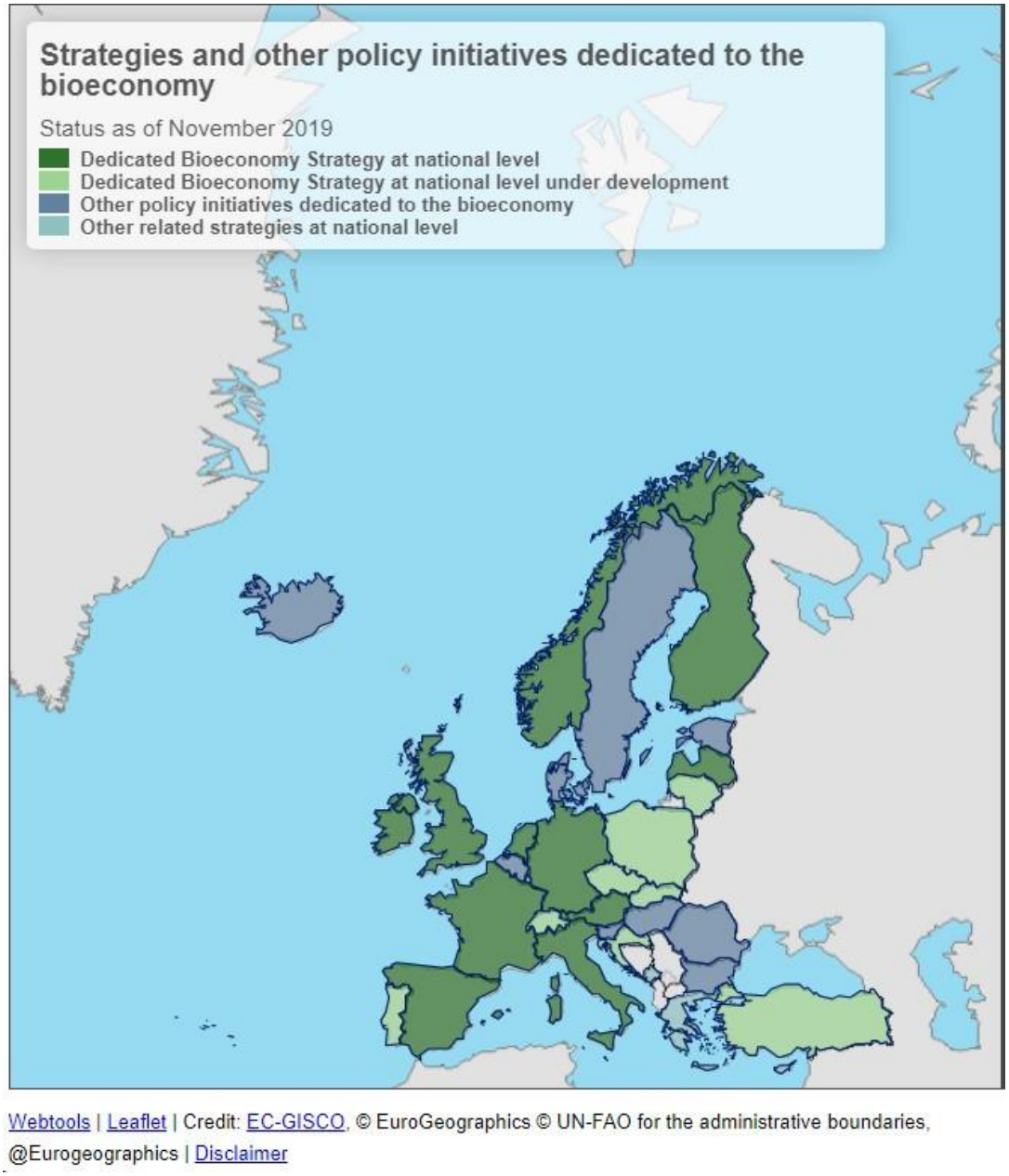


Figure 7 Strategy and other policy initiatives dedicated to the bioeconomy

[40] Lusser, M., Sanchez Lopez, J., Landa, L., Avraamides, M., Motola, V., Zika, E., Mallorquin, P., Joint survey on bioeconomy policy developments in different countries. Background, methods used and recommendations for future editions, Report of JRC, BBI JU and IEA Bioenergy. 2018. European Commission's Knowledge Centre for Bioeconomy. Available at https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en (Last visited 10/09/2020)

5.3 Future Opportunities and Developments in the Bioeconomy

By identifying future opportunities and developments in the Bioeconomy, we are providing all relevant WaysTUP! stakeholders a wider perspective on trends in this area, enabling them to recognize different future opportunities on time that can be utilized as competitive advantage on the market.

Various sectors within Bioeconomy area are analyzed in order to identify key opportunities. Main bioeconomy sectors that are expected to have a bright perspective in the future include energy (biofuels and biogas), agriculture and food (innovative production methods), chemicals and bioplastics, urban waste valorization, pharmaceutical and biomedical industry.

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Food and energy security are of the most important fields bioeconomy is expected to contribute and simultaneously bioeconomy is considered central to climate protection and to innovative industrial transformation. In the Global Expert Survey[41] conducted by the German Bioeconomy Council in 2018, future opportunities and investments in the field of bioeconomy as well as conflicting targets were thoroughly identified.

In particular, bioeconomy in energy sector has gained a lot of attention. Bioenergy in general as well as **biofuels and biogas** seem to be the most prominent case in the future. Moreover, **agriculture and food production sector** will be a key issue of bioeconomy development. Novel plant varieties and innovative production methods especially in food industry through the utilization of new raw materials such as alternative protein sources (e.g. algae or insects) are expected to be developed successfully. Moreover, **chemicals and bioplastics and other innovative new materials were considered future success cases**. In addition, valorization of urban waste and the creation of new value chains in bio-based industry were also highlighted in the same survey as promising future opportunities.[42]

[41] Delbrück, Sebastian, Griestop, Laura, Hamm, Ulrich, "Future Opportunities and Developments in the Bioeconomy – a Global Expert Survey", German Bioeconomy Council, 2018. Available at https://biooekonomierat.de/fileadmin/Publikationen/berichte/GBS_Expert_Survey.pdf (Last visited 10/09/2020)

[42] Delbrück, Sebastian, Griestop, Laura, Hamm, Ulrich, "Future Opportunities and Developments in the Bioeconomy – a Global Expert Survey", German Bioeconomy Council, 2018. Available at https://biooekonomierat.de/fileadmin/Publikationen/berichte/GBS_Expert_Survey.pdf (Last visited 10/09/2020)

In the study "Top 20 innovative bio-based products" that was conducted by the University of Bologna (Italy) and Fraunhofer ISI (Germany) for the EC-DG RTD[43], general trends are investigated and recorded with regard to the value chains and materials which are promising for the future. In particular, as mentioned in the same study urban waste valorization is a significant sector and innovative products from urban waste are expected to be developed in the next few years. In addition, innovative solutions that are more mature and consequently close to commercialization derive from plant fibres while bio-based solutions linked to the plastics sector are considered promising as well. Furthermore, various engineering materials, high added-value products for the pharmaceutical & biomedical sector, as well as substitutes for critical raw materials become prominent.

Finally, the Bio-based Industries Joint Undertaking (BBI JU), which constitutes the public-private partnership between the European Union, represented by the European Commission (EC), and the Bio-based Industries Consortium (BIC), aims at implementing a program of research and innovation activities in Europe that will support the establishment of sustainable biobased value chains. BBI JU operates under Horizon 2020 and it is driven by the Strategic Innovation and Research Agenda (SIRA), last updated on July 2017. The SIRA[44] describes the main technological and innovation challenges that need to be overcome in order to develop sustainable and competitive bio-based industries in Europe on the basis of four Strategic Orientations (SO). SOs of the bio-based industry focus on the steps of a Value Chain (VC) and more specifically include:

1. Foster supply of sustainable biomass feedstock to feed both existing and new value chains.
2. Optimize efficient processing for integrated biorefineries through R&D&I.
3. Develop innovative bio-based products for identified market applications.
4. Create and accelerate the market-uptake of bio-based products and applications

SOs are presented also on the following Figure.

[43] Directorate-General for Research and Innovation (European Commission), Fraunhofer ISI, University of Bologna, "Top 20 innovative bio-based products", December 2018. Available at https://op.europa.eu/s/oiFG (Last visited 10/09/2020)

[44] BBI JU, "Strategic Innovation and Research Agenda (SIRA)", May 2017. Available at https://www.bbi-europe.eu/sites/default/files/sira-2017.pdf (Last visited 10/09/2020)

Figure 8 The SIRA value chains pillars form the four Strategic Orientations of the bio-based industry in Europe

5.4 Technical barriers

There are a lot of benefits of the bio-economy approach, but in order to make that system work major investment in the development and deployment of efficient biomass conversion technologies is necessary. However, it means that certain technical barriers must be overcome. Since WaysTUP! Pilots are using cutting-edge technologies in order to produce its end products, they have to be aware of technological barriers can hamper the implementation of circular and green practices. These barriers include product design and the integration into production processes, lack of technical skills and lack of data and insufficient transparency in the supply-chain information among others.

Information given in this chapter will be useful not only to WaysTUP! stakeholders, but also to renewable energy researchers, students, policymakers and individuals or organizations who may be concerned with promoting renewable energy technologies, as it highlights gaps in renewable energy development which they may need to address in their research and decision-making processes.

The Circular Economy is a **new economic paradigm** characterizing recent technological and economic growth framework. This new approach has begun to shape the choices made by industrialized countries and companies moving towards **a sustainability-driven business model**. The Circular Economy requires essential changes in current production and

consumption patterns, as it represents **the opportunity for emerging novel technologies** and the need for a variety of business activities and their interplay.[45]

There are **several barriers** to the transition to Circular Economy most of which are on the **regulatory technical and logistic sector**. Specifically, technological barriers can hamper the implementation of circular and green practices. The **product design and the integration into production processes** are two recognized categories of technological barriers which are translated into segments of higher complexity such as the quality of the recycled material, the energy resources, the product standardization and manufacturing, service and distribution processes and data management.[46]

The **lack of technical skills** is also an additional obstacle that prevents exploitation of Circular Economy opportunities. Many companies do not have the technical capacity to identify, assess and implement more advanced technical options, as they usually prioritize technologies with which they are already familiar.[47] In order to assess technological new options they still need a certain level of technical skill and knowledge which usually entails an excessive reliance on the opinions and recommendations provided form external actors.[48, 49]

According to Kirchherr et al. "Barriers to the circular economy: evidence from the European Union (EU)"[50] the **technological barriers are mainly focused to the lack of standardized technologies to implement Circular Economy**. The reduced ability to deliver high quality remanufactured products combined with the limited availability and quality of recycled materials constitutes a significant technological factor which integrates further extensions in regulatory and logistic barriers.[51] In addition, **the difficulty in implementing circular design processes in the production of materials, structures, and systems causes limited application**

[45] Den Hollander, M. C., Bakker, C. A., & Hultink, E. J. (2017). Product design in a circular economy: Development of a typology of key concepts and terms. Journal of Industrial Ecology, 21(3), 517-525.
[46] Ritzén, S., & Sandström, G. Ö. (2017). Barriers to the Circular Economy–integration of perspectives and domains. Procedia Cirp, 64, 7-12.
[47] Rizos, V., Behrens, A., Kafyeke, T., Hirschnitz-Garbers, M., & Ioannou, A. (2015). The circular economy: Barriers and opportunities for SMEs. CEPS Working Documents.
[48] Calogirou, C., Sørensen, S. Y., Larsen, P. J., & Alexopoulou, S. (2010). SMEs and the environment in the European Union, PLANET SA and Danish technological institute. Brussels: European Commission, DG Enterprise and Industry.
[49] Rademaekers, K., Asaad, S. S. Z., & Berg, J. (2011). Study on the competitiveness of the European companies and resource efficiency. ECORYS: Rotterdam, The Netherlands.
[50] Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., & Hekkert, M. (2018). Barriers to the circular economy: evidence from the European Union (EU). Ecological Economics, 150, 264-272.
[51] IMSA, 2013. Unleashing the Power of the Circular Economy. Available at: http://mvonederland.nl/system/files/media/unleashing_the_power_of_the_circular_economy-circle_economy.pdf

of circular business models in the real economy.[52] Finally, an important technological obstacle can be the **lack of data and insufficient transparency in the supply-chain information** which is indirectly related to the progress of policies on open data and the integration of information systems into the production process.[53]

In 2015, van Eijk[54] examined and identified some aspects of technological barriers such as the modularization and standardization prospects in circular product design which includes easier disassembly, durability, reuse and higher efficiency in production process. Furthermore, **material and energy-flow innovations for industrial symbiosis and Circular Economy is hard to access due to competition and privacy policies within business**. The interdependence on the technological advances increases the risks economically for businesses, when at the same time there is lack of investment in new recycling and recovery infrastructure and technologies.

The above-mentioned technological barriers demonstrate that Circular Economy strategies and model designs have ample room for development worldwide. Europe is playing a central role in this evolutionary process, at the institutional, regulatory and technological level. In fact, there are many pioneering entities currently involved in the transformation of production chains and consumption patterns operating to keep materials circulating in the economy for longer, re-designing industrial systems and encouraging cascading use of materials and waste.

5.5 Conclusions

In chapter 5.1 we examined economic, social and environmental impacts of the bioeconomy since WaysTUP! Project together with its Pilot solutions aims to contribute to further development of the EU Bioeconomy sector. We found out that economic impact reflects in the fact that changing production processes lead to changing demand for Bioeconomy-related and non-related products. Moreover, all these changes together will impact food prices that will further result in a GDP/GNI change. Also, social impact refers to changing behaviour, state of health, employment and food security, while environmental impact includes changing biodiversity, water/soil quality, carbon emissions etc.

[52] Mont, O., et al., 2017. Business model innovation for a circular economy drivers and barriers for the Swedish industry – the voice of REES companies. Available at: http://lup.lub.lu.se/search/ws/files/33914256/MISTRA_REES_Drivers_and_Barriers_Lund

[53] Pheifer, A.G., 2017. Barriers and Enablers to Circular Business Models. Available at: https://www.circulairondernemen.nl/uploads/4f4995c266e00bee8fdb8fb34fbc5c15.pdf

[54] van Eijk, F., 2015. Barriers & Drivers Towards a Circular Economy. Available at: http://www.circulairondernemen.nl/uploads/e00e8643951aef8adde612123e824493.pdf

Chapter 5.2 is dedicated to introducing the latest EU Policies regarding Bio-economy, to WaysTUP! stakeholders, particularly Pilots. Here, we found out that updated Bioeconomy Strategy aims (1) to accelerate the deployment of a sustainable European bioeconomy, and (2) to contribute towards the Sustainable Development Goals (SDGs). Currently, there is no specific EU bioeconomy legislation. However, sectorial legislation, in many cases has major impact in the field. So far, 19 Member States have developed their bioeconomy strategies, and other EU countries are going in the same direction. These actions will further boost bioeconomy and contribute to its sustainability.

Within chapter 5.3 we analyzed different bioeconomy sectors in order to identify future opportunities and developments that WaysTUP! Pilots could seize. Most promising sectors are energy, agriculture and food, chemicals and bioplastics, urban waste valorization, pharmaceutical and biomedical industry. We can conclude that WaysTUP! Pilots are headed in the right direction considering that their business areas include almost all of these emerging bioeconomy segments.

For example, innovative production methods especially in food industry through the utilization of new raw materials are expected to be developed successfully. This means that such initiatives will be strongly supported in the upcoming period.

This is beneficial for WaysTUP! partners participating in Pilot 1 and Pilot 2 where urban food waste will be utilized for production of functional ingredients and gelatine in the first case, and coffee oil in the second case. Also, food industry is looking for new production methods to produce alternative protein sources, such as insect protein. This means that Pilot 3 end products (protein insect flour), as well as specific know-how that has been developed within this Pilot, are expected to be valuable and widely accepted assets on the market.

Overall, valorization of urban waste and the creation of new value chains in bio-based industry are highlighted as promising future opportunities, and this implies on all WaysTUP! Pilots.

Finally, in order to prepare Pilots for the existing technical barriers in implementing bio-economy approach, we carefully explored this topic and concluded that the most significant technical barriers include product design and integration into production processes, lack of technical skills and lack of data and insufficient transparency in the supply-chain information. Therefore, we highly recommend all WaysTUP! Pilots to pay special attention to these challenges.

6. Market Breakup by geographic areas (countries)

The aim of this report is to develop a complete view of the entire urban biowaste value chain focusing on detailed market analysis. That said, this market outlook report will analyse market drivers and barriers to entry for technologies and end-products within each country and on a broader European basis, taking into account economic, technological and political factors for different geographic areas, technological solutions, end-products and user groups.

Our approach is based on different market segmentations - market breakups by geographic areas, technological solutions, end-products and user groups/industries. The first market breakup incorporates the geographic segmentation by countries where WaysTUP! Pilots will take place. By taking a closer look into the current economic, political and technological situation within these counties, Pilots will be able to implement their business strategies accordingly. Also, in situations where an organization has a marketing strategy for a particular location, it becomes additionally convenient for this organization to apply the same strategy to neighboring locations which demonstrate similar geographical characteristics.

Geographical segmentation gives an organization an essential early competitive edge by understanding trends in localized markets. Furthermore, for organizations that have limited reach, geographic segmentation is a strategy to focus their resources on accurate target audiences and potentially receive better revenue results.

6.1 United Kingdom

6.1.1 The Economic dimension

Before we start analyzing the economic situation in UK, it is important to emphasize that the **United Kingdom withdrew from the European Union as of 1 February 2020**. The Agreement on the withdrawal of the United Kingdom of Great Britain and Northern Ireland from the European Union and European Atomic Energy Community (OJ L 29, 31.1.2020, p. 7) entered into force on the same date. It provides for a transition period which will last until 31 December 2020. During the transition period, Union law (with a few exceptions) is applicable to and in the United Kingdom. For the purposes of Union law applicable to it during the

transition period, the United Kingdom is treated as an EU Member State, but will not participate in EU decision-making and decision-shaping.[55]

In 2019 UK GDP growth was unstable. Stockpiling and other mitigation activity driven by fears of a possible disorderly exit from the EU in March temporarily boosted growth in the first quarter of 2019. However, in the second quarter of 2019, the UK experienced an opposite, dampening effect. What is interesting is that a similar, though less pronounced pattern was again visible in the months around the possible withdrawal date at the end of October.[56]

In general, the UK's GDP has only increased by 1.4% in 2019, compared to 1.3% in 2018 (International Monetary Fund - IMF). Based on the updated IMF forecasts from 18th October 2020, due to the outbreak of the COVID-19, **GDP growth is expected to fall to -9.8% in 2020 and pick up to 5.9% in 2021**, taking into account the post-pandemic global economic recovery, conclusion of a broad free trade agreement (FTA) with the EU and a smooth post-Brexit transition period.[57] **The unpredictability created by the existing negotiation process around Brexit and by the anticipated increase in future trade costs will have huge effects on the country's economy.** Moreover, possible growth slowed due to the slow-moving accumulation of capital, the decline in net migration from the European Union and the continuously low productivity. According to the IMF, **reverting to WTO** (World Trade Organization) **trade rules**, even in an ordered way, **would cause long-term production losses for the UK of around 5% to 8% of GDP in comparison to a scenario without Brexit**.[58]

Since 2018, business investment has dropped, consumption has been decreased by weak growth in real income and public debt has remained at above 85% of GDP. Nevertheless, thanks to steady fiscal consolidation, the public deficit fell below 2% of GDP. Government authorities are focused on the preparations for Brexit, including major administrative and legislative changes. **One of the first concerns will be to conclude a free trade agreement with the EU,** and many analysts consider the end of 2020 deadline unrealistic. A comprehensive strategy aims to increase productivity, by strengthening investment in physical and human capital. The conservative party's manifesto prioritized achieving Brexit ("get Brexit done") and has few details in terms of economic policy. The government tends to rise investment spending to 3% of GDP and to increase budget spending. On the other hand, **there are no plans for increasing income taxes, value added tax or the cost of national insurance**.

[55] https://ec.europa.eu/info/sites/info/files/economy-finance/ip121_en.pdf
[56] https://ec.europa.eu/info/sites/info/files/economy-finance/ip121_en.pdf
[57] https://www.imf.org/en/Countries/GBR
[58] https://santandertrade.com/en/portal/analyse-markets/united-kingdom/economic-political-outline

Despite moderate growth, the employment rate has reached historic highs. **Unemployment is estimated at 3.8% of the working population according to the IMF and is expected to rise to 4.8% and 4.4% in 2020 and 2021, respectively**. Having said that, job creation has been attributed by job insecurity, the growth of part-time work and wage freezes. Unemployment is still present among young population. It is roughly calculated that currently one out of five people under the age of 24 is unemployed. The relatively solid macroeconomic performance of the United Kingdom conceals weaknesses and situations of inequality. Thus, **strengthening human capital is a key priority.** In addition, measures that will further support more sustainable and inclusive growth are the government's efforts to invest in infrastructure, strengthening the supply of housing and increase the participation of women in the labour market.

Main Sectors of Industry

The United Kingdom is actually among the world's largest producing countries, with particularly important civil, pharmaceutical industries and military aerospace. The agricultural sector accounts approx. 0.6% share of GDP, but is extremely productive, the country managing to produce enough to meet around sixty percent of its food demand. The major sector employs 1% of the active population. The main crops produced in the UK are barley, wheat, beets, and potatoes. **Livestock farming (especially cattle and sheep) remains one of the primary agricultural activities**. Another industry that is well developed is the fishing industry. However, it is currently suffering from the depletion of fish volumes in traditional fishing areas.

The UK is rich in mineral resources. Even though it was once the 10th largest oil producer in the world with large natural gas reserves, its production is actually quickly declining. However, groups like British Petroleum and Shell are still known as the world leaders in the petroleum industry. Nevertheless, the industrial sector, which accounts for 17.5% of GDP and hires eighteen percent of the working population, is not really competitive, primarily as a result of the reduced productivity. The key sectors are machine tools, chemicals and transport equipment. But, there are also other **sectors which are recognized as sectors which have a very strong potential, and these are: bio-technologies, renewable energies, aviation, defence and information and communication technologies**.

The engine of the UK's economy is the service sector. It employs more than 80% of the workforce and contributes more than 70% of GDP. London is the largest financial center in Europe. The banking sector is very dynamic. London is also home to the headquarters of many multinationals.

The uncertainty caused by Brexit has increased the pressures on economic activity. The depreciation of the pound sterling increased the cost of imports and reduced the margins

achieved by businesses. Insolvency cases have multiplied, particularly in the retail, food and construction sectors.[59]

6.1.2 The Political dimension

United Kingdom has defined bioeconomy as the economic activity derived from utilizing biological resources or bio-processes for the production of value added products such as food, feed, materials, chemicals, fuels, bio-based products (products that are wholly or partly derived from materials of biological origin) and bioenergy.[60]

The bioeconomy represents the economic potential of harnessing the power of bioscience. It aims to produce innovative products, processes and services that rely on renewable biological resources instead of fossil fuel alternatives.

The UK bioeconomy strategy operates within the broader remit of UK government's industrial strategy.[61]

Lead national institutions involved in the bioeconomy are department for Business, Energy & Industrial Strategy, the Welsh Government and the Scottish Government. However, there are also other institutions that support development of UK's bioeconomy. Some of them boost and foster investments in this area, and these are: UK Research and Innovation, Highlands & Islands Enterprise, Scottish Enterprise, Innovate UK - Knowledge Transfer Network (Innovation Network) and Industrial Biotechnology Innovation Centre - IBioIC (Innovation cluster). There are also Public-Private Partnerships (PPP) that ensure an integrated and cross-policy approach.

Bodies that contribute to the design and development of the bioeconomy strategy are:

- Industrial Biotechnology Leadership Forum (IBLF),
- Synthetic Biology Leadership Council,
- Food and Drink Sector Council,
- Chemistry Council,
- Medicines Manufacturing Industry Partnership.[62]

There are also Research Institutions such as Biotechnology and Biological Sciences Research Council (BBSRC), BEACON (Wales) and Biorenewables Development Centre (BDC – York) that present knowledge hubs which transfer and foster the national bioeconomy and its competitiveness together with two Innovation Networks (Innovate UK - Knowledge Transfer

[59] https://santandertrade.com/en/portal/analyse-markets/united-kingdom/economic-political-outline
[60] https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en
[61] https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en
[62] https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en

Network and Biotechnology and Biological Sciences Research Council - BBSRC funded networks in Industrial Biotechnology and Bioenergy) and Innovation cluster – IbioIC.

BBSRC and IBioIC manage and coordinate Research and Development programs that are focused on bioeconomy, and the following institutions conduct research activities and technological developments specifically on the bioeconomy:

- The James Hutton Institute
- Scottish Association for Marine Science
- York University
- Manchester University
- Agri-food and Biosciences Institute.[63]

United Kingdom has a national bioeconomy strategy to 2030 that aims to grow UK's bioeconomy sector. According to this strategy, there are two quantitative targets:

1. to double the impact of the bioeconomy in UK from £220bn in 2014 to £440bn by 2030.
2. to invest an additional £406m to address the shortage of STEM (Science, Technology, Engineering, and Math) skills.[64]

6.1.3 The Technological dimension

According to the Regional Innovation Scoreboard (RIS) 2021 which provides a comparative assessment of performance of innovation systems across 240 regions of 23 EU Member States (and Norway, Serbia, and Switzerland), we can see **Europe's regions classified into groups of regional Innovation Leaders, regional Strong Innovators, regional Moderate Innovators, and regional Modest Innovators**.[65]

Figure below shows average indicator scores by regional performance group.

[63] https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en
[64] https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en
[65] https://ec.europa.eu/growth/sites/growth/files/ris2019.pdf

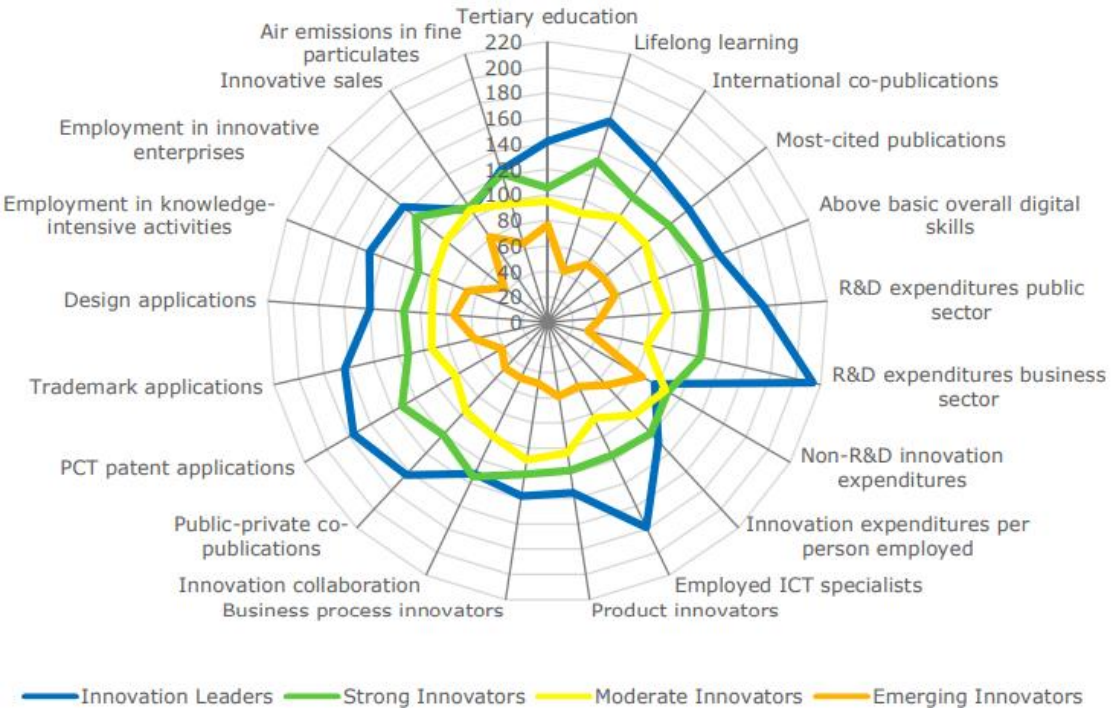


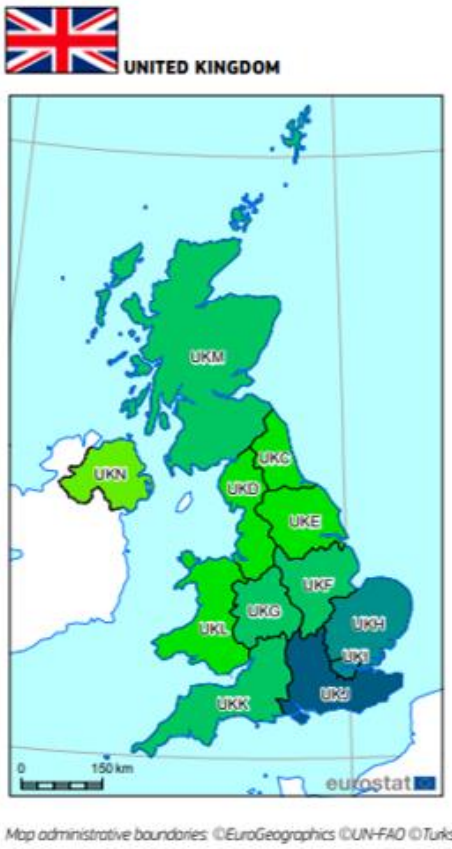
Figure 9 Average indicator scores by regional performance group

Source: Regional Innovation Scoreboard 2021, European Commission

There are also three subgroups within each performance group to allow for more diversity at the regional level: the top one-third regions (+), the middle one-third regions and the bottom one-third regions (-).[66]

Within this section – "The Technological dimension" we will present for each country the performance of the regions within that country. For each country, a map is included showing the location of the regions in that country. Regions that are highlighted in bold are the once which include the country's capital city.

[66] https://ec.europa.eu/growth/sites/growth/files/ris2019.pdf



NUTS	Region	RII	Rank	Group	Change
UKC	North East	112.0	71	Strong	19.9
UKD	North West	114.0	66	Strong	10.8
UKE	Yorkshire and The Humber	113.3	68	Strong	18.2
UKF	East Midlands	117.6	52	Strong +	10.9
UKG	West Midlands	121.1	46	Strong +	20.6
UKH	East of England	130.5	26	Leader -	15.6
UKI	**London**	133.0	22	Leader -	11.0
UKJ	South East	137.6	12	Leader	17.6
UKK	South West	124.7	39	Strong +	13.3
UKL	Wales	114.5	65	Strong	21.2
UKM	Scotland	122.2	43	Strong +	19.2
UKN	Northern Ireland	106.8	87	Strong -	20.4

RII: performance in 2021 relative to that of the EU in 2021. Rank: rank performance in 2021 across all regions. Group: respective sub-group. Change: performance change calculated as the difference between the performance in 2021 and 2014 relative to that of the EU in 2014.

Figure 10 Performance of the regions within United Kingdom

Source: Regional Innovation Scoreboard 2021, European Commission

The United Kingdom is a Strong Innovator and includes 12 regions.

Three regions are Innovation Leaders,while the other nine regions are Strong Innovators. The most innovative region is South East (UKJ). Performance relative to the EU in 2014 has increased for all regions, most strongly for Wales (UKL).

6.1.4 The Bioeconomy in United Kingdom

According to UK's national bioeconomy strategy (from 2018 to 2030), UK tends to become a global leader in developing, manufacturing, using and exporting bio-based solutions. In order to achieve this, Bioeconomy Strategy sets out **a collective approach from government, industry and the research community to transform the UK economy through the power of bioscience and biotechnology.** They have worked together and have set out four strategic goals:

1. Capitalize on their own world-class research, development and innovation base to grow the bioeconomy

Constant advancement of their research, development and innovation base, leveraging greater investment to turn their innovative ideas into commercial success in the global market.

2. Maximize productivity and potential from existing UK bioeconomy assets

Making the most of their knowledge, facilities and people to increase productivity from their existing renewable biological resources.

3. Deliver real, measurable benefits for the UK economy

Support Industry sectors to ensure that this strategy delivers real, measurable benefits for the UK, meaning to create jobs, increase productivity and double the size of the impact of the bioeconomy to £440bn by 2030.

4. Create the right societal and market conditions to allow innovative bio-based products and services to thrive. [67]

In order to achieve these goals, it is necessary to engage with a wide range of country's organizations, to cover the length and breadth of the UK to support this transformation, from UK's research councils and universities, through to regional and national government agencies and industrial leaders.

The role of the policy, regulations and guidance is to help overcome barriers and create the right market conditions for growth. Funding has a crucial role in maintaining and growing UK's research and innovation landscape. Also, private sector investment and the commercialization of innovative products to the market are recognized to be essential for bringing forward new highly skilled jobs and retain the current skills base. Furthermore, this strategy provides a lasting platform for open dialogue between researchers, innovators, industrialists and policy makers.[68]

Another characteristic of UK's bioeconomy strategy is reflected in **bringing industrial sectors together**. Bioeconomy operates across different sectors and connects a number of different disciplines such as industrial biotechnology and synthetic biology, aquaculture, agriculture and food technology, medicines manufacturing and chemicals. Therefore, a national strategy is needed to coordinate activities and set out an appropriate framework for growth.

67 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/761856/181205_BEIS_Growing_the_Bioeconomy_Web_SP_.pdf

68 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/761856/181205_BEIS_Growing_the_Bioeconomy_Web_SP_.pdf

Third pillow of transformation of UK's economy into a world-class bioeconomy lies in the **scale of the opportunity**. Investment in the highest-quality research and innovation in the country will support multidisciplinary and interdisciplinary areas such as the bioeconomy, fostering a collaborative environment for universities, researchers and businesses. This approach will contribute to attracting funding from new sources and to developing the talent pipeline.[69]

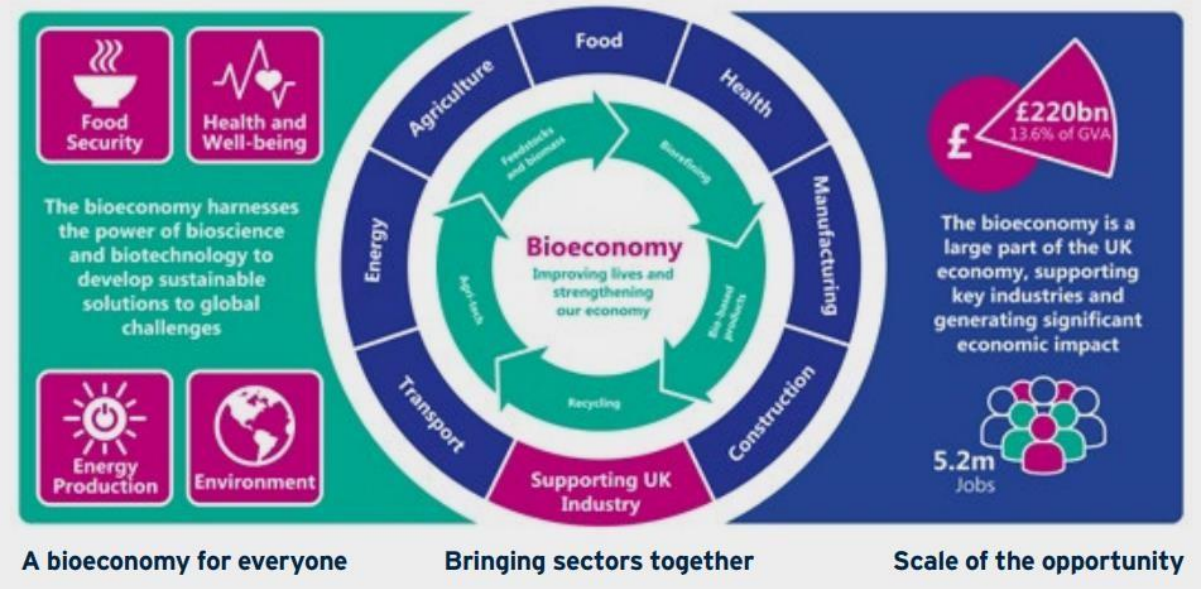


Figure 11 UK's Bioeconomy Strategy

Source:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/761856/181205_BEIS_Growing_the_Bioeconomy Web_SP_.pdf

6.1.5 Conclusions

In order to understand current situation in the United Kingdom, we analyzed economic, political and technological dimensions, as well as, current state of the bioeconomy sector in the country, since this is the area in which WaysTUP! Pilots are operating.

When it comes to UK, the most important information is that it withdrew from the European Union as of 1 February 2020. It is currently in the transition period that will last until the end of 2020. The unpredictability created by the existing negotiation process around Brexit and by the anticipated increase in future trade costs will have huge effects on the country's economy. However, Brexit is not the only factor that brings uncertainty. Based on the

69 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/761856/181205_BEIS_Growing_the_Bioeconomy Web_SP_.pdf

updated IMF forecasts from 18th October 2020, due to the outbreak of the COVID-19, GDP growth is expected to fall to -9.8% in 2020 but will pick up to 5.9% in 2021, thanks to the post-pandemic global economic recovery. Moreover, unemployment is expected to rise to 4.8% and 4.4% in 2020 and 2021, respectively. Therefore, strengthening human capital will be a key priority in the upcoming period.

Regarding main sectors of the UK's industry, we can conclude that particularly important are civil, pharmaceutical industries and military aerospace, as well as service sector and agriculture (specifically livestock farming). On the other hand, sectors which have a very strong potential include bio-technologies, renewable energies, aviation, defence and information and communication technologies.

Pilot 2 is located in London, and is doing business related to bio-technologies, which is considered to be a high-potential sector of the UK economy. Overall economic situation in UK is uncertain due to Brexist and Covid 19 health crisis, but forecasts indicate that the situation will improve in the upcoming period.

Considering the political aspect, lead national institutions involved in the bioeconomy are department for Business, Energy & Industrial Strategy, the Welsh Government and the Scottish Government, and these bodies are supported by lots of other research institutions and networks. Significant thing is that United Kingdom developed a national bioeconomy strategy to 2030 that aims to grow UK's bioeconomy sector. This means that initiatives such as Pilot 2 coffee oil production will be strongly supported by policies, regulations and guidance that aims to help overcome barriers and create the right market conditions for growth. Also, there will be different funding opportunities available for projects related to bioeconomy.

Finally, considering technological dimension, UK is a strong innovator according to the Regional Innovation Scoreboard (RIS), which makes this country a positive surrounding for starting an innovative business.

6.2 Spain

6.2.1 The Economic dimension

Between 2014 and 2018, Spain had an average GDP growth of 2.8%. For 2019, the IMF estimated a GDP increase of 2% amid net exports and a slower private consumption. Nevertheless, since 2014 private consumption has been growing at its slowest pace, due to the increased level of households' precautionary savings.[70] Based on the updated IMF forecasts from 18th October 2020, that take into account the outbreak of the COVID-19, **real**

[70] https://santandertrade.com/en/portal/analyse-markets/spain/economic-political-outline

GDP growth is expected to fall to -12.8% in 2020 and pick up to 7.2% in 2021, thanks to the post-pandemic global economic recovery. Domestic demand should remain the main growth driver.[71]

Looking at the public finances, the country's budget deficit - at 2.3% in 2019 – is expected to stay stable in the upcoming years (according to IMF). A rise in the revenues from personal income taxes and social contributions had a positive impact on the budget. The debt-to-GDP ratio – which is nearly three times greater than before the 2008 financial crisis – declined to 96.4% in 2019 and is expected to decrease gradually to 94% by 2021, thanks to nominal GDP growth and lower borrowing costs. Private debt and credit outstanding are still at elevated levels, but continue to contract. **Structural reforms to give autonomous regions greater budgetary and financial stability are still one of the top priorities**. Other pending reforms include technological innovation to diversify the Spanish economy, fostering better employment conditions, an improved research and development (R&D) ecosystem, and social programs based on the European Pillar of Social Rights. In early 2019, the minimum wage was increased by 22.3%. Inflation rate was at 0.7% in 2019 and it is expected to decrease to -0.2% in 2020 and increase to pre-pandemic levels of 0.8% in 2021, according to the latest World Economic Outlook of the IMF (18th October 2020).[72]

The unemployment rate decreased from 15.3% in 2018 to 14.1% in 2019; however, taking into account the negative economic impact of the COVID-19 pandemic, **the rate is estimated to increase to 16.8% in 2020 and stay at the same level in 2021.** In the following years, the unemployment rate is predicted to decrease gradually. Another issue facing the Spanish labour market is the **low level of active population compared to the potential workforce**, which denotes that many people gave up on looking for an employment. Furthermore, Spain remains a country with **strong inequalities**: according to the latest data by the Spanish Statistical Office, 21.6% of the population lives under the poverty threshold (set at EUR 8,500 per year), and the social expenses in the public budget only account to roughly 17% of GDP, compared to a EU average of around 19% (Eurostat).[73]

Main Sectors of Industry

Agriculture contributes to around 2.8% of country's GDP and employs 4% of the workforce (World Bank, 2019). There are almost one million agricultural and livestock businesses in Spain that cover 30 million hectares of land. **Spain is the world's largest producer of olive oil and the world's third largest producer of wine**. It is also a great producer of strawberries and

[71] https://www.imf.org/en/Countries/ESP
[72] https://www.imf.org/en/Countries/ESP
[73] https://santandertrade.com/en/portal/analyse-markets/spain/economic-political-outline

oranges in the world. The main crops are wheat, sugar beet, olives, grapes, barley, tomatoes, citrus fruits and cork. Livestock is also dominant, especially for pigs and cattle.[74]

The industrial sector contributes to 20% of GDP and of total employment. **The most significant industry is manufacturing.** It accounts approx. 11% of GDP (World Bank). The industrial sector is dominated by textiles, iron and steel, industrial food processing, naval machines, and engineering. Also, **sectors that have a huge growth potential are information technology, outsourcing of electronic components production, and telecommunications**.

The tertiary sector accounts for 67.7% of GDP and 76% of the active population is working within this sector. Very important sector for the Spain's economy is tourism, as it presents the country's main source of income. The banking sector is also powerful and is consisted of 12 banking groups, including 52 private banks, 2 saving banks and 62 cooperative banks.[75]

6.2.2 The Political dimension

Spain defined bioeconomy as "*the set of economic activities that obtain products and services, generating economic value, making efficient and sustainable use of resources of biological origin as fundamental elements. Its objective is to produce and market food, along with forestry products, bioproducts and bioenergy obtained by physical, chemical, biochemical or biological processing of organic matter not destined for human or animal consumption and involving processes which are respectful of the environment, along with the development of rural areas*".[76]

Regional bioeconomy strategies that have been adopted (or are still in the preparation phase) in the previous years are:

- Circular Bioeconomy Strategy of Andalusia
- Valencia Bioeconomy Strategy (in preparation)
- Extremadura Bioeconomy Strategy (in preparation)
- Catalonia Bioeconomy Strategy (pending publishing)
- Castile-Leon Bioeconomy strategy (in preparation)
- Aragon Bioeconomy Strategy (in preparation)
- Asturias Bioeconomy Strategy (in preparation)

[74] https://santandertrade.com/en/portal/analyse-markets/spain/economic-political-outline
[75] https://santandertrade.com/en/portal/analyse-markets/spain/economic-political-outline
[76] https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en

- Murcia Bioeconomy Strategy (in preparation).[77]

All bioeconomy strategies have, among others, the following goals:

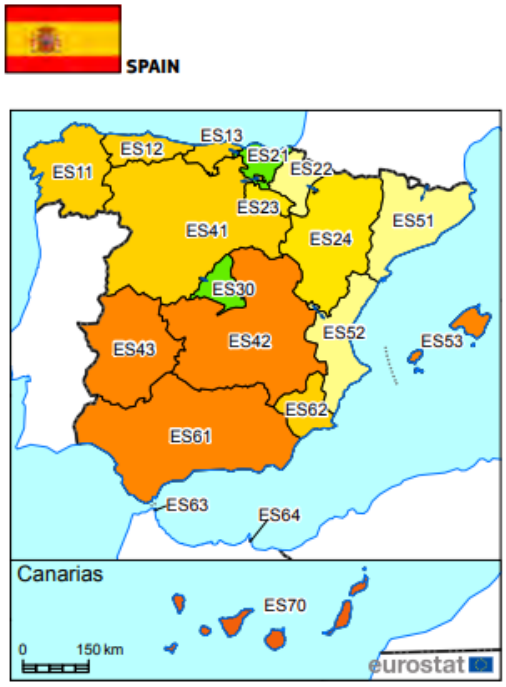
- To enhance the competitiveness and internationalization of Spanish companies
- To keep the Spanish bioeconomy as an vital part of country's economic activity
- To assist in attaining all the bioeconomy's development potential to 2030 Operational Objectives
- To promote development of the bioeconomy
- To encourage cooperation between the public and private Spanish and international science and technology systems and the productive sectors.[78]

When it comes to the main institutions involved in the national bioeconomy sector, lead ministries are Ministry of Science, Innovation and Universities (MICINN) and Ministry of Agriculture, Fisheries and Food (MAPA). Other relevant institutions include Ministry of Economy and Business, Research institutions - Spanish Bioeconomy Observatory, National Institute of Food and Agricultural Research & Technology (INIA) , Spanish National Research Council – CSIC, Catalonia Agriculture Research and Technology Institute – IRTA, Agrifood Research and Technology Centre of Aragón – CITA and Spanish Institute of Oceanography – IEO etc.[79]

6.2.3 The Technological dimension

Spanish science and technology have reached a considerable level of excellence over the last three decades due to the incorporation of facilities and infrastructures of first international level.

77 https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en
78 https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en
79 https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en



NUTS	Region	RII	Rank	Group	Change
ES11	Galicia	78.9	156	Moderate -	16.0
ES12	Principado de Asturias	73.7	166	Moderate -	8.9
ES13	Cantabria	73.5	168	Moderate -	9.5
ES21	País Vasco	103.6	93	Strong -	14.7
ES22	Comunidad Foral de Navarra	98.1	114	Moderate +	17.5
ES23	La Rioja	80.7	150	Moderate	7.9
ES24	Aragón	80.9	148	Moderate	9.1
ES3	**Comunidad de Madrid**	101.0	100	Strong -	13.7
ES41	Castilla y León	76.9	160	Moderate -	17.4
ES42	Castilla-la Mancha	64.4	183	Emerging +	12.3
ES43	Extremadura	61.1	188	Emerging +	14.1
ES51	Cataluña	98.9	108	Moderate +	16.9
ES52	Comunitat Valenciana	91.3	128	Moderate +	18.3
ES53	Illes Balears	67.4	178	Emerging +	9.9
ES61	Andalucía	67.5	177	Emerging +	10.6
ES62	Región de Murcia	76.3	161	Moderate -	17.5
ES63	Ciudad de Ceuta	33.6	231	Emerging -	4.2
ES64	Ciudad de Melilla	40.6	226	Emerging	12.5
ES7	Canarias	48.8	216	Emerging	10.7

RII: performance in 2021 relative to that of the EU in 2021. Rank: rank performance in 2021 across all regions. Group: respective sub-group. Change: performance change calculated as the difference between the performance in 2021 and 2014 relative to that of the EU in 2014.

Figure 12 Performance of the regions within Spain

Source: Regional Innovation Scoreboard 2021, European Commission

According to RIS, **Spain is a Moderate Innovator and includes 19 regions**.

It is noticeable that regional performance differences are high. The best performing region is Pais Vasco (ES21), and the lowest performing region is Ciudad Autonoma de Ceuta (ES63). Two regions are Strong Innovators, 10 regions are Moderate Innovators, and 7 regions are Emerging Innovators. Performance relative to the EU in 2014 has increased for all regions, and most strongly for Comunitat Valenciana (ES52).

Scientific and technological research in Spain is coordinated by the Science, Technology, and Innovation Policy Council (CPCTI), made up of representatives of the Central Government and the Autonomous Communities. This institution has coordinated the Unique Scientific and Technical Infrastructure (ICTS) map, which refers to facilities, resources, or services for the development of top-quality cutting-edge research, as well as the communication, exchange, and preservation of knowledge, the transfer of technology, and promotion of innovation related to a wide range of fields [80]. They comprise:

1. Health, demographic change and well-being

[80] MAP of unique scientific and technical infrastructures (ICTS). Ministerio de Economía y Competitividad. Spain

2. Food safety and quality; productive and sustainable activity; sustainability of natural resources, marine and maritime research
3. Safe, sustainable and clean energy
4. Smart, sustainable and integrated transport
5. Action on climate change and efficiency in the use of resources and raw materials
6. Social innovation and changes
7. Economy and the digital society
8. Security, protection and defence

Because of their nature, all of them encompass large fundamental areas which determine unique spaces for the multidisciplinary and inter-sectoral collaboration of the different stakeholders of the Spanish Science, Technology and Innovation System.

These eight areas are societal challenges, which require a major effort in terms of basic scientific research, development and innovation developed by research groups both in the public and business sector and in collaboration.

Despite this, **map of infrastructures is one of the most relevant key indicators of the Spanish Science, Technology and Innovation System**, other actions can be also accounted, in particular, the following aspects [81]:

1. The international opening of the System, reflected in the participation of researchers and companies in international projects and programmes, especially the EU 7th Framework Programme.
2. The creation of new research and technology development centres, the recognition of campuses and centres of excellence and the consolidation throughout the country of new spaces for innovation, especially around science and technology parks, together with the promotion of Technology Platforms and Alliances for Science and Innovation directed at stimulating collaboration among public and private stakeholders and companies.

Nevertheless, and in spite of the above advances, some barriers are identified in the Spanish Science, Technology and Innovation System:

1. **A lower percentage expenditure on R&D**, which continues to be lower than that of neighbouring countries, in spite of the implementation of new public-private collaboration instruments and the existence of a favourable fiscal framework for

[81] Spanish Strategy for science and technology and innovation 2013-2020 Ministerio de Economía y Competitividad. Spain

RDI. The persistence of this gap results in the low innovative capacity of the country (see Figure 12) in clear contrast to the scientific capacities developed.

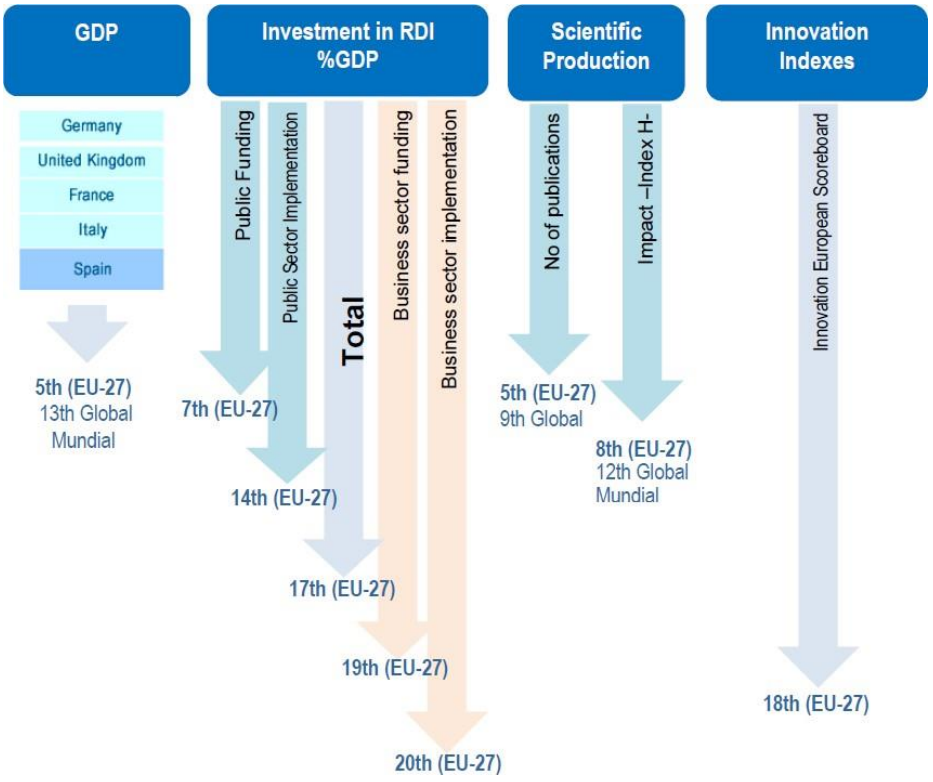


Figure 13 Relative position of Spain on an international level [82]

2. **The low number of innovative companies**, especially SMEs, and the limited weight of medium/high technology sectors (See Figure 13), in addition to the fact that the companies that do systematically conduct R&D activities are fewer than is desirable.

[82] Marius Hasenheit, Holger Gerdes, Zoritza Kiresiewa, Volkert Beekman, Summary report on the social, economic and environmental impacts of the bioeconomy, February 2016

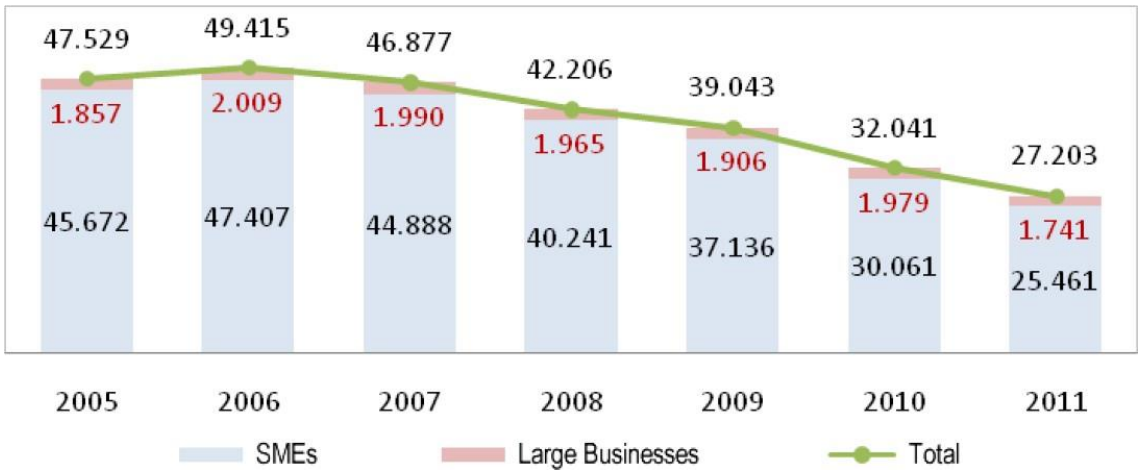


Figure 14 Technologically innovative companies by size of company. 2005-2010 [83]

3. The persistence of major regional disparities with respect to effort and investment in RDI.

Biotechnology sector in Spain

Spain's industrial biotech sector is most developed in bioenergy applications such as biofuels. The country is also said to be a **world leader in marine biotechnology**. Biotechnology is the third largest contributor to Spain's GDP and industrial biotechnology is considered as one key sector driving the country's economic competitiveness.

This sector is characterized by strong focus on innovative R&D. The existing industrial biotechnology know-how coupled to a strong academic base in IB and feedstock availability contributes to promote the development of projects related to the reuse and treatment of wastes and residues. In Spain, there is **presence of human resources with skills and curricula to address current challenges within the Spanish IB industry, which is an advantage for the further development of this sector coupled to first class scale-up facilities and academic research** [84].

The more relevant weaknesses related to the Spanish industrial biotechnology is that there is **no dedicated policies promoting industrial biotechology and with the exception of biofuels**, there are no subsidies for industrial biotech products limited number of companies and

[83] Marius Hasenheit, Holger Gerdes, Zoritza Kiresiewa, Volkert Beekman, Summary report on the social, economic and environmental impacts of the bioeconomy, February 2016
[84] Industrial biotechnology in Europe. Available at: http://industrialbiotech-europe.eu/map/spain/

SMEs because of the **lack of funding** and high investment needs for development high energy costs [85].

To overcome exiting barriers, the Spanish strategy is focused on four **main general objectives:**

- Fostering and promoting talent and its employability
- Promotion of scientific and technical research of excellence
- Boosting business leadership in RDI
- Support for RDI aimed at societal challenges

Institutions of the biotechnology sector in Spain

The industrial biotechnology sector in Spain counts around 40 companies which participate in 271 national and international projects focusing on bioproducts and bioprocesses.

- Associations

ASEBIO – the Spanish Bioindustry Association

FEBiotec – the Spanish Federation of Biotechnologists

SEBiot – Spanish Biotechnology Society

- Companies

Abengoa Bioenergy – bioethanol production

Algaenergy – microalgae biotech

Biochemize – microbial fermentation, biocatalysis and enzymatic screening

Bioiberica – R&D and production of biomolecules for pharmaceutical, veterinary and agricultural industries

Bionet Ingenieria – design and building of fermenters and bioreactors, process development and engineering services

Biopolis – design, production and purification of microorganisms, and microbial metabolites

Biosearch – biotech company dedicated to R&D and commercialization of products for the pharmaceutical, nutraceutical and functional food sectors

Camelina Company – production of sustainable second generation feedstock for the advanced biofuels industry, with a special focus on biojetfuel for the aviation industry

[85] Industrial biotechnology in Europe. Available at: http://industrialbiotech-europe.eu/map/spain/

Inkemia IUT group – knowledge generation for chemical, pharmaceutical, biopharmaceutical, biotechnological and other life sciences sectors

Neol Biosolutions – development of bioprocesses and microbiological expertise for industrial-scale application

Pevesa – design, R&D and production of proteins, peptics, aminoacids and biochemical compounds through biotechnology

Proteos Biotech – production and commercialization of recombinant enzymes for their application in research, cosmetics and biomedicine

Repsol – integrated energy company which set up the Cenit VIDA project which seeks new eco-efficient solutions for application to the urban environment, entailing the need to make the most of natural resources, waste and polluting substances, using algae as an element in the process.

Seprox Biotech – industrial production of Hydroxytyrosol, Hydroxytyrosol Acetate and 2-3,4 Dihydroxyphenilacetic acid

AB-Biotics – R&D and biotech solutions provider

Natac Biotech – development and manufacturing of ingredients for functional foods and food supplements

Recombina – advice and genetic engineering services applied to microorganisms and molecular biology

- Research and academia

Bioserentia – Biotech accelerator provides strategic advice to companies, entrepreneurs, investors, governments to create and accelerate ventures in life sciences

CSIC is the largest public research organisation in Spain. It encompasses 130 centres across the country, 6000 researchers and represents grossly 180 patents annually

Institut Quimic de Sarria is a renowned national institute dedicated to tackling new modern challenges

Leitat Technology Centre aims to collaborate with companies through research initiatives in order to add value to products and processes in different economic sectors, including the pharmaceutical, cosmetic, biomedical, biotechnology and biomaterials fields.

Neiker is a public institute for research and technological development which seeks to provide input to improve agriculture, food and environmental sectors with, amongst others, biosciences and biotechnology tools

Biotechnology facilities

In Spain, there are different pilot and demonstration plants in terms of biotechnology, which are listed below:

- Planta Piloto de Química Fina in Alcalá de Henares (Madrid) – Diverse fermentative processes, enzymatic reactions, design of residual water treatments, design of biopolymers.
- BIOT in Armilla (Granada)- Fermentation and bioprocesses in general (Synthesis of functional foods, production of bioalcohol, biogas, bioplastics).
- Barcelona University fermentation pilot plant in Bellaterra (Barcelona) – Development of continuous or batch processes with microorganisms (bacteria, fungi or yeasts, genetically modified or not); development of products obtained from crops; primary downstream steps.
- Centro de Biotecnologia Marina in Las Palmas (Canary Islands) – Isolation, identification and maintenance of germoplasm banks; cultivation, production and industrial evaluation of microalgae and cyanobacteria; design and validation of photobioreactors for microalgae; selection and conservation of algae strains.
- Ciemat in Madrid – Lignocellulosic biomass fractionation.
- Bioplis in paterna (Valencia) – Development and optimization of fermentative processes; optimization of recovery processes for biomass and microbial products, standardized batch production according to established procedures.
- Gaiker Technological Centre in Zamudio – Optimisation of enzymatic reactions for maximum yield, scaling-up, support in industrial applications of the system.
- Pevesa in El Viso del Alcor (Sevilla) – Production of peptides and amino acids from plant origin; design for product development and market introduction studies.
- Instituto Technologico De Canarias in Las Palmas (Canary Islands) – Cultivation and processing of microalgae for biomass production; downstream processing of biomass for food production; process optimization.
- Abengoa bioenergy Biocarburantes Castilla y León in Babilafuente (Salamanca) – World's first commercial scale bioethanol plant using lignocellulosic biomass (cereal straw) as feedstock; fuel bioethanol production demonstration plant in construction.

6.2.4 The Bioeconomy in Spain

At the end of the year 2015, the Spanish Government adopted the **Spanish Bioeconomic Strategy**. This strategy defines the bioeconomy as the set of economic activities that obtain products and services, generating economic value, using, as fundamental elements, resources of biological origin in an efficient and sustainable way. Its objective is the production and marketing of food, as well as forest products, bioproducts and bioenergy, obtained through physical, chemical, biochemical or biological transformations of organic matter not intended for human or animal consumption and involving environmentally friendly processes, as well as the development of rural environments.

The national strategy pivots around the public sector, responsible for promoting, energizing and coordinating the strategy, the productive and technological bioeconomic sectors that are key players in mobilizing economic activity, and finally the R&D system, responsible for generating knowledge and technological development in the field of bioeconomics. Thus, the **Spanish strategy is based on the science-economy-society triangle**. Specifically, this strategy has a goal to transfer and use the knowledge generated in the scientific field in productive activities that allows further growth in those potential areas. Therefore, it requires the direct and indirect participation of all the agents that make up this triangle.

The main Spanish Bioeconomy fields of action are agrifood, forestry, fishing, aquaculture and exploitation of marine resources, chemical industry, bioenergy and water.

As the Spanish Strategy points out, "**the bioeconomy can contribute to economic development in many areas of activity, taking advantage of public-private collaboration to transform knowledge into innovation**". Specifically, the areas of interest contemplated by the Spanish Strategy are the following:

- In the **agri-food field**, the improvement of the efficiency of the productive, organizational and logistic processes will be deepened through the technologies and innovations in different environments (primary production, transformation), necessary to maintain the presence of the Spanish agri-food products in the markets with greater demand.
- In the **forestry field**, progress will be made in incorporating sustainability into resource management systems based on the development of models that combine their capacity for carbon sequestration with current use and that of future generations. Likewise, in this area, the contribution of this sector to the production of biomass as a raw material for bioindustry, mainly biochemistry and bioenergy, will be fundamental.
- In the **fishing field**, aquaculture and exploitation of marine resources, fishing activity will be conditioned by a better knowledge of the biology and marine ecosystems, establishing sustainable management strategies adapted to the evolution of scientific knowledge and the integrated use of marine resources for the production of bioproducts and algae.

- In the **chemical industry**, it is expected that the use of renewable resources, not competitive with human food, will increase. Furthermore, the advance in the biological based processes will allow the obtaining of numerous bioderivatives (plastics, fibers, detergents, paints, cosmetics, oils, lubricants, construction materials), as well as basic chemical products that can be active ingredients or compounds (enzymes or microorganisms) for the pharmaceutical industry, the food industry or animal feed.
- In the **bioenergy field**, the advance in knowledge and commercialization of new routes of biofuel synthesis with thermochemical or biochemical technologies is also contemplated. These technologies, together with the improvement of already existing techniques (gasification or pyrolysis) will allow, in the same way, the improvement of the efficiency in obtaining fuels for transport, electricity or heat.
- In the **water field**, the efficient and sustainable use of this resource will be deepened in order to maintain the capacities and potentialities of the productive systems in a new context of production and demand for food. The aim is to improve efficiency in the use of water in all target sectors.

The Spanish Strategy highlights that this set of activities is characterized by the fact that they are developed in the places where organic matter is generated, such as agricultural, livestock and forestry farms, agri-food companies, coastal environments and waste management centers. Therefore, the Spanish Strategy stresses that "the bioeconomy will bring new economic activities to boost development in rural areas and the interaction between rural and urban areas.

The Strategy also defines two types of objectives, strategic and operational, which are described below.

Strategic objectives:

1. To improve the competitiveness and internationalization of Spanish companies working in the field of resources of biological origin, and to generate new economic activities and new jobs, through the generation of knowledge and its adaptation to new scientific and technological developments, which respond to the demands of the productive sectors and consumers.
2. To maintain the Spanish bioeconomy as an essential part of our economic activity and to position it, as an area of strategic innovation based on knowledge, among the leaders in an international context.
3. To contribute to achieving the full development potential that the bioeconomy may have in the next 15 years in Spain, based on social and environmental sustainability and technological, organizational and managerial innovation as a tool to solve problems and take advantage of market opportunities.

Operative objectives:

1. To promote the development of the bioeconomy in Spain through permanent collaboration between the Spanish administrations and the productive sectors and the participation of society
2. To promote interaction between the Spanish and international system of science and technology, public and private, with the productive sectors and their companies in order to stimulate the creation of multidisciplinary teams capable of developing technologies that diversify and improve the efficiency of the use of resources of biological origin, consolidating the structures already in operation.
3. To facilitate and promote the creation of scientific knowledge and its application to the market and innovation, through the creation and consolidation of technology-based companies, as well as their incorporation into national and international knowledge networks.
4. To facilitate the transversal analysis of the problems of all sectors linked to the bioeconomy, in order to identify the limitations to its expansion, proposing measures of an administrative, regulatory, legislative or other nature, when considered appropriate.
5. To integrate all the support tools for the generation of knowledge and its transformation into technologies and innovations applicable to the productive processes, concentrating them in a coordinated way in the bioeconomy sector, improving the availability of financial resources.
6. To facilitate the internationalization of companies in the area of bioeconomics, both in the development of technologies and in access to markets.
7. To develop and generate tools for the education and training of workers, to advance in the training of employees in this sector in new technologies and create new employment opportunities, as well as to adapt existing professional profiles to the requirements of companies in the sector.
8. To facilitate knowledge, dialogue and social diffusion around the bioeconomy, considering all scientific, social, economic and financial agents, and society in general. To show that it is an activity in which science and technology complement each other to produce food, and other products of biological origin and to achieve a more environmentally sustainable society that, at the same time, generates economic activity.
9. To promote the economic development in the rural environment and the diversification of the productive activities, through the use of the available knowledge and its application to the improvement of the economic, social and environmental sustainability of the traditional activities and to the generation of other new ones based on the transformation of resources of biological type generated in that environment and in some processes that contribute to the mitigation of the climate change.
10. Creation of new markets that allow the revaluation and use of biological resources in an effective way, obtaining new products and services that solve the needs of the population, taking into account new sources, contributing to a greater development of the rural areas that imply processes that respect the environment.

This Strategy will be developed by involving, in the process of its development and application, the related Public Administrations, all companies and economic sectors, scientists and technologists related to bioeconomics, and organizations representing society, constituting the tool for the integration of the whole system, and through a permanent dialogue with the EU.

The achievement of the operational objectives will be pursued through actions in five specific areas: that of innovation through the generation of knowledge and its application in a business environment; that of interaction between the different agents involved in the bioeconomy; that of market development for existing or new products, products that arise from the field of bioprocesses; that of demand; and that of the expansion of the bioeconomy through collaboration, cooperation and dissemination of success stories.

Each of these areas constitutes a strategic line of work. The measures proposed from different collaborative environments are organized within the framework of these **five major strategic lines:**

1. Promoting public and private research and investment by companies in innovation in the area of the bioeconomy: This strategic line incorporates those measures aimed at promoting the generation of knowledge through research and its application to the development of innovation, using all the instruments that the public sector makes available to the science and innovation system, and transferring the possibilities of the bioeconomy to the private financial sector.

2. To strengthen the social, political and administrative environment of the bioeconomy: Within the framework of this strategic line, the aim is to organize the support, promotion and cooperation structure necessary for the development of the Spanish Strategy, both in the area of the central and regional administrations, as well as their relations with the different agents of science, the economy and society as a whole.

3. Promoting the competitiveness and development of the market associated with bioeconomics: this strategic line aims to define the framework in which the market for bioeconomic products is to be developed, considering all those elements that both supply and demand will have to specify, as well as the regulatory requirements associated with this new market.

4. Developing the demand for new products: This strategic line incorporates measures that will aim to facilitate the creation of demand for new products.

5. Plan for the expansion and promotion of the bioeconomy: In this strategic line, measures will be considered aimed at the knowledge of experiences that are developed and implemented in different territories.

The Spanish Bioeconomic Strategy is proposed as a key piece of the new Spanish Strategy for the Circular Economy (España Circular 2030), **which expands the scope of action to include other productive sectors and essential aspects**. In this line, in the field of biological resources and bioeconomics, progress is being made in the integral use of raw materials and efficiency in the use of resources. At present it is common to find cases in which certain

materials, which until recently were managed as waste, have become the raw material for new products that are introduced into the market in the fields of cosmetics, agrifood or bioproducts, taking advantage of innovative technologies for extraction or transformation for economic recovery.

As already mentioned, at the regional level, **some autonomous communities have also developed specific bioeconomic strategies**, such as Andalusia with its “Andalusian BioEconomy Strategy Circular 2030” approved in 2018, or Extremadura with the "Extremadura 2030 Citizen Green Economy Strategy", which aims to make Extremadura a reference in research and innovation around the green economy, bioeconomy, circular economy and sustainable development to mitigate climate change and boost economic growth and employment in the region.

6.2.5 Conclusions

Spain has been hit hard by Covid 19 health crisis, which reflects in the expected fall of real GDP growth to -12.8% in 2020. However, IMF forecasts that it will pick up to 7.2% in 2021, thanks to the post-pandemic global economic recovery. On the other hand, an employment rate is estimated to increase to 16.8% in 2020 and stay at the same level in 2021. Another issue comes from the labour market - the low level of active population compared to the potential workforce. Furthermore, country faces with strong inequalities that are present among its population.

Even though, the overall situation doesn’t seem very promising, country is working hard on its economy improvement. Structural reforms to give autonomous regions greater budgetary and financial stability are still one of the top priorities. Also, Spain is relying on its strong industries such as agricultural, livestock businesses, manufacturing and biotechnology that contribute most to the country’s GDP. The country is also said to be a world leader in marine biotechnology. Moreover, sectors that have a huge growth potential are information technology, outsourcing of electronic components production, and telecommunications.

From the technological point of view, Spain is a Moderate Innovator, according to RIS. Also, Valencia, Alicante and L'Alcúdia (located in the provinces of Valencia), where Pilot 1, Pilot 3 and 6 will be located, respectively, belong to the Comunidad Valenciana region that is recognized as Moderate Innovator. These WaysTUP! Pilots will definitely contribute to improving performance of this region.

Great development of biotech sector is considered as a good advantage for Pilots 1 and 6 as country has human resources with skills and curricula to address current challenges within the Spanish Industrial biotech industry., as well as first class scale-up facilities and academic research. However, there is no dedicated policies promoting industrial biotechology and with

the exception of biofuels, there are no subsidies for industrial biotech products limited number of companies and SMEs because of the lack of funding and high investment needs for development high energy costs. Spanish strategy is focused on overcoming these barriers. The main Spanish Bioeconomy fields of action are agrifood, forestry, fishing, aquaculture and exploitation of marine resources, chemical industry, bioenergy and water. We can see that business fields of Pilot 1 and Pilot 3 (food and feed) and Pilot 6 (biofuels) are included, which implies that it is very possible that these initiatives will be supported by the country.

6.3 Czech Republic

6.3.1 The Economic dimension

Czechia's economy grew more moderately in 2019 than in previous years. Real GDP is estimated to have grown by 2.3% in 2019, mainly supported by domestic demand.[86] As in 2018, private consumption increased strongly, supported by high wage growth, which happened because of a persistently tight labour market. On the other hand, industrial orders and production fell significantly, especially in the second half of 2019, due to the decrease in manufacturing activity in the key trading partners. This affected firms' profits, and, together with an uncertain external outlook, dragged down investment. Due to the slowdown in investment and industrial production, imports — particularly of intermediate and capital goods — fell in the second half of 2019. At the same time, exports continued to grow at a more moderate pace than 2018, as inventories declined. That being so, net exports are expected to have contributed positively to GDP growth in 2019.[87]

According to the updated IMF forecasts from 18th October 2020, due to the outbreak of the COVID-19, **GDP growth is expected to fall to -6.5% in 2020 and pick up to 5.1% in 2021, thanks to the post-pandemic global economic recovery**.[88]

Czech Central Bank maintained its mildly expansionary policy in 2019 from a year earlier, by raising the policy interest rate by a further 0.25% to 2%. Government spending, especially on health, pensions and disability benefits, continued to rise, which affected on general government balance. Public budget was estimated to narrow to 0.2% of surplus in 2019 from 0.5% a year earlier and turn to a deficit of -0.1% in 2020 and 0.3% in 2021.[89] **There is a possibility that government spending may grow even more in order to address labour shortages, promote inclusion of women with children in the workforce, but also manage immigration**. Actually, labour shortages are still the major domestic difficulty that slows

[86] https://www.imf.org/en/Countries/CZE
[87] https://ec.europa.eu/info/sites/info/files/economy-finance/ip121_en.pdf
[88] https://www.imf.org/en/Countries/CZE
[89] https://santandertrade.com/en/portal/analyse-markets/czech-republic/economic-political-outline

growth of economic activity. At the same time, foreign investment rates fell in 2019 amid a decline in disbursement of EU funds and the country needs to adopt better planning of the use of such funds for infrastructure.[90] Nevertheless, most Czech macroeconomic indicators remained healthy, with government gross debt falling to 30.2% in 2019, on the back of improvement in fiscal balance. But, due to COVID-19 outbreak, IMF evaluates the government debt at 39.1% in 2020, expecting it to increase further to 41.4% in 2021. Inflation rate increased from 2.9% in 2019 to 3.3% in 2020. However, in the following years inflation rate is expected to decline continuously.

Unemployment rate increased from 2% in 2019 to 3.1% in 2020. Furthermore, it is expected to grow up to 3.4% in 2021 before it starts falling gradually.[91]

The IMF expects country's economy to be heavily affected by the negative economic impact of the COVID-19 pandemic, even though the government announced a fiscal package of CZK 243.4bn (€9.2bn, 4.4 percent of GDP). Until the end of October 2020, the government is expected to contribute 80% of wages to employers if (i) employees are sent into quarantine; or (ii) employers' businesses have been closed or reduced as a result of the crisis management or emergency measures taken by the government. A contribution of 60% of wages is paid to employers due to obstacles to work on the part of the employer caused by the current epidemiological situation and related measures to prevent the spread of the disease both locally and abroad.[92]

Main Sectors of Industry

In 2019, agricultural sector accounted for only 2% of the country's GDP and employed 2.8% of the labour force. The main agricultural products are sugar beet, wheat, potatoes, barley and poultry.[93]

Industry contributes to 32.2% of GDP and hires 37.7% of the labour force. Growth in performance has been accompanied by an increase in the productivity of the labour force. **The largest industry is the automotive sector**, with companies such as Skoda (owned by Volkswagen). Since 2005, huge foreign investors started producing cars in the Czech Republic - such as Toyota and PSA. Czech Republic mostly export cars, which comprise 80% of the total country's exports. Also, **services account for 54.2% of the GDP and employ nearly 60% of the active population.**[94]

6.3.2 The Political dimension

[90] https://santandertrade.com/en/portal/analyse-markets/czech-republic/economic-political-outline
[91] https://www.imf.org/en/Countries/CZE
[92] https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19#C
[93] https://santandertrade.com/en/portal/analyse-markets/czech-republic/economic-political-outline
[94] https://santandertrade.com/en/portal/analyse-markets/czech-republic/economic-political-outline

In Czech Republic the bioeconomy is perceived by the Ministry of Agriculture as a tool for ensuring sustainable management of natural resources, sustainable agriculture and aquaculture, sustainable food and feed production, water management, forestry, and strengthening the role of primary producers and their integration into the bioeconomic value chain as well as forestry involving the entire value chain of the downstream industries.[95]

There are four Ministries involved in the bioeconomy of Czech Republic. Ministry of Agriculture and Ministry of the Environment are lead ministries in this area, but there are also Ministry of Industry and Trade and Ministry of Education, Youth and Sports. Other institutions involved in the country's bioeconomy are:

- Czech Academy of Agricultural Sciences, which contributes to the design and development of the bioeconomy strategy
- Bioeconomy platform of the Czech Republic
- Czech University of Life Sciences Praha
- Faculty of Economics - University of South Bohemia
- National Cluster Association

Knowledge hubs transferring and fostering the national bioeconomy and its competitiveness

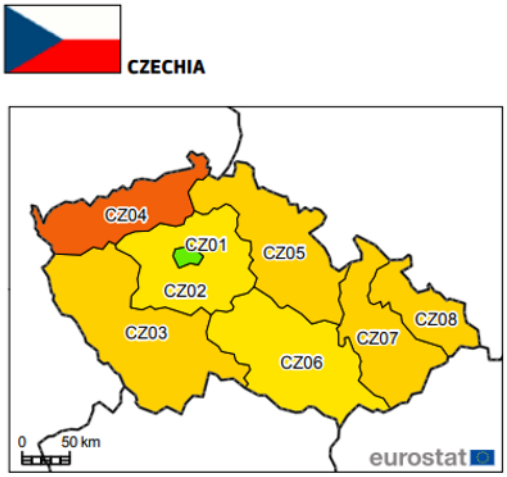
Several research institutions supported by the Ministry of Agriculture of the Czech Republic are conducting research activities and technological developments specifically on the bioeconomy.

Even though the bioeconomy has not been officially included in national policies yet, an overarching strategy on sustainable development exists. Czech Republic participates in BIOEAST[96], a macro-regional bioeconomy initiative being developed by Central and Eastern European countries. The forthcoming Czech strategy aims at:

- Ensuring management of the implementation of the Bioeconomy Concept at national level,
- Supporting the development of bioeconomy in the Czech Republic using international cooperation,
- Strengthening technological development and innovation.[97]

6.3.3 The Technological dimension

[95] https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en
[96] https://bioeast.eu/
[97] https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en



NUTS	Region	RII	Rank	Group	Change
CZ01	**Praha**	107.5	83	Strong -	15.9
CZ02	Střední Čechy	88.8	133	Moderate	23.8
CZ03	Jihozápad	74.0	165	Moderate -	8.2
CZ04	Severozápad	47.8	218	Emerging	-5.4
CZ05	Severovýchod	79.4	155	Moderate -	6.9
CZ06	Jihovýchod	88.6	134	Moderate	11.9
CZ07	Střední Morava	73.6	167	Moderate -	3.7
CZ08	Moravskoslezsko	74.8	162	Moderate -	20.0

RII: performance in 2021 relative to that of the EU in 2021. Rank: rank performance in 2021 across all regions. Group: respective sub-group. Change: performance change calculated as the difference between the performance in 2021 and 2014 relative to that of the EU in 2014.

Figure 15 Performance of the regions within Czech Republic

Source: Regional Innovation Scoreboard 2021, European Commission

Czechia is a Moderate Innovator and includes 8 regions.

Praha (CZ01), the capital region, is a Strong Innovator Six regions are Moderate Innovators, and one region is an Emerging Innovator. For 7 regions performance relative to the EU has increased, most strongly for . Střední Čechy (CZ02) and Moravskoslezsko (CZ08), and for one region performance relative to the EU has decreased.

6.3.4 The Bioeconomy in Czech Republic

The Czech Republic is in the middle of the adoption process of the bioeconomy strategy. In this country, the bioeconomy has not been officially included in national policies yet. However, the bioeconomy has been mentioned in rural development policy documents, the 2018 draft strategy of the Czech Ministry of Agriculture (MoA)[98] and, more recently, in the 2020 concept of state forest policy.[99] Here's what is currently available for their bioeconomy strategy:

- INFORMAL INTER-MINISTERIAL WG – MoE, MoEYS, MIT, research institutions
- RESEARCH PROJECTS

[98] https://www.scar-swg-sbgb.eu/lw_resource/datapool/_items/item_24/survey_bioeconomy_report1501_full_text.pdf
[99] http://eagri.cz/public/web/file/646382/Koncepce_statni_lesnicke_politiky_do_roku_2035.pdf

- national:
    - RedPot (Reduction of food waste)
    - Project Circular Economy as an opportunity
    - Diversification of the impact of the bioeconomy in the forest-wood sector
- international:
    - DanuBioValNet (international networking, good practice in bioeconomy)
    - Power4BIO (bioeconomy value chains in selected European regions)
    - BIOEASTsUP

- STAKEHOLDER PLATFORMS
    - Platform for Bioeconomy of the Czech Republic
    - Circular Economy Institute
    - National cluster association
- EXPERT GROUP - Czech Academy of Agricultural Sciences
- PREPARED STRATEGIC DOCUMENT - "Concept of bioeconomy in the Czech republic from the perspective of the Ministry of Agriculture"[100]

Czech Republic targeted the following sectors for bioeconomy: ecosystems and its services, rural social sector, food sector, industry and economic sector, science and research. According to the recent study *Bioeconomy in the National Forest Strategy: A Comparison Study in Germany and the Czech Republic*, it is concluded that even though the current related forest policies in the Czech Republic have acknowledged bioeconomy principles, its strategies are only regulated in this sector, which might limit forest bioeconomy implementation in the country. The next expected step is to extend to multisectoral and interministerial committees at the government level.[101] Also, through the adoption of the bioeconomy principles, the forest-based industries in the Czech Republic might face further challenges. In the wood production line, the country needs to reduce the bureaucracy of the Czech state forest management and to promote the state forest law that accommodates the needs of the private forests and forest enterprises. The collaboration gap between those involved in science, research, and innovation with industries hinders the commercialization of high value-added products. Additionally, the next concerns of the Czech forest-based industries are related to the market and consumer acceptance of the high value-added products.

[100] https://bioeast.eu/wp-content/uploads/2020/01/WS3_Czech.pdf
[101] https://www.mdpi.com/1999-4907/11/6/608/htm#B30-forests-11-00608

The bioeconomy also aims to promote rural development; thus, growth in economy and job opportunities in rural areas are expected. A specific intervention from the government is needed in the Czech Republic, e.g., to set an acceptable salary level and to promote some cultural events and public services in the forests, as this might encourage forest owners to diversify their products and services and thus attract more investors.[102]

Czech Republic is aware of the obstacles it faces on its way to full adoption of bioeconomy principles. Below you can see its short and long-term external policy support needs.

	Process related support	Technical assistance support	Strategy drafting support
Building Block 1: Describe the bioeconomy concept at national level	• Public awareness on bioeconomy (different target groups) • Incentive to support horizontal cooperation	• Study on success criteria • Data base	• Common simple understanding of the concept of bioeconomy
Building Block 2: Assess current state of bioeconomy and ambition within the EU Strategy	-	• EU support for national bioeconomy studies • Development of database about state of bioeconomy • Biomass data evaluation	• Collecting bottom-up feedback
Building Block 3: Define bioeconomy measures, platforms and initiatives to achieve targets	• Development of clusters/networks • Building capacity (within the ministry)	• Pilot cases • Educating farmers advisors • Financing bioeconomy projects • Database of funding sources for bioeconomy	• Collecting bottom-up feedback
Building Block 4: Leverage on the national and EU policies for sustainable bioeconomy	• Mutual learning at transnational level	• Pilot cases	• SCAR WGs mirror at the level of the member states • Training, explaining

Figure 16 Short-term external policy needs

Source: https://bioeast.eu/wp-content/uploads/2020/01/WS3_Czech.pdf

[102] https://www.mdpi.com/1999-4907/11/6/608/htm#B30-forests-11-00608

	Process related support	Technical assistance support	Strategy drafting support
Building Block 1: Describe the bioeconomy concept at national level	• Good examples • Demo-farms	• Better traceability and statistical use of biomass • Collecting and monitoring data from the processing industry	-
Building Block 2: Assess current state of bioeconomy and ambition within the EU Strategy	• Align with CAP and other policies	• Expert studies on evaluation of economy and impact of bioeconomy	• Collecting bottom-up feedback
Building Block 3: Define bioeconomy measures, platforms and initiatives to achieve targets	• Align policies to promote demand for biomass product markets	• Support the development of small scale bioeconomy processing technologies	• EIP Agri support at local level
Building Block 4: Leverage on the national and EU policies for sustainable bioeconomy	• Common council agendas • Adapting legislation to the situation	-	• Inter-sectoral collaboration between different policy & technical expert groups

Figure 17 Long-term external policy support needs

Source: https://bioeast.eu/wp-content/uploads/2020/01/WS3_Czech.pdf

Actions that will be taken in the future in order to advance the development of the bioeconomy strategy are the following:

- Collecting and monitoring data from the processing industry
- Raise public awareness on bioeconomy (within different target groups)
- Study on success criteria
- Learn from good examples
- Provide education of farmers (AKIS).[103]

6.3.5 Conclusions

In 2020 economic activity of a country contracted dramatically due to Covid 19 pandemic and the following measures such as lockdowns and social distancing. GDP growth is expected to fall to -6.5% in 2020 and pick up to 5.1% in 2021, thanks to the post-pandemic global economic recovery. Public budget was estimated to a deficit of -0.1% in 2020 and 0.3% in 2021. There is a possibility that government spending may grow even more in order to address labour shortages, promote inclusion of women with children in the workforce, but also manage immigration. Labour shortages are recognized as the major domestic difficulty that slows growth of economic activity. On the other hand, unemployment rate is expected

[103] https://bioeast.eu/wp-content/uploads/2020/01/WS3_Czech.pdf

to grow from 3.1% in 2020 to 3.4% in 2021 before it starts falling gradually. Main industry sectors that are drivers of Czech Republic's economy include automotive sector and services.

From the technological dimension perspective, Czechia is a Moderate Innovator according to RIS. However, Praha, the capital region of a country, where first part of Pilot 4 (Pilot 4A) will take place, is a Strong Innovator. This means that this region supports innovative technological solutions and therefore they are often successfully implemented. Pilot 4 should be encouraged by this fact.

The Czech Republic is in the middle of the adoption process of the bioeconomy strategy. Even though the bioeconomy has not been officially included in national policies yet, an overarching strategy on sustainable development exists. There are a lot of institutions involved in the country's bioeconomy from ministries to different knowledge hubs and research institutions that joined forces to overcome obstacles the country faces on its way to full adoption of bioeconomy principles. Short-term external policy support needs include development of clusters/networks, funding opportunities for bioeconomy projects, and EU support for national bioeconomy studies. Furthermore, on a long-term level, external policy support needs will expand to development of demo-farms, alignment of policies to promote demand for biomass product markets, as well as support of the development of the small-scale bioeconomy processing technologies. We hope that these changes will be adopted soon, because that would ease Pilot 4A implementation.

6.4 Italy

6.4.1 The Economic dimension

According to the quarterly outturn data, the Italian economy grew by 0.2% in 2019. After four quarters of slowly rising economic activity, real GDP in Italy fell by 0.3% in the final quarter, based on the data given by Istat, the national statistical office. Both agriculture and industrial production declined, while the services sector remained stagnant. Economic sentiment has remained muted amid the fragile external environment, thus weighing on trade and investment activity.[104]

According to the updated IMF forecasts from 18th October 2020, due to the outbreak of the COVID-19, **GDP growth is expected to fall to -10.6% in 2020 and pick up to 5.2% in 2021**, thanks to the post-pandemic global economic recovery.[105]

When it comes to Italy's public finances, the public debt was at 134.8% of GDP in 2019, and it later increased to 161.8% in 2020. After EU institutions applied pressure on the Italian

[104] https://ec.europa.eu/info/sites/info/files/economy-finance/ip121_en.pdf
[105] https://www.imf.org/en/Countries/ITA

government in order to lower the 2019 deficit that was originally planned at 2.4% in its budget act (due to the welfare measures introduced and a rise in public investments), the actual deficit was estimated at 2.2% by the European Commission, amid weaker economic growth and lower-than-expected revenues. Inflation rate was at 0.6% in 2019 and is currently at 0.1%. **Inflation rate should increase to 0.6% in 2021**, according to the latest World Economic Outlook of the IMF (18th October 2020).[106]

Unemployment rate dropped down to 9.9% in 2019, although youth unemployment remains high at 25.7% (ISTAT). Regional inequalities between the highly industrialized and dynamic North and the poorer, rural southern "Mezzogiorno" areas are still high, and issues such as black economy and organized crime remain open. Furthermore, Italy has to face a falling birth rate and a declining population. **The IMF expects the unemployment rate to be affected by the negative economic impact of the COVID-19 pandemic, the rate being currently estimated to increase to 11% in 2020 and increase to 11.8% in 2021**. In the period after 2021, it is expected to start dropping.[107,108]

Main Sectors of Industry

Italy has a very **strong agricultural sector**. Actually, it is the biggest European producer of rice, vegetables, fruits, and wine. The agricultural sector represents 1.9% of Italian GDP and is heavily reliant on the import of raw materials utilised in agricultural production due to the country's limited natural resources (Italian imports of raw materials are responsible for more than 80% of the country's energy). The primary sector employs around 4% of the workforce (World Bank, 2020). Italy's main crops include cereals (particularly wheat), rice, barley, corn, and oats. Also, Italy is the biggest producer of wine in the world.[109]

Italy is a dominantly industrial country, with the secondary sector contributing to 21.4% of GDP and employing 26% of the active population. **The country's industrial activity is mainly concentrated in the northern Italy, in cities such Venice, Turin and Milan**. Italian industry is consisted of small and medium-sized family businesses, and therefore great number of industrial companies in Italy have less than 50 employees. When it comes to exports, **Italy is the largest exporter of luxury goods (cars, clothing, etc.) in the world**. Other important industries that contribute to the country's GDP are motor vehicles, precision machinery, electrical items, pharmaceuticals, chemical products, fashion and clothing. In addition, the

[106] https://santandertrade.com/en/portal/analyse-markets/italy/economic-political-outline
[107] https://santandertrade.com/en/portal/analyse-markets/italy/economic-political-outline
[108] https://www.imf.org/en/Countries/ITA
[109] https://santandertrade.com/en/portal/analyse-markets/italy/economic-political-outline

country still represents the second largest manufacturing power in Europe and is on the seventh place worldwide, even though it has suffered from deindustrialization.[110]

The **service sector** accounts for incredible 66.3% of country's GDP and employs 71% of the Italian workforce. **Tourism** is known as one of the most profitable industries of the country – however, Italian tourism sector was hit hard by the COVID-19 pandemic, that brought strict measures such as border closures, lockdowns, capacity limits at cultural sites etc. Currently, mask wearing in public places (both in and outdoors) is required and this measure will last until the end of January 2021. Fines were raised for those who do not follow anti-contagion and quarantine rules. COVID tests are required for travelers who are coming back from a number of countries in Europe.[111] On the other hand, the business-related services also play an important role in the Italian economy. It is estimated that approx. five million Italian companies operate in the tertiary sector.[112]

6.4.2 The Political dimension

Based on the Italian Bioeconomy Strategy from 2019, the bioeconomy is consisted of those parts of the economy that use renewable biological resources from land and sea – such as crops, animals, forests, and micro-organisms – to produce food, materials and energy. That said, **bioeconomy includes production sector** - such as agriculture, aquaculture, forestry and fisheries - **and industrial sectors** that are using and/or processing biological resources, such as the food and pulp and paper industries, waste water and biowaste exploitation industries and parts of the chemical, biotechnological and energy industries.[113]

Overall, the bioeconomy is reflected in the set of economic activities that has to do with the invention, development, production and use of biological products, services and processes across four macro-sectors:

1. Agri-food
2. Forestry
3. Biobased industry (bioenergy, biofuels, chemical intermediates)
4. Marine and maritime.

Bioeconomy in the cities is also a new priority for the Country.

When it comes to national institutions that are involved in the bioeconomy, lead institutions are National Committee of Biosafety, Biotechnology and Life Sciences, and Presidency of the Council of Ministers. On the other hand, there are also other ministries that play an

[110] https://santandertrade.com/en/portal/analyse-markets/italy/economic-political-outline
[111] https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19#I
[112] https://santandertrade.com/en/portal/analyse-markets/italy/economic-political-outline
[113] https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en

important role in this area and these are Ministry of the Environment and Protection of Land and Sea (MATTM), Ministry of Education, University and Research (MIUR), Ministry of Agricultural, Food and Forestry Policies and Tourism (MIPAAF), as well as Ministry of Economic Development (MISE).[114]

Italy is one of the leaders in bioeconomy and therefore this area is well regulated. Two major documents that present national policies in the field of bioeconomy are National Strategy for Bioeconomy - BIT II and its Implementation Action Plan (2020-2025).

Italian bioeconomy strategy, drafted and currently being implemented by a coordination group for the Bioeconomy active in the Council Presidency, aims to achieve a 15% increase in the current turnover and employment of the Italian Bioeconomy by 2030. **Even though it was impacted by health emergency for COVID19, the bioeconomy model has showed to be resilient** knowing how to enhance its intrinsic adaptive and community spirit, rethinking production logics in a timely manner, ensuring production stability while giving absolute priority to the health and safety of people and leveraging on a spirit of solidarity along the entire supply chain, as an essential force to overcome the emergency.[115]

Within the Implementation Action Plan (2020-2025) it is stated that considering the fact that the current linear business models have showed their limits and fragility and because it is not possible to overcome future challenges with a simple return to "normal" business as usual, **circular bioeconomy can represent the tool for the country to accelerate the post COVID19 departure** and, in parallel, decarbonize the economy. In order to achieve this, thanks to a rapid strengthening of the public-private partnership, **it is necessary to implement the following actions**:

- to promote the development / adoption of a clear and stable regulatory framework,
- to implement circular and regenerative approaches that focus on protection of ecosystems, reduction of risks for biodiversity, and that bring clean organic matter back to the soil and close the carbon cycle,
- to develop investments at local level to support the national and rural Bioeconomy and the circular Bioeconomy in the sectors of the agri-food, biological, forestry, maritime and urban sectors, and
- to promote the active involvement of citizenship, the improvement of skills, education, training and entrepreneurship throughout the Bioeconomy sector.[116]

6.4.3 The Technological dimension

[114] https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en
[115] http://cnbbsv.palazzochigi.it/media/1962/implementation-action-plan_bioeconomy_28_-7-2020.pdf
[116] http://cnbbsv.palazzochigi.it/media/1962/implementation-action-plan_bioeconomy_28_-7-2020.pdf

Map administrative boundaries: ©EuroGeographics ©UN-FAO ©Turkstat

NUTS	Region	RII	Rank	Group	Change
ITC1	Piemonte	97.8	115	Moderate +	25.0
ITC2	Valle d'Aosta/ Vallée d'Aoste	67.4	179	Emerging +	14.7
ITC3	Liguria	88.3	136	Moderate	28.2
ITC4	Lombardia	102.3	97	Strong -	27.9
ITH1	Provincia Autonoma Bolzano/ Bozen	94.8	120	Moderate +	23.8
ITH2	Provincia Autonoma Trento	107.1	85	Strong -	29.8
ITH3	Veneto	102.8	95	Strong -	29.0
ITH4	Friuli-Venezia Giulia	106.6	89	Strong -	25.1
ITH5	Emilia-Romagna	109.4	76	Strong	34.2
ITI1	Toscana	101.3	98	Strong -	27.9
ITI2	Umbria	98.8	109	Moderate +	29.2
ITI3	Marche	90.6	130	Moderate +	26.6
ITI4	**Lazio**	100.4	104	Strong -	26.6
ITF1	Abruzzo	84.7	142	Moderate	22.7
ITF2	Molise	82.9	146	Moderate	26.4
ITF3	Campania	83.3	144	Moderate	30.0
ITF4	Puglia	74.1	164	Moderate -	21.6
ITF5	Basilicata	79.7	154	Moderate -	30.1
ITF6	Calabria	68.2	174	Emerging +	20.1
ITG1	Sicilia	70.3	173	Moderate -	21.9
ITG2	Sardegna	70.4	172	Moderate -	19.5

RII: performance in 2021 relative to that of the EU in 2021. Rank: rank performance in 2021 across all regions. Group: respective sub-group. Change: performance change calculated as the difference between the performance in 2021 and 2014 relative to that of the EU in 2014.

Figure 18 Performance of the regions within Italy

Source: Regional Innovation Scoreboard 2021, European Commission

Italy is a Moderate Innovator and includes 21 regions.

Regional performance differences are high in Italy with seven Strong Innovators, 12 Moderate and two Emerging Innovators. Emilia-Romagna (ITH5) is the most innovative region. Performance relative to the EU in 2014 has increase for all regions, and most strongly for Emilia-Romagna (ITH5).

6.4.4 The Bioeconomy in Italy

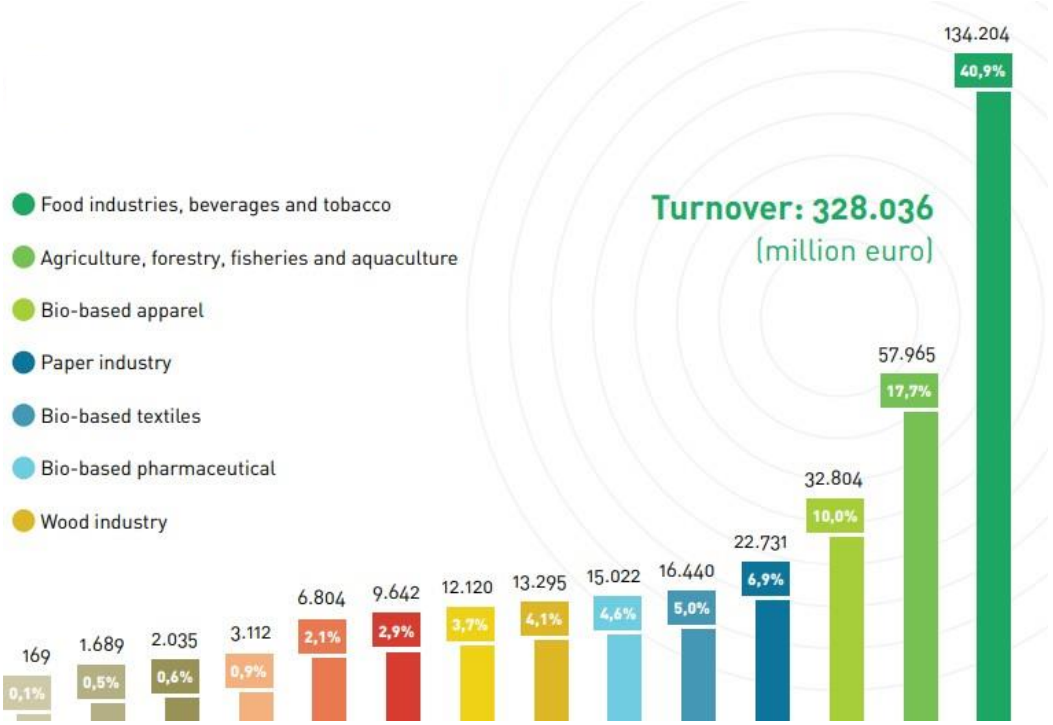
The entire bioeconomy sector in Italy (including agriculture, forestry, paper, pulp and tobacco industries, fisheries, bio-pharmaceuticals, textiles from natural fibers, green chemistry, leather, food and beverages production, biochemicals and bioenergy) accounted for a total turnover of EUR 330 billion in 2017, and around 2 million employees.[117]

These estimated numbers refer to all sectors of primary production at land and sea, those of biomass transformation and of products coming out from it including bioenergy, plus the

[117] http://cnbbsv.palazzochigi.it/media/1774/bit_en_2019_02.pdf

exploitation of wastewater (12,100 Mio €) and of the municipal organic fraction (6,804 Mio €). Nevertheless, the potential for the substitution of renewable inputs within the chemical industry is high: based on one estimate, in the current technological framework (not considering therefore economic and environmental sustainability), approx. 40% of chemical products could be (theoretically) produced with renewable inputs. The share of effective substitution will mostly rely on industrial and environmental policy and technological innovation.[118]

Graphic below shows the latest data (from March 2019) of bioeconomy in Italy - total turnover and employment as well as share of the following sectors in it.



[118] http://cnbbsv.palazzochigi.it/media/1774/bit_en_2019_02.pdf

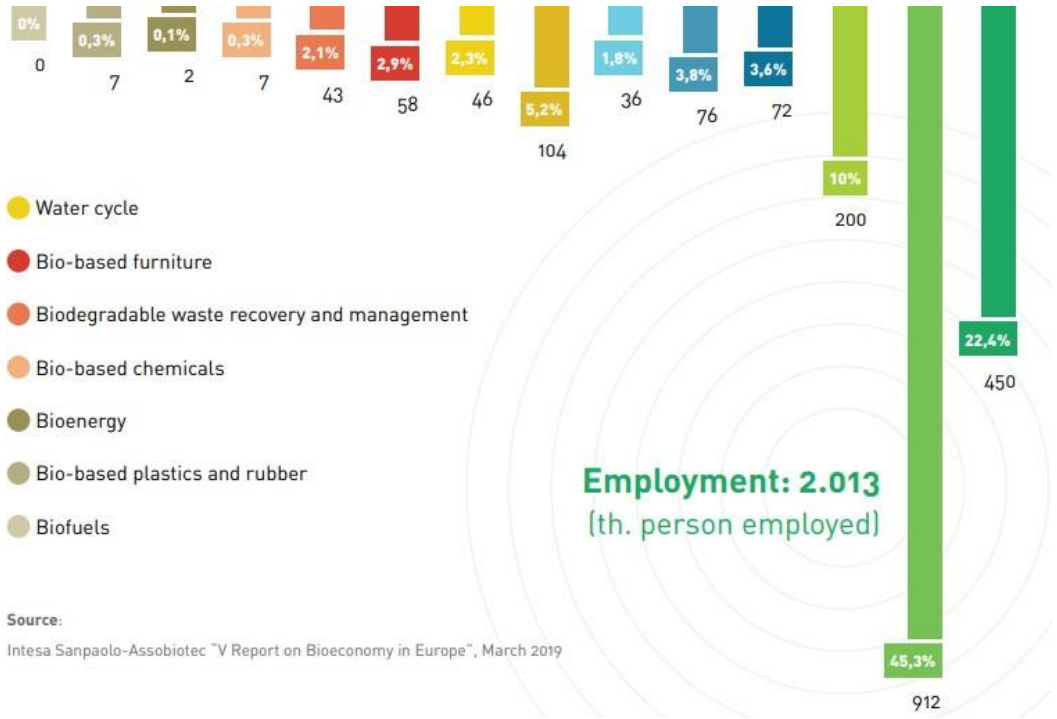


Figure 19 Bioeconomy in Italy

Source: http://cnbbsv.palazzochigi.it/media/1719/bit_en_2019_web.pdf

BIOECONOMY AT REGIONAL LEVELS

A recent work for the drawing up of a Position Paper on bioeconomy (6/129/CR08b/C11), developed by the Conference of the Italian Regions, monitored the strategic position of the Italian regions according to three pillars of the bioeconomy: Marine bioeconomy, Agri-food, the Bio-based industry. The study aims to find the way for interregional cooperation in the area of bioeconomy, particularly between neighboring territories, opening up also the necessary dialogue with national programs and strategies.

Country's regions are especially motivated to keep rural economies alive, to put into place regional economic cycles and to support agro-industrial local projects with the strategic idea of using bio-resources in a more innovative and efficient way. Some of the initiatives that were carried out show the potential and the socio-economic impact of the development of the bioeconomy at a local level.

Figure 20 Strategic positioning of the Italian regions with respect to the three main pillars of bioeconomy

Source: http://cnbbsv.palazzochigi.it/media/1719/bit_en_2019_web.pdf

It's notable that all the regions put the agri-food sector as a priority in their strategic plans, reflecting the value and significance of the sector linked to the quality and strong identity of the products. According to the vision of the regions, emphasis will be placed on the agri-food system issues related to quality, sustainability and recovery of environmental value, and the relationship between food and health.

Italian regions consider that there is a great potential in the development of the bio-based industry - the second sector in the strategic assessment. The potential is mainly related to the exploitation of food chain wastes and byproducts, in order to reduce the environmental impact. However, there is also a potential in the development and increase of crops production in marginal and underutilized agricultural areas and increase of intermediate crops, such as catch crops and cover crops. Some territories host important projects for the reconversion of de-industrialized sites into biorefineries for the production of bioproducts

and biochemicals from local renewable sources, leading to positive impacts on employment, environment, product profitability and integration with regional agriculture systems.[119]

The Italian regions are willing to establish a distributed bioeconomy system built on modular and multiple concepts, by building cross territorial links and interregional value chains. The key components of the Distributed Business Models are the distributed units and the modular nodes. Each module or production site is a node of its own, and is linked to several other nodes according to the needs and deliverables of each node.[120]

BIT report from 2019 provides more information about Italian bioeconomy – it's goals, legislative framework, funding measures and market pull measures, as well as challenges that it faces.

6.4.5 Conclusions

Due to the outbreak of the COVID-19, GDP growth of a country is expected to fall to -10.6% in 2020 and pick up to 5.2% in 2021, thanks to the post-pandemic global economic recovery. Also, inflation rate is estimated to increase to 0.6% in 2021. Moreover, the unemployment rate is expected to increase to 11% in 2020 and to reach 11.8% in 2021. Regional inequalities between the highly industrialized and dynamic North and the poorer, rural southern areas are still high. The country's industrial activity is mainly concentrated in the northern Italy, in cities such Venice, Turin and Milan.

Strong agricultural and service sector together with export of luxury goods contribute most to the country's GDP, among the other industries such as motor vehicles, precision machinery, electrical items, pharmaceuticals, chemical products, fashion and clothing. Tourism is known as one of the most profitable industries of the country – however, Italian tourism sector was hit hard by the COVID-19 pandemic and negative effects of it will remain strong in the first quarter of 2021.

Italy is one of the leaders in bioeconomy and therefore this area is well regulated. national policies in the field of bioeconomy are presented within National Strategy for Bioeconomy - BIT II and its Implementation Action Plan (2020-2025). Even though it was impacted by health emergency for COVID19, the bioeconomy model has showed to be resilient knowing how to enhance its intrinsic adaptive and community spirit, rethinking production logics in a timely manner and ensuring production stability. Italy has recognized circular bioeconomy as a tool for the country to accelerate the post COVID19 departure and, in parallel, decarbonize the economy. Therefore, Pilot 4, specifically Pilot 4B which takes place in Terni, Italy, will be supported by positive environment (including country's policies, stakeholders' and citizens'

[119] http://cnbbsv.palazzochigi.it/media/1719/bit_en_2019_web.pdf
[120] http://cnbbsv.palazzochigi.it/media/1719/bit_en_2019_web.pdf

perception of bioeconomy) for implementation of bioeconomy solutions. According to strategic positioning of Italian regions with respect to the three main pillars of bioeconomy (agro-food, blue economy, bio-based industry), this region is focused on agro-food.

From the technological perspective, Italy is a Moderate Innovator, and its region of Umbria in central Italy (where Terni is located) is rated the same. However, performance of this region is strongly improving.

6.5 Greece

6.5.1 The Economic dimension

The Greek economy relies mainly on the 'services' sector which accounted for 79,1% of the national GDP in 2017[121] having as a main driver the **tourism industry**[122] which accounted for 20,8% of the GDP in 2019. On the other hand, the industry sector accounted for 16,9% and the agriculture sector for 4,1% of the Greek GDP in 2017.[123]

The Greek industry in 2019 relied mainly on the production of the following products with the respective ranking:

1. basic pharmaceutical products and pharmaceutical preparations;
2. computers, electronic and optical products;
3. basic metals;
4. chemicals and chemical products;
5. fabricated metal products except machinery and equipment;
6. rubber and plastic products;
7. paper and paper products and
8. wood and products of wood and cork, except furniture (Hellenic Statistical Authority, 2020).

Important thing to emphasize is that the products (1, 4, 6, 7 and 8) are directly related to the Greek bioeconomic sector while all the others have an indirect relation to bioeconomy. On

[121] Central Intelligence Agency (CIA), 2017). The world fact book. Available online: https://www.cia.gov/library/publications/the-world-factbook/geos/gr.html

[122] INSETE. (2020, August 5). Retrieved from: https://insete.gr/bi/%ce%b7-cf%83%cf%85%ce%bc%ce%b2%ce%bf%ce%bb%ce%ae-%cf%84%ce%bf%cf%85-%cf%84%ce%bf%cf%85%cf%81%ce%b9%cf%83%ce%bc%ce%bf%cf%8d-%cf%83%cf%84%ce%b7%ce%bd-%ce%b5%ce%bb%ce%bb%ce%b7%ce%bd%ce%b9%ce%ba%ce%ae/

[123] Central Intelligence Agency (CIA), 2017). The world fact book. Available online: https://www.cia.gov/library/publications/the-world-factbook/geos/gr.html

the other hand, the main agricultural products that contributed to the country's agriculture sector in 2019 were: a). Wheat, b). Cotton, c). Tobacco, Must, d). Olive oil, e). Oranges and Lemons.

The Greek bioeconomic sector is estimated to have a turnover of approximately 33,105 million euros while 619,632 employees worked in this sector in 2017 based on rough EC estimations. Considering the abovementioned data there is a slight increase to the turnover since 2008 which was 33,105 million euros with not much of a significant growth since then. **The most important bioeconomic sectors in Greece** based on the annual turnover and employment are considered to be **agriculture** (turnover: 11,802, employment: 437,820), **fishing and aquaculture** (turnover: 1,047, employment: 20,850), **food beverage and tobacco** (turnover: 15,900, employment: 121,613)[124,125] . The abovementioned data have taken into account the EC exports in order to be estimated. It is stressed that there is no available concrete data or a monitoring system at the national level in regard to bioeconomy while no data and/or estimations were recorded for the years 2019 and 2020.

In 2017 Greece performed below the EU average on resource productivity (how efficiently the economy uses material resources to produce wealth), having a 1.45 EUR/kg compared to an EU average of 2.04. Moreover, the circular (secondary) use of materials in Greece was 2.4% in 2014 compared to the EU-28 average which was 11.4 %.[126] No data regarding the efficiency of resource utilization in other materials use has been recorded for the case of Greece.

It should be stressed that based on Ernst & Young (EY), (2020) report[127], Greece *''….shows that the country has improved its performance, ranking 29th in 2019, up from 35th in 2018, also improving on the 32nd position it held on average in the past decade''* giving a good investment profile to the country for 2019.

Economically speaking, bioeconomically related activities in different Greek sectors are considered to be financed at national, regional and private level.

The consequences of the 'COVID-19' virus pandemic to the Greek economy and the expected 10% approximate GDP reduction (maybe more) in 2020, have not been taken into

[124] European Commission (EC), 2020. Knowledge for policy. Bioeconomy. Greece. Available online: https://ec.europa.eu/knowledge4policy/bioeconomy/country/greece_en
[125] European Commission (EC), 2020. The Environmental Implementation Review 2019 COUNTRY REPORT GREECE. Available online: https://ec.europa.eu/environment/eir/pdf/report_el_en.pdf
[126] European Commission (EC), 2020. The Environmental Implementation Review 2019 COUNTRY REPORT GREECE. Available online: https://ec.europa.eu/environment/eir/pdf/report_el_en.pdf
[127] Ernst & Young (EY), 2020. The EY Attractiveness Survey Greece (2020). Available online: https://assets.ey.com/content/dam/ey-sites/ey-com/en_gr/topics/attractiveness/ey-attractiveness-survey-greece-2020.pdf

consideration and/or recorded in detail as for their impact to the overall economy at national level since which is expected to influence the Greek market at least for the next 1-2 years.

Financially speaking, at the national level, the following funding tools have been identified and recorded:

- the Greek Rural Development Programme 2014-2020 (agriculture, food beverage and tobacco, forestry);
- the Operational Programme "Fisheries and Maritime 2014-2020" (sector: fishing and aquaculture);
- the Operational Programme Competitiveness, Entrepreneurship and Innovation 2014-2020 (EPAnEK) (sector: all sectors);
- the Development Law L.4399 / 2016 (sector: all sectors);
- the Hellenic Development Bank (sector: all sectors).

At the regional level, bioeconomy could be financed through the 12 Regional Operational Programmes (ROPs):

- ROP Eastern Macedonia and Thrace
- ROP Central Macedonia
- ROP Western Macedonia
- ROP Epirus
- ROP Thessaly
- ROP Ionian Islands
- ROP Western Greece
- ROP Sterea Ellada
- ROP Attica
- ROP Peloponnese
- ROP Northern Aegean
- ROP Southern Aegean
- ROP Crete

The private sector in Greece also finances bioeconomy through the existing banking system and mainly though bank loans. Such a financial effort has been recently made by the European Development Bank in collaboration with the National Bank of Greece and the Piraeus bank who launched a 560 million euros agriculture targeted investment scheme directly related to bioeconomy.

Bioeconomy in Greece is also funded though the European banking system (e.g. European Investment bank (EIB)) or through various financial programmes which are indicatively recorded below:

- the LIFE 2014-2020 programme;
- the Horizon 2020 programme;
- the Interreg programme;
- the ENI CBC Med Programme;
- the COSME programme;
- the Urban Innovative Actions programme.

6.5.2 The Political dimension

Political dimension is incorporated in biowastes' management and valorization mainly through "Legislation", "Political willingness of the central government and local authorities" and "Ability to use residues". **The legislative framework for waste management in Greece follows closely all relevant EU Directives as well as the principles of EU waste management**. The compliance was achieved mainly through the Greek Law 4042/2012 accompanied by a set of regulatory acts. The Law employs the conceptual ideas of «by products» and "end-of-waste status"; however, specific criteria for such characterizations have not yet been established by EC (except in few cases) and, therefore, the relevant competent Authorities decide case by case.[128] These case – specific decisions undoubtedly consist a barrier to the overall exploitation of "end-of-waste status".

The country has also devised and adopted a **National Waste Management Plan (NWMP)** and an updated version was set up on an open public consultation in August 2020; the updated NWMP introduces **the innovative goal of promotion of secondary materials to market**. The NWMP defines the strategy, the policy, and the targets of waste management on a national level while the proposed measures and actions for waste management are specialized at a regional level through respective Regional Management Plans. The NWMP promotes source separation of biowaste to enhance high-quality recycling. Moreover, the Joint Ministerial Decision 56366/4351/2014, among others, sets technical specifications for waste treatment and specific limits for compost and RDF. In 2018, the National Strategy on Circular Economy, which promoted the use of biofuels, was approved by the Greek Government. However, a **sound framework for products (others than compost and RDF) derived from urban biowastes does not exist** and there is a deep need for informing local authorities as well as central government about the potential gain of such treatment.

[128] Greek Law Digest, The Official Guide to Greek Law, 2019.

In Greece, the competent **Authorities for waste management include public bodies from different governance levels** (e.g. the Ministry of the Environment is responsible for licensing, Municipalities are responsible by default for the collection and transport of mixed municipal wastes, Decentralized Administration Authorities are responsible for environmental matters, etc.) while obtaining the required permits for waste management is a time consuming procedure hindered by bureaucracy. Very recently there has been an increasing interest by the private sector to participate in urban solid waste treatment, mainly through the scheme of Public – Private partnerships that is believed to accelerate the whole procedure. Administrative procedures must be undoubtedly simplified. The average amount of biowaste in Europe is about 32% by weight of the total municipal waste while Greece has the highest share (up to 40-50%). Moreover, in Greece the annual biowaste generation is 2.47 million tonnes, of which only 2% is composted.[129] This clearly depicts that biowastes can constitute a valuable raw material; however, the common practice is unfortunately that most quantity is transferred to landfills and it is not valorized.

Based on recently published data, **Greece performance towards the promotion and adaptation of a Circular Economy model is characterized as poor due to limited 3R (Reduce, Reuse, Recycle) actions.** For many years, the country's economy focused on linear economy and the adoption of EU proposals was slow. However, efforts have been made to promote new legislation and to allocate funds for educational and organizational purposes. Moreover, data show that the Production Material Reuse Rate (showing how much of the recovered material is reintroduced into the economy) and the Market Rate of Recyclable Raw Materials, measuring the percentage of traded goods produced using recycled raw materials, are very low in case of Greece as well as the patents related to Circular Economy are few.[130] This is perhaps related to the fact that the source – separated materials are of low quality while most of municipal wastes are sent to landfills.

~~To sum up, it is obvious that~~ **there is no clear legislative framework about the utilization of end products of biowastes; these products are usually developed in pilot scales and high quality biowastes are collected as a result of initiatives driven by individuals and volunteers**. Without doubt a barrier to the whole valorization is the limited source separated collection of biowastes which leads to poor quality and low quantities which is the main prerequisite to produce high-quality compost or other products. Recently more and more Municipalities have undergone measures for promoting the source separated collection of biowastes, e.g. through the supply of brown bins which are exclusively intended for the collection of biowastes from households while the Attica Regional Authority has announced the creation

[129] European Environment Agency – European Topic Centre on Waste and Materials in a Green Economy: Municipal Waste Management – Country fact sheet – Greece, 2016.
[130] Marino, A. and Pariso, P., 2020. Comparing European countries' performances in the transition towards the Circular Economy. Science of the Total Environment, 729, p.138142.

of three waste and biowaste facilities till 2025 as part of the bid to reduce the volume of trash that is buried. However, this is not enough; **Greek municipalities should move faster to implement the necessary reforms,** political willingness, and commitment (at all levels of governance levels) must be stronger and more effective legislation regarding end products is required. Finally, awareness programs should be developed to increase the participation of citizens to recycle programs while actions to fight bureaucracy must be taken.

6.5.3 The Technological dimension

Technological environment - Scientific and technological advances in society that can impact business operations

Circular economy is the catalyst for the productive reconstruction of Greece aiming at the achievement of climate change mitigation targets. It is expected that the transition to a circular model can lead to a significant reduction in greenhouse gas emissions through recycling and reuse of materials, resource efficiency, better product design and the introduction of new circular business models.

The new circular model is part of the Greek development planning that exploits the abundance of financial opportunities and technical possibilities, especially in the field of waste management. The National Strategy for the Circular Economy, approved by the Central Economic Policy Council in 2018, aims precisely at the:

- acceleration of the actions of the circular economy
- facilitation of growth, including series of activities on creating financial instruments, establishment of regulatory framework and regulations
- interconnection of small and medium-sized enterprises and the social economy with scientific innovation improving governance, networking, speeding technological upgrade.

A key development fund is the Greek Investment Law (Law 3908/2011), as amended in 2012 (Law 4072/2012), in 2013 (Law 4146/2013) and in 2019 (Law 4635/2019), which aims at promoting the economic development of the country by formulating investment support schemes, which improve entrepreneurship, technological development, business competitiveness, regional cohesion and promote the green economy.

The Investment Law in combination with the European co-financing funds support the framework for the scientific and technological advances in society that can impact business operations. Specifically, there are funding entities for promoting green technological advances such as the Green Fund[131] and the Operational Program for

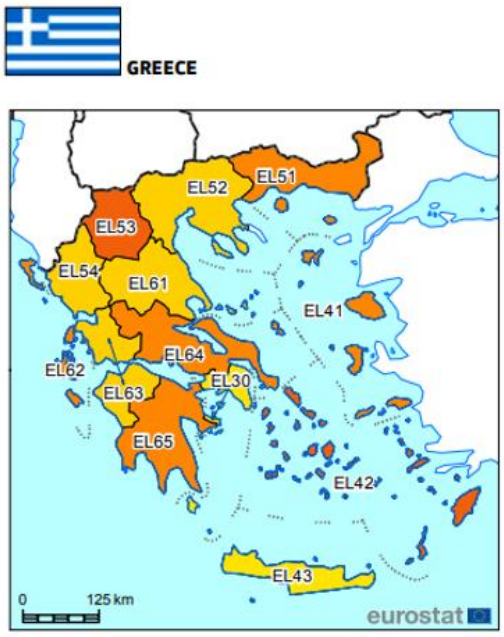
[131] https://www.prasinotameio.gr/
[132] http://www.epperaa.gr/en/Pages/Default.aspx

Environment and Sustainable Development[132], as well as the General Secretariat for Research and Technology
that coordinates the implementation of the national policy for Research, Technological Development and Innovation.

Society can benefit from scientific and technological advances via the development of companies and public entities. Local authorities (Municipalities) as well as the industrial facilities can improve their field of activities in greening economy adopting technological, organizational and social innovation across and within value chains.

For example, the smart city context which is related to the European Cohesion Policy Objectives[133] for: a smarter Europe target for innovative and smart economic transformation, and a Europe closer to citizens (sustainable development of urban, rural and coastal areas and local initiatives) enhance sustainable urban development[134] that incorporates the new circular business models.

Innovation dimension



NUTS	Region	RII	Rank	Group	Change
EL3	**Attiki**	86.9	139	Moderate	27.3
EL41	Voreio Aigaio	63.4	185	Emerging +	26.2
EL42	Notio Aigaio	47.6	220	Emerging	15.6
EL43	Kriti	82.1	147	Moderate	24.8
EL51	Anatoliki Makedonia, Thraki	56.4	198	Emerging +	22.8
EL52	Kentriki Makedonia	77.8	158	Moderate -	30.0
EL53	Dytiki Makedonia	49.5	211	Emerging	12.2
EL54	Ipeiros	71.0	171	Moderate -	36.0
EL61	Thessalia	74.4	163	Moderate -	30.8
EL62	Ionia Nisia	60.2	189	Emerging +	35.6
EL63	Dytiki Ellada	71.8	169	Moderate -	23.9
EL64	Sterea Ellada	62.6	186	Emerging +	14.9
EL65	Peloponnisos	59.0	190	Emerging +	22.2

RII: performance in 2021 relative to that of the EU in 2021. Rank: rank performance in 2021 across all regions. Group: respective sub-group. Change: performance change calculated as the difference between the performance in 2021 and 2014 relative to that of the EU in 2014.

Map administrative boundaries: ©EuroGeographics ©UN-FAO ©Turkstat

Figure 21 Performance of the regions within Greece

Source: Regional Innovation Scoreboard 2021, European Commission

Greece is a Moderate Innovator and includes 13 regions.

Attiki (EL3) and Kriti (EL43) are the two most innovative regions**.** In total there are six Moderate and seven Emerging Innovators. Performance relative to the EU in 2014 has increased for all regions, and most strongly for Ipeiros (EL54) and Ionia Nisia (EL62).

6.5.4 The Bioeconomy in Greece

The bioeconomy in Greece is at its initial stages with regards to its development since even though based on its economic dimension (it is estimated there is a significant turnover over bioeconomic activities in Greece 33,105 million euros in 2017), **it lacks a concrete strategy or an action plan, targets or a monitoring system** (statistics) that will bring all the bioeconomically related stakeholders together to provide guidance and organize them towards the country's sustainable, circular bioeconomic transition.

The country hasn't set a ministry and/or body responsible for bioeconomic growth in Greece, thus there is a lack of connection between the different policies coming from different ministries and also different data (economic, technological and environmental) related to this sector.

There are several central government bodies (Ministries) related to bioeconomy in Greece which are mainly related to the sector's policy and financing which include:

- Ministry of Environment and Energy
- Hellenic Center for Marine Research
- Hellenic Agricultural Organization (HAO) DIMITER
- Ministry of Rural Development and Food
- Center for Renewable Energy
- General Secretariat of Research and Innovation (Under the Ministry of Education).[139]

Even though the country hasn't set its bioeconomic goals through a strategy or an action plan, **there are existing bioeconomy related strategies from different ministries** which have been recorded and are related to Greece's bioeconomy growth.

More specifically:

- the National Strategy for Fair and Sustainable Growth 2030
- the National Strategy and Action Plan for the Circular Economy
- the National Adaptation Strategy (Article. 45, Law.4414/2016)
- the Regional Adaptation Strategies
- the National Energy and Climate Plan (Law 4893.2019)
- the Rural Development Programme 2014-2020
- the National Research and Innovation Strategy For Smart Specialization 2014-2020
- the National Strategic Framework for Research & Innovation 2014-2020

[139] https://ec.europa.eu/knowledge4policy/visualisation/bioeconomy-different-countries_en

At regional level, in Greece, based on the EC (2017), the RIS3 of **Crete** (Greece) is considered to be a good example to **show the most prominent funding sources for a RIS3**. At the same side, agro-food is the broad thematic focus area is considered to most frequently ranked at first by the Greek regions. **Regions with "biomass processing and conversion" and biomass processing and conversion are at their first rank**.[140]

No additional recording of data in regard to bioeconomy at the regional and national level has been found since there is a lack of official data.

It has also been recorded though that there are several municipalities that have developed initiatives to recycle and exploit biomass such as the Municipality of Kalamata that has created "green spots" where pruning and gardening waste can be deposited and Crete that started to link Bio-economy development with their Research and Innovation Strategies for Smart Specialization (RIS3) . Data regarding the exact bioeconomic profiles of regions in Greece has not been recorded.

Other important market stakeholders besides the abovementioned central government bodies, which are related to the Greek market, and which considered to play an important role to the Greek Bioeconomic growth are the following:

Name/Title	Basic info	Web-site
Hellenic Federation of Enterprises (SEV)	*''…The SEV is the largest business network in Greece, representing a broad spectrum of the country's economic activity, including manufacturing and services…."*	https://en.sev.org.gr/
Federation of Hellenic Food Industries	*''…..SEVT represents the Greek Food & Drink Industry on national, European and international level. It consists of food and drink companies and sector associations….."*	https://www.sevt.gr/?lang=en
Federation of Industries in Greece	*''"….The SBE target's to promote not only industrial development,*	https://sbe.org.gr/en/

[140] Spatial Foresight, SWECO, ÖIR, t33, Nordregio, Berman Group, Infyde (2017): Bioeconomy development in EU regions. Mapping of EU Member States'/regions' Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy for 2014-2020.

(SBE)	*but also economic and social progress in Greece. It proposes and contributes to actions aimed at establishing and promoting the competitive advantages of Greece, as well as to the promotion of the overall economic development of the region…."*	
Association of the Greek Manufacturers of Packaging & Materials	*''…..Members of the Association are companies producing packaging materials out of paper and carton, aluminum, tin, plastics, glass, wood and natural fibers…."*	https://www.pac.gr/?lang=en
Association of Hellenic Plastics Industries	The association represents the plastics industries in Greece	https://www.ahpi.gr/2019/11/04/interview-of-vasilis-gounaris-at-insider-gr/
Federation of Recycling and Energy Recovery Industries and Enterprises (SEPAN)	SEPAN was established and includes companies operating in Greece and engage in industrial activity in the area of waste recycling and recovery of by-products and secondary raw materials.	https://sepan.gr/index.php/en/
Hellenic Plastics recycling Association (HPRA)	The HPRA serves the member recyclers and the plastics recycling industry in whole. By serving we mean, training, guiding, connecting and representing.	http://hpra.gr/
Greek Association of Environmental Protection Companies (PASEPPE)	The PASEPPE includes and represents environmental sector companies with an emphasis in waste management and treatment	https://www.paseppe.gr/el
Hellenic Association of Chemical Industries (HACI)	The HACL represents the chemical industry in Greece	http://www.haci.gr/

Hellenic Association of Biogas Producers (HABio)	The HABio represents biogas producers in Greece	https://habio.gr/en/
Hellenic Biomass Association (Hella Biom)	The Hella Biom represents biomass producers in Greece	http://hellabiom.gr/about-hellabiom/?lang=en
Hellenic Biofuels and Biomass Association (S.BI.B.E)	The S.BI.B.E represents biofuels and biomass producers in Greece	www.sbibe.gr
Hellenic Petroleum Marketing Companies Association (SEEPE)	*''…The Association's mission is to develop positions and handle issues regarding the smooth operation of the Oil Industry in Greece. Association contributes with constructive and specialized advice and suggestions to organizations and the State.* *The main purpose of the Association is to inform its members of proposed changes in the legislation and to help form and advocate the industry's position…..''*	https://www.seepe.gr/%ce%bf-%cf%83%ce%b5%ce%b5%cf%80%ce%b5/?lang=en
Association of Greek Regions	It represents all 13 Greek regions	https://enpe.gr/en/
Central Union of Municipalities of Greece (KEDE)	It represents all Greek Municipalities	https://www.kedke.gr/el/index.php
Central Union of Chambers of Commerce (UHC)	The UHC represents all chambers in Greece	https://uhc.gr/

Considering all the abovementioned information, the **main barriers for the Greek bioeconomy growth** are considered to be:

- the lack of a concrete national bioeconomy strategy or action plan;
- the lack of coordination between the central government and the market due to the lack of a related bioeconomy strategy (to bring all interested parties together);
- the lack of sufficient and concrete bioeconomic data for many bioeconomic sectors at the national and European level;
- the significant economic crisis that Greece faces for a decade now (which is expected to be further deepened by the Covid-19 virus pandemic consequences);
- the lack of a single national authority dedicated to Greece's bioeconomic growth;
- the limited use of secondary materials in the Greek market.

The advantages for the Greek bioeconomy are considered to be:

- the fact that there are many bioeconomic related products that are already produced in Greece;
- the significant turnover of the bioeconomic related activities as this has been estimated by the EC;
- the existence of an important number of bioeconomically related strategies in other economic sectors;
- the existence of a significant number of funding tools for financing bioeconomy in Greece.

6.5.5 Conclusions

Main drivers of the Greek economy are tourism industry, industry sector and agriculture sector. The most important bioeconomic sectors in Greece include agriculture, fishing and aquaculture, food, beverage and tobacco. Overall, based on Ernst & Young (EY), (2020) report Greece has improved its performance in comparison to the last years, so it is considered as a country with a good investment profile (data for 2019). Considering the consequences of the Covid 19 pandemic to the Greek economy, GDP reduction of approx. 10% is expected in 2020.

Activities related to bioeconomy in different Greek sectors are able to be financed from public and private sources, at national and regional level. It means that there are lots of funding opportunities available for Pilots 5 and 7.

Also, the legislative framework for waste management in Greece follows closely all relevant EU Directives as well as the principles of EU waste management. Greece adopted National Waste Management Plan that aims to promote secondary materials to market, and overall improve this bioeconomy area. However, framework for products derived from urban

biowastes does not exist. There is no clear legislative framework about the utilization of end products of biowastes; these products are usually developed in pilot scales and high quality biowastes are collected as a result of initiatives driven by individuals and volunteers.

Moreover, as the bioeconomy in Greece is at its initial stages with regards to its development, it lacks a concrete strategy or an action plan, targets or a monitoring system (statistics) that will bring all the bioeconomically related stakeholders together to provide guidance and organize them towards the country's sustainable, circular bioeconomic transition. However, there are existing bioeconomy-related strategies from different ministries.

From the technological prospective, Greece is a Moderate Innovator. Region Attiki, that includes Athens where Pilot 5 will take place, as well as Crete, where Pilot 7 will take place , are recognized as Moderate Innovators. Crete shows the most prominent funding sources for research and innovation activities. By comparing the current performance in EU28 and Greece, we can conclude that areas that need to be improved are related to venture capital investments, number of ICT trainings provided by enterprises, number of public-private co-publications. On the other hand, country is above the EU average when it comes to the number of SMEs with product or process innovations, as well as SMEs with marketing or organizational innovations or SMEs innovating in-house. This is a very significant achievement that's encouraging for Pilots 5 and 7.

6.6 Conclusions

Within the market breakup by geographical areas, countries where WaysTUP! Pilots will take place, we analyzed current economic, political and technological situation within these counties, in order to enable Pilots to adjust their business strategies in line with our findings. This opens them opportunity to focus their resources on accurate countries and their regions, and potentially receive better revenue results. Provided analysis of trends in localized markets should give a vital early competitive edge for Pilots.

Chapter 6.1 is dedicated to the scanning of the economic, political and technological situation of United Kingdom. One of our main conclusions is that country is under a lot of pressure because of two factors that bring unpredictability. The first one is Brexit, since UK withdrew from the European Union as of 1 February 2020 and now is in transition period, and the second one is Covid 19 pandemic that negatively affected economic activity of the whole world. However, even though UK is not in an easy position, it is expected that it will recover its economy in the upcoming period.

Analysis of United Kingdom is particularly significant to Pilot 2, which is located in London, and is focused on a business related to bio-technologies, which is recognized a high-potential sector of the UK economy. Also, the fact that United Kingdom developed a national bioeconomy strategy to 2030 that aims to grow UK's bioeconomy sector means that initiatives such as Pilot 2 coffee oil production will be strongly supported by the country's policies and regulations. Furthermore, there will be different funding opportunities available for projects related to bioeconomy.

To conclude, UK is rated as a strong innovator according to the Regional Innovation Scoreboard (RIS), which makes this country a positive surrounding for starting an innovative business.

Chapter 6.2 refers to our exploration of the general situation in Spain and how it may affect Pilots 1, 3 and 6 which will take place in Valencia, Alicante and L'Alcudia respectively. We concluded that overall situation is hard considering Covid 19 crisis. However, the country is relying on its strong industries such as agricultural, livestock businesses, manufacturing and biotechnology that contribute most to the country's GDP and Spain's economy is estimated to rise in the future.

From the technological point of view, Spain is a Moderate Innovator, according to RIS, as well as Comunidad Valenciana region where Pilot 1, 3 and 6 will be located. We expect that implementation of WaysTUP! Pilots will contribute to improving performance of this region.

Also, since business fields of Pilot 1 and 3 (food and feed) and Pilot 6 (biofuels) present main Spanish Bioeconomy fields of action, among others, we expect that it is very possible that these initiatives will be supported by the country.

Chapter 6.3 is related to overall situation in Czech Republic, its economic, political and technological aspects together with country's bioeconomy sector. The aim of this chapter is to present our findings to Pilot 4, that will take place in Prague (specifically first part of the Pilot - Pilot 4A), and to point out main advantages that Czechia offers for bioeconomy initiatives, as well as challenges that may occur while implementing Pilot 4 solutions.

Covid 19 pandemic brought some serious negative consequences to this country, but economy is expected to get back on the track slowly as of 2021 thanks to the post-pandemic global economic recovery. Labour shortages and high unemployment rate are two main indicators that need to be improved in the future.

From the technological perspective, we've noticed that even though Czech Republic is a Moderate Innovator according to RIS, Praha, the capital region of a country, where Pilot 4A will take place, is a Strong Innovator. This encourages us to conclude that this region supports innovative technological solutions.

On a national level, the bioeconomy of Czechia has not been officially included in national policies yet, but an overarching strategy on sustainable development exists. There is still a need for different short-term and long-term external policy support.

Chapter 6.4 covers overall situation in Italy and its impacts on the implementation of Pilot 4, particularly second part of the Pilot – Pilot 4B, that is located in Terni.

Italy, as all the other countries analyzed so far, faces difficulties due to Covid 19 outbreak. Inflation rate is estimated to increase to 0.6% in 2021 and the unemployment rate will continue its increase in 2021 and will reach 11.8%. On top of that, regional inequalities are remaining high between developed North and the poorer southern areas.

Country is successfully fighting with the Covid 19 health crisis, and will hopefully recover its economy in the upcoming period.

Regarding bioeconomy sector, Italy is one of the leaders in the area and therefore this area is well regulated. The bioeconomy model has showed to be resilient considering Covid 19 situation. Moreover, Italy considers circular bioeconomy as a tool for the country to accelerate the post COVID19 departure and, in parallel, decarbonize the economy. Hence, Pilot 4B initiative will definitely be supported by positive environment for implementation of bioeconomy solutions.

According to the technological innovation perspective, Italy is a Moderate Innovator, and its region of Umbria in central Italy (where Terni is located) is rated the same. Nevertheless, performance of this region is strongly improving.

Chapter 6.5 is dedicated to comprehensive analysis of economic, political and technological situation of Greece, with regards to the bioeconomy sector. The purpose of this analysis is to prepare Pilots 5 and 7 for their implementation, business strategy developments and other aspects of their business activity.

Even though, Greece faces numerous challenges because of Covid 19 pandemic, its economy, with tourism and agriculture as main sectors, is trying to recover as soon as possible and is headed in the right direction.

Considering bioeconomy, it is still at its initial stages of development, since it lacks a concrete strategy or an action plan, targets or a monitoring system (statistics) that will bring all the relevant stakeholders together. These mechanisms are necessary in order to provide guidance and organize bioeconomy actors towards the country's sustainable, circular bioeconomic transition. Nevertheless, there are existing bioeconomy-related strategies from different ministries. Moreover, they adopted National Waste Management Plan that tends to promote secondary materials to market, and overall improve this bioeconomy area.

It is evident that Greece is taking the right set of measures towards implementing principles of bioeconomy, including providing public and private funding opportunities, at national and regional level. However, this process is not fast enough. For example, there is still no clear legislative framework about the utilization of end products of biowastes; these products are usually developed in pilot scales.

According to RIS, Greece is considered to be a Moderate Innovator. On the other hand, we found out that Crete, where Pilot 7 will take place, is the most prominent funding source for research and innovation activities, which should be taken as advantage by Pilot 7.

To conclude, Greece has a great number of SMEs with product or process innovations, as well as SMEs with marketing or organizational innovations or SMEs innovating in-house. Based on statistics, these numbers exceed EU average, which means that this country is a very suitable environment for innovation development.

7. Market Breakup by technology type

This section is dedicated to the technological processes that will be implemented within WaysTUP! Project. These are **fermentation, extraction, larval breeding, and slow pyrolysis.**

Each of these processes will enable the production of targeted end products. That said, it is crucial to understand **how these processes work, what they entail, how they can be applicated for different purposes and what their major products are.**

In order to identify different factors and possibilities on the market that can have an impact on the final realization of Pilots' business solutions, **we will explore potential markets of the primary products that come as a result of technical processes mentioned before**. Collection of already published data to create a comprehensive database will help in situation analysis and will also help in determining the market segments that should be targeted. Additionally, our market analysis will explore the current market competition so we can get clarity on what Pilots' competitive advantages are or could be.

7.1 Fermentation

7.1.1 Definition

Fermentation is defined as an anaerobic enzymatic conversion process. It includes a series of chemical reactions in order to break down the glucose component of biomass material to its basic contents. This is performed with the help of bacteria or yeast. **Fermentation is usually used for commercial purposes to produce bioethanol from sugar crops and starch crops, which can be further distilled to obtain a purified alcohol to be used as an automotive fuel**. The process of fermentation involves the conversion of biomass by microorganisms in a process similar to anaerobic digestion, but instead of methane, the products are alcohols or organic acids.[141]

Efficient feedstocks for fermentation are agricultural crops that contain high amounts of sugar (corn, sugarcane, sweet potatoes) and also starchy materials like rice, oats, barley, and wheat. Other biomass sources that can be used for bioethanol production include lignocellulosic biomass, such as forest residues, agricultural wastes, food processing wastes, energy crops, wood residues, sawdust, and paper mill residues. Lignocellulosic biomass is made up of cellulose and hemicellulose contents that can be broken down into simple sugars, hence are fermentable, and lignin content that cannot be converted into sugars. Even though agricultural crops and lignocellulosic materials differentiate in the decomposition

[141] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/fermentation

stage - the fermentation, distillation, and dehydration stages are almost identical for both of the biomass types. The yield from the fermentation process mainly depends on the proportions of cellulose, hemicellulose, and lignin parts of lignocellulosic materials, which changes according to the biomass source.[142]

7.1.2 Product/application insights

When it comes to global fermentation chemicals market, **the major products are alcohols, enzymes, and organic acids.** Alcohols are used widely in bread, pickles, cheese, and alcoholic beverages. There has been spotted an increasing alcohol consumption particularly in Asia Pacific markets such as China, Thailand, India, and Australia along with other markets such as Brazil, Montenegro, Mongolia, and the Caribbean, which is expected to grow even more over the period 2019 - 2025.

Enzyme consumption is mostly driven by its usage in a wide range of chemical and industrial applications. Enzymes are usually used as an active ingredient in detergents. Also, enzymes can be used in biomass pre-treatment for biofuel production. As a result of rising concerns regarding depleting oil reserves and unstable fuel prices, demand for biofuels increases and drives demand for enzymes as a catalyst.

Organic acids are acids with pKa values ranging from 3 (carboxylic) to 9 (phenolic). Technological innovations in fermentation technology have enabled the production of organic acids on an industrial scale. **Organic acids such as lactic acid, tartaric acid, and fumaric acid are widely used as preservatives in foods**, because they can inhibit bacterial growth. Rising importance of products with better shelf life is expected to drive demand for organic acids in processed meat and foods.[143]

Application Insights

Fermentation chemicals are mostly for industrial applications. Higher penetration has been recorded thanks to the implementation of green chemistry and different regulations for industrial and commercial applications. **Industrial fermentation refers to the utilization of fermentation by microorganisms (fungi, eukaryotic cells and bacteria) for producing various products such as ethanol, acetic acid and citric acid**. Products derived are commonly applied as additives into food. That is mostly done in the form of antioxidants, flavors, preservatives, vitamins and colors. These additives are proved to be more desirable than food additives that are chemically produced.[144]

7.1.3 Market analysis

[142] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/fermentation
[143] https://www.grandviewresearch.com/industry-analysis/fermentation-chemicals-market
[144] https://www.grandviewresearch.com/industry-analysis/fermentation-chemicals-market

The **fermentation products market** is segmented into four categories - based on type, feedstock, process, and end-user industry. **On the basis of type, it is divided into alcohols, amino acids, organic acids, biogas, polymers, vitamins, antibiotics, and industrial enzymes**. According to feedstock, it is categorized into corn, rice, wheat, sugar cane, cassava, barley, potatoes, sorghum, sugar beet, other coarse grains, and other roots & tubers. Other coarse grains comprise oats, millet, triticale, buckwheat, rye, canary seed, fonio, and quinoa, while other roots & tubers include yams, sweet potatoes, yautia, and taro. Based on process, the market is classified into batch fermentation, continuous fermentation, and others (aerobic fermentation and anaerobic fermentation). In terms of end-user industry, it is divided into food & beverages, pharmaceutical, agriculture, personal care, animal feed, textile & leather, and others (paper, bioremediation, environment, and biochemistry).[145] Graphic below shows fermentation-based chemical value chain.

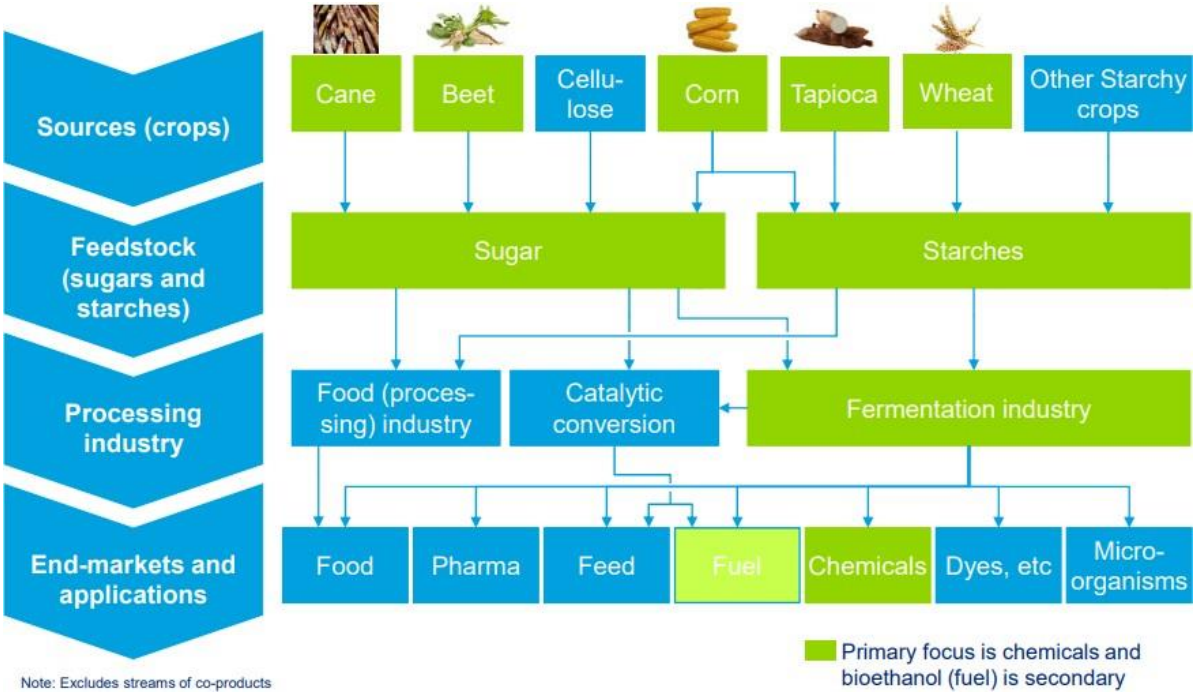


Figure 22 Fermentation-based chemical value chain

Source:
https://www2.deloitte.com/content/dam/Deloitte/de/Documents/Mittelstand/Deloitte%20Zukunftsforum%20Agrar%202016_Villem%20Vaessen %20Fermentation%20Study%20Summary.pdf

The table below presents currently commercial fermentation processes.

[145] https://www.alliedmarketresearch.com/fermentation-products-market

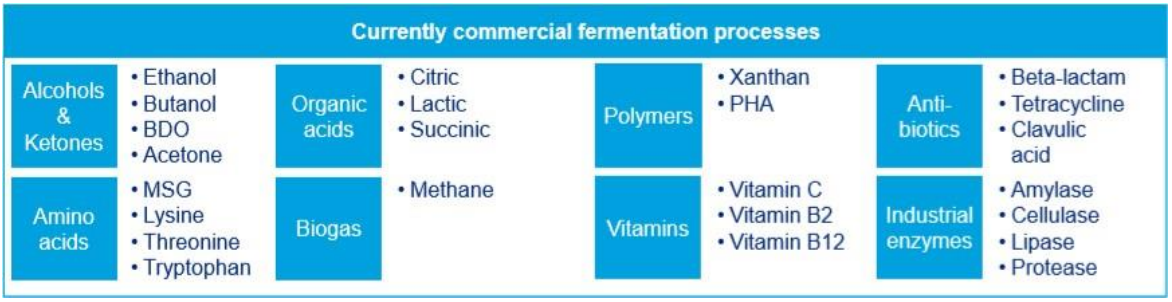


Figure 23 Currently commercial fermentation processes

Source:

https://www2.deloitte.com/content/dam/Deloitte/de/Documents/Mittelstand/Deloitte%20Zukunftsforum%20Agrar%202016_Villem%20Vaessen_%20Fermentation%20Study%20Summary.pdf

Organic acids segment, which includes citric, lactic and succinic acid, is the most prominent segment by type in global fermentation products market. It **is expected to be first preference for new entrants, due to their high use in food & beverage industry**. Lactic acid is utilized in food & beverage products as a flavor enhancer, acidulant, and shelf life extender.[146]

The Europe fermentation chemical market is expected to grow in the next period (forecasted until 2026). The main driver of this market is increasing consumption of end-user industries such as chemicals industry, food and beverages, pharmaceuticals and feed market. The market growth is estimated to 5.06%.[147] **Fermentation chemicals markets of Spain, France, UK and Germany are going to witness steady growth as a result of rising preference towards green chemistry**. Regulations by European commission and Environmental Protection Agency (EPA) regarding the use of safe chemicals along with promoting bio-based products will probably have a positive impact on product demand.[148]

[146] https://www.alliedmarketresearch.com/fermentation-products-market
[147] https://www.inkwoodresearch.com/reports/europe-fermentation-chemicals-market/
[148] https://www.gminsights.com/industry-analysis/fermentation-chemicals-market

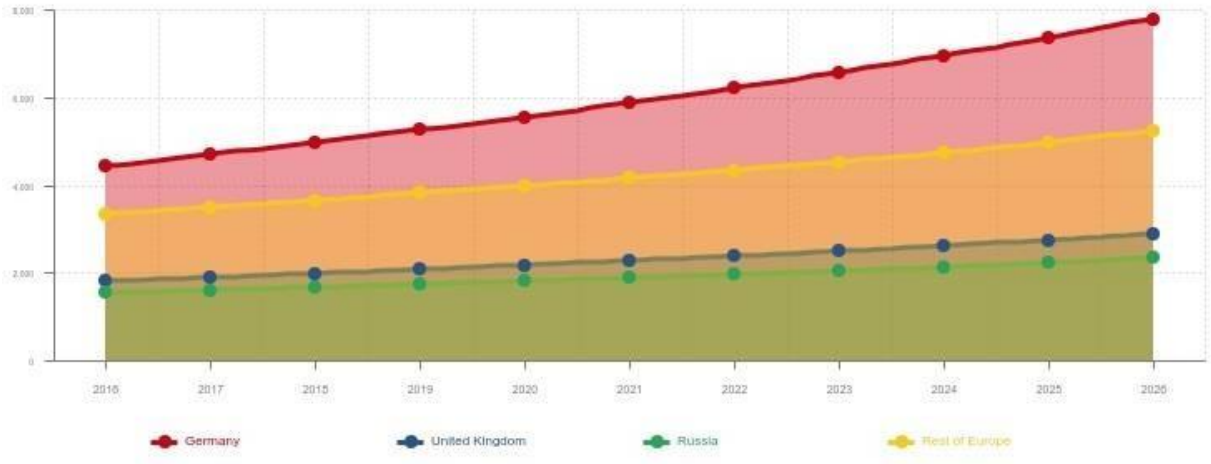


Figure 24 Europe Fermentation Chemicals Market, By Country (In $ Million)

Source: Inkwood Research

The German fermentation chemical market is estimated to account for the huge share of the market by the end of 2026. German has a mature market because of the high healthcare expenditure and pharmaceutical production. Moreover, one of the key drivers of the country's demand for fermentation chemicals, is growth in food and beverages industry.[149]

Another market that has a huge potential and is expected to grow in the future is **UK Fermentation Chemicals market.** Rising demand for fermentation chemicals in the alcohol industry is primarily driving the UK market.[150] The United Kingdom also represents a significant market share for fermented ingredients, owing to increasing application of fermented ingredients in dairy products in Europe. In the recent past, growth in the European fermented ingredient market was driven by surging growth in the pharmaceutical market in Germany and France, which are the major markets for fermentation ingredients, subsequently followed by the rest of Europe. Due to the trending market saturation witnessed in the developed economies, the **European region is expected to be a future potential market.**[151]

In the Russian market, changing lifestyle and growing urbanization have led to the growth in packaged foods industry, which is proportionately leading to the growth of fermentation chemicals market in the region.[152]

Here's a SWOT Analysis of European Fermentation Chemical Market.

[149] https://www.inkwoodresearch.com/reports/europe-fermentation-chemicals-market/
[150] https://www.inkwoodresearch.com/reports/europe-fermentation-chemicals-market/
[151] https://www.mordorintelligence.com/industry-reports/europe-fermented-ingredient-market
[152] https://www.inkwoodresearch.com/reports/europe-fermentation-chemicals-market/

Market Drivers	Restraint
Growing demand from alcohol industry	Fluctuating production due to limited availability of raw material
Rising consumption in the cosmetics and pharmaceutical industry	Storage of large quantities of ethanol can lead to fire
Growing demand from agricultural industry owing to eco-friendly nature of fermentation chemicals	Improper functioning safety systems may lead the equipment to rupture
Growth and development of bioethanol industry	
Rising awareness about food preservation	
High demand for antibiotics	
Opportunities	**Challenges**
Increase in enzymes demand from several industrial applications	High cost of manufacturing
Increasing demand for fermentation chemicals in the leather industry	Seasonal availability of raw materials
Emerging economies with high growth potential	Stringent regulations
Technological innovation and increase in number of applications	Restricted temperature and ph operational range
New product development and acquisition by key players	

Table 7 SWOT Analysis of European Fermentation Chemical Market

Source: Inkwood Research

When it comes to the competitive landscape of European fermented ingredient market, major players are Ajinomoto Foods Europe SAS, Koninklijke DSM NV, Chr. Hansen Holdings AS, Kerry Group, BASF SE, Lallemand Inc., Cargill Inc., Lonza Group, CSK Food Enrichment BV, and Bioerg Srl.[153]

[153] https://www.mordorintelligence.com/industry-reports/europe-fermented-ingredient-market

7.1.4 Conclusions

This chapter aims to better understand the fermentation process and to identify different factors and possibilities on the market that can have an impact on the final realization of Pilots' business solutions.

Fermentation is an anaerobic enzymatic conversion process, usually used for commercial purposes - for producing bioethanol from sugar crops and starch crops, which can be further distilled to obtain purified alcohol to be used as an automotive fuel.

This technology process will be utilized within Pilots 1, 4, 5, and 6. However, these Pilots will produce different end products. End products of Pilot 1 include functional ingredients, gelatin, and active peptides, flavors, polyphenols, and carotenoids, while the end product of Pilot 4 will be monomers and PHAs. Pilots 5 and 6 are producing bio solvents, bioethanol.

Feedstocks used for fermentation can be **agricultural crops** (with high sugar and starch content, like rice, oats, barley, and wheat) or **different biomass sources** like forest residues, agricultural wastes, food processing wastes, energy crops, wood residues, sawdust, and paper mill residues.

Products that come as a result of the fermentation process can be alcohols (widely in bread, pickles, cheese, and alcoholic beverages), enzymes (chemical and industrial applications), and organic acids (used as preservatives in foods). Fermentation chemicals are mostly for industrial applications, meaning that microorganisms are used for the production of various products such as ethanol, acetic acid, and citric acid.

As a result of **rising preference towards green chemistry**, fermentation chemical markets of Spain, France, the UK, and Germany are expected to grow. Moreover, **regulations by the European Commission and Environmental Protection Agency (EPA)** regarding the use of safe chemicals along with promoting bio-based products are expected to further boost product demand.

The German fermentation chemical market is estimated to account for a huge share of the market by the end of 2026. Also, the UK Fermentation Chemicals market has great potential and is driven by the UK's alcohol industry and fermented ingredients. Moreover, the major markets for fermentation ingredients are Germany and France pharmaceutical markets that are growing. Therefore, there are lots of market opportunities for Pilots 1, 4, 5, and 6.
Due to the trending market saturation in the developed economies, the European region is expected to be a future potential market. However, fluctuating production due to the limited availability of raw material and the fact that storing large quantities of ethanol can lead to fire are some of the restraints of the **European Fermentation Chemical Market**.

7.2 Extraction

7.2.1 Definition

"Extraction is the process by which a product is dissolved or separated from a crude starting material. Some of the most common types of laboratory extraction are liquid-liquid extraction, solvent extraction, and solid-liquid extraction".[154]

Solvent extraction is defined as a method used for separation of one substance (solid, liquid or gas) from others by using a solvent. The method depends on variations in the solubilities of different compounds in different substances. Usually, the substance to be extracted is dissolved in a liquid, together with other substances, and a liquid solvent is used for the extraction. The technique may also be applied to solid materials that contain compounds that need to be extracted.[155] However, **the efficiency of the overall extraction relies on the chosen solvent**. Typical solvents include:

- Water,
- Organic solvents (hexane, methylene chloride, ethyl acetate),
- Alcohol,
- Supercritical CO2.[156]

The main aim of extraction process is to recover valuable soluble components from raw materials by firstly dissolving them in a liquid solvent, so that the components can be separated and recovered later from the liquid. Even though in most cases, the purpose of extraction is to recover just one specific compound in pure form from the residue, sometimes this process tends to separate all the soluble compounds from a raw material – such as the case of extraction of coffee.[157]

7.2.2 Product/application insights

Extraction is widely used in industry, and in the laboratory for refining, isolating and purifying a variety of useful compounds. One of the most widespread industrial uses of this technique is in the **petrochemical refining industry**. As petroleum products are processed, impurities remain in the raw products. Using suitable solvents, the useful material can be separated from the unwanted substances, and then further extraction can be used to separate out the different grades of hydrocarbons according to their uses, which may be as fuels, lubricants,

[154] https://labsociety.com/lab-equipment-category/extraction/
[155] https://www.wisegeek.com/what-is-solvent-extraction.htm
[156] https://www.reportlinker.com/d0123941490/Energy-and-Environment-Industry-in-Europe.html
[157] BAT in the Food, Drink and Milk Industries, June 2005

or as raw materials for the chemical industry. Solvent extraction is also used in the refining of uranium for nuclear reactors.

This method is also widely used in the **production of essential oils**, which are used in perfumes, aromatherapy, and as flavorings, from plant material. The technique is often performed when distillation is not suitable. Where soil has been contaminated by pollutants, solvent extraction may be used to remove some of them as part of an environmental remediation project. This can be an effective method where the contaminants are themselves solvents.[158]

Furthermore, extraction is applied to a wide variety of **food products**. Typical examples are:

- the extraction of sugar from sugar-beets or sugar-cane,
- the extraction of oil from oil seeds and from virgin pomace,
- the extraction of coffee extract from coffee beans,
- the extraction of caffeine from coffee beans,
- the extraction of various other compounds such as proteins, pectins, vitamins, pigments, essential oils, aroma compounds, flavour compounds etc. from many different materials.[159]

Within WaysTUP! Project, Pilot 2, which will be located in Alconbury, Cambridgeshire (United Kingdom), spent coffee grounds will be recycled into advanced biofuels. PILOT 2 end-product will be coffee oil. Coffee beans carry natural oils that can be activated by application of heat. There is a high demand for this oil - “caffeol”. Used within different segments including biodiesel, health supplements, cosmetics and fragrance oil, the extraction is applicated in expensive commercial machinery.[160]

Also, within the same pilot, there is potential to extract the nitrogen from the coffee grounds prior to the coffee grounds being dried and the oil extracted. The extraction of the nitrogen is not expected to reduce the oil yield from the grounds, but would provide a Protein Rich Liquid (PRL) which could perform well in an organic fertilizer. Extracting the nitrogen from the coffee grounds will also enhance their performance as a biomass.

7.2.3 Market analysis

Extraction Solvents are widely used in the processing and production of different food products and ingredients. Generally, they are removed after the processing of the foodstuff, nevertheless, could leave some of the residues in the food ingredient or product, in an unintentional but technically unavoidable way. However, thanks to the rising demand as well

[158] https://www.wisegeek.com/what-is-solvent-extraction.htm
[159] BAT in the Food, Drink and Milk Industries, June 2005
[160] https://javacoffeeiq.com/how-to-extract-coffee-oil-from-a-coffee-bean/

as increasing applications and technological improvements, the global **extraction solvents market** is expected to grow during the next eight years (by 2028).[161]

Growing demand from the pharmaceutical, automobile, printing, adhesives sealants, and construction industry is the main driver of the solvent market. Moreover, another driver of the market is regulatory pressure by the governments for the use of organic solvents.[162]

The ever-growing **food industry** has increased the demand for processed food and that ultimately has a positive impact on the extraction solvent market. The rising demand for processed food products or use of processed ingredients in the various recipes has been a major driver for extraction solvent. Also, modern way of living caused increased demand for processed food. Extraction Solvents are used in many aspects of food preparation, as well as in the production of various oils, fats, flavorings, essential oils, seed oils, and liquid formulation of essences and flavorings. That said, growing demand for flavor and fragrance industry, as well as increasing stature of vegetable and essential oils, has a positive impact on the solvent markets. However, there are some **market restraints such as an increasing concern about the safety of the food products that comes as a result of frequent food contamination incidents.** The residues of extraction solvents in food products have alerted food safety and other regulations worldwide, especially in Europe to regulate the use of extraction solvents in food products.[163]

Overall, having in mind the increasing number of technological improvements in this area, the global extraction solvent market is projected to increase over the next eight years (by 2028).[164]

Another relevant market that should be analyzed when it comes to coffee oil is **Food Flavor Market**. In the period from 2020 to 2025, global food flavor market is expected to grow at a compound annual growth rate (CAGR) of 4.8%. The increasing demand for natural ingredients in food products is the main driver of the market. Consumers worldwide are developing awareness about the long-term health effects of artificial ingredients (such as benzophenone, pyridine, ethyl acrylate, and styrene, that are proved to be carcinogens) and additives in food products. Hence, **there is an increasing demand for naturally sourced ingredients, especially in Europe (in countries like Germany, Spain, and France).** Food and beverage companies have been affected to a great extent with almost all international and local players forced to remove artificial flavors and additives from their product lines. At the

[161] https://www.persistencemarketresearch.com/market-research/extraction-solvents-market.asp
[162] https://www.hexaresearch.com/research-report/solvent-market/
[163] https://www.persistencemarketresearch.com/market-research/extraction-solvents-market.asp
[164] https://www.persistencemarketresearch.com/market-research/extraction-solvents-market.asp

same time, the clean label has affected the global flavor market, wherein producers have responded with high innovation and investments in R&D activities.

Figure 25 Global Food Flavor Market - Market Size (2018), by Region

Source: https://www.mordorintelligence.com/industry-reports/food-flavor-market

Other factors that drive the market are rising demand in numerous food applications, and the growing popularity of exotic flavours. Furthermore, there are new product launches related to exotic and unique flavours that have a positive impact on the demand for compounded flavours.

On the other hand, one of the biggest restraining factors of the market is high cost involved in the production of natural flavours. In addition, natural flavours are less stable, thereby decreasing the shelf life of products.[165]

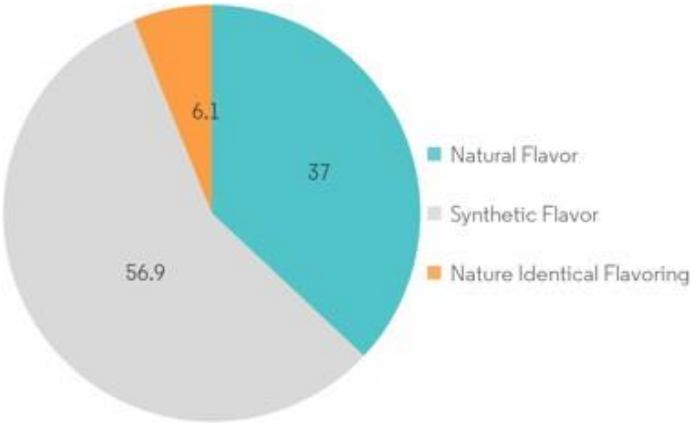


Figure 26 Global Food Flavor Market - Market Share (%), by Type (2018)

Source: https://www.mordorintelligence.com/industry-reports/food-flavor-market

[165] https://www.mordorintelligence.com/industry-reports/food-flavor-market

So far, **Europe holds the major share in Food Flavor Market, especially UK**. The United Kingdom dominates the natural food flavors market as there is a continuous demand for organic products in the country. For example, the sales of organic foods and drinks in the UK increased with significant rate from last few years. One in every three products that are launched in the United Kingdom contains natural food ingredients, including natural flavors. Similar situation is happening in France, where the food and beverage industry has witnessed a reduction in synthetic food flavors due to the increasing application of natural flavors in beverages and the bakery and confectionery industry.[166] Countries with the biggest European Food Flavor Market share are United Kingdom, Germany, France, Russia, Italy and Spain, respectively.

However, it is important to emphasize that Spain is the fastest growing country, the sixth-highest food and drink exporter in the EU and the tenth highest globally. It is evident that in this country, natural food flavors derived from herbs and spices are becoming extremely popular and that is expected to drive significant growth in the future. Even though Spanish consumers are seeking healthier food ingredients, domestic natural food flavors market is not witnessing such a huge growth as expected, although production and exports remain the largest in Spain.[167]

There is a lot of competition in the European food flavor market. Main market player are Kerry Group, Cargill Inc., and BASF. Companies are looking for different ways to increase market penetration in the new markets. Some of them are introducing clean labels and organic flavor ranges, and some of them are acquiring and partnering with local players.[168]

7.2.4 Conclusions

Pilot 2 will use the extraction process to produce coffee oil from spent coffee grounds. Within this chapter, we defined this technology process and explored its possible outcomes, as well as relevant markets. The main aim is to **identify possible market opportunities and restraints.**

Solvent extraction is a method used for the separation of one substance (solid, liquid, or gas) from others by using a solvent. **The efficiency of this method** relies on the chosen solvent (which can be water, organic solvents, alcohol, and supercritical CO2), and **it can be used for many different purposes** - in the petrochemical refining industry, in the refining of uranium for nuclear reactors, in the production of essential oils, and a wide variety of food products.

[166] https://www.mordorintelligence.com/industry-reports/food-flavor-market
[167] https://www.mordorintelligence.com/industry-reports/food-flavor-market
[168] https://www.mordorintelligence.com/industry-reports/europe-food-flavor-market

PILOT 2 end-product will be coffee oil and we noticed that there is a high demand for this oil - “caffeol”. Also, within the same pilot, there is **potential to extract the nitrogen from the coffee grounds** before the coffee grounds being dried and the oil extracted. The nitrogen extraction process provides a **Protein-Rich Liquid (PRL)**, which could perform well in organic fertilizer and it also **enhances the coffee ground’s performance as biomass.**

When it comes to **the market analysis,** we found out that the global extraction solvents market is expected to **grow during the next eight years** (by 2028). Also, the food industry has increased the demand for processed food, and that ultimately has a positive impact on the extraction solvent market. However, there are **some market restraints** such as increasing concern about the safety of the food products that come as a result of frequent food contamination incidents.

Moreover, since coffee oil can be used in the Food Flavor Market, we explored current trends in this market and found out that in the next five years, the global food flavor market is expected to grow. **There is an increasing demand for naturally sourced ingredients**, especially in Europe (in countries like Germany, Spain, and France). Actually, Europe holds the major share in Food Flavor Market, especially the UK. Also, Spain is the fastest growing country, the sixth-highest food and drink exporter in the EU, and the tenth highest globally.

One of **the biggest restraining factors** of the market is the high cost involved in the production of natural flavors. Also, natural flavors are less stable, thereby decreasing the shelf life of products.

7.3 Larval breeding

7.3.1 Definition

When insects are mass produced under controlled conditions, they can break down large quantities of food waste. Then, when insects consume this waste, they produce multiple valuable commodities, such as insect biomass (proteins, lipids), biofuels, pharmaceuticals, lubricants, and fertilizer from their excrement. This process is called **bioconversion** and it is known as one of the most significant food waste treatment processes of the future.[169]

Presently, only a few insect species are commercially used for insect-based bioconversion of food waste, with **black soldier fly larvae** (Hermetia illucens L.) being **the most commonly used species**. However, there is a great diversity of insects that are adapted to a wide range of food sources and therefore likely capable of providing effective bioconversion of different food waste materials. That said, **industrial insect rearing can efficiently turn many tonnes of**

[169] https://link.springer.com/chapter/10.1007%2F978-3-030-20561-4_12

food waste feedstock into valuable products, with some sources suggesting most food waste can be diverted to insect-based bioconversion.[170]

7.3.2 Product/application insights

Considering that the world's population is growing at a startling rate and that there is a limited amount of agricultural land on our planet, there is an urgent need to find alternatives to conventional meat products. Having in mind that livestock production is a leading cause of anthropogenic-induced climate change, different food sources need to be investigated. The world needs more sustainable diets, with reduced meat consumption or the use of alternative protein sources. **Insects are promoted as human food and animal feed worldwide**.[171]

Insects market segmented by product type includes **whole insects, insect powder and insect meal**. On the other hand, **application of edible insects** can be different:

- Processed Whole Insects,
- Animal and Pet Feed Products,
- Processed Insect Powder,
- Insect Protein Bars and Protein Shakes,
- Insect Baked Products and Snacks,
- Insect Confectionaries,
- Insect Beverages,
- Others.[172]

When it comes to insects as food, it is important to say that besides that they can breed and grow quickly, the nutritional value of insect 'meat' is comparable to that of meat from traditional livestock. Moreover, for the production of one kilo of edible product, cold-blooded insects need much less food than warm-blooded livestock. Also, the greenhouse gas emissions from insects are up to one hundred times lower than those from pigs or cattle. This makes insects a sustainable and economically interesting solution for part of the world food problem.[173]

Research has shown that the nutritional value of insects is at least comparable with the nutritional value of soya beans and fish meal products. **Feed from insects can play a major**

[170] https://link.springer.com/chapter/10.1007%2F978-3-030-20561-4_12
[171] https://link.springer.com/article/10.1007/s13593-017-0452-8
[172] https://www.meticulousresearch.com/product/edible-insects-market-forecast/
[173] https://www.wur.nl/en/Dossiers/file/insects-food-and-feed.htm

role in making the food chain circular. The reason lies in the fact that insects can be grown on by-products and residual flows from the agri-food sector and on livestock manure. As a result, they can contribute to sustainable livestock farming.[174]

However, as with chicken and pork, insect 'meat' could pose a danger to **food safety**. Insects can potentially transmit bacteria that originate from contaminated insect feed. Furthermore, they can transmit heavy metals and pesticides that can be found in their feed. In addition, certain insect species may carry the same allergens as dust mites and crustaceans. That means that people who are sensitive to dust mites and crustaceans could also experience an allergic reaction from eating these insects.[175]

In order to protect consumers, foods with insects have been categorized as 'novel foods' according to European legislation (since 01.01.2018), meaning that products with **insects can enter the European market only after they have been approved by the European Food Safety Authority (EFSA).** Since 2017, the use of insects in animal feed for fish farming has been permitted in Europe. Before that time, insects could only be fed to pets, such as reptiles, and after processing the fat from insects could be used in feed for pigs and chickens.[176]

Another application of bioconversion is the **production of fertilizers**. The chemical and physical properties of insect frass used as a fertilizer are compatible to other commercial products. For example, in one study the growth rate and chemical composition of cabbages grown using black soldier fly frass were identical to commercial fertilizers. Reduction of pathogenic microbes and pesticides are the benefits of insect frass compost. However, as mentioned as a possibility before, there are concerns that heavy metals may accumulate in the frass of some insects.[177]

In addition, insects are proven to be an **alternative source for generating precursors for biodiesel (fats and oils)**, due to immature insect's predisposal for sequestering high energy fat prior to pupating into adults. Food wastes that are naturally high in fat, such as palm oil cake and restaurant waste, may be used as a feedstock with the added benefit of reducing the food waste problem while generating sustainable biodiesel. The methodology for

[174] https://www.wur.nl/en/Dossiers/file/insects-food-and-feed.htm#:~:text=Insects%20as%20animal%20feed%20Both%20the%20food%20industry,major%20role%20in%20making%20the%20food%20chain%20circular.
[175] https://www.wur.nl/en/Dossiers/file/insects-food-and-feed.htm#:~:text=Insects%20as%20animal%20feed%20Both%20the%20food%20industry,major%20role%20in%20making%20the%20food%20chain%20circular.
[176] https://www.wur.nl/en/Dossiers/file/insects-food-and-feed.htm#:~:text=Insects%20as%20animal%20feed%20Both%20the%20food%20industry,major%20role%20in%20making%20the%20food%20chain%20circular.
[177] https://link.springer.com/chapter/10.1007%2F978-3-030-20561-4_12

producing biodiesel from insects is similar to producing biodiesel from other biological fat sources.[178]

Here are some examples of insect bioconversion companies. Reduction rates are estimated from a Feed Conversion Ratio of 1.7 and 68% moisture content of extracted larvae.[179]

Company	Food waste eliminated	Daily reduction (estimate)	Insects used	Products sold	Country
Agriprotein	Pre- and post-consumer organic waste	72 Mg	Black soldier fly	Protein feed ingredient (MagMeal™), oil feed ingredient (MagOil™) and compost (MagSoil™)	South Africa
Nextalim	100% traceable EU approved by-products	41 Mg	Black soldier fly	Insect fertilizer, black soldier fly larvae live or dried, black soldier fly larvae defatted proteins and BSF oil	France
Alapre	Organic waste and animal by-products	24 Mg	Black soldier fly	Insect meal and compost sold under the trademark "ENTHOS"	Colombia
Proti-farm	Vegetable by-products	confidential	Lesser mealworm+various	Various applications with focus on food: buffalo's frozen, freeze-dried, grinded (EntoPure)	Netherlands

[178] https://link.springer.com/chapter/10.1007%2F978-3-030-20561-4_12
[179] https://link.springer.com/chapter/10.1007%2F978-3-030-20561-4_12

Entofood	100% vegetal by-products	240 kg	Black soldier fly	Whole insect meal, defatted insect meal, insect oil	Malaysia
Insectum	Former foodstuff including milk and eggs	22 kg	Black soldier fly	Black soldier fly larvae frozen, dried and/or defatted	Lithuania
Nextprotein	Organic inconsumable food matter	4.5 Mg	Black soldier fly	Insect protein meal, oil, and fertilizer	France / Tunisia
Hermetia	Bruised rye	4.3 Mg	Black soldier fly	Dried larvae, insect meal, insect oil, fertilizer	Germany
F4F	Pre-consumer organic waste	1.3 Mg	Black soldier fly	Starter feed functional ingredients (fish and poultry), exotic pet snacks, fertilizer and feed development trials	Chile
Innovafeed	Cereal by-products	1.1 Mg	Black soldier fly	Defatted meal and purified fat of black soldier fly larvae	France
Enterra feed	Pre-consumer recycled food products	confidential	Black soldier fly	Whole dried larvae, meal, and oil	Canada

Ynsect	Vegetal material only, like cereal by-products	confidential	Mealworm	Protein, oil, frass	France

Table 8 Insect bioconversion companies

7.3.3 Market analysis

The **global edible insects market** is was estimated to grow by a CAGR of 24.4% during the period from 2019 to 2030. Moreover, in terms of volume, this market is expected to grow at a CAGR of 27.8% in the same period to reach 732,684.1 tons by 2030.[180]

Some of the factors that are driving the growth of the global edible insects market include the world population growth and food resources decrease, growing demand for protein-rich food, the high nutritional value of insects, the high cost of animal meat, low risk of transmitting zoonotic diseases, environment sustainability with production and consumption of edible insects. On the other hand, psychological and ethical barriers, non-standardized regulations across the world, lack of awareness, and possible allergies due to insect's consumption are the main restraints of this market.[181]

Based on insect type, crickets commanded the largest share in 2018 and are expected to dominate the global edible insects market in the future. The reason of growth lies in crickets' high nutritional value, easy farming, easy processing, and wide application in various food recipes & products. Also, increasing demand for cricket-based products, such as protein powder, protein bars, and snacks, among other factors further supports the growth of this segment. **Based on application, the insect protein bars and protein shake application segment is expected to grow at the highest CAGR during the upcoming period**. Factors that contribute to the fast growth of this segment include: the increasing inclination of young generation towards the fitness and wellness, the rising number of health clubs and fitness centers, and busy lifestyle and swelled disposable income which demands highly nutritious and convenient food.[182]

[180] https://www.globenewswire.com/news-release/2019/04/01/1790970/0/en/7-95-Billion-Edible-Insects-Market-Global-Forecast-to-2030.html
[181] https://www.globenewswire.com/news-release/2019/04/01/1790970/0/en/7-95-Billion-Edible-Insects-Market-Global-Forecast-to-2030.html
[182] https://www.globenewswire.com/news-release/2019/04/01/1790970/0/en/7-95-Billion-Edible-Insects-Market-Global-Forecast-to-2030.html

Geographically, Asia-Pacific area had the biggest share of the global edible insects market in 2018, followed by Europe and North America. Main market drivers include the insect's diversity and great production, positive acceptance of insects as food and feed, and no regulatory barriers related to use of insects in food and feed.[183]

Prominent players of the global edible insects market are: Kreca Ento-Food Bv, Aspire Food Group, Haocheng Mealworm Inc, A Proti-Farm Company, Hargol Foodtech, Entomo Farms, Agriprotein, Ynsect, Tiny Farms, Coalo Vally Farms, Deli Bugs Ltd., All Things Bugs, LLC, Beta Hatch, Nordic Insect Economy, Entocube, The Cricket Lab, Rocky Mountain Micro Ranch, Cowboy Cricket Farms, Armstrong Cricket Farm Georgia, Global Bugs Asia Co., Ltd. and Jr Unique Foods Ltd., among many other local and regional players.[184]

When it comes to the global **insect feed market**, it is projected to grow at a CAGR of 12% by 2030. In the insect feed sector, there are some difficulties such as commercial-scale production, in comparison to conventional animal feed products. Since 2019, by animal type, **the aquaculture segment dominated the market with a share of 49.2%**. Growing demand for farmed fish across the world has led to a rise in prices of fishmeal and fish oil. Therefore, insect feed serves as a viable protein rich option for aqua feed, thus, driving the market.[185]

Insects are efficient in converting feed into protein, for example, crickets need 12 times less feed than cattle, four times less feed than sheep, and half as much feed as pigs and broiler chickens to produce the same amount of protein. The need for grain and protein feeds is likely to increase in the future as the demand for meat is rising.[186]

[183] https://www.globenewswire.com/news-release/2019/04/01/1790970/0/en/7-95-Billion-Edible-Insects-Market-Global-Forecast-to-2030.html
[184] https://www.meticulousresearch.com/product/edible-insects-market-forecast/
[185] https://www.mordorintelligence.com/industry-reports/insect-feed-market
[186] https://www.mordorintelligence.com/industry-reports/insect-feed-market

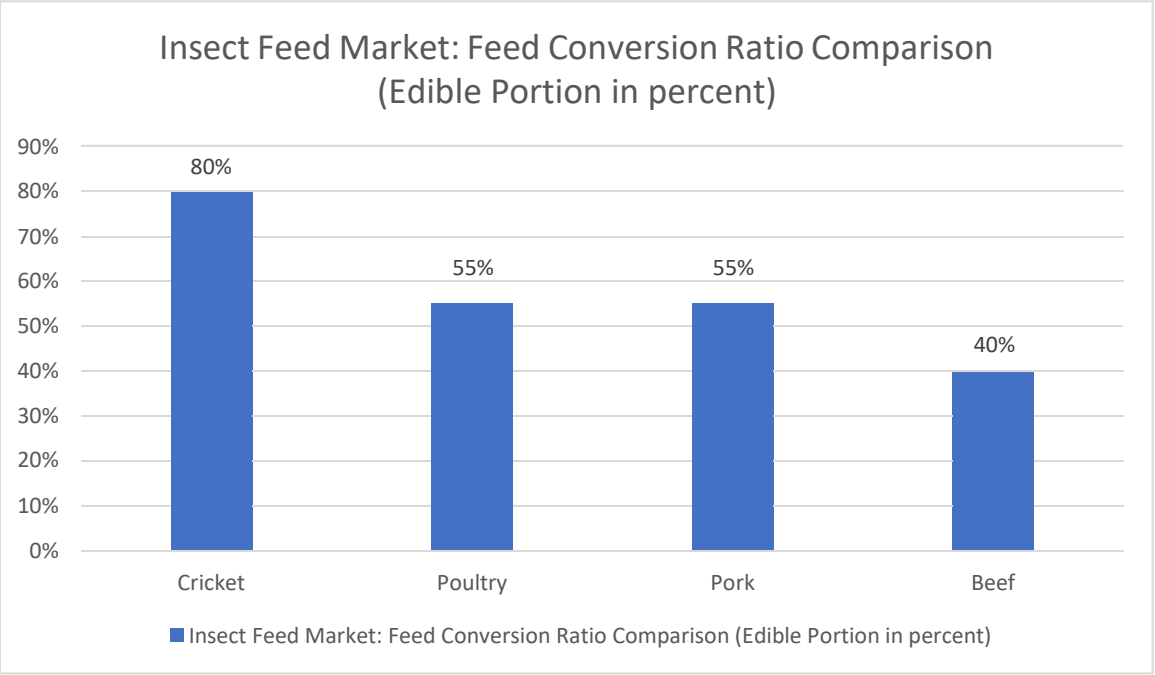


Figure 27 Insect Feed Market: Feed Conversion Ratio Comparison

Source: https://www.mordorintelligence.com/industry-reports/insect-feed-market

Insect feed is more and more used in poultry and pig nutrition. There are number of reasons for that. First, both these sectors witness high demand because of the rising population around the world. Second, consumers have become more conscious about the nutrition present in food they eat. The rising demand for healthier meat products and over increase in demand for the same has spurred insect feed sales across the world. Insect feed supplies nutrition promoting healthy growth in livestock. The insect feed market is expected to grow in the future as farmers from all over the world are seeking alternative sources of protein.[187]

Looking at the key market trends, **Asia-Pacific dominated the global market and Europe is projected to be the fastest-growing market in the years to come**. In Asia-Pacific, the growing meat consumption is attributed to the demand for nutritious insect feed in recent years. In addition, investments by the insect feed companies in the region supported the market growth. On the other hand, **European insect feed market is expected to grow thanks to the resent technical innovations and other developments**. Great example of the developments in Europe is that in 2017, RSK ADAS Ltd (with the support of the British Ecological Society Agricultural Ecology Group, the Royal Entomological Society, and the Woven Network) conducted a workshop for the expansion of insect farming in the United Kingdom. Together with additional UK legislation and orders from the Food Standards Agency, strict rules may

[187] https://www.futuremarketinsights.com/reports/insect-feed-market

be applied to all aspects of feed production. The EU amended this legislation to allow some insect meals to be used in poultry feed apart from aquaculture.[188]

Major players of the global insect feed market are Multibox, from UK, NextProtien (France), Enviroflight (US), Alltech Coppens and Protix (the Netherlands). Next Protein and InnovaFeed are some of the incredible insect feed production startups. Insect feed manufacturing companies are primarily investing their funds on research and development.[189]

Due to the novelty of industrially mass-produced insects for food and feed, risks of associated contaminants entering the food chain warrant investigation and oversight. In anticipation of new products making their way into European markets, **in October 2015 the European Food Standards Agency (EFSA) has published an opinion on the risk profile of insects as food and feed, concluding that food and feed products should pose no greater threat than products already on the market**.[190] Further, the agency highlighted the need for continued research in microbial, chemical, and allergenic hazards, as well as impacts on processing, storage, and environmental hazards.[191] However, the European Union prohibits insect meal as feed for pigs and poultry, but not aquiculture (Regulation EC No. 999/2001), it is prohibited to use catering waste as feedstock (Regulation EC No. 1069/2009); and insects must be “slaughtered” off-site (Regulation EC No. 1099/2002). In addition, the United States and European Union consider some insects as “mini-livestock”, thus affording protections against inhumane slaughter.[192]

7.3.4 Conclusions

Pilot 3 is focused on the massive production of larval biomass. The end product coming from this Pilot is insect protein. Presently, only a few insect species are commercially used for insect-based bioconversion of food waste, with black soldier fly larvae being the most commonly used species. In Pilot 3 the artificial rearing of the Black Soldier Fly Hermetia illucens will take place. Furthermore, blowflies, Calliphoridae will grow on the feedstock of animal origin. Both types of flies can work simultaneously improving the final result.

Nowadays, insects are promoted as human food and animal feed worldwide. When it comes to insects as food, it is important to say that besides that they can breed and grow quickly, the nutritional value of insect ‘meat’ is comparable to that of meat from traditional livestock. However, as with chicken and pork, insect ‘meat’ could pose a danger to food safety. In order

[188] https://www.mordorintelligence.com/industry-reports/insect-feed-market
[189] https://www.mordorintelligence.com/industry-reports/insect-feed-market
[190] European Food Safety Authority Scientific Committee (EFSA). (2015). Risk profile related to production and consumption of insects as food and feed. European Food Safety Authority Journal, 13(10), 4257.
[191] European Food Safety Authority Scientific Committee (EFSA). (2015). Risk profile related to production and consumption of insects as food and feed. European Food Safety Authority Journal, 13(10), 4257.
[192] https://link.springer.com/chapter/10.1007%2F978-3-030-20561-4_12

to protect consumers European regulatory bodies declared that insects can enter the European market only after they have been approved by the European Food Safety Authority (EFSA).

Another application of bioconversion is the production of fertilizers. The chemical and physical properties of insect frass used as a fertilizer are compatible to other commercial products.

Furthermore, insects are proven to be an alternative source for generating precursors for biodiesel (fats and oils), due to immature insect's predisposal for sequestering high energy fat prior to pupating into adults.

From the market prospective, we analysed global edible insects market and global insect feed market. Both of these markets are expected to grow in the next 10 years.

Crickets dominate global edible insects market and this trend is expected to continue in the future as they have a high nutritional value, and wide application in various food recipes & products. Asia-Pacific area had the biggest share of the global edible insects market in 2018, followed by Europe and North America.

Within the insect feed market, aquaculture segment has the largest share. Here again, Asia-Pacific dominates the global market, but Europe is projected to be the fastest-growing market in the upcoming years, thanks to the resent technical innovations and other developments.

7.4 Slow Pyrolysis

7.4.1 Definition

Pyrolysis is a conversion technology involving the thermal decomposition of organic matter at atmospheric pressure, temperatures ranging from 300 to 600 °C, and in the absence of oxygen.[193] The word has Greek origins, meaning pyro "fire" and lysis "separating". The fragmentation of the biomass molecules creates chemical structures that, upon cooling, result in gaseous products, condensable liquids (bio-oil) and residual solids (bio-carbon). The gas consists mainly of carbon monoxide, hydrogen and methane, with lower amounts of carbon dioxide and ethane. The bio-oil is a dark, viscous mixture of many chemicals, including acids, ketons, aldehydes, phenolics, furfural, anhydrosugars and water. The bio-carbon consists of the mineral matter of the original biomass entrapped into a porous carbon structure.[194]

[193] https://biocharforcarboncapture.com/research/fast-and-slow-pyrolisis
[194] https://biocharforcarboncapture.com/research/fast-and-slow-pyrolisis

Slow pyrolysis at low to moderate temperatures (around 300 °C) and long reaction times (up to days) has been used for thousands of years for the conversion of wood into high yields of charcoal (bio-carbon). The slow pyrolysis process creates also lower yields of bio-oil and gaseous products. Nevertheless, during the last 30 years, fast pyrolysis, carried out at intermediate temperatures (around 500 °C) and very short reaction times (1 to 5 seconds) has become very interesting as a method for generating higher yields of bio-oil (typically around 65 wt%) with remarkably higher energy density than the original biomass, in addition to bio-carbon (20%) and gas (15%).[195]

Slow and fast pyrolysis generate solid bio-carbon products with different characteristics, even when produced from the same raw biomass material. These differences include:

- the evolution of the specific surface area resulting from the development of a porous structure during the pyrolysis process, and
- the average pore size and pore size distribution (i.e. the fraction of micro-pores and meso/macro-pores).[196]

7.4.2 Product/application insights

Pyrolysis is considered to be one of the sustainable solutions that may be economically profitable in large scales. It minimizes environmental concerns especially in terms of:

- Waste minimization,
- Soil amendment,
- Value added chemicals,
- Carbon sequestration,
- Energy/heat supply and
- Development of rural areas.[197]

Pyrolysis has various applications of interest to green technology, such as:

- This process is widely used in the chemical industry to produce methanol, activated carbon, charcoal and other substances from wood.
- Synthetic gas produced from the conversion of waste using pyrolysis can be used in gas or steam turbines for producing electricity.
- A mixture of stone, soil, ceramics, and glass obtained from pyrolytic waste can be used as a building material - construction slag or for filling landfill cover liners.
- It plays a major role in carbon-14 dating and mass spectrometry.
- It is also used for several cooking procedures like caramelizing, grilling, etc.[198]

[195] https://biocharforcarboncapture.com/research/fast-and-slow-pyrolisis
[196] https://biocharforcarboncapture.com/research/fast-and-slow-pyrolisis
[197] https://www.oeaw.ac.at/forebiom/WS1lectures/SessionII_Uzun.pdf
[198] What is Pyrolysis? (azocleantech.com)

Main end products **of pyrolysis process are: bio-oil, bio-char and gaseous product.** Compositions of these products are given in the table below.

Compositions of Products		
Bio-oil	**Bio-Char**	**Gaseous products**
Acids, Esters, Alcohols, Ketones, Aldehydes, Phenols, Alkenes, Aromatics, Nitrogen compounds, Furans, Syringols, Sugars, Miscellaneous oxygenates Inorganics such as Ca, Si, K, Fe, Al, Na etc.	Char contains elemental carbon along with hydrogen and various inorganic species.	CO, CO2, CH4, H2, propane, propylene, butane, butenes, C5, ethane, etc.

Table 9 Compositions of products made by pyrolysis process

Source: https://www.oeaw.ac.at/forebiom/WS1lectures/SessionII_Uzun.pdf

Pyrolysis products and their possible applications regarding different types of feedstock

Usually, the pyrolysis of waste is used for energy recovery, because the products often have good properties as fuels. Also, there is a high market demand for energy (especially electricity), which is always easy to sell. Pyrolysis can also be used to convert waste into an energy source for the home, and on a larger scale pyrolysis plants may use the pyrolysis products for other purposes, which increases the profitability of the process. The complex composition of pyrolytic oil and some properties of char could make them favorable as a raw material for some industry sectors.

Pyrolytic gas

Composition of the pyrolytic gas is strongly dependent on the pyrolysis temperature and feedstock. **Slow pyrolysis of biomass waste such as wood, garden waste and food residue** at low temperatures (below 400 °C) produces small amounts of gas, which is high in CO2, CO and light hydrocarbons. The yields of gas at these conditions usually do not exceed 30 wt% of products. Increasing the temperature causes an increase in gas yields, because of the secondary reactions and partial char decomposition. On the other hand, higher temperatures (above 700 °C) produce syngas, which contains more hydrogen and carbon monoxide. In this case gas is the main product of the process.

The **pyrolysis of plastics** produces pyrolytic gas, that is composed of hydrogen light hydrocarbons: methane, ethane, ethene, propane, propene, and butane. This gas has a

great calorific value.

Similar properties characterized the gas originated from the **pyrolysis of tyres or other artificial products like textiles**. In turn, **co-pyrolysis of polymers and biomass leads to a higher production of CO and CO2 especially at lower temperatures**.

Finally, the **pyrogas from municipal solid waste** consists of CO2, CO, hydrogen, methane and other light hydrocarbons with an average heating value of around 15 MJ/Nm3, which increases with increasing temperature.[199]

The most suitable demand on pyrogas is its use as a source of the energy required for the pyrolysis process itself. However, the exhaust gas has to be controlled, because, for example, food waste processing could be a source of dangerous nitrogen compounds. Usually the precise composition of waste is not known, thus some unwanted compounds can appear in pyrogas. Therefore, emission control units and gas cleaning devices should be used, and it does not matter whether the gas will be combusted or not.[200]

Pyrolytic oil

Pyrolytic oil offers more opportunities for use than gas, but, depending on the composition of the feedstock and the process parameters, the composition of the liquid product from pyrolysis may differ radically. **Pyrolytic oil produced from biomass** consist largely of the following compounds: acids, sugars, alcohols, ketones, aldehydes, phenols and their derivatives, furans and other mixed oxygenates. Phenolic compounds are often present in high concentrations (up to 50 wt%), consisting of relatively small amounts of phenol, eugenol, cresols, xylenols, and much larger quantities of alkylated (poly-) phenols. They can be used for the production of heat, electricity, synthetic gas or chemicals.[201]

When it comes to the **pyrolysis of plastics**, the liquid phase is usually the predominant product. Those oils are a valuable material. For example, the oil obtained from the pyrolysis of polyethylene at 425 °C consists of more than 30 wt% of the aliphatic fractions from C12 to C18 and alpha-olefins, and these components can be used in detergent industries. Even pyrolysis of real plastic waste consisting of polyethylene, polypropylene, polystyrene, polyethylene terephthalate and polyvinyl chloride allows the extraction of a valuable liquid fraction. The pyrolysis liquids have a high heating value (~37 MJ/kg) so that they can be used as an alternative to fossil fuels. This oil also contains significant amounts of styrene, toluene and ethyl-benzene; thus it can be a source of chemicals. These aromatics are highly valuable as solvents, and as precursors for a wide variety of compounds including drugs, lubricants, detergents, plastics (e.g., polystyrene, polycarbonate), and explosives.[202]

Finally, **co-pyrolysis of biomass and synthetic polymers** could be an environmentally friendly way for the transformation of waste into valuable products such as chemicals or fuels. Furthermore, co-pyrolysis allows the simplification of expensive and complicated waste separation and classification processes and it still provides valuable products.

199 Potential of pyrolysis processes in the waste management sector - ScienceDirect
200 Potential of pyrolysis processes in the waste management sector - ScienceDirect
201 Potential of pyrolysis processes in the waste management sector - ScienceDirect
202 Potential of pyrolysis processes in the waste management sector - ScienceDirect

Pyrolytic char

In general, pyrolytic char obtained from **co-pyrolysis of waste** (mixture of biodegradable and non–biodegradable) **can be combusted to provide energy for the pyrolysis process** or other purposes. For example, char obtained in pyrolysis can also be processed into activated carbon. **Coal, coconut shells, wood, peat and fruit stones are most commonly used to manufacture activated carbon**. However, in a laboratory scale study, an enormous range of alternative raw materials has been used to produce activated carbons. The use of waste materials to produce activated carbon is preferable because it reduces the cost of producing activated carbons. An interesting application of char from the pyrolysis of mixtures of wastes is its valorisation as an **adsorbent of pollutants**.[203]

Biochar can fix carbon for many years due to the strong resistance of its aromatic carbon structure to biological decomposition. While ordinary biomass fuels are carbon neutral as the carbon captured in the biomass by photosynthesis would have eventually returned to the atmosphere through natural processes, **sustainable biochar systems can be carbon negative** because they hold a substantial portion of the carbon in soil. This results in net reduction of carbon dioxide in the atmosphere and helps in reducing the GHG emissions.

Biochar is the only current reasonable method for human action to remove significant amount of atmospheric CO_2 through carbon sequestration. **Biochar can clean the air** in two ways: preventing rotting biomass from releasing harmful CO_2 into the atmosphere and allowing plants to store the CO_2 that they pull from the air via photosynthesis.[204]

Another application of **char from the pyrolysis of wood** is its use as an **organic fertilizer**, which offers many advantages. Biochar increases the retention of nutrients and water in soil and provides habitats for symbiotic microorganisms, thus crop yields increase.

Also, since 2010, **livestock farmers increasingly use biochar as a regular feed supplement to improve animal health, increase nutrient intake efficiency and thus productivity**.[205] Different studies related to the incorporation of biochar in animal feed show that biochar can be used as a feed additive for ruminants (cattle and goats), pigs, poultry (chickens and ducks) and fish. Documented positive responses to biochar supplementation include improved growth performance, blood profiles, egg yield, ability to resist pathogens including gut pathogenic bacteria and a reduction of methane production by ruminant animals. In addition, the high sorption capacity of biochar efficiently aids the removal of pollutants and toxins from animals' bodies as well as from farm environments. It is expected that there will be increasing use of biochar in animal farming in the future.[206]

As explained above, the treatment of feedstock for the production of biooil, biogas and biochar differs considering the target end product. **Within WaysTUP! Pilot 7 slow pyrolysis process will be applied for the production of biochar that will be used as soil amendment or (slow release) fertilizer**. However, we have we investigated other possible applications of biochar for future reference.

[203] Potential of pyrolysis processes in the waste management sector - ScienceDirect
[204] Biochar – A Carbon Negative Biomass Energy - FutureEnTech
[205] The use of biochar in animal feeding - PubMed (nih.gov)
[206] Use of biochar as feed supplements for animal farming: Critical Reviews in Environmental Science and Technology: Vol 51, No 2 (tandfonline.com)

7.4.3 Market analysis

Pyrolysis oil is a synthetic fuel which is manufactured as a substitute for petroleum. It is also known as biocrude or bio-oil. The global market for pyrolysis oil is expected to grow at a CAGR of over 4% during the period between 2020 to 2025. Increasing demand of pyrolysis oil for generating heat and power, as well as rising demand from fuels segment, are driving this market. However, problems associated with storage and transportation of pyrolysis oil and difficult conditions arising due to COVID-19 outbreak are the major restraints, which are expected to hinder the growth of market.[207]

The growing usage of pyrolysis oil to produce heat by direct combustion in a boiler or furnace is projected to increase the demand of pyrolysis oil. The application of pyrolysis oil in boiler is expected to grow in the future as the usage of pyrolysis oil can reduce the carbon emissions by 90% due to which it can replace natural gas and heavy & light fuel oils. Also, the usage of pyrolysis oil in gas turbines and diesel engines to generate heat & power is likely to provide lucrative opportunities for the growth of pyrolysis oil market from 2020 to 2025. The industrial boilers market is expected to grow at a CAGR of above 5% during the same period. Consequently, the demand for pyrolysis oil is also expected to increase.[208]

Bio-oil market is segmented by type into bioethanol and biodiesel, whereas by application, it is divided into industrial fuels, transportation fuels and chemical industry.[209]

End-users of renewable ethanol are automotive and transportation industry, and drinks industry. Bio-ethanol is used in alcoholic beverages, such as vodkas, liquors, and other spirits for fermentation process. In recent times, bio-ethanol is one of the most desired fermentation products in beer brewing and wine-making. Bio-ethanol is also used as a natural product to extract and concentrate flavors and aromas, which are then used by the food and drink industry. As a food additive, ethanol can help evenly distribute food coloring, as well as enhance the flavor of food extracts.[210]

The market for bio-ethanol is expected to grow at a CAGR of more than 4% during the forecast period from 2020 to 2025. Major factors driving the growth of the market, are the increasing demand from the automotive industry, and increasing government initiatives. In case of the United States, which has the largest consumption of bio-ethanol, uplifting restrictions on selling gasoline containing a higher percentage of ethanol in the country will be a major driver in the country.[211]

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The market for bio-ethanol is expected to grow at a CAGR of more than 4% during the forecast period from 2020 to 2025. Major factors driving the growth of the market, are the increasing demand from the automotive industry, and increasing government initiatives. In case of the United States, which has the largest consumption of bio-ethanol, uplifting restrictions on selling gasoline containing a higher percentage of ethanol in the country will be a major driver in the country.

On the other hand, the global biodiesel market is also expected to witness growth at 7.3% CAGR in the period from 2020 to 2025, thanks to growing demand for biodiesel as

[207] https://oklahoman.com/article/feed/10082568/global-pyrolysis-oil-market-2020-2025-growing- applications-in-biorefineries-to-offer-lucrative-opportunities-researchandmarketscom
[208] https://oklahoman.com/article/feed/10082568/global-pyrolysis-oil-market-2020-2025-growing- applications-in-biorefineries-to-offer-lucrative-opportunities-researchandmarketscom
[209] https://market.us/report/bio-oil-market/
[210] https://www.mordorintelligence.com/industry-reports/bio-ethanol-market
[211] https://www.mordorintelligence.com/industry-reports/bio-ethanol-market
[212] https://oklahoman.com/article/feed/10082568/global-pyrolysis-oil-market-2020-2025-growing- applications-in-biorefineries-to-offer-lucrative-opportunities-researchandmarketscom

automobile fuel as they are characterized as environment friendly. Europe and North America dominate the biodiesel industry.

Based on geography, **North America region dominate the overall bio-oil market across the globe with the largest consumption from countries such as United States and Canada**. The United States combined heat & power market is expected to grow at a CAGR of above 7% during the forecast period from 2020 to 2025 which is likely to increase the demand of bio-oil and stimulate its market during the forecast period. Some of the major companies operating in North America region are Klean Fuels (Klean Industries Inc.) and Chevron Phillips Chemical Company.[213] **Europe region is also providing a huge demand in the global bio-oil market as a reflection of the upturn in growth of the industrial boilers and industrial diesel engines industry**. However, Asia Pacific and Latin America houses some of the fastest emerging economies and heavy investment on research and development is expected to turn these two regions into highly profitable towards 2025.[214]

Main players of the global bio-oil market are: Diester Industries, Ital Green Oil, Neste Oil Rotterdam, ADM, Cargill, Infinita Renovables, Elevance, Biopetrol, Evergreen Bio Fuels, Glencore, Minnesota Soybean Processors, Louis Dreyfus, Renewable Energy Group, RBF Port Neches, Hebei Jingu Group, Ag Processing, Flint Hills Resources, Marathon Petroleum Corporation, Caramuru, Green Plains.[215]

When it comes to the **European Biogas Market,** its biggest drivers are: (1) Shifting trends toward utilization of clean energy resources, (2) Shifting trends toward the circular economy, and (3) Favorable government initiatives. Countries across the region have announced nationally determined targets toward clean fuel adoption which will further complement the business landscape. Considering these factors, European Biogas Market has been forecast to exhibit a CAGR of 10.4% through 2025.[216]

Europe organic waste biogas market is anticipated to witness grow over 14% by 2025.[217] Organic waste includes food waste, paper waste, slaughterhouse waste and other biodegradable waste generated from the various sources. Rising waste generation from urban centers together with shifting trends toward resource recovery will propel the industry growth in coming years.

Energy crops are one of the most favorable resources for the biogas production, because of reduced investment and high energy density. **By process**, the European Biogas Market is

[213] https://www.transparencymarketresearch.com/pyrolysis-oil-market.html
[214] https://www.grandviewresearch.com/press-release/global-biodiesel-market
[215] https://www.theinnovativereport.com/2020/03/12/bio-oil-market-opportunities-and-advanced- technologies-in-emerging-industry-2025/
[216] Europe Biogas Market Share Size 2019-2025 Trends Forecast Report (gminsights.com)
[217] Europe Biogas Market Share Size 2019-2025 Trends Forecast Report (gminsights.com)

segmented to:

- Landfill,
- Sewage Sludge,
- Anaerobic Digestion (wet and dry),
- Pyrolysis and Gasification.

Anaerobic Digestion, in 2018, accounted for over 70% of the Europe biogas market revenue. The process involves production of biogas in anaerobic digesters through the fermentation of agricultural waste, energy crops and manure. Besides Anaerobic Digestion, which is the most prominent market segment considering the process of obtaining biogas, landfill is the most promising one. Landfills are utilized to decompose organic waste to produce landfill gas which is composed of nearly 45% methane. It offers comparatively lower cost of biogas production when compared to other available alternatives which will further stimulate the industry growth.[218]

Both segments of the European biogas market (by application), industrial and commercial, are expected to grow in the upcoming years (by 2025). The main reason for this lies in the growing need for the reliable and cost-effective waste treatment technologies, as well as in availability of cheap feedstock which will further fuel the deployment of biogas plants across industrial centers.

Germany holds the biggest share of the European biogas market and is set to witness strong growth on account of supportive regulatory schemes toward utilization of biogas for electricity production. The UK biogas market is also expected to grow (over 10% by 2025).[219]

The most prominent players on the European biogas market are EnviTec Biogas, Scandinavian Biogas Fuels International, Agrinz Technologies, Viessmann Group, Weltec Biopower, Agraferm Technologies AG, BDI - Bioenergy International GmbH, Gasum, PlanET Biogas Global, Xergi, AB Holding and Engie. In order to gain competitive edge over other participants, companies are engaged in extensive research and development.

Analysis of the European biochar market is provided within section 8.6.3 of this document.

7.4.4 Conclusions

Pilot 7 uses slow pyrolysis to produce biochar. Slow pyrolysis is a very old technology process that involves thermal decomposition of organic matter at atmospheric pressure, low to moderate temperatures (around 300 °C) and long reaction times (up to days), in the absence of oxygen. It can convert wood into high yields of charcoal (bio-carbon). It also creates lower yields of bio-oil and gaseous products.

Pyrolysis has various applications of interest to green technology. Pyrolyzing biomass can be

[218] Europe Biogas Market Share Size 2019-2025 Trends Forecast Report (gminsights.com)
[219] Europe Biogas Market Share Size 2019-2025 Trends Forecast Report (gminsights.com)

used for producing energy that could supplement or completely replace petroleum-based energy. End products of pyrolysis process include bio-oil, bio-char and gaseous product. These products have different applications considering different types of feedstock from which they can be obtained.

The global market for pyrolysis oil is expected to slowly grow in the upcoming period. Bioethanol and biodiesel are two prominent types of bio-oil, and they have application as industrial fuels, transportation fuels and in chemical industry.

Global biodiesel market is expected to have a slightly bigger growth in comparison to bio-ethanol market, thanks to growing demand for biodiesel as automobile fuel as they are characterized as environment friendly. Europe and North America dominate the biodiesel industry.

When it comes to the European Biogas Market**,** it is expected to grow in the upcoming period thanks to shifting trends toward utilization of clean energy resources and favorable government initiatives. Europe organic waste biogas market is anticipated to witness grow over 14% by 2025.

Germany has the biggest share of the European biogas market and is expected to witness strong growth on account of supportive regulatory schemes toward utilization of biogas for electricity production.

7.5 Urban Biowaste Processing Technologies (general overview)

Biowaste processing technologies are processes that convert discarded biowaste into new products with potentially some value. Graphic below shows a holistic classification of the most common treatment technologies for urban biowaste. They are grouped into four main categories:

- Direct use,
- Biological treatment,
- Physico-chemical treatment and
- Thermo-chemical treatment.

We can see the examples of treatment technologies or processes that fall under each category, as well as value products that are generated from each technology. Furthermore, graphic also shows possible end-uses for each product.

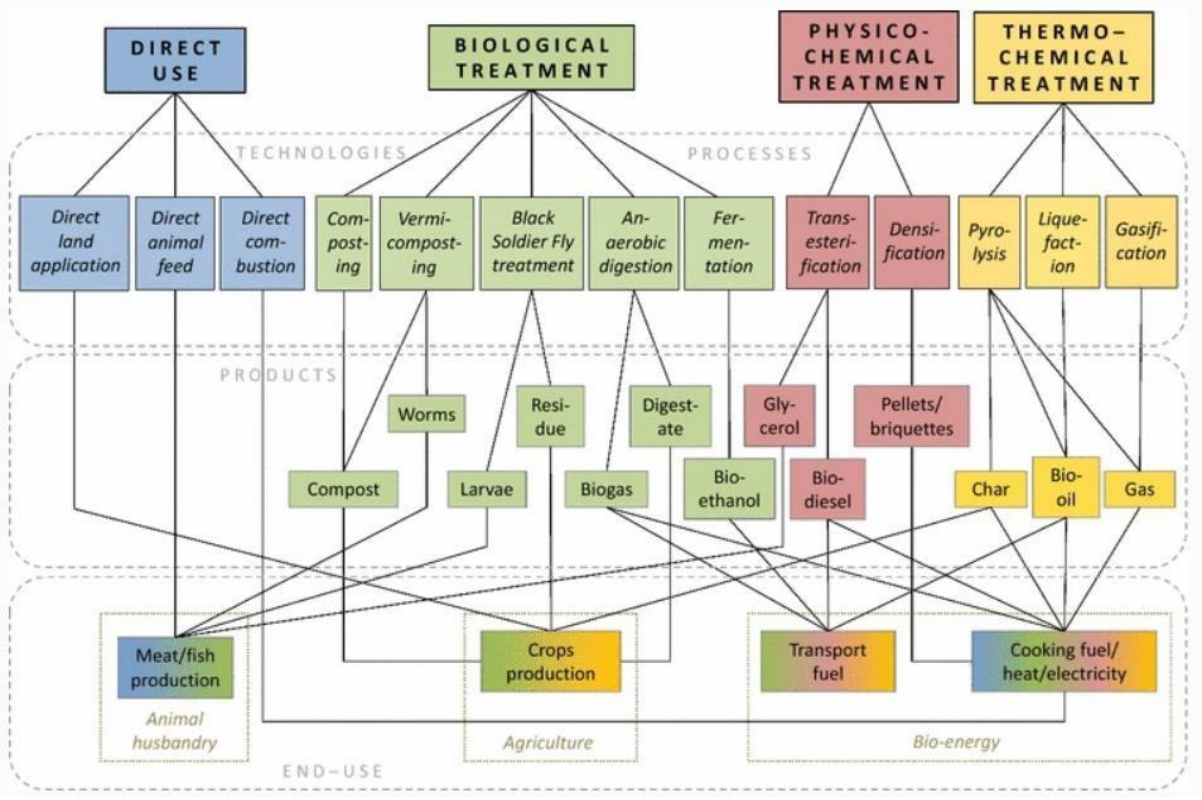

Figure 28 Overview of biowaste treatment technologies as presented in this review with the respective products generated from waste and their end-use

Source: https://link.springer.com/article/10.1007/s11157-017-9422-5

The direct use of biowaste is an ancient form of waste treatment/disposal. It is the simplest waste treatment and can be done at low costs. **Direct land application, waste fed directly to animals and direct open combustion (also known as open burning)** are included in this category of 'direct uses'. There are certain risks of such practices that depend on the composition of the biowaste. Contamination can easily jeopardize human, animal and environmental health. Direct biowaste use on land and for feed is still practiced today, mainly in rural settings. However, this practice is less frequent in urban settings, because of the high population density and increasing waste complexity.[220]

Biological treatment processes can be defined as the controlled conversion of waste by living organisms. Biotechnological and biochemical conversion processes also fall under this category. Biochemical processes are substantially slower than a thermochemical conversion but require significantly less external energy input. Considering that all living organisms need water for survival, biological treatment always takes place in a moist environment. Hence, biochemical conversion processes are mainly applied to wastes with high moisture levels.[221]

Biological treatment processes are:

- **Composting** - involves the controlled aerobic decomposition of organic matter that results in a relatively stable organic end-product called humus;
- **Vermicomposting** - aerobic process of organic waste degradation and stabilization by interaction of microorganisms and earthworms under controlled conditions;
- **Black soldier fly treatment** - an emerging technology in organic waste treatment. It involves the transformation of biowastes into insect protein and insect oil;
- **Anaerobic digestion** - a robust, well-established engineered process to biochemically decompose both liquid and solid organic matter by various bacterial activities in an oxygen-free environment. This process occurs naturally in many anoxic environments, such as watercourses, soils, animal intestines, and landfills;
- **Fermentation** - key process step in the production of bio-ethanol (see chapter 6.1 of this report).[222]

Physico-chemical treatment summarizes conversion processes that are induced by chemical reactions or apply physical, mechanical force. The chemical process of transesterification for

[220] https://link.springer.com/article/10.1007/s11157-017-9422-5
[221] https://link.springer.com/article/10.1007/s11157-017-9422-5
[222] https://link.springer.com/article/10.1007/s11157-017-9422-5

biodiesel production, and the physical densification process for the production of pellets and briquettes are included here.

Physico-chemical treatment processes are:

- **Transesterification** (also called alcoholysis) - entails a catalyzed reaction of oil or fat in the presence of alcohol to form fatty acid methyl esters (biodiesel) and glycerol. The purpose of the transesterification process is to lower the viscosity of the oil or fat to enhance its suitability for diesel engines;
- **Densification** - involves the compaction of biomass by applying mechanical force or sometimes binding agents to create inter-particle cohesion, resulting in homogenous briquettes or pellets with consistent shapes and sizes, and bulk densities ranging from 450 to 700 kg/m^3.[223]

The last category of treatment technologies for urban biowaste analysed here, is **thermochemical treatment** that includes:

- **Pyrolysis** - decomposition of biomass by heat in the absence of oxygen, resulting in the production of solid, liquid and gaseous products (see chapter 6.4 of this report);
- **Liquefaction** - processing of biomass in a hot, highly pressurized water environment for sufficient time to break down the solid bio-polymeric structure into mainly liquid components called bio-oil or bio-crude;
- **Gasification** - a thermal treatment that converts carbonaceous material into a gas (producer gas, synthesis gas or syngas), which can be used as fuel or for the production of value-added chemicals.[224]

Sustainable waste recycling requires a supply of adequate waste materials as input, and the market demand for the output products. For biowaste such markets will depend on the intended end-use of the outputs, which can roughly be clustered into three end-use groups:

- Animal husbandry,
- Agriculture and
- Bio-energy.[225]

[223] https://link.springer.com/article/10.1007/s11157-017-9422-5
[224] https://link.springer.com/article/10.1007/s11157-017-9422-5
[225] https://link.springer.com/article/10.1007/s11157-017-9422-5

7.6 Other Potential Technologies of interest

In order to find out if there are any other technologies that WaysTUP! Pilots consider to utilize in the future, we prepared and distributed a Questionnaire to all the Pilots. The Questionnaire also included questions regarding Pilots' feedstock and end-products, as well as geographical areas and markets of Pilots' interest. Their responses proved that we have already covered almost all technological processes of their interest by following our initial approach. However, we have identified three additional processes that will be implemented within Pilots, that should therefore, be analyzed in more detail.

Reactive distillation

Reactive distillation is a process where the chemical reactor is also the still. Separation of the product from the reaction mixture does not need a separate distillation step, which saves energy (for heating) and materials.[226]

This technique is particularly useful for equilibrium-limited reactions such as esterification and ester hydrolysis reactions. Conversion can escalate more than what is expected by the equilibrium thanks to the constant removal of reaction products from the reactive zone. This contributes to the reduction of capital and investment costs and could be crucial for sustainable development owing to a lower consumption of resources.[227] Since this is a relatively new field, there are still ongoing researches on different aspects, such as modeling and simulation, column hardware design, process synthesis, non-linear dynamics and control. So far, successful commercial processes that implement reactive distillation are installed for producing different chemicals, for example: methyl tert-butyl ether (MTBE), ethyl-benzene, cumene, and 3-methyl-1-butene, among others.
Advantages of application of reactive distillation:

- Shifting of equilibrium
- Reduction in plant cost
- Heat integration benefits
- Avoidance of azeotropes.[228]

However, there are some disadvantages of its application, and these are:

- Volatility constraints
- Residence time requirements
- Operating conditions for reaction and distillation.[229]

[226] https://www.chemeurope.com/en/encyclopedia/Reactive_distillation.html
[227] https://www.chemeurope.com/en/encyclopedia/Reactive_distillation.html
[228] https://www.slideshare.net/karnavrana007/reactive-distillation-166250265
[229] https://www.slideshare.net/karnavrana007/reactive-distillation-166250265

Pervaporation (membrane process) for the recovery of unreacted feedstock

Pervaporation is known as an efficient and irreplaceable membrane process in liquid separation and especially for breaking azeotropes of liquid mixtures. It is based on the use of a polymeric or inorganic membrane from the interface between a liquid feed mixture to be treated and the vapor phase (permeate). This membrane technology has many applications including the dehydration of an organic solvent, the removal of volatile organic compounds (VOCs) from water and organic/organic separation.[230]

Nowadays, pervaporation is a mature technology. It has a number of applications with proven performance. For example, this process is used for the extraction of acetone, ethanol from ABE fermentation broth and butanol. For solvent dehydration, **pervaporation is a standard method because of the two reasons (1) the selectivity for water is very high with state-of-the-art membranes and (2) the concentration range for dehydration, in which a relatively small amount of water has to be removed, is perfect for pervaporation**. Therefore, even though dehydration is proven to be feasible for a lot of solvents (the most studied compounds are ethanol and isopropanol), research challenges mainly remain in the development of robust processes for dehydration of a wide range of solvents that form azeotropes with water at relatively low water fractions, not only by developing new materials but also considering their application on a larger (time)scale.[231]

The advantages of pervaporation compared to traditional dehydration or organic separation processes are:

- Prevents the use of entrainers (leading to higher product purity),
- Reduces chemical process steps,
- Reduces time required for start-up (simply to operate and start-up, start-down),
- Reduces formation of by-products,
- Reduces system dimensions,
- Reduces emissions from entrainers, by-products and heat process.[232]

[230] https://www.sciencedirect.com/topics/chemical-engineering/pervaporation#:~:text=Pervaporation%20%28PV%29%20is%20considered%20an%20efficient%20and%20indispensable,to%20be%20treated%20and%20the%20vapor%20phase%20%28permeate%29.

[231] https://www.sciencedirect.com/topics/chemical-engineering/pervaporation

[232] https://www.hybsi.com/technology/#:~:text=In%20short%2C%20the%20advantages%20of%20pervaporation%20compared%20to,formation%20of%20by-products%20-%20Reduces%20chemical%20process%20steps

These advantages all lead to a great reduction in energy consumption for the separation process. Furthermore, they result in a higher product purity and quality and less resource dependency.[233]

While there are many advantages of pervaporation and the available polymeric and ceramic membranes on the market, this method is still not broadly performed in the chemical industry. The reason for this lies in the fact that the currently commercialized polymer and silica and zeolite pervaporation membranes have some shortcomings. The state-of-the art polymer membranes have a limited application window in terms of temperature (up to ~100°C). Also, the polymer membranes have limited resistance against organic solvents and acids. The alternatives, an all ceramic or a zeolite membrane, has a low hydrothermal and acid stability.[234]

Blown film extrusion

Blown films extrusion is one of numerous polymer manufacturing processes. It involves extruding a tube of molten polymer through a die and inflating to several times its initial diameter to form a thin film bubble. This bubble is then collapsed and used as a lay-flat film or can be made into bags.[235]

This process is used to produce goods and specialized polymer films that are commonly used in packaging such as shrink, barrier films (used to protect deli meat), stretch, shopping bags and frozen food packaging. The most common polymers that are used in blown film extrusion are polypropylene and polyethylene (LDPE, HDPE and LLDPE).[236]

Nowadays, **blown film extrusion is one of the widely used thin gauge fabrication processes for manufacturing plastic films in the world**. Majority part of the commodity films such as agricultural films, grocery bags, and other flexible packaging films are produced by blown film extrusion. Nevertheless, this method is one of the most complex and sensitive of all the plastics fabricating technologies and it presents many inherent challenges. Additionally, the increasing demand and its dynamics are experiencing different obstacles to sustain on part of plastic manufacturing industry.[237] It is required to optimize energy use, raw material consumption and productivity, while blown film extrusion process is considered. That said, the best practices for blown film manufacturing are elaborated here.

233 https://www.hybsi.com/technology/#:~:text=In%20short%2C%20the%20advantages%20of%20pervaporation%20compared%20to,formation%20of%20by-products%20-%20Reduces%20chemical%20process%20steps

234 https://www.hybsi.com/technology/#:~:text=In%20short%2C%20the%20advantages%20of%20pervaporation%20compared%20to,formation%20of%20by-products%20-%20Reduces%20chemical%20process%20steps

235 https://www.appropedia.org/Blown_film_extrusion#cite_note-Plasticswiki-1

236 https://amcorplastics.com/blog/blown-film-extrusion-process-explained/

237 http://www.tjprc.org/publishpapers/--1360158669-8.Adopting.full.pdf

7.6.1 Conclusions

By taking a comprehensive view of the urban biowaste processing technologies, we are able to better understand types of technology processes implemented within WaysTUP! Pilots, and also to identify new, similar or different, technologies that can be used for biowaste processing.

Biowaste processing technologies are defined as processes that can convert discarded biowaste into new, valuable products. The simplest type of waste treatment that can be done at low costs is described as direct use of biowaste. These are, for example, direct land application, waste fed directly to animals and open burning.

More complex biowaste procedures are biotechnological and biochemical processes. Two biological treatment processes are implemented within WaysTUP! Pilots. These are Black soldier fly treatment and fermentation.

The last two categories of biowaste processing technologies include physico-chemical treatment and thermochemical treatment. Pyrolysis, technology type used within Pilot 7, is a one of the thermochemical treatments.

Each of these biowaste processing technologies enables production of some end products, that can be classified into three main groups: animal husbandry, agriculture and bioenergy.

In chapter 7.6 we analyzed additional three biowaste processing technologies, that were not mentioned specifically within the general overview of biowaste technologies, but are particularly important to WaysTUP! Pilots. These are reactive distillation and pervaporation (membrane process) for the recovery of unreacted feedstock that will be applied within Pilot 6, and blown film extrusion process that will be utilized within Pilot 4.

7.7 Industry Trends Under COVID-19

The coronavirus COVID-19 pandemic is the defining global health crisis of our time. Since its emergence in Asia in December 2019, the virus has spread to every continent except Antarctica. As of 13 October 2020, more than 37.8 million cases have been confirmed, with more than 1.08 million deaths attributed to COVID-19.[238]

To stem further spread of the virus, authorities around the world implemented measures to lock down countries and cities to varying degrees. That includes closing borders, shutting schools and workplaces, and limiting large gatherings.

238 https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6

Here are some **major problems that Covid-19 pandemic brought to the global economy**:

- Rise in unemployment,
- Businesses in the transportation, real estate, and travel and tourism sectors are experiencing some of the largest declines in activity so far,
- Slump in manufacturing activity,
- Decline in global merchandize trade.[239]
- Major disruption to supply chains due to panic buying,
- Stock markets worldwide saw their largest single-week declines since the 2008 financial crisis[240]
- Global conferences and events across technology, fashion, and sports are being cancelled or postponed.[241]

Impact of COVID-19 on the global fermentation chemicals market

The COVID-19 pandemic has had a significantly negative impact on various industries, such as oil and gas, metalworking, and packaging. However, the materials industry is expected to have a mixed impact. Problem such as stringent government regulations is challenging the growth in the global fermentation chemicals market. Also, it is important to emphasize that all manufacturers have been hit by the pandemic (especially by the lockdown measures implemented by authorities around the world), and world trade volume could plummet this year. Many businesses have been forced to reduce operations or shut down, and an increasing number of people are expected to lose their jobs.[242]

On the other hand, there are numerous factors that will drive the fermentation chemicals markets across the globe, during the time of pandemic, and these are:

- high adoption of alcohol in the production of hand (and other) sanitizers,
- increasing popularity of pharmaceutical and nutritional industry,
- increased demand for eco-friendly fermented chemicals,
- increased usage of organic acids in cosmetics and personal care products,

[239] https://www.cnbc.com/2020/04/24/coronavirus-pandemics-impact-on-the-global-economy-in-7- charts.html
[240] https://www.cnbc.com/2020/02/28/global-stocks-head-for-worst-week-since-financial-crisis-on- coronavirus-fears.html
[241] https://www.businessinsider.com/major-events-cancelled-or-postponed-due-to-the-coronavirus-2020
[242] https://www.cnbc.com/2020/04/24/coronavirus-pandemics-impact-on-the-global-economy-in-7- charts.html

- high adoption of sustainable manufacturing process by vendors,
- growing end-user industry and
- health concerns.[243]

Therefore, we can conclude that **the global fermentation chemicals market will have neutral impact due to the spread of pandemic**.[244]

Impact of COVID-19 on solvents market

The solvents market is expected to get negatively affected due to the disturbance in the global supply chain. Solvents are mainly used in paints & coatings applications in sectors such as automotive, construction, shipbuilding, aircraft manufacturing. That said, the solvent market is highly dependent on the growth in these sectors. China is the biggest market for manufacturing and construction in the world. Strict lockdown in the country's major provinces has affected construction activities in China. Consequently, the demand for paints & coatings has declined in the first quarter of this year, mainly due to the outbreak of COVID-19, thereby hitting the demand for solvents.[245]

Geographically, China is a major producer and consumer of solvents. The biggest issue that weakened the production of solvents in the country is the lack of supply of raw materials. Europe and North America are also negatively affected by the pandemic; therefore the economic recession in countries such as the US, Canada, Spain and Italy, is expected in the next two-three years. The demand for solvents has contracted in the first two quarters of 2020 due to the COVID-19 pandemic.[246]

Impact of Covid-19 on the edible insects market

The COVID-19 pandemic brought numerous challenges to the food industry, especially meat products producers across the globe. The meat products manufacturing industry has faced major challenges such as the risk of continuation of production, distribution, transportation, and other supply chain activities; lack of manpower; and delays in the development activities

[243] https://www.businesswire.com/news/home/20200506006071/en/Analysis-Covid-19-Pandemic-%E2%80%93-Global-Fermentation-Chemicals
[244] https://www.businesswire.com/news/home/20200506006071/en/Analysis-Covid-19-Pandemic-%E2%80%93-Global-Fermentation-Chemicals
[245] https://www.marketsandmarkets.com/Market-Reports/solvent-market-1325.html
[246] https://www.marketsandmarkets.com/Market-Reports/solvent-market-1325.html

as R&D projects. Another factor that restricts the development of the food industry is the postponement of private investment financing and public funding initiatives towards the development of this sector. All these **negative factors that influence the meat product suppliers across the globe have a positive impact on the demand for alternative protein substitutes including insect protein products**.[247]

Moreover, other factors that drive edible insects market are increasing health & wellness trend among consumers and rising awareness about the health concerns, such as the risk of viral infections, liver diseases, cardiovascular diseases, and increased risk of certain cancer associated with the long term use of animal protein. Another thing that should be considered is the fact that edible insects can be cost effectively reared on the waste feed and water. Furthermore, many vendors in this industry strategically enhance their production capacity, processes, end products, and receiving funds from many investors in recent years, which is also seen more prominently in 2020.[248]

According to the International Platform of Insects for Food and Feed (IPIFF), the EU's **European Food Safety Authority is expected to approve the sale of insects, including ground mealworms, lesser mealworms, crickets, grasshoppers and locusts for human consumption in 2020**. This will definitely drive demand for the edible insects in the future, since currently only some of the countries in EU region are using insect-based products as protein diets.[249]

Impact on Bio-fuel industry

In 2020, the EU is facing a 7-10% economic downturn as a result of the Covid-19 pandemic. The longer the crisis lasts, the higher the impacts will be felt in the economy, including in the energy sector.[250]

Reductions in economic activities across the globe, has led to the weak demand for crude oil, which brings a large drop in crude oil prices. Also, competition among major oil producers has further pushed down the price of crude oil. The decline in oil prices resulted in prices for transportation fuels declining as well. The sharp decline in the price of ethanol reduced ethanol producers' profit.

[247] https://www.globenewswire.com/news-release/2020/06/05/2044335/0/en/COVID-19-Impact-on-Edible- Insects-Market-Meticulous-Research-Viewpoint.html

[248] https://www.globenewswire.com/news-release/2020/06/05/2044335/0/en/COVID-19-Impact-on-Edible- Insects-Market-Meticulous-Research-Viewpoint.html

[249] https://www.globenewswire.com/news-release/2020/06/05/2044335/0/en/COVID-19-Impact-on-Edible- Insects-Market-Meticulous-Research-Viewpoint.html

[250] https://www.iea.org/reports/european-union-2020

Therefore, due to the lack of profitability in ethanol production coupled with reduced demand for gasoline, ethanol producers are expected to either reduce their production levels or, in some cases, even shut down their plants.[251]

On the other hand, the impact of COVID-19 on demand for biodiesel, soy biodiesel, and soybeans is expected to be smaller than its impact on gasoline, ethanol, and corn demand. The main reason is because the consumption of diesel fuel may decline less than the consumption of gasoline due to the reduction in demand for transportation. Diesel fuel is mainly used in heavy duty trucks, agricultural machinery, construction equipment, and other industrial activities. Therefore, while its demand is expected to drop due to reductions in economic activities, the shelter in place restrictions may not reduce diesel demand as much as expected for gasoline.[252]

The EU set a target of 14% renewable energy in transport by 2030 (with a 3.5% target for advanced biofuels) with the RED II (Renewable Energy – Recast to 2030). Overall, the transport target for renewables will be increasingly met through the promotion of electric vehicles. However, besides electric vehicles, advanced biofuels and biomethane are expected to play a significant role in a number of transport sectors, notably aviation and maritime.[253]

7.8 Conclusions

Within the market breakup by technological processes, that will be implemented within WaysTUP! Pilots, we analyzed fermentation, extraction, larval breeding, and slow pyrolysis.

Through analyzing and understanding these processes, we explored the main indicators regarding Pilots' relevant markets that will affect their business solutions. Furthermore, we identified market segments that Pilots should target, and that should be of great help to Pilots to understand their strengths and weaknesses in comparison to the existing players operating on the targeted markets.

Chapter 7.1 is dedicated to **fermentation**, a technology process that will be utilized within Pilots 1, 4, 5, and 6. Here, **we explored** what types of feedstock is the most efficient, what are the usual end products, and what is the current state and future trends of the relevant markets. **As a result,** we found out that the **most efficient feedstocks** used for fermentation include agricultural crops and biomass based on forest residues, agricultural wastes, food

[251] https://ag.purdue.edu/commercialag/home/wp-content/uploads/2020/04/202004_TaheripourMintert_ImpactofCOVID19ontheBiofuels.pdf
[252] https://ag.purdue.edu/commercialag/home/wp-content/uploads/2020/04/202004_TaheripourMintert_ImpactofCOVID19ontheBiofuels.pdf
[253] https://www.iea.org/reports/european-union-2020

processing wastes, energy crops, wood residues, sawdust, and paper mill residues. Furthermore, we concluded **that the main outputs** of this technological process include alcohols, enzymes,

and organic acids. When it comes to the **global fermentation chemicals markets**, we identified the German fermentation chemical market as the most dominant one, followed by UK Fermentation and France pharmaceutical markets, which gives lots of market opportunities for Pilots 1, 4, 5, and 6.

Chapter 7.2 refers to **extraction**, technology process that will be utilized within Pilot 2 to produce coffee oil from spent coffee grounds. Here, we found out that the efficiency of the overall extraction relies on the chosen solvent, and that this technology type has various applications across different industries, which opens new opportunities for technology provider of Pilot 2. When it comes to **market analysis,** we found out that the global extraction solvents will grow in the future. Increasing **demand for naturally sourced ingredients**, especially in Europe (in countries like Germany, Spain, UK, and France), which holds the major share in Food Flavor Market, is leading this market to a great expansion in the coming years.

Chapter 7.3 is related to Pilot 3 and **larval breeding**. The **end product** coming from this Pilot is insect protein from the most commonly used larve - Black Soldier Fly Hermetia. This Pilot aims to offer its end product, insect protein, to Food and Feed industry. However, **the main**

Challenge is related to the European Food Safety Authority (EFSA) and their approval of the insects that can enter the EU market as food. On the other hand, there are other allocations of bioconversion – such as the production of fertilizers and insects as an alternative source for generating precursors for biodiesel.

From the market perspective, we've come to three main conclusions regarding the analysis of the global edible insect market and global insect feed market that are expected to grow in the future. **First**, crickets dominate and will continue to dominate the global edible insect market in the upcoming period, because of their high nutritional value. **Second**, the aquaculture segment has the largest share of the insect feed market. And **third**, the Asia-Pacific area has the biggest share of analyzed markets and is followed by Europe and North America.

Chapter 7.4 covers **slow pyrolysis** process that will be applied within WaysTUP! Pilot 7. The **end product** coming from this Pilot is biochar. However, pyrolysis has various applications of interest to green technology. End products of pyrolysis process include bio-oil (the most popular bioethanol and biodiesel that are used as industrial fuels and transportation fuels), biochar, and gaseous products. The global biodiesel market is expected to have a slightly bigger growth in comparison to bio-ethanol market because of the growing demand for biodiesel as automobile fuel, as they are characterized as environmentfriendly.

Chapter 7.5 is dedicated to a comprehensive overview of **the urban biowaste processing technologies** and aims to identify new, similar, or different, technologies that can be used for biowaste processing. The purpose of this is to expand the horizons of WaysTUP! stakeholders and identify new possibilities regarding the production based on urban biowaste. Four groups of types of urban biowaste processing technologies include direct use, biological treatment, physical and chemical treatment.

Chapter 7.6 was dedicated to the analysis of additional biowaste processing technologies, that were not mentioned specifically within the general overview of biowaste technologies, but are particularly important to WaysTUP! Pilots. These are a reactive distillation and pervaporation (membrane process) for the recovery of unreacted feedstock that will be applied within Pilot 6, and blown film extrusion process that will be utilized within Pilot 4.

8. Market Breakup by end products

This chapter is focused on end products that will come as results of technological processes applied within WaysTUP! Pilots. The aim of our exploration is to identify characteristics of these end products, their applications in different industries and also to analyze markets of each relevant industry where the final transactions will take place in a value chain.

End markets are a key driver of value chain growth and development. End-market demand informs supply chain actors who in turn build capacity to meet demand and compete in the marketplace.
Furthermore, considering that the COVID-19 pandemic continues to transform the growth of various industries, the immediate impact of the outbreak is varied. That said, special attention will be placed on identification of the industry trends under COVID-19.

8.1 Gelatine

8.1.1 Definition

Gelatin (or gelatine) is a translucent, flavorless, colorless, food ingredient, that is derived from collagen taken from animal bones, hides, and skins. Pig and cattle bones are typically used to make gelatin. It is brittle when dry and gummy when moist. It may also be referred to as hydrolyzed collagen, collagen hydrolysate, gelatine hydrolysate, hydrolyzed gelatine, and collagen peptides after it has undergone hydrolysis.[254]

8.1.2 Application insights

Gelatin can be edible and non-edible, and it has many uses, including use in cooking, industrial uses, cosmetics and photography. Edible gelatin is the most common form available that does not contain additives or preservatives. Non-edible gelatins are used mostly in cosmetics and photography.

In the food industry, gelatin is mainly used as an enhancer to add elasticity, consistency and stability to food products. Gelatin is also used as a stabilizer mainly in the dairy products. It is usually available in granular powder form, although in some European countries, sheet gelatin is still available. In the food industry, water or aqueous polyhydric alcohols of gelatin are used in candy, marshmallow and dessert preparations. Further, in dairy products and

254 https://en.wikipedia.org/wiki/Gelatin#:~:text=Gelatin%20or%20gelatine%20%28from%20Latin%3A%20gelatus%20meaning%20%22stiff%22,and%20collagen%20peptides%20after%20it%20has%20undergone%20hydrolysis.

frozen foods, gelatin is used as a colloid to prevent crystallization of ice and sugar. It is also used as an emulsifier and extender in the production of reduced-fat margarine products.

Gelatin also has applications **in pharmaceuticals and nutraceuticals industries**.

In the pharmaceutical industry, gelatin is used primarily to make hard and soft gelatin capsules. Other uses include tablets, emulsions, suppositories and syrups.[255]

8.1.3 Market analysis

The market for gelatin is segmented into source, type and application. It is mostly applicated in food & beverages industry which account for about 31% of the global gelatin demand. On the other hand, almost 46% of the world's gelatin is sourced from pig skin, followed by bovine hides (29.4%), bones (23.1%) and other sources such as fish skin (1.5%). Further, the gelatin sourced from fish and poultry is among the trendy ones and are mostly processed to satisfy the demand of specific religious consumer groups.

Gelatin, based on type, is classified into type A and B, where type A gelatin is used in confectionary and type B in dairy products. The type A gelatin is used as food grade gelatin. There is a growing demand of gelatin in sports drinks, owing to its high protein and low-fat content. Furthermore, the application of gelatin in this segment is projected to accelerate at a high pace.[256]

The growth of the market for food gelatin is driven by the end-use industries, such as confectionary, nutritional drinks and bakery. Another factor that influences the food gelatin products demand is the increasing appetite for functional foods, derived from natural sources. Although the market is growing, it is facing different challenges that include low acceptance from strict vegetarians and religious groups such as Muslims, Hindus and Jews. In addition, there is a rising concern among researchers about whether animal tissue-gelatins can transmit pathogenic vectors such as prions. Furthermore, raw material availability for bovine gelatin production is an issue in places like South America, where there is a strong demand from the global leather industries, an alternative end-markets for the same raw material.

Customers that have a high level of health awareness became be more careful about the use of gelatin, as well as advantages that it offers. That said, they are currently willing to spend more on gelatin-based items. This is the key driver of the market. Gelatin is also being more and more used in few applications as a consistency controlling, purifying and stabilizing agent, and that has a positive impact on the worldwide gelatin market. The factors such as

[255] https://www.drugs.com/inactive/gelatin-57.html

[256] https://www.marketresearch.com/Mordor-Intelligence-LLP-v4018/Global-Food-Gelatin-Segmented-Type- 11529199/

rising income levels, enhancing expectations for everyday comforts across emerged economies, along with a solid development of end use industries are also positively impacting the market development. On the other hand, the social and wellbeing aspects of the body parts of dead creatures utilized for manufacturing of gelatin is holding back the market growth of gelatin.[257]

Europe dominates the global food gelatin market. In Europe, the dominance of gelatin is attributed to the high demand for nutritional & functional food & beverage products along with the growing pharmaceutical industry.

Europe dominate the global food gelatin market with 38% of share. In Europe, the main source for producing gelatin is pig, which accounts for 44% of the market share. Bones and bovine hides were the two largest raw material segment that accounted for over 55% of market share. Bone is the fastest growing raw material segment as bones of pigs and cows consists of large quantities of collagen.[258] Increased consumption of gelatin, as a functional and low-calorie diet alternative, is one of the major factors driving the market.[259] The primary markets which intake gelatin are UK, Germany, France, and Belgium. European food gelatin market is expected to grow at rapid rate in the next six years (by 2026).[260]

The reason for that is the growing awareness among the health-conscious people supplemented with the rise in aged population which is expected to further fuel the gelatin market growth. Food & beverage application segment accounted for over 28% of the gelatin market share while nutraceuticals, the second largest application market, accounted for over 25%.[261]

A CAGR of 3.53% is projected to be recorded in the European region by 2024, with respect to the food gelatin market. The increasing demand for nutraceutical products in the market regions of the European region as a result of the increased consumption of multivitamin tablets by the population is another factor propelling the growth of the food gelatin market.[262]

The food and beverage industries in the various countries of the region are witnessing increasing expenditure in respect to the incorporation of functional ingredients for various benefits. The growth of the food gelatin market in countries like Germany is impacted by the product launches and supplies by the local players in the region. This results in a competitive

246 257 https://www.acumenresearchandconsulting.com/gelatin-market
247 258 https://www.transparencymarketresearch.com/gelatin.html
248 259 https://www.orbisresearch.com/reports/index/global-food-gelatin-market-growth-trends-and-forecasts-2017-2022
249 260 https://www.oganalysis.com/industry-reports/212242/gelatin-market
250 261 https://www.transparencymarketresearch.com/gelatin.html
251 262 https://www.inkwoodresearch.com/reports/europe-food-gelatin-market-forecast-2019-2027

environment with international players, thereby benefiting the growth of the country. The increased consumer demands have resulted in considerable growth of the chocolate confectionery in Germany. This results in the increased utilization of food gelatin, driving its market growth in the region. Furthermore, the country is presenting a shifting preference towards non-animal products, all of which are set to benefit the growth of the food gelatin market.[263]

The increased competitiveness among the players of the market is resulting in added benefits to market growth. Key market players in the global gelatin market are: Darling Ingredients (US), Gelita (Germany), Nitta Gelatin (Japan), Tessenderlo Group (Belgium), Weishardt (France), India Gelatine & Chemicals (India), Junca Gelatines (Spain), Italgelatine (Italy), Trobas Gelatine (Netherlands), Sterling Biotech Group (India), Lapi Gelatine (Italy), and Gelnex (Brazil). These players have wide industry coverage and strong operational and financial strength. Recently, all of them expanded their businesses organically and inorganically.[264]

8.1.4 Conclusions

The growing demand for functional and convenience food & beverage products, increasing application in the pharmaceutical industry, and the rising demand for clean label products **drive the demand for gelatin**. Europe accounted for the largest share of the gelatin market. The abundant availability of raw materials as well as the presence of key gelatin manufacturing contributes to the growth of the market in the region.

Gelatin is extracted from by-products of the meat industry that would be discarded if it were not for the state-of-the-art gelatin processes developed by some companies. **Maximizing the output of the meat industry** and **avoiding waste** contributes to the circular economy and more sustainable production. **Bioeconomy** strongly supports sustainability in the food industry, which gives gelatine a strong market advantage.

8.2 Coffee-oil

8.2.1 Definition

Coffee grounds are the most significant production waste in the coffee industry and contain about 15% coffee oil. **Coffee oil is usually produced through cold pressing roasted or green coffee beans.** Cold pressed coffee oil is not a true essential oil. It contains volatile aromatic

[263] https://www.inkwoodresearch.com/reports/europe-food-gelatin-market-forecast-2019-2027
[264] https://www.marketsandmarkets.com/Market-Reports/gelatin-market-850.html

compounds, but it is primarily composed of lipids. There are cases when coffee oil is made by infusing coffee beans into a vegetable oil, in order to produce so-called infused oil. Nevertheless, because coffee oil is so aromatic, some suppliers put them among their essential oils or classify it as an essential oil.[265]

8.2.2 Application insights

Coffee grounds are rich in fats, sugars, and proteins, of which coffee oil is 14% or more. Coffee grounds are used as a raw material for extracting surfactants, such as coffee oil, biodiesel, and polyphenols. These surfactants are commonly used as food additives, in energy, and skin care.[266]

When it comes to skin care, coffee oil extracted from unroasted coffee beans helps the skin barrier and improves hydration. Moreover, it has capacity to absorb UVB radiation, and protective features.[267] On the other hand, the essential oil of coffee can be used to treat depression, stress and other nervous system related problems.[268]

8.2.3 Market analysis

European coffee market can be segmented by type and by end products. **On the basis of type**, the coffee business has been fragmented into **Arabica, Robusta and Liberica- Arabica** being the largest segment.

The Coffee arabica seed oil market is driven mostly because of its great source of antioxidant properties that contribute to curing skin-related disorders, respiratory issues, and lots of other problems such as depression, fever, nausea, and other similar issues. Also, Coffee arabica seed oil is used as anti-aging product and it can reduce inflammation. The Coffee arabica seed oil plays an important role in aromatherapy and therefore have a high demand from aromatherapy services and many aromatic products manufacturers. Since Coffee arabica seed oil can be used for various purposes, it is expected to offer different skincare benefits in the future.[269]

More and more people are becoming aware of the Coffee arabica seed oil advantages on the skin. That fact has a positive impact on its market. Also, the availability of products is expected to grow the Coffee arabica seed oil market in the next nine years. A lot of market opportunities will be created for the manufacturers thanks to regional expansion and new products launch.

[265] https://www.aromaweb.com/essential-oils/coffee-oil.asp
[266] https://www.mdpi.com/2075-163X/9/9/505/htm
[267] https://www.cosmeticsdesign-europe.com/Article/2015/10/23/Green-coffee-oil-safe-to-use-in-skin-care- applications
[268] https://www.mordorintelligence.com/industry-reports/coffee-market
[269] https://www.futuremarketinsights.com/reports/coffea-arabica-coffee-seed-oil-market

Geographically, Latin America has a high production of Coffee arabica seed oils and accounts a prominent market share. A significant percentage of Coffee arabica seed oil market is held by the Middle East and Africa (MEA) sourcing good quality of products. Also, South Asia has many manufacturers with a growing customer base for Coffee arabica seed oils. The Coffee arabica seed oil market in North America is expected to grow due to changing lifestyle and awareness about the benefits of the oil. European market for Coffee arabica seed oil is anticipated to have a high demand owing to several manufacturers of fragrances. The Coffee arabica seed oil market in East Asia and Oceania are estimated to grow due to increasing personal care and cosmetics industry in these regions.

Some of **the major players in the Coffee Arabica Seed Oil market** are: Indenta Chemicals (India) Pvt. Ltd., H. Interdonati, Inc. & FlavorPlus Division, Ernesto Ventós, S.A., Hallstar, India Essential Oils, Natural Sourcing, LLC., Avi Naturals, Eden Botanicals, Sher-Ray Organic Cosmetics, and others.[270]

When it comes to prices, **we can compare average prices of two species of coffee bean: Arabica and Robusta.** The former is more expensive, selling for 2.93 U.S. dollars per kilogram in 2018 and projected to increase in price to 3.11 U.S. dollars in 2025. Robusta, named because it can grow at a wider range of altitudes and temperatures, sold for 1.87 U.S. dollars in 2018, projected to sell at 1.91 U.S. dollars per kilogram in 2025.[271]

[270] https://www.futuremarketinsights.com/reports/coffea-arabica-coffee-seed-oil-market
[271] https://www.statista.com/statistics/675807/average-prices-arabica-and-robusta-coffee-worldwide/

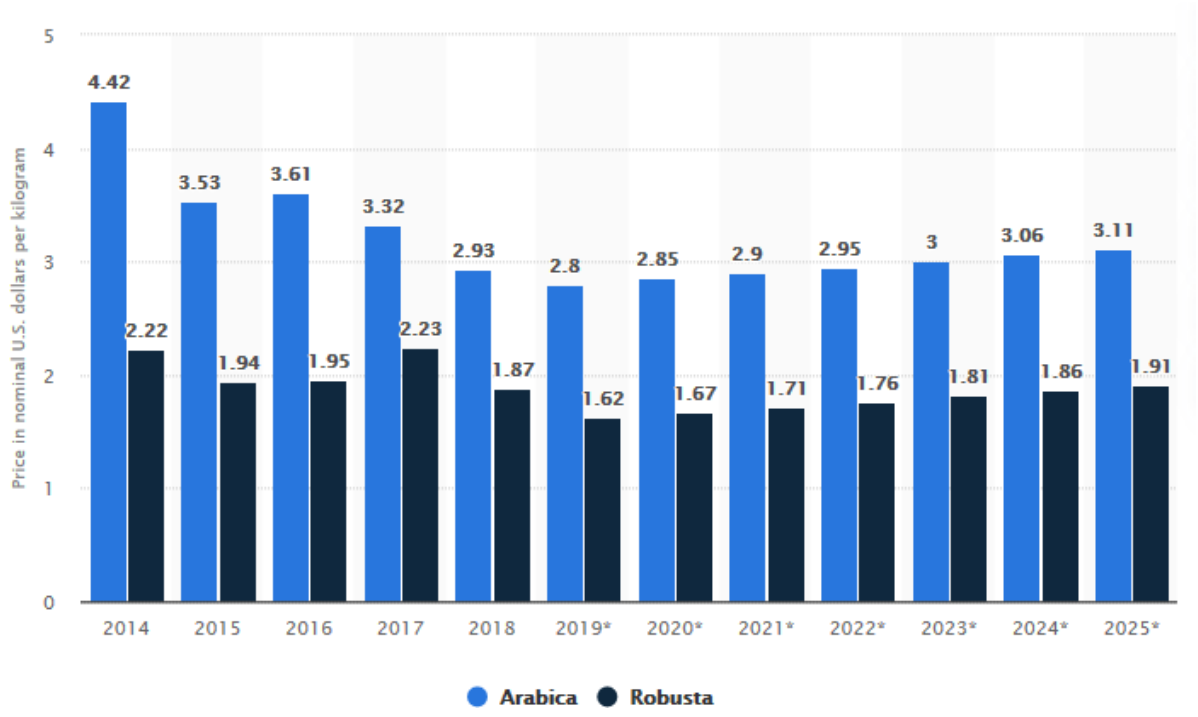

Figure 29 Average prices for Arabica and Robusta coffee worldwide from 2014 to 2025

Source: ***https://www.statista.com/statistics/675807/average-prices-arabica-and-robusta-coffee-worldwide/***

On the basis of the end product, the coffee business can be divided into **Coffee Powder, Pod, Capsule, Dips, etc.**, where the instant coffee segment has the biggest market share and records a promising growth rate. Key factors that drive Instant Coffee market include its versatile flavours, prompt refreshment it provides and economic feasibility.

The Europe Instant Coffee Market was worth USD 8.01 billion in 2018 and is estimated to be grown at a CAGR of 5.3% to reach USD 10.37 billion by 2023. Instant coffee is the soluble coffee powder made from grounded or roasted coffee beans. Currently, fresh coffee is dominating the coffee industry, however instant coffee is progressively gaining a bigger share of the global market because it is easier and quicker to make.

Driving factors of the Europe Instant Coffee Market include the convenience provided to the consumers on different scales, the availability of instant coffee across different channels, and the moderate price of product together with the decline in demand for aerated drinks in the global market. Nevertheless, the market also faces cartain restraints, such as required market penetration and the aversion to coffee that is propagated by a part of the citizenry.

The Europe Instant Coffee Market is segmented in two major categories - on the basis of distribution channels and packaging type. According to the first category, instant coffee is classified into B2B (business-to-business) and retail stores. The B2B segment includes hotels

and restaurants and others, while retail segment includes online and offline channels (for example, supermarkets) Based on packaging type, the instant coffee market has been segmented into jars and sachets.

Europe holds the second position in the global market share analysis. The sudden growth in new distribution channels is expected to generate a great market growth in Europe. Prominent players operating in the Europe Instant Coffee industry include: Nestle S.A. (Switzerland), Starbucks Corporation (United States), Jacobs Douwe Egberts (Netherlands), Strauss Group Ltd. (Israel), Matthew Algie&Company Ltd (United Kingdom), The Kraft Heinz Company (United States), Tata Global Beverages (West Bengal), Tchibo Coffee (Germany), Keurig Green Mountain (United States) and Unilever Plc. (United Kingdom) among others.[272]

Besides instant coffee, **speciality coffee** is another emerging segment, that targets consumers who are prioritising experience over price. There are various coffee shops and baristas that provide unique aroma made of coffee of different origins.

When it comes to **overall coffee consumption**, northern countries like Finland are the leaders, based on the research from 2017. In terms of per capita consumption, Finland was leading the position, followed by Sweden, Netherlands, Germany, Norway and Denmark. However, the market growth was evident in France and UK.[273]

Since coffee oil can be used in aromatherapy, the important thing is to get an overview of **the global aromatherapy market**. The global aromatherapy market is growing, witnessing augmented uptake of aromatherapy as an alternative medicine practice. Nowadays, there are different therapeutic-grade aromatherapy products and oils, that are available to most people since they are sold at a moderate price. However, there are some growth restraining factors such as stringent regulations about the obligatory differentiation label on the product citing therapeutic grade or cosmetic grade products, lack of expertise among the therapists and toxic nature of some of the essential oils like Cineole which is poisonous above the recommended dose and an overdose may cause some severe respiratory symptoms.[274]

Aromatherapy market shows a high growth potential that will probably attract many entrants to the market resulting in intensified competition further. Some oil manufacturers use steam distillation or solvent extraction because it is an easier way to extract essential oils as the natural herbs and plants may change its medication value and nutrients compound due to heat.

[272] https://www.marketdataforecast.com/market-reports/europe-instant-coffee-market

[273] https://www.marketwatch.com/press-release/europe-coffee-market-trends-growth-opportunities-and- forecast-2026-2022-2019-11-29

[274] https://www.medgadget.com/2019/09/aromatherapy-market-2019-global-size-trends-analysis-report- growth-competitive-landscape-business-opportunities-and-challenges.html

North America is accounted for major share in aromatherapy over the period from 2019 to 2025. The regions of North America and Western Europe are estimated to continue their dominance in the aromatherapy market.[275] European market is expected to grow at a CAGR of 9.5% to reach USD 2.7 billion by 2024.[276] This region has strong aromatherapy markets in France, Austria, Germany and Switzerland. These countries usually look at aromatherapy as a medicine. On the other hand, the UK and the Netherlands are also good markets, but in these countries aromatherapy is primarily marketed as a cosmetic product.[277]

Overall, countries that offer the most opportunities for suppliers of essential oils are France, Germany, the Netherlands, the UK, Spain and Austria. They are also the largest importers of other essential oils.[278]

Prominent players of Global Aromatherapy Market are: doTERRA International (United States), Young Living Essential Oils (United States), Mountain Rose Herbs (United States), Edens Garden (United States), Frontier Natural Products Co-op (Norway), Rocky Mountain Oils (United States), Puzhen Life (United States), and Muji Europe Holdings Ltd (United Kingdom) among others.[279]

8.2.4 Conclusions

The coffee market is **currently experiencing considerable growth** in economies around the world, with the rise in urbanization and the demand for quick, quality products fueling the expansion. The market is expected to continue to inflate in the next five years, leaving ample room for returns and profit. **Coffee use generates massive quantities of spent coffee grounds**, a valuable resource, rich in fatty acids, amino acids, polyphenols, minerals, and polysaccharides. Having that in mind, we can conclude that the coffee market has one more dimension - the use of coffee grounds after the coffee fulfilled its primary role - which adds a **wide range of business opportunities in line with bioeconomy**.

8.3 Insect protein

[275] https://www.medgadget.com/2019/08/aromatherapy-market-global-industry-analysis-size-share-trends- segmentation-and-forecast-2019-2025.html

[276] https://www.cbi.eu/market-information/natural-ingredients-health-products/essentials-oils/market- potential/

[277] https://www.cbi.eu/market-information/natural-ingredients-cosmetics/essential-oils-aromatherapy

[278] https://www.cbi.eu/market-information/natural-ingredients-health-products/essentials-oils/market- potential

[279] https://www.marketwatch.com/press-release/aromatherapy-market-growth-share-and-segmentation- edens-garden-inc-doterra-international-llc-and-young-living-essential-oils-lc-2020-08-18

8.3.1 Definition

Considering the fact that the world's population is growing and that feeding more than 9 billion people will require the production of twice as much food as we currently produce (and there isn't enough arable land available to do it), nowadays researchers all over the world are looking for a solution for this problem.

One of the proposed solutions is eating edible insects. There are over 2,000 types of edible insects, with beetles, caterpillars, bees, wasps, ants, grasshoppers, locusts, crickets, cicadas, leaf and planthoppers, scale insects and true bugs, termites, dragonflies and flies leading the pack. Insects have a high feed-conversion efficiency rate, which is measured in kg of feed per kg of weight gain. This is an animal's capacity to convert feed into increased body mass. Also, insects require far less water than do cattle, sheep, goats or poultry.

Insect protein is high-quality protein. In a comparison of beef and cricket protein, crickets are 69% protein while beef is only 29%. Crickets contain nine essential amino acids, along with B12, zinc, iron, potassium, magnesium, sodium, and calcium. Cricket flour contains more calcium than milk, and more iron than spinach.[280]

A single hectare of ground is able to produce 150 tons of insect protein per year, and crickets produce 80 times less methane gas than cows. This could have a tremendous impact on greenhouse gasses and global warming.[281]

Benefits of using insects as a source of protein are numerous. First, they can reproduce rapidly, and they have high feed conversion rates. Also, there is the advantage of a low environmental food print, because insects require significantly less water and land for production. Furthermore, insects can be reared on food waste, which would otherwise be destined for landfill, and are really efficient converters of waste to protein.[282]

8.3.2 Application insights

Insect protein is majorly used in **animal feed** – aquafeed, poultry feed, pet food and others (exotic pets, birds, and swine). However, due to the rising necessity of protein alternatives among food & beverage manufacturers to fulfill the increasing demand of consumers, the adoption of insect protein has been growing in the **food & beverages segment**. Finally, insect protein also has applications in **pharmaceutical and cosmetic industries**.[283]

8.3.3 Market analysis

[280] https://interestingengineering.com/the-explosion-of-insect-protein
[281] https://interestingengineering.com/the-explosion-of-insect-protein
[282] https://www.newfoodmagazine.com/article/85536/insect-protein-food-cycle/
[283] https://www.marketsandmarkets.com/Market-Reports/insect-protein-market-150067243.html

Rising environmental and health concerns over the consumption of traditional animal protein sources contribute to driving growth for insect protein manufacturers. **The global insect protein market is expected to grow at an astounding CAGR of 28% from 2019 to 2029**. This growth can be attributed to rapid adoption from manufacturers and consumers alike. Cost benefits, production efficiency, and nutritional value offered by insects are main drivers of growth in insect protein market.[284]

Preferred insect protein source is a protein from beetles. Beetles hold more than 1/4th market share followed by caterpillars that register a staggering double-digit growth rate of more than 33%. Growth in these segments is due to the nutritional value and high availability of these insects. Grasshopper, cricket, & locust offer lucrative growth opportunities with the highest double digit CAGR among all insect types. Researchers are developing baby food and animal feed for fish & chicken from locusts and grasshoppers. This segment will help manufacturers enhance their product portfolio and gain early-adopter's advantage.[285]

On a regional basis, the global insect protein market is segmented into the following regions: Asia Pacific, Latin America, Africa, Europe the Middle East and North America. Even though North America and Europe are not traditionally insect-eating regions, **increasing concerns regarding the environmental impact of over-consumption of animal-based food products have shifted European and North American people towards insects for proteins and nutrients**. Since the idea of eating insects is still strange to consumers in these regions, producers have come up with the idea of producing insect protein in powder form. It is proved that consumers in both regions are seeking protein powders and bars, pasta, and several insect protein-based bakery products. This trend is estimated to continue over the next few years and, consequently, grow the insect protein markets in North America and Europe significantly.[286]

Europe and North America together account for more than 3/5th of market share. Budding start-ups such as Eat Grub (UK) and Aspire Food Group (US) are developing insect protein products that are gaining consumer traction. The reason for this lies in the rising consumer awareness about adverse effects of animal farming on the environment. Insect protein presents a sustainable alternative to the information savvy consumer segment in these developed regions. Even though Latin America, Middle East and Africa (MEA) are minor

[284] https://www.futuremarketinsights.com/reports/insect-protein-market
[285] https://www.futuremarketinsights.com/reports/insect-protein-market
[286] https://www.transparencymarketresearch.com/insect-protein-market.html

market-share holders, they are estimated to register double digit growth rate through the next period (by 2029).[287]

The food and the feed industries are the two main verticals, wherein insect protein finds prominent usage. Both industries have their separate insect protein producers. Prominent producers of insect protein used for food products are: EntomoFarms, Aspire Food Group, Jimini's, Protifarm, Swarm Nutrition GmbH, Chapul Cricket Protein. On the other hand, the key producers of insect protein used in feed include: AgriProtein Holdings Ltd., EnviroFlight LLC, Innovafeed, Ÿnsect, Hexafly and Protix.[288]

EU Law regulates the conditions for food and feed business operators. At the beginning of 2000, EU policy makers have adopted a package of regulations that define general principles and standards in the area of food and feed safety: The main regulations include the 'General Food Law' (Regulation No 178/2002) and the 'Hygiene Package' (e.g. Regulation No 852/2004 on the hygiene of foodstuffs and Regulation No 183/2005 laying down requirements for feed hygiene). Producers of insects are responsible for ensuring the safety of the marketed products. That said, their general obligations are listed in the regulations mentioned before.[289]

Relevant EU makers have also established restrictions on the feed which may be given to 'farmed animals' – meaning, animals that are kept for the production of food, feed or other derived products (e.g. wool or hides). Insect cultivation for human consumption or for animal feed use are also included here. Consequently, such insects may only be fed with materials of vegetal origin. Some exceptions are however admitted for materials of animal origin such as milk, eggs and their products, honey, rendered fat or blood products from non-ruminant animals. However, the feeding of farmed animals with other slaughterhouse or rendering derived products, manure, or catering waste is prohibited. The same ban applies to the use of unsold products from supermarkets or food industries (e.g. unsold products in reason of manufacturing or packaging defects) if these contain meat or fish.[290]

Insect producers are also obligated to make sure that their insects are kept in good health in order to prevent the spreading of diseases among their production flock. That said, EU policy makers have established the responsibilities of animal breeders in the area of health and biosecurity in the legislative text known as 'EU Animal Health Law'.[291] More information on the EU legislation regarding insects is available on the International Platform of Insects for Food and Feed – IPIFF.

[287] https://www.futuremarketinsights.com/reports/insect-protein-market
[288] https://www.transparencymarketresearch.com/insect-protein-market.html
[289] https://ipiff.org/insects-eu-legislation/
[290] https://ipiff.org/insects-eu-legislation/
[291] https://ipiff.org/insects-eu-legislation/

The European insect sector is a leader in terms of innovation. There are lots of start-up initiatives that slowly became trustworthy players in the food and feed chains. The supportive EU regulatory framework made this possible.[292]

8.3.4 Conclusions

Different start-up initiatives and increasing R&D investments, together with the rising demand for alternate protein, and growing health awareness, present some of the main **factors fuelling the insect protein market growth.** Although the abundant characteristics of edible insects should benefit human health, in Western societies, edible insects have a **greater potential as animal feed than as human food**, because of cultural biases associated with harmful insects. On the other hand, many countries in Asia, Oceania, Africa, and Latin America utilize **insects as a major protein source.** Using insects can potentially be one of the problem-solvers related to the conventional food-supply chain, including global water, land, and energy deficits.

Various strategies have been deployed to expand the edible-insect market and to counteract existing animus among Western societies toward insects as the protein source. The current status of edible insects **remains insufficient to replace traditional animal foods** worldwide, although edible insects have a strong potential to become a primary source of nutrients. Nevertheless, the insect protein market is constantly growing thanks to the agricultural industry, where it is **widely utilized as a feed component,** and some segments of the food industry, where is **used as a supplement.** Insects reared on organic wastes and used as feed for monogastric animals **can reduce the environmental impact and increase the sustainability** of meat/fish production, which gives such production a great advantage in terms of supporting the bioeconomy.

8.4 Monomers and PHAs to bioplastics for packaging

8.4.1 Definition

Term "bioplastics" refers to the plastics that are bio-derived, biodegradable or both. Bioplastics are increasingly feasible technical alternative to conventional polymers. New industrial processes now mean that bioplastics can be produced from post-consumer content, converting environmentally damaging waste into valuable resource to be used as a feedstock for these processes.[293]

[292] https://www.europeaninterest.eu/article/interview-european-insect-sector-alternative-source-proteins/
[293] http://www.kpsimpex.com/download/PHA%20bioplastics.pdf

8.4.2 Application insights

Bioplastics are widely used in food service. However, there are certain limitations in terms of its technical performance at high temperatures, cost and limited supply. Even though there has been limited production of cups for cold beverages made from polylactic acid (PLA), a bioplastic derived from cornstarch, it is proved that these are not suitable for hot drinks.

PHA (Poly-Hydroxy-Alkanoates or polyhydroxy fatty acids) is a family of biobased polyesters that are convenient for various challenging food applications. *PHAs are biodegradable, readily compostable thermoplastics, produced by microbial fermentation of carbon-based feedstocks. The properties of PHA polymers are customizable to the application, according to the specific combinations of different monomers incorporated into the polymer chain*.[294]

Examples of PHAs are:

- PHB, PHV, PHBV, PHBH and many more.
- Poly-4-hydroxybutyrate (P4HB)
- Poly-3-hydroxybutyrate (P3HB)
- Poly-3-hydroxyvalerate (P3HV)
- Poly (3-hydroxybutyrate-co-3-hydroxyvalerate) or PHVB co-polymer
- Poly (3-hydroxybutyrate-co-3-hydroxyhexanoate) or PHBH.[295]

We can see that it is a whole PHA platform. This PHA-platform is made up of different bioplastics raw materials made from various renewable resources. **Based on the type of PHA**, **they can be used for applications in films and rigid packaging, consumer electronics, biomedical applications, toys, paints, coatings, inks, automative, adhensives, appliances, glues, fibers for woven and non-woven**. Thus, PHAs cover a broad range of properties and applications.[296]

Figure below shows current applications of bioplastics and what's foreseeable in the near future.

[294] http://www.kpsimpex.com/download/PHA%20bioplastics.pdf
[295] http://www.kpsimpex.com/download/PHA%20bioplastics.pdf
[296] http://www.kpsimpex.com/download/PHA%20bioplastics.pdf

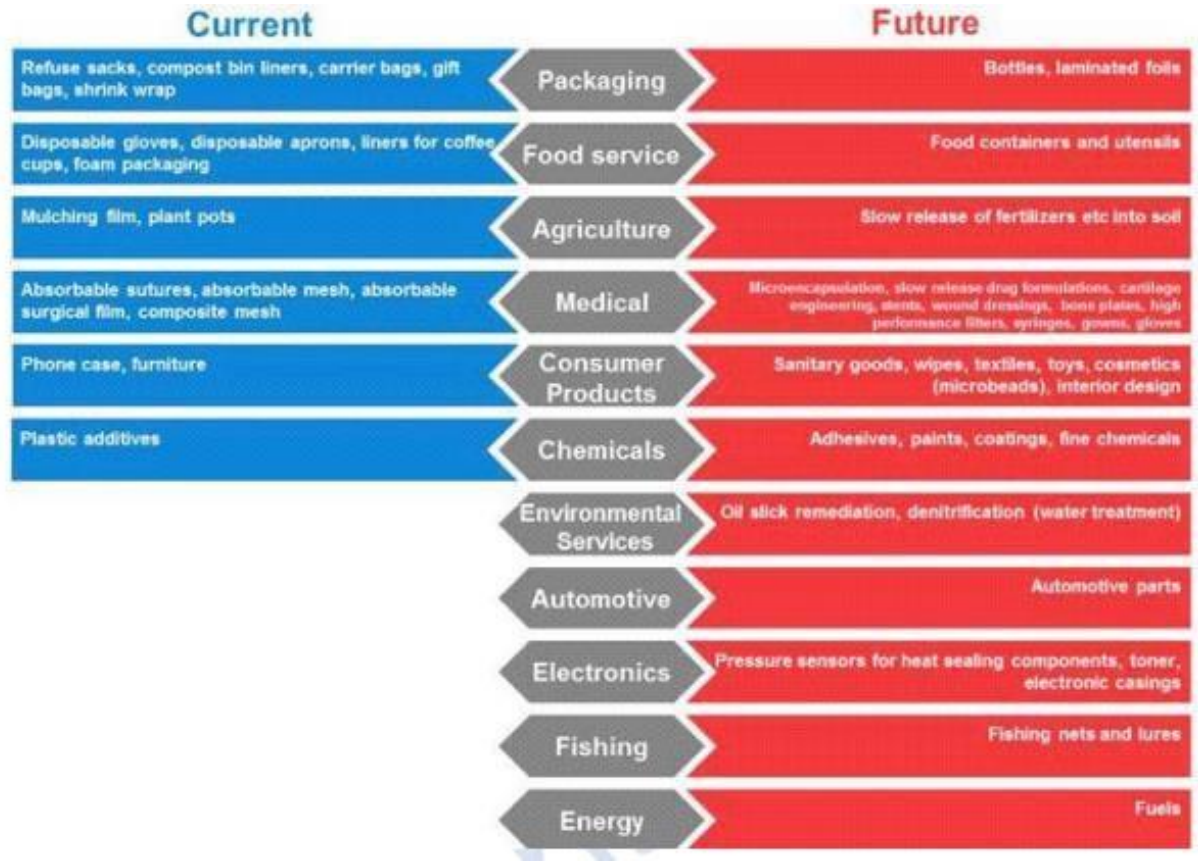

Figure 30 Current and future applications of bioplastics

Source: http://www.kpsimpex.com/download/PHA%20bioplastics.pdf

Figure below presents processes and typical applications for bioplastics in packaging.

					Blends made from							
	PLA	PHA	PBS	Cellulosic materials	Starch	PBS	PHA	PLA	PBAT	Bio-PE	Bio-PET	PEF
Process												
Blow film extrusion	o	o	+	o	+	+	+	++	++	++	o	+
Cast film extrusion	++	+	+	+	+	+	+	++	+	++	+	+
Co-extrusion	+	+	+	o	+	++	++	++	++	++	++	++
Lamination	+	+	+	++	+	++	+	+	++	+	+	++
Paper lamination	+	+	+	o	++	+	+	+	+	++	o	o
Thermoforming	++	+	o	o	+	+	+	++	o	o	++	++
Injection moulding	+	+	+	+	+	++	++	++	+	+	+	+
Blow moulding	++	+	+	o	+	++	+	++	+	+	++	++
Injection blow moulding	+	+	o	o	o	o	o	+	o	o	++	++
Flexibles												
Pouch	+	o	+	+	++	+	+	++	++	++	+	++
Clear film	++	o	o	++	o	+	o	++	o	++	++	++
Outer packaging	o	o	+	++	++	+	+	++	+	++		
Strech film	o	o	o	o	o	o	o	o	+	++	o	o
Shrink film	+	o	o	o	o	o	+	+	++	+	+	++
Shopping/waste bags	o	o	o	o	++	++	++	++	++	++	o	o
Nets	o	o	o	o	+	++	+	++	+	++	o	+
Labels	+	+	o	o	+	+	+	+	++	++	+	+
Rigid Packaging												
Bottles	+	+	o	o	o	+	+	+	o	+	++	++
Clear Trays	++	o	o	o	o	o	o	+	o	o	++	++
Other Trays	+	+	o	o	+	+	+	+	+	++	++	++
Container (larger)	+	++	o	o	+	++	+	+	+	++	+	++
Tubes	o	o	o	o		++	+	++	+	++	o	o
Caps	+	+	o	o	+	++	+	++	+	++	+	+
Cups	++	+	o	o	o	++	++	+	+	+	+	+
Blister packaging	++	+	o	o	+	+	+	+	+	o	++	++
Moulded foam	+	+	o	o	++	+	+	+	o	+	o	+
Cutlery	+	+	o	++	++	++	+	+	+	+	o	o

Source: European Bioplastics

Legend: ++ very suitable; + partly/mostly suitable; o not suitable

Figure 31 Process and typical applications for bioplastics in packaging

Source: European Bioplastics

8.4.3 Market analysis

The global market for compostable plastic packaging material is expected to grow at a CAGR of 5,1% from 2018 to 2028. The market will reach a value of over USD 2000 million by the end of 2028. Compostable plastic packaging is a significant part of the current eco-friendly plastics market. The market is consisted of different materials such as PBAT, PBS, PLA and PHA, all of which are made up of components that are highly decomposable. Among these, PHA is expected to have the strongest market growth, thanks to its high barrier properties. Food, beverage and pharmaceutical products require high barrier material for packaging to extend the shelf life of the products and maintain the quality of the product. According to the report on the global compostable plastic packaging materials market, PHA plastic type is expected to witness a CAGR of 15,9% by the end of2018.[297]

Currently, bioplastics represent about 1% of the more than 359 million tonnes of plastic produced annually. However, with the increasing demand, and with more applications, sophisticated biopolymers, and products emerging, the market for bioplastics is constantly growing and diversifying.

Figure below provides a visual abstract of the physical requirements of some common plastic products, the current materials that fulfil these requirements and the PHA types that can replace these traditional materials.

Figure 32 Abstract of the physical requirements of common plastic products, the current materials that fulfil these requirements and the PHA types that can replace traditional materials

Source: http://www.kpsimpex.com/download/PHA%20bioplastics.pdf

[297] http://www.kpsimpex.com/download/PHA%20bioplastics.pdf

According to the latest market data compiled by European Bioplastics in cooperation with the research institute nova-Institute, global bioplastics production capacity is set to increase from around 2.11 million tonnes in 2019 to approximately 2.43 million tonnes in 2024.[298]

Figure 33 Global production capacities of bioplastics

Source: European Bioplastics, nova-Institute (2019)

New and innovative biopolymers, such as bio-based PP (polypropylene) and PHAs (poly-hydroxy-alkanoates) show the highest relative growth rates. Bio-based PP has the widespread application across a lot of sectors. Their production capacities are expected to grow tremendously by 2024. Also, production capacities of PHAs are estimated to increase significantly (more than triple) in the next five years. These polyesters are 100% bio-based and biodegradable, and feature a wide range of physical and mechanical properties according to their chemical composition.[299]

All biodegradable bioplastics, including bio-based PE (polyethylene), bio-based PET (polyethylene terephthalate), and bio-based PA (polyamides), currently account for more than 44% of the global bioplastics production capacities. In Europe, the production of bio-based PE is expected to keep growing in the future. Also, it is predicted that a new polymer -

[298] https://www.european-bioplastics.org/market/
[299] https://www.european-bioplastics.org/market/

PEF (polyethylene furanoate), will enter the market in 2023. PEF is comparable to PET, but unlike PET it is 100% bio-based and has better barrier and thermal properties. On the other hand, production capacities for bio-based PET declined in the last couple of years.[300]

Bioplastics have wide application across different markets, including packaging, consumer electronics, agriculture/horticulture, catering products, automotive, and textiles among other segments. Packaging is the greatest field of application for bioplastics with more than 53% (1.14 million tonnes) of the total bioplastics market in 2019. Nevertheless, the portfolio of application continues to diversify. Segments, such as automotives and transport or building and construction, remarkably increased their share.[301]

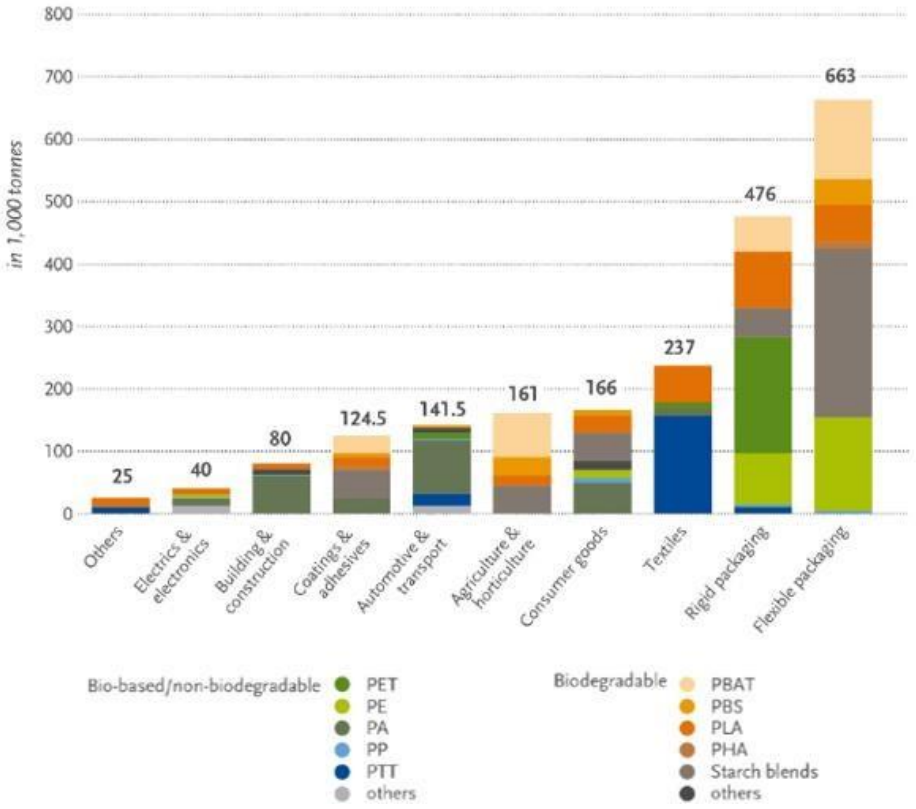

Figure 34 Global production capacities of bioplastics 2019 (by market segment)

Source: European Bioplastics, nova-Institute (2019)

Europe is a major hub for the whole bioplastics industry. It ranks highest in the field of research and development and is the industry's largest market in the world (with ¼ of the global bioplastics production capacity). However, looking at the regional production capacity development, Asia is the largest production hub. In 2019, 45% of bioplastics were produced

[300] https://www.european-bioplastics.org/market/
[301] https://www.european-bioplastics.org/market/

in Asia. On the other hand, Europe is still at the second place with 25% of the total bioplastic production.[302]

In order for European bioplastics market to reach its full potential, a supportive policy is required to enable and promote the market for bio-based products. This industry is still lacking a level playing field for the access to biomass, and specific regulatory measures to increase market penetration and ensure long-term investment security.[303]

Measures such as extended producer responsibility or product design rules related to a minimum bio-based and recycled content in plastic products, or a carbon pricing mechanism to incorporate the external costs of climate change into product prices would definitely contribute to bioplastics market grow. Furthermore, regulations related to support of biodegradable and compostable plastics in particular application fields such as agricultural mulch films, biowaste bags, fresh food packaging, tea bags, disposable catering items, or coffee capsules will contribute to make waste management more efficient and to reach the new increased recycling targets.[304]

Figure 35 Global production capacities of bioplastics in 2019 (by region)

Source: European Bioplastics, nova-Institute (2019)

Prominent players operating in the global biodegradable plastics market are BASF SE, Mitsubishi Chemical Corporation, Biome Bioplastics, NatureWorks LLC, and Corbion.[305]

[302] https://www.european-bioplastics.org/market/
[303] https://www.european-bioplastics.org/market/
[304] https://www.european-bioplastics.org/policy/
[305] https://www.openpr.com/news/632608/biodegradable-plastics-market-swot-analysis-of-top-key-player- forecasts-to-2023.html

8.4.4 Conclusions

With their inherent versatility and capacity for innovation, **bioplastics** have a crucial role to play in a **sustainable and resource-efficient economy**. The utilization of bioplastic in the transport sector helps reduce greenhouse gas emissions and can save energy and water when used in the building and construction sector. Plastic packaging plays an important role in ensuring food safety and reducing food waste. Also, bioplastic is lightweight, long-lasting, and has high performance, which makes it **a resource for the future.**

To fully deliver on its potential, bioplastics must address the many challenges relating to **littering** and **the end-of-life options for plastic waste** – particularly packaging waste.

Plastic waste is a valuable resource that can be used to produce new plastic raw materials and manufacture plastic parts and products, or to generate energy when recycling is not viable. The circular economy model can be applied almost perfectly in the process of bioplastics production. **The plastics circular economy** is a model for a closed system that promotes the reuse of plastic products, generates value from waste, and avoids sending recoverable plastics to landfills.

8.5 Biosolvents

8.5.1 Definition

Bio-solvents, also known as green solvents, are environmentally friendly solvents which are mostly derived from the processing of agricultural crops.[306] They were developed as solvents that will be environment friendly alternative to petrochemical solvents. Bio-solvents are produced using green, environmentally friendly feedstock and thus are carbon neutral, free from volatile organic compounds (VOCs), non-toxic and sustainable alternatives for application across industries. The typical feedstock used for production of bio-solvents include agricultural products, sugars, cellulose, oils and fats, among others.[307]

There are two types of solvents - water based and hydrocarbon based. In the second case, volatile organic compounds are emitted during manufacture, handling, and use that has the negative impact on the environment.[308]

8.5.2 Application insights

[306] http://www.chm.bris.ac.uk/webprojects2004/vickery/green_solvents.htm
[307] https://www.persistencemarketresearch.com/market-research/bio-solvents-market.asp
[308] https://databridgemarketresearchdotcom.wordpress.com/tag/global-green-and-bio-solvents-research- report/

Green solvents are consumed across wide range of industries such as **paints & coatings, printing inks, adhesives & sealants and industrial & domestic cleaning, cosmetics, and pharmaceutical**, etc. Among these segments, paints and coatings application segment has the largest share in the global green solvents market. Growing environmental concerns together with rising consumer awareness towards eco-friendly products are the major drivers of the adoption of green solvent in paints and coating industry. Moreover, as the result of increasing concern of health and hygiene among household consumers' and institutional workers, there is a high consumption of green solvents in industrial & domestic cleaning industry.[309]

8.5.3 Market analysis

The global bio-solvents market has been developing strong over the last few years. Factors that have a positive impact on the bio-solvents market include their **eco-friendly nature, low volatile organic compound emission, concrete and strict environmental laws, as well as high demand and acceptance rate from end user industries.** Furthermore, it is expected that in the upcoming years the application of bio-solvents in the domestic and industrial cleaning will be highest, because of the rising health concerns and hygiene issues among users. Governments and academic institutions set different measures in order to increase growth of bio-solvents market. For example, the first product standard in the world for bio-based solvents was published in November 2017.[310]

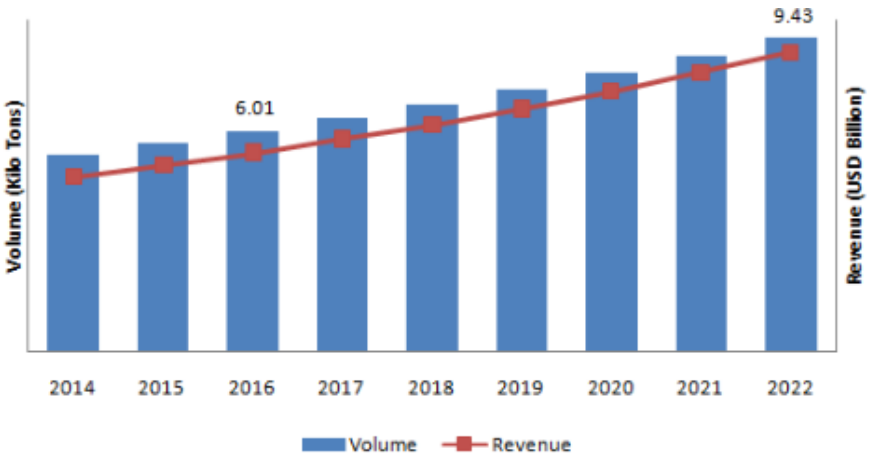

Figure 36 Global Bio-solvents Market, 2014 - 2022 (Kilo Tons) (USD Billion)

Source: Zion Market Research 2017

Bio-solvents can be applied in different sectors such as paints and coatings, domestic and industrial cleaners, printing inks, adhesives, among others. In 2016, the paints and coatings

[309] https://www.alliedmarketresearch.com/green-solvents-bio-solvents-market
[310] https://www.zionmarketresearch.com/news/bio-solvents-market

segment dominated the bio-solvents market and accounted for almost 40% share of the global bio-solvents market. This segment kept its dominance in the following years. The main reason for this lies in the growing issues about the environment that have pressurized paints and coatings makers to shift toward solvents that have low VOV presence.

Based on type, bio-solvents market can be classified into glycols, diols, solvent alcohols, methyl soyate, lactate esters, d-limonene, and others. Lactate esters have comparatively lower price, broad application area, and easy availability in comparison to other bio-solvents, so this segment is expected to grow in the future. Also, methyl soyate division has a great share in the bio-solvents market.[311]

Global bio-solvents market is expected to grow in the upcoming years, thanks to the recent developments of sustainable bio-solvents that are efficient as compared to petroleum-based solvents and also, thanks to the increasing adoption and penetration of these bio-solvents across key end-use industries. Furthermore, steady growth of the major end-use industries across developing regions of the globe is expected to further grow the market for bio-solvents during the next six years (by 2026). Nevertheless, concerns regarding the effectiveness of these alternative solvents in comparison to petroleum-based solvents is one of the factors that can slow the growth of global bio-solvents market. Also, relatively less stringent or absence of regulations pertaining to use of sustainable alternatives, relatively higher prices and lack of awareness regarding such alternatives will likely impact global bio-solvents market growth negatively.[312]

Market Drivers	Market Restraints
Environmental & regulatory pressure designed to reduce the emissions of ods, vocs, and haps.	Factors that will restrain market growth are huge investment cost to start production.
Reduced dependency on petrochemical solvents and the exporting countries.	Decreasing price of oil and gas and slow reaction rate compared to chemical solvents.
Improved competitiveness from product differentiation.	
Uncertainty about oil price development	

[311] https://www.zionmarketresearch.com/news/bio-solvents-market
[312] https://www.persistencemarketresearch.com/market-research/bio-solvents-market.asp

Table 10 Market drivers and restraints of the global bio-solvents market

Source: Zion Market Research 2017

Figure below shows the forecast of the global bio-solvent market in the period of 2020-2027.

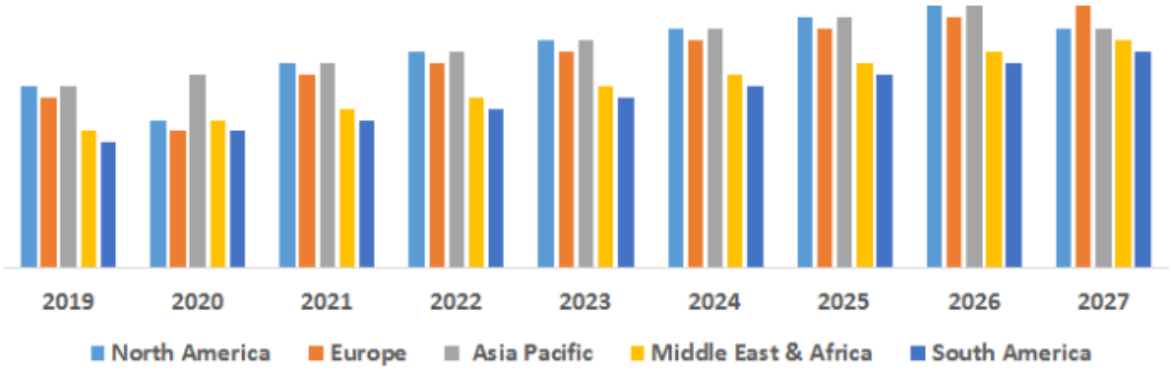

Figure 37 Global Bio-solvent Market, by region (2020-2027)

Source: Maximize Market Research Pvt. Ltd.

North America and Europe are the dominant regions in the green and bio-solvents market thanks to growing application of paint and coating in commercial and residential buildings. High demand for automotive coating and presence of big pharmaceutical companies headquartered in countries such as US, Germany, France and Canada, will positively impact the demand for bio-solvents. Rigid environment protection measures are supporting the growth of the European market among other developed regions.[313]

Asia Pacific region is also expected to register robust growth in the future, offering significant investment and growth opportunities. Main drivers of bio-solvent market in this region include the continuously growing demand from India and China. These emerging markets sustain huge growth potential owing to the government policies that promote the adoption of bio-solvents over conventional solvents. On the other hand, bio-solvents market in Latin America is also expected to grow because of the favorable government initiatives. The Middle East and Africa have a great potential for bio-solvents, that will hopefully be developed in future by improving economic activity.[314]

When it comes to the competition landscape of the global bio-solvents market, some prominent of players are Dow Chemical Company, BASF SE, Archer Daniels Midland Company, BioAmber Inc., Cargill, Incorporated., Stepan Company,Corbion, Vertec Bio-

[313] https://www.hexaresearch.com/research-report/green-bio-solvents-market
[314] https://www.maximizemarketresearch.com/market-report/global-bio-solvents-market/26035/

solvents & Carbon Neutral, Shenzhen Esuns Industrial Co., Ltd, Huntsman International LLC., and Florida Chemical Company, among others.[315]

8.5.4 Conclusions

Only 3% of global bio-based solvents production takes place in the EU and **43% of the bio-based** solvents consumed in the EU are imported. These figures are not expected to improve soon, with the industry dealing with more pressing problems such as VOC emissions and health and safety issues rather than greenhouse gas emission reduction. This keeps bio-based solvents limited to applications such as paints, coatings, inks, pharmaceuticals, and cosmetics.

But still, eco-friendly nature and low volatile organic compound (VOC) content emission than conventional petroleum-based solvent, was **the prime reason for manufacturers to shift towards green solvent.**

The new paradigm of a **circular economy** suggests an innovative way of exploiting resources that is only viable through closed industrial loops. In terms of sustainability and circular economy, bio solvents have great potentials with **the introduction of innovative recycling practices** that represents a promising opportunity to **reduce the overall chemical industry's environmental footprint** by contributing to the development of a lower carbon society.

8.6 Biochar

8.6.1 Definition

Biochar is a charcoal-like substance that's made by burning organic material from agricultural and forestry wastes (biomass) in a controlled process called pyrolysis (see chapter 6.4 of this report). Even though biochar looks a lot like common charcoal, it is produced using a specific process to reduce contamination and safely store carbon. During pyrolysis organic materials, such as wood chips, leaf litter or dead plants, are burned in a container with very little oxygen. As the materials burn, they release little to no contaminating fumes. During the pyrolysis process, the organic material is converted into biochar, a stable form of carbon that can't easily escape into the atmosphere. The energy or heat created during pyrolysis can be captured and used as a form of clean energy. Biochar is

[315] https://www.persistencemarketresearch.com/market-research/bio-solvents-market.asp

by far more efficient at converting carbon into a stable form and is cleaner than other forms of charcoal.[316]

Biochar is black, lightweight, highly porous, fine-grained and has a large surface area. Approx. 70% of its composition is carbon. The remaining percentage consists of nitrogen, hydrogen and oxygen among other elements. In terms of chemical composition of biochar, it varies according to the feedstocks used to make it and methods used to heat it.[317]

8.6.2 Application insights

Biochar can be used to improve the quality of construction materials such as concrete or asphalt. It is also broadly used as a fodder additive for animal health, for cleaning of air and water, and it also fosters beneficial microbial life, helps regulating humidity and absorbs toxins. It can be (and it's recommended) locally sourced from residual material, limiting transportation costs and emissions. It replaces scarce resources while improving the quality of the end-products.[318]

However, wide application of biochar makes negative emissions possible at a large scale. The sequestration has already begun by thousands of farmers worldwide, communal services, providers of building materials and many more.[319]

Figure 38 Application of Biochar

Source: http://www.biochar-industry.com/biochar/

[316] https://regenerationinternational.org/2018/05/16/what-is-biochar/
[317] https://regenerationinternational.org/2018/05/16/what-is-biochar/
[318] http://www.biochar-industry.com/biochar/
[319] http://www.biochar-industry.com/biochar/

Considering the fact that biochar production technology is progressively developing, with more than 500 research projects worldwide looking into biochar properties and interactions, the European Biochar Certificate (EBC) has been developed by biochar scientists. It tends to become the voluntary European industrial standard. The aim of EBC is to limit the risks of biochar usages and to help users and producers of biochar to prevent or at least to reduce any hazard for the health and for the environment while producing and using biochar. The EBC ensures a viable biochar production and low hazard use in agronomic systems. It is based on the latest scientific data, it's economically sustainable and close to technical and agricultural practice.[320]

Biochar produced in line with the EBC standards fulfils all the requirements of sustainable production and a positive carbon footprint. These standards guarantee ecologically sustainable procurement and production of biomass feedstock for biochar production, compliance with emission standards and environmentally safe storage. Biochar quality is comprehensively monitored and documented. All threshold values, corresponding to those of the Ordinance on Soil Protection are complied with. The EBC certifies:

1. Sustainable provision and production of biomass feedstock
2. Energy efficient, low emission pyrolysis technique
3. Biochar quality – low contaminant level
4. Low hazard use and application of biochar.[321]

8.6.3 Market analysis

The European biochar market is expected to reach a CAGR of 14.41%, in terms of revenue, during the period between 2020 and 2028. In terms of volume, the market is estimated to grow at a CAGR of 11.71% at the same time. The main driver of the market is the availability of huge forest waste. European regulations on organic waste disposal in addition to high disposal costs further support market growth.[322]

In the UK, the use of biomass for energy has significantly increased over the past decade. Biomass caters to around 7% of the UK's primary energy needs. Every year there is 50 Mt of biomass suitable for biochar production available from wastes in the UK. In France, the key factor increasing the market is the soil enhancing the capacity of the biochar. Moreover, other factors that positively impact the market growth include the growing demand from the wastewater and dairy waste management sector, and the increasing demand for organic food products. In countries such as Italy, the Italian Biochar Association tends to promote the

[320] http://www.european-biochar.org/en
[321] http://www.european-biochar.org/en
[322] https://www.inkwoodresearch.com/reports/europe-biochar-market/

use of biochar in reducing gas emissions and boost crop productivity. The purpose of the National Energy strategy issued by the Italian government is to make the national energy system more sustainable, secure, and competitive, that positively impacts the biochar market.[323]

The European Biochar market is expected to record a growth at a CAGR of 14.70% in terms of revenue and 12.13% in terms of volume over the period from 2019 to 2027.[324]

Properties such as carbon sequestration and soil enhancement are the reasons for adopting biochar on a large scale in agricultural and horticulture applications. Moreover, number of efforts have been made to standardize biochar products and manufacturing processes, which are expected to boost the biochar market in Europe.[325]

Germany is anticipated to maintain the largest market share in the future. The country has been taking several initiatives to reduce its annual greenhouse gas emissions by 55% by the year 2030 (compared to 1990 levels). Biomass sources are widely used for generating energy such as heat, electricity, and fuels, which contributes to the reduction of greenhouse gas emissions. Biochar's potential for reducing greenhouse gas emissions is limited by the availability of biomass. It is expected that the agricultural benefits of biochar in the form of enhanced soil fertility can improve its potential for greenhouse gas reduction and costs.[326]

Besides Germany, which is a leader on the European biochar market, France and UK also have a great market share that is expected to grow in the future. Carbon Gold, headquartered in the UK, is a leading company engaged in research and development of biochar, and sells biochar to a wide range of customers.[327]

Other prominent players in the European market are: Agri-Tech Producers LLC , Pacific Biochar , Biochar Now , Biogreen-Energy , Tolero Energy , ArSta Eco , Carbon Gold , Phoenix Energy, Earth Systems Pty Ltd. , AirTerra, Cool Planet Energy Systems , Airex Energy.[328]

Crucial role in European Biochar Industry belongs to the European Biochar Industry consortium. It is a non-profit organization that promotes and supports the development of a European biochar and pyrolysis industry, particularly by eliminating / alleviating market entry barriers.[329]

EBI is focusing on the following key activities:

[323] https://www.inkwoodresearch.com/reports/europe-biochar-market/
[324] https://www.tritonmarketresearch.com/reports/europe-biochar-market
[325] https://www.tritonmarketresearch.com/reports/europe-biochar-market
[326] https://www.tritonmarketresearch.com/reports/europe-biochar-market
[327] https://www.tritonmarketresearch.com/reports/europe-biochar-market
[328] https://www.tritonmarketresearch.com/reports/europe-biochar-market
[329] http://www.biochar-industry.com/about/

- Support/initiate adaptation of legal regulations regarding production and usage of biochar
- Provide relevant market information for members and for publications
- Increase the level of awareness of biochar and its commercial and environmental benefits
- Develop and establish scientifically sound standards for biochar for different applications in industry (based on EBC).[330]

8.6.4 Conclusions

Biochar is a high-carbon, fine-grained residue that today is produced through modern pyrolysis processes. Producing biochar, a carbon-rich material, from organic waste is the ultimate **sustainable solution for waste management**: it sequesters CO2, reintroduces important elements in the environment, substitutes highly polluting materials, and allows all of us to create a stronger circular economy.

Biochar is mostly known as a **great soil amendment**, but it can be also used as an absorber in functional clothing, insulation in the building industry, as carbon electrodes supercapacitors for energy storage, food packaging, wastewater treatment, air cleaning, silage agent, or feed supplement, and as a composting agent.

Since it has been widely used for versatile applications **in agriculture and environment sectors**, the biochar market is growing rapidly due to the constant availability of huge forest waste and a huge demand for eco-friendly products.

8.7 Other Potential end-products of interest

Following the same approach as in the chapter 6.7 of this report, this section is written according to the WaysTUP! Pilots' feedback from the distributed questionnaire. What we have found out is that volatile fatty acids for bioplastics production are the additional, potential end-products of WaysTUP! Pilots. Hence, these acids need to be briefly elaborated in order to understand their characteristics and application.

Volatile Fatty Acids (for bioplastics production)

Volatile fatty acids (VFAs) are a class of commonly used compounds in the chemical industry, that serve as starting molecules for bioenergy production and for the synthesis of different

[330] http://www.biochar-industry.com/about/

products, such as biopolymers, derivatives and reduced chemicals.[331] However, **obtaining VFAs in a usable form is more challenging as it requires higher thermal energy input or larger use of additional chemical reagents**, such as Sodium Hydroxyde.[332]

Despite bioplastics production, **applications of VFAs** include biofuels and nutrients removal in biological wastewater treatment processes.

Prominent players operating in the global Volatile Fatty Acids market include AppliTek NV, Merck KGaA, Colgate-Palmolive Ltd, Hach Company Inc., Behn-Meyer Holding AG, BASF SE, Ferro Corporation, The Dow Chemical Company, Croda International Plc., Koninklijke DSM NV, Arizona Chemicals, Eastman Chemical Company, and Vantage Oleochemicals.[333]

8.8 Industry Trends Under COVID-19

All industries have been impacted by the COVID-19 crisis, with varying degrees of severity. Some have stronger defenses, while others will struggle to return to a constantly shifting "normal." Consumer demand patterns are shifting, global supply chains are disrupted and remain under pressure, and different regions, markets and governments are responding uniquely to the COVID-19 crisis. Companies must continuously adapt to new and uncertain market conditions.[334] In order to help WaysTUP! Pilots with adjusting to this situation, we decided to investigate the newly created trends under Covid-19 within the markets that play the crucial role for the Pilots. Within chapter 6 of this report, we have already examined certain markets, and here, we will continue with identification of the Covid-19 problems/trends on the markets that have been analyzed in this chapter 7.

Impact of Covid-19 on the EU food industry

The COVID-19 pandemic is having a seismic effect on businesses around the world, but food manufacturers and their suppliers have additional factors to consider.

331 https://www.sciencedirect.com/science/article/pii/S0301479718309101#:~:text=Volatile%20fatty%20acids%20%28VFAs%29%20are%20a%20class%20of,products%2C%20such%20as%20biopolymers%2C%20reduced%20chemicals%20and%20derivatives.

332 https://www.knowledge-share.eu/en/patent/biodegradable-bioplastics-production-method/

333 https://bulletinline.com/2020/09/24/volatile-fatty-acids-market-expected-to-witness-a-sustainable- growth-over-2018-to-2027/

334 https://www.accenture.com/us-en/about/company/coronavirus-business-economic-impact

At the onset of the crisis, the food supply chains were strained as many countries imposed restrictions on movement of goods and people across and within borders. As a result, **the challenge was not availability of food but easy access to it**. Another factor which made this situation more challenging is fear. At the beginning of the health crisis, there were people who started buying more food than they actually needed, creating food supplies. Also, some countries restricted food exports because of the anxious over the uncertainties linked to food supply. These protectionist measures were partly introduced to avoid driving up local food prices as weakening of national currencies made it more advantageous for food producers to export rather than sell domestically. The resulting food price inflation could have had significant consequences – making poverty worse and leading to social and political unrest. Fortunately, excessive protectionism was avoided and many of the initially imposed restrictions have been removed, with countries adopting overall a restrained and reasonable approach. Globally, food supply has been adequate, and markets have been stable so far. However, disruptions to the food supply chains remain and situations vary.[335]

Although reductions in production of high value commodities (i.e. fruits and vegetables) is already likely, they are not as yet noticeable because of the lockdowns and disruption in the value chain. Small-scale producers are facing challenges accessing inputs – such as seeds and fertilizers because of several reasons. These are:

- rising prices of these inputs;
- severely reduced household incomes; and/or
- lack of availability of these inputs in markets.[336]

The closure of restaurants and street food outlets removes a key market for many producers and processors that may produce a temporary glut or trigger upstream production cuts as can be seen in the fish and meat sectors. In some developing countries, urban supply and demand for fresh produce are both in decline due to restrictions and aversion behaviour by traders and consumers.[337] While restaurants and bars may be closed, people are still eating and so safe, high quality food must still be produced, shipped, and provided to the customer. It means that **implementation of food safety management systems should be priority.**

[335] http://www.fao.org/2019-ncov/q-and-a/impact-on-food-and-agriculture/en/?fbclid=IwAR0LkDhDLGABJx6kgwXJs9R4f0CjocQVnIMEpMGFmBnV4Fo57yCAqXhnRss

[336] http://www.fao.org/2019-ncov/q-and-a/impact-on-food-and-agriculture/en/?fbclid=IwAR0LkDhDLGABJx6kgwXJs9R4f0CjocQVnIMEpMGFmBnV4Fo57yCAqXhnRss

[337] http://www.fao.org/2019-ncov/q-and-a/impact-on-food-and-agriculture/en/?fbclid=IwAR0LkDhDLGABJx6kgwXJs9R4f0CjocQVnIMEpMGFmBnV4Fo57yCAqXhnRss

Also, the pandemic contributed to a shift in global foodservice to a more delivery- and smartphone-driven industry, because consumers worldwide look for cheaper, more convenient options that require less human contact.[338]

Overall, food markets will face many more months of uncertainty due to COVID-19, but the agri-food sector is likely to show more resilience to the pandemic crisis than other sectors.

The latest forecasts for production and market trends in 2020-2021 for the world's most traded food commodities are available here. Also, information on global food prices for most commonly traded food commodities, can be found here.

In addition, when it comes to **the global gelatin market**, the rising preference for convenience foods and beverages has been instrumental in driving the market. However, the rising raw material costs might hamper market growth.[339] This market will have **neutral impact** due to the Covid-19 pandemic.[340]

Impact of Covid-19 on the coffee market

The global coffee sector has gone through a prolonged period of low producer prices and now the global pandemic presents additional challenge. Out-of-home consumption decreased significantly in the period when lots of countries adopted a full or partial lockdown. Major risk of coffee consumption is also the closure of offices, coffee shops and restaurants in order to reduce the spread of the virus. On the other hand, retail- and supermarket-level data suggest that panic buying and stockpiling has led to increased consumer demand in some countries.[341] Nevertheless, this is unlikely to have a sustained effect on consumption. Following an initial spike in demand, there will be proportionally less demand in the coming period as consumers draw down stocks kept at home. Overall, a global recession due to Covid-19 will likely have a more profound effect on global coffee demand. Reduced household incomes could result in lower demand for coffee in volume terms. In addition, price-sensitive consumers may substitute higher-value coffee by lower-value blends or brands. However, the income elasticity of coffee demand is likely to be low,

[338] https://www.euromonitor.com/consumer-foodservice--quarterly-statement-q3-2020/report
[339] https://www.businesswire.com/news/home/20200903005074/en/
[340] https://mms.businesswire.com/media/20200903005074/en/817999/5/IRTNTR43803.jpg?download=1
[341] https://www.iriworldwide.com/IRI/media/Library/IRI-BCG-COVID-Global-Consumer-Spending-Tracker- 2020-03-26.pdf

especially in high-income countries and traditional markets with high per-capita consumption rates.[342]

Impact of Covid-19 on the bioplastics market

In the first half of 2020 the market experienced slow down compared to the 2019 growth estimates due to the impact of the COVID-19 pandemic. However, steady growth is expected to continue in the future.

Decline in crude oil prices will be a linear disadvantage for bioplastics, further affected by the higher price point. Post pandemic, green investments are highly likely to be delayed due to a climate of uncertainty created by the crisis. A headwind coming from closure of factories and halt in manufacturing and supply chain operations will become restraint to the market growth.[343] On the other hand, the market will be driven by increasing government support and the rising awareness of sustainable packaging solutions. It is estimated that 32% of the future bioplastic packaging market growth will originate from Europe.[344]

Impact of Covid-19 on the biochar market

Even though the biochar fertilizer market was predicted to grow in the forecast period 2020-2030, the COVID-19 pandemic has delayed growth prospects, with production facilities being inhibited due to curbs on economic activities to contain the virus. Consequently, a stagnancy is anticipated over the short-term forecast.[345]

Farmers were obligated to stay indoors due to social distancing measures and this has reduced farming activity, which resulted in the weak demand for biochar fertilizers. However, growth is anticipated to pick up pace eventually. Countries such as China and India have eased restrictions imposed during the lockdown, enabling production cycles and supply chains to revert to normalcy. Therefore, key manufacturers will find it easier to import the raw materials that are used as a feedstock to produce biochar, offsetting the current demand-supply gap. Currently, manufacturers are looking to leverage their existing supply

[342] http://www.ico.org/documents/cy2019-20/coffee-break-series-1e.pdf
[343] https://www.accesswire.com/594914/COVID-19-Impact-Analysis-Bioplastics-Market-Faces-a-Downtrend- in-2020-as-COVID-19-Crisis-Delays-Green-Investments--Future-Market-Insights
[344] https://mms.businesswire.com/media/20200907005237/en/818918/5/IRTNTR44804.jpg?download=1
[345] https://finance.yahoo.com/news/double-digit-growth-predicted-biochar-134000628.html

chains by resorting to staggered work timings for their on-site staff, ensuring basic social distancing protocols, regular temperature screenings of employees and mandatory sanitizing and washing of hands by employees over regular intervals. Such measures have helped the biochar fertilizer market remain afloat during the pandemic.[346]

8.9 Conclusions

The technological processes used within WaysTUP! Pilots are innovative, but what is obtained as the end product is not a novelty on the market. End products such as gelatine, essential oil (from coffee), bioplastics, bio solvents, and biochar are present in the EU market for the past decades. The goal is to explore new ways of utilization for those particular products, in line with bioeconomy, sustainability, and environmental care.

Chapter 8.1 refers to **gelatine**, which is the end product of **Pilot 1**. We found out that Europe has the largest share of the global gelatin market and it is expected to grow in the future. Therefore, Pilot 1 can expect lots of competitors on the market, but also high demand, especially for new innovative solutions. **Bioeconomy strongly supports sustainability in the food industry**, which gives gelatine a strong market advantage.

Chapter 8.2 is dedicated to **coffee oil,** the end product of **Pilot 2**. The key finding of this chapter is that coffee market has two main dimensions. The first one is related to coffee as a drink and the second one has to do with application of coffee oil in different industries such as cosmetics, aromatherapy etc. The use of coffee grounds after the coffee fulfilled its primary role adds a **wide range of business opportunities in line with bioeconomy**.

Chapter 8.3 is related to **insect protein**, which is the end product of **Pilot 3**. Here, we found that although the abundant characteristics of edible insects should benefit human health, in Western societies, edible insects have a greater potential as animal feed than as human food, because of cultural biases associated with harmful insects. However, insect protein is **widely utilized as a feed component and as a supplement in food industry.**

Chapter 8.4 is focused on **monomers and PHAs**, as the end product of **Pilot 4**. Key findings from this chapter include that **bioplastics** have a crucial role to play in a **sustainable and resource-efficient economy and therefore, it is considered to be a resource for the future. The plastics circular economy** is a model for a closed system that promotes the reuse of plastic products, generates value from waste, and avoids sending recoverable plastics to landfills.

[346] https://finance.yahoo.com/news/double-digit-growth-predicted-biochar-134000628.html

Chapter 8.5 is dedicated to bio-solvents, that are end products of **Pilots 5 and 6**. Detailed analysis enabled us to conclude that and **43% of the bio-based solvents consumed in the EU are imported. Therefore, WaysTUP! Pilots have a huge market opportunities.**

Bio-solvents have great potentials with the introduction of innovative recycling practices that represents a promising opportunity to reduce the overall chemical industry's environmental footprint by contributing to the development of a lower carbon society.

Chapter 8.6 refers to biochar, which represents the end product of **Pilot 7** in the contect of WaysTUP! Project. Here, we found out that Biochar is **a great soil amendment**, but it can be also used as an absorber in functional clothing, insulation in the building industry, as carbon electrodes supercapacitors for energy storage, food packaging, wastewater treatment, air cleaning, silage agent, or feed supplement, and as a composting agent. Constantly gowing demand for eco-friendly products encourages further production of biochar, in Europe and worldwide.

Chapter 8.7 is dedicated to other end products streaming from the WaysTUP! Pilots that were not previously analysed in the Chapter 8. We identified only one additional end-product of WaysTUP! Pilots - volatile fatty acids for bioplastics production.

Key finding of this chapter is that obtaining VFAs in a usable form is not easy as it requires higher thermal energy input or larger use of additional chemical reagents.

Chapter 8.8 is focused on Covid 19 impacts on the key industries analysed within this Chaper 8. Many industries are currently collapsing due to the COVID-19 pandemic, but at the same time, there are many new opportunities on the market and they should be used to the best of their ability. For our Pilots, the growing demand for "green" and "eco-friendly" products, which is a result of the change in consumer thoughts and behavior, is a crucial factor to consider for further product development. Many large companies worldwide are beginning to cater to the demands of conscious consumers and are also paying more attention to their evident impact on the environment.

Initially, the drive to gain a competitive advantage and meet consumer demands drove companies to focus on sustainability. Now, sustainability has become a necessity, because we live in a world of ever-shrinking natural resources.

9. Market Breakup by end users/industry

The term end market (also known as "target market") is used to indicate where the final transaction takes place in a value chain. Typically, it is where the end-user is located, meaning the individual or organization for whom the product or service has been created, and who is not expected to resell that product or service.

For a business-related product or service, **the end market is where the sale occurs to the organization that will use the product or service in its own operations**.[347]

Therefore, this chapter is dedicated to **plastic, food and feed, chemical and biofuel industries, as well as biofertilizer market.** These markets are key drivers of the future WaysTUP! Pilots' value chain growth and development. The aim of this chapter is to inform WaysTUP! Pilots' supply chain actors about the current and future trends of each market in order to help them to compete in the marketplace.

9.1 Plastic Industry

9.1.1 Market analysis

Plastics are a huge family of different materials. Some of plastics families are **thermoplastics**, which include polyethylene (PE), polypropylene (PP), polyvinyl-chloride (PVC), polyethylene terephthalate (PET) among others, and **thermosets** such as polyurethane (PUR), unsaturated polyesters, silicone etc. Each plastic is designed with specific characteristics that make it ideal for the application to which it is intended, providing us with very resource-efficient solutions. Plastic materials can be produced from different sources. Its raw materials can be of fossil origin (crude oil, gas, etc.) or renewable (sugar cane, starch, vegetable oils, etc.) or even mineral base (salt). Regardless of the nature of their raw materials, certain plastics are also biodegradable. This means that provided they are properly collected and treated together with organic waste, they can biodegrade and become compost.[348]

In 2018, global plastics production almost reached 360 million tonnes. In Europe, plastics production almost reached 62 million tonnes. When it comes to the distribution of global plastics production, Asia reached 51% of the total 359 million tonnes from which China

[347] https://www.marketlinks.org/good-practice-center/value-chain-wiki/end-markets-overview
[348] https://www.plasticseurope.org/en/resources/market-data

reached 30% of it, in 2018. On the other hand, **Europe reached only 17% of the total number**.[349]

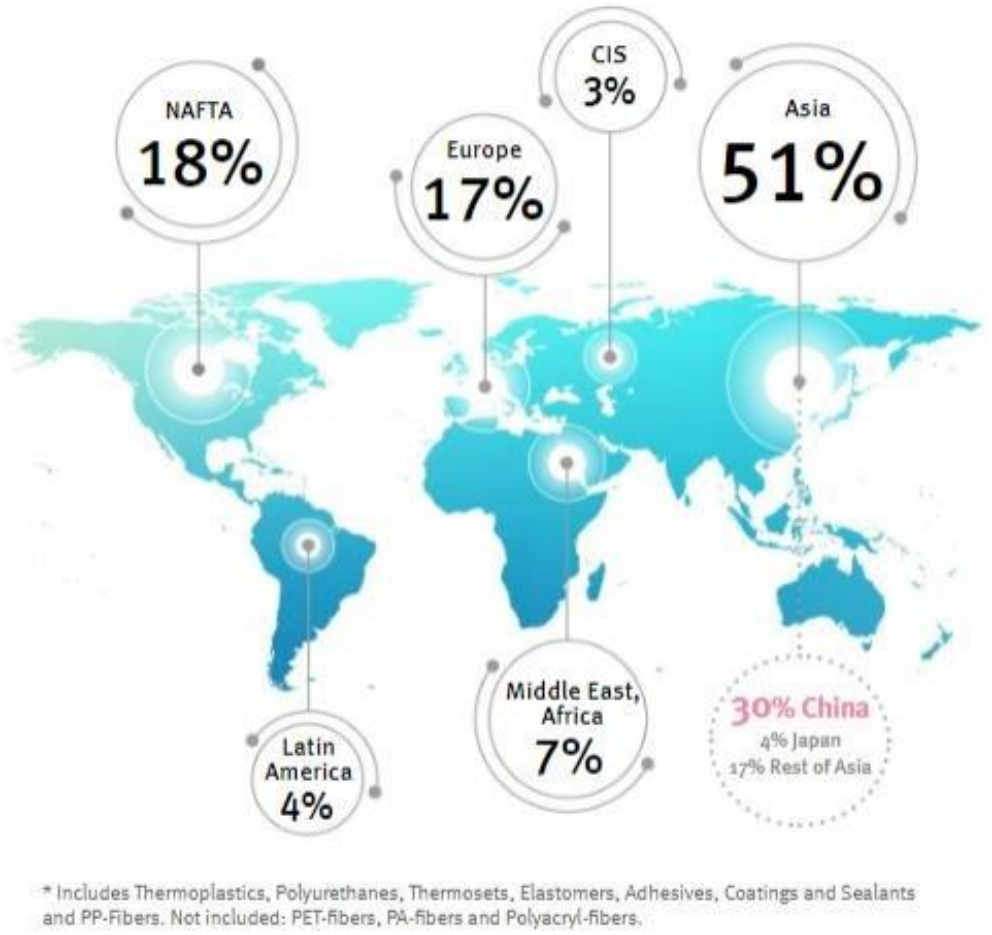

Figure 39 Global Plastics production

Source: Plastics – the Facts 2019. An analysis of European latest plastics production, demand and waste data

However, in 2018 the European plastics industry reached a positive trade balance of more than 15 billion euros. The graphic below shows that the **USA was the first trade partner of the European Plastics Industry**.[350]

[349] https://www.plasticseurope.org/en/resources/market-data

[350] https://www.plasticseurope.org/en/resources/market-data

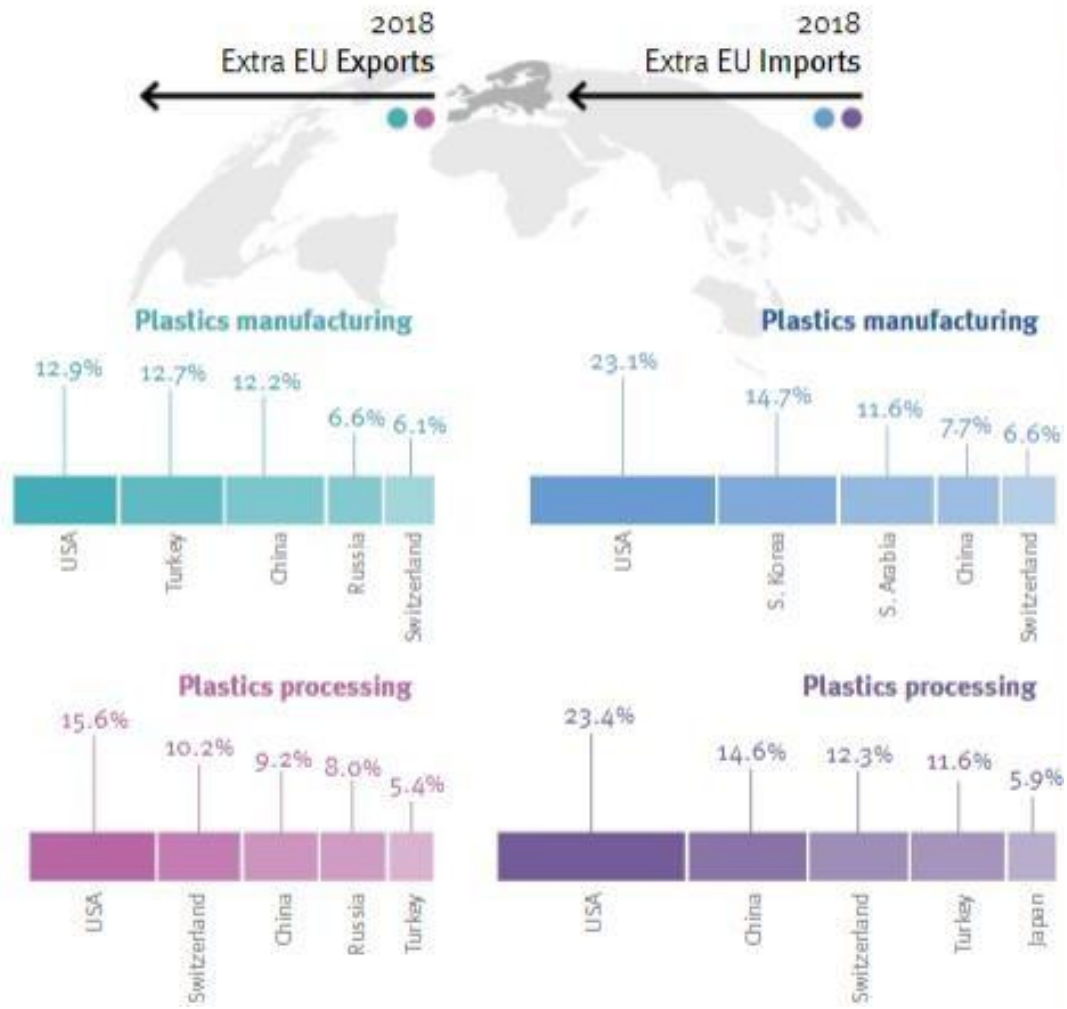

Figure 40 Top Extra EU trade partners in value

Source: Plastics – the Facts 2019. An analysis of European latest plastics production, demand and waste data

According to the analysis of plastic converters demand by countries, which includes thermoplastics, polyurethanes and other plastics, it is evident that six European countries – **Germany, Italy, France, Spain, United Kingdom and Poland cover almost 80% of the European demand**.

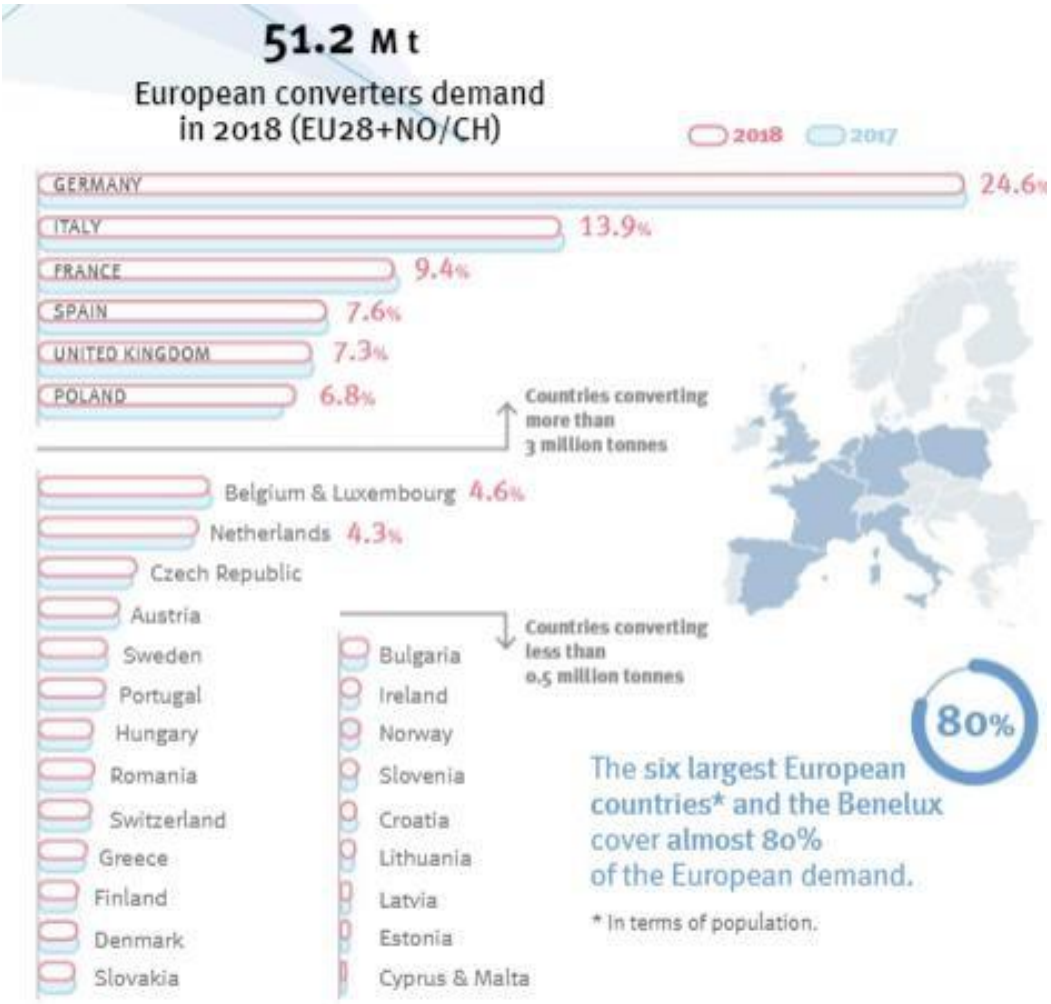

Figure 41 European plastic converters demand (2018)

Source: Plastics – the Facts 2019. An analysis of European latest plastics production, demand and waste data

Furthermore, if we break this demand by segment, we can see that **Packaging (39,9%) and Building & Construction (19,8%) are the largest end-use markets**. The third biggest end-use market is the Automotive industry (9,9%).[351]

[351] https://www.plasticseurope.org/en/resources/market-data

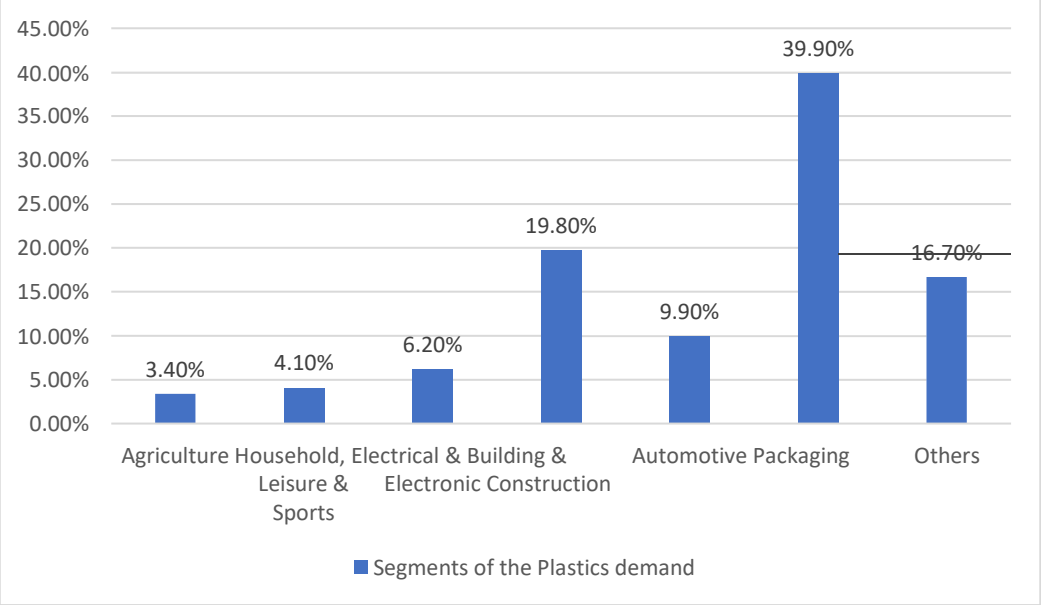

Figure 42 Segments of the Plastics demand

Source: Plastics – the Facts 2019. An analysis of European latest plastics production, demand and waste data

This increasing consumption of plastics has led to the use of bioplastics and replacing plastic materials that are toxic in nature. The European Bioplastics market is expected to grow at amazing CAGR of 26.07% by 2023. Thanks to the environmental regulations and government initiatives of growing awareness, the consumers are progressively shifting towards bio-based plastics. The important market driver is a significant number of bans on traditional plastics. Currently, in Europe, the packaging market is among the highest applications of bioplastic materials, with increasing demand by consumers. There is a **high demand for packaging made from bioplastics to be used for wrapping organic food.**

Overall, there are **different application of plastics in Packaging Industry**. Flexible packaging such as packaging films, bags and sacks, shrink and stretch films are mainly used for food packaging, but also as a secondary and tertiary packaging, for example for transportation. Bags and sacks made of plastic films are used in a variety of shapes and applications including shopping bags, garbage bags, shipping bags as well as large sacks for industrial and agricultural goods. The application area flexible packaging is dominated by the polyethylene types LDPE and LLDPE that account for almost 53%, followed by polypropylene and the High-Density Polyethylene (HDPE).[352]

[352] https://www.ceresana.com/upload/Marktstudien/brochueren/Ceresana-Brochure_Market-Study_Plastics-Europe.pdf

The area rigid packaging includes containers such as cans, bottles, cups, trays, boxes and caps. The consumption rate of these articles of daily use is increasing. Therefore, the importance of plastics in their production process is rising as more conventional materials such as aluminum, tin plate or glass are being replaced. As plastics are lightweight and versatile, they have cost and environmental advantages, facilitate handling and manufacturing, improve quality and security and offer new opportunities in packaging design. Even though plastics already have a low weight, the industrial sector is still trying to produce ever lighter containers (known as "lightweighting") in order to minimize resource consumption and transport costs even further. Having in mind that this process can't continue infinitely, **plastic bags are increasingly used as an alternative**, for example in some segments of the beverages market. In Europe, above all PET is used for rigid packaging, followed by PP and HDPE. Also, the most used plastic in European Construction Industry is PVC.[353]

Graphic below shows distribution of European plastics converters demand by resin types in 2018. Leading polymers are the polyolefins (PE and PP).

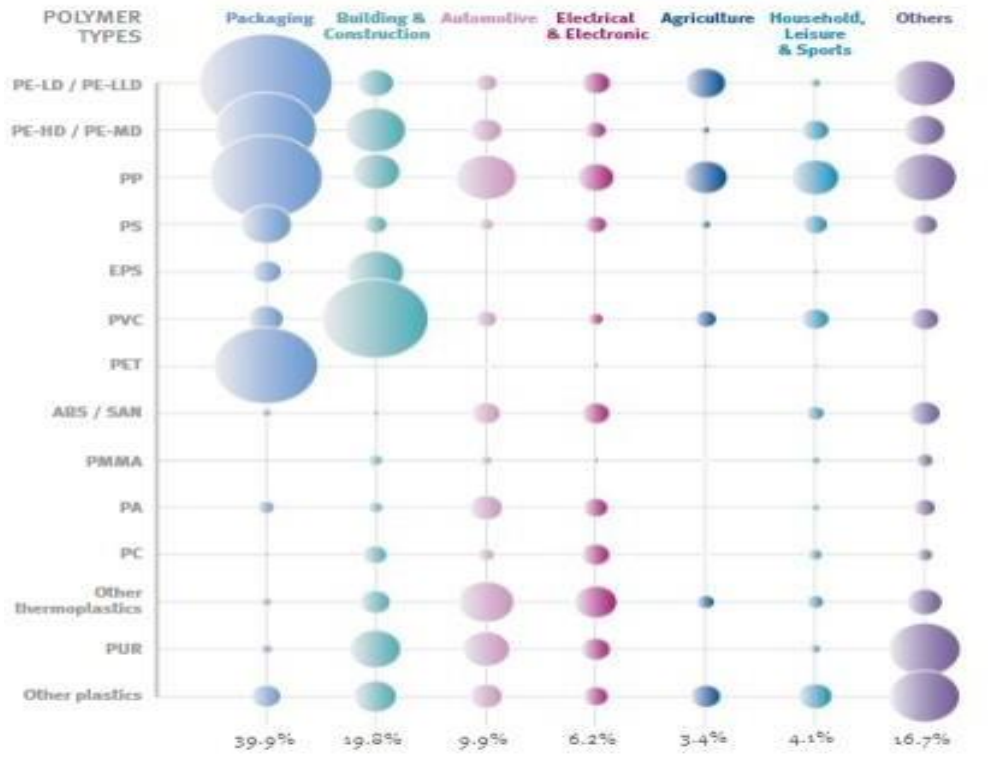

Figure 43 Distribution of European plastics converters demand by resin types (2018)

[353] https://www.ceresana.com/upload/Marktstudien/brochueren/Ceresana-Brochure_Market-Study_Plastics-Europe.pdf

Source: Plastics – the Facts 2019. An analysis of European latest plastics production, demand and waste data

The European plastics industry supports the European Commision's strategy for plastics in a circular economy and is highly committed to accelerate its transformation towards an even more circular and resource efficient plastic economy. With the **Plastics Strategy**, the Commission aims to encourage and support product design choices which take into account the entire life cycle of plastics and plastic products, making them more durable, reusable and easily recyclable. As packaging is one of the main uses of plastics, **by 2030 all plastic packaging should be recyclable.** The quality of recycled plastics is increasing, but the overall uptake of recycled plastics remains low. Only 6% of new plastic materials come from recycling and 95% of the potential economic value in plastic packaging currently goes to waste. To boost the use of recycled plastics, the Commission is launching a pledging exercise for EU industries. The target is to ensure that by 2025, 10 million tonnes of recycled plastics find their way into new products on the EU market.[355]

9.1.2 Conclusions

Since end products of Pilot 4 are monomers and PHAs, and long chain dicarboxylic acid to bioplastics for packaging, their targeted end users belong to plastic industry. Therefore, we analysed this industry in order to inform WaysTUP! Pilots' supply chain actors about the current and future trends within this European Plastic industry in order to help them to compete in the marketplace.

Our main conclusions are summarized below:

- In 2018, Asia dominated Global Plastic industry by producing 51% of the total worlds' plastics production, while Europe produced only 17% of the total number;
- USA was the first trade partner of the European Plastics Industry;
- Germany, Italy, France, Spain, United Kingdom and Poland cover almost 80% of the European demand;
- Packaging (39,9%) and Building & Construction (19,8%) are the largest end-use markets of European Plastics Industry;
- The European Bioplastics market is expected to witness a significant grow in the upcoming period;
- In Europe, the packaging market is among the highest applications of bioplastic materials;

[354] https://ec.europa.eu/commission/sites/beta-political/files/plastics-factsheet-industry_en.pdf
[355] https://ec.europa.eu/commission/sites/beta-political/files/plastics-factsheet-industry_en.pdf

- Different application of plastics in Packaging Industry such as food packaging, transportation etc.
- EU Plastic Strategy - By 2030 all plastic packaging should be recyclable.

9.2 Food and Feed Industry

9.2.1 Market analysis

FOOD INDUSTRY

The global food industry refers to the entire food supplying industry, from the agriculture processes and farmers to the actors who deliver the food to the consumers (wholesalers and retailers). The job of this industry is also to try to ensure that adequate food supplies are available to everywhere in the world.[356] In European Union, food industry is, together with drink industry, one of the main contributors to the bioeconomy.[357]

The UK Food Standards Agency describes food industry as a complex value chain - "*the whole food industry – from farming and food production, packaging and distribution, to retail and catering*."[358]

Only subsistence farmers, those who survive on what they grow, and hunter-gatherers can be considered outside the scope of the modern food industry.[359]

Therefore, **in order to understand situation in European food industry, at least major markets within this industry must be analyzed, and these are: Agri-food market, Food processing market and Food service market**. Also, significant factor that can contribute to this analysis is related to developments within food technology sector which can be found on the European Federation of Food Science and Technology website. Furthermore, regulations within European food sector should also be separately analyzed. Regulations include the EU General Food Law, which imposes general obligations to provide safe food, and the Food hygiene law (Regulation (EC) No 852/2004). Moreover, when it comes to ensuring safe food and animal feed in the EU, responsible EU body is EFSA - European Food Safety Authority.

[356] https://www.wisegeek.com/what-is-the-global-food-industry.htm

[357] https://www.fooddrinkeurope.eu/uploads/publications_documents/FoodDrinkEurope_Data_and_Trends_2018_FINAL.pdf

[358] https://www.food.gov.uk/

[359] https://en.wikipedia.org/wiki/Food_industry#cite_note-2

In addition, **future trends that are influencing Europe's food sector** should also be investigated – scientists and experts from the Competence Center Foresight of the Fraunhofer Institute for Systems and Innovation Research (ISI) have identified and analyzed a variety of trends (by 2035) and their conclusions are available here.

Agri-food market

Market data on national and European agriculture is available on the European Commission's website – here. Information on imports, exports, prices, production and aid schemes, is organized by theme while covering all agricultural sectors.[360]

Future trends of each agri-food sector are presented in the latest short-term outlook report for EU agricultural markets , published on 20 April 2020 by the European Commission.[361] This report takes into account the outbreak of the coronavirus which brings about unprecedented challenges for the global economy.

Food processing market

A food processor is a kitchen appliance that allows the user to easily and quickly perform monotonous food preparation activities such as chopping, grinding, and slicing. Food processors help people to convert raw food ingredients into food items through physical and chemical procedures. There are different categories of food processors - dryers, mixers, grinders, chillers, separators, feeders, roasters, ovens, fryers, slicers and homogenizers.[362]

The Europe Food Processing Machinery market was worth USD 23.03 billion in 2018 and estimated to witness a grow at a CAGR of 7.8% to reach USD 32.91 billion by 2023. Drivers of this market are rising global demand for food, rising demand for processed foods, increasing disposable incomes, changing preferences of consumers towards packaged foods as a result of increased awareness about their benefits etc. However, this market faces challenges like consumers concerned about loss of nutrients as food is processed, addition of genetically engineered ingredients.[363]

Germany has the largest market share in Europe due to both diversified offerings in foods as well as their readiness in responding tochanging customer needs andwants.[364]

[360] https://agridata.ec.europa.eu/extensions/DataPortal/agricultural_markets.html

[361] https://ec.europa.eu/info/news/short-term-outlook-despite-challenges-arising-coronavirus-outbreak-eu- agri-food-sectors-show-resilience-2020-apr-20_en

[362] https://www.transparencymarketresearch.com/food-processors-market.html#:~:text=On%20the%20basis%20of%20application%2C%20the%20global%20food,that%20the%20processing%20activities%20are%20performed%20on%20time.

[363] https://www.marketdataforecast.com/market-reports/europe-food-processing-machinery-market

[364] https://www.marketdataforecast.com/market-reports/europe-food-processing-machinery-market

Major players on the Europe Food Processing Machinery market are: Anko Food Machine Co. Ltd., Bucher industries, Berkshire Hathaway Inc., John Bean Technologies Corporation (JBT), Hosokawa Micron Corp, GEA Group among others.[365]

Food service market

Food services, also known as catering services, refer to all services for out-of-home consumption of food, including restaurants, schools and hospital cafeterias, cafés, bars, takeaway, food delivery, contract catering, cafeterias and other food vendors. The global restaurants and food services market is expected to decline from USD 2898.3 billion in 2019 to USD 2812.4 billion in 2020 at CAGR of -3%. The decline is mainly due to economic slowdown across countries because of the COVID-19 outbreak and the measures to contain it. The market is then expected to recover and grow at a CAGR of 8% from 2021 and reach USD 3456.6 billion in 2023.[366]

The European foodservice market is the second most significant area in the world for foodservice operators - North America takes the first place.[367]

The GIRA Foodservice institute provides information about the European foodservice markets - an extensive portfolio of descriptive and prospective research services to suppliers and service providers in these markets. GIRA Foodservice covers 18 European countries, providing individual country reports that analyze the restaurant and catering business in social and commercial market segments.[368]

Also, top foodservice trends of 2020 are available here.

FEED INDUSTRY

In 2018, the feed industry registered 1.103 billion metric tons and is expected to keep an upward trajectory thanks to the growing population — especially the middle class, which is increasingly showing its interest in protein consumption.[369]

[365] https://www.marketdataforecast.com/market-reports/europe-food-processing-machinery-market
[366] https://www.marketwatch.com/press-release/restaurants-and-mobile-food-services-market-current- trends-growing-demand-and-business-analysis-2020-to-2030-2020-08-25
[367] https://www.girafoodservice.com/en/catering-market/foodservice-studies-europe.php
[368] https://www.girafoodservice.com/en/catering-market/foodservice-studies-europe.php
[369] https://www.alltech.com/sites/default/files/2019-01/GFS_Brochure_2019_English%20FINAL.pdf

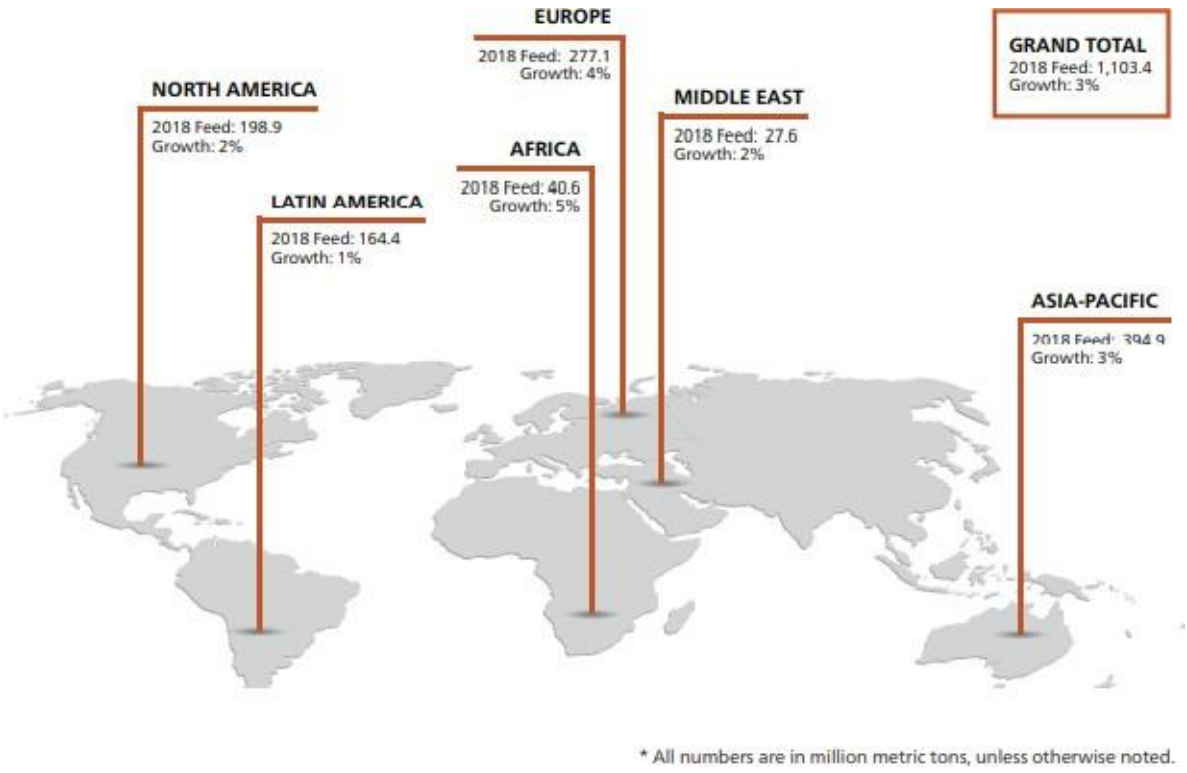

Figure 44 Global Feed Industry

Source: Alltech Global Feed Survey (2019)

European region registered increase of approx. 4% over 2017, making it the second-fastest-growing region. Growth was seen within the most of the main protein areas - layer and broiler feed production were up 7% and 5%, respectively, while the feed production of pig, dairy and aquaculture were up 3, 4 and 5%, respectively. However, when it comes to beef there was a small decline (<1%). Feed production increased in both, smaller-producing countries (Azerbaijan, Turkmenistan, Kazakhstan, Macedonia, Montenegro, and Uzbekistan), and larger-producing countries (Russia, Spain and Turkey).[370]

Graphic below shows feed production in 2018 by species (all numbers are in million metric tons).

[370] https://www.alltech.com/sites/default/files/2019-01/GFS_Brochure_2019_English%20FINAL.pdf

SWINE	
Africa	2.2
Asia-Pacific	126.8
Europe	80.0
Latin America	31.5
Middle East	0.0
North America	52.7
Total	293.2

POULTRY		
	Layer	Broiler
Africa	9.2	13.6
Asia-Pacific	68.1	112.3
Europe	32.5	55.0
Latin America	22.8	30.8
Middle East	5.5	9.6
North America	14.5	53.4
Total	152.6	304.6

RUMINANTS		
	Dairy	Beef
Africa	6.8	4.2
Asia-Pacific	24.8	12.9
Europe	44.4	21.6
Latin America	20.3	14.3
Middle East	6.6	1.5
North America	28.2	27.7
Total	131.2	82.1

OTHER SPECIES		
	Aquaculture	Pet
Africa	1.5	0.4
Asia-Pacific	28.5	3.2
Europe	4.0	8.6
Latin America	3.9	5.6
Middle East	0.5	0.1
North America	1.7	8.8
Total	40.1	26.6

Figure 45 Global feed production by species (2018)

Source: Alltech Global Feed Survey (2019)

The latest statistics (2018-2019 estimates) about the industrial compound production by countries is given here.

Europe Compound Feed Market is expected to grow at a CAGR of 4.3% from 2020 to 2025. The market drivers include increasing demand for high protein diets, especially in the Russian and German economies where per capita income is rising rapidly. However, there were several animal disease outbreaks that have resulted in growing concern over meat quality and safety, which will probably negatively impact the market growth unless responsible institutions improve regulations in the area of feed for better animal health and disease protection.[371]

Spain dominates the market. The demand for meat protein is growing in the European region particularly in Germany, Spain, Russia and United Kingdom, with rapid economic growth in the region. This rising demand for meat protein has triggered meat production in

[371] https://www.mordorintelligence.com/industry-reports/european-compound-feed-market-industry

the region, where uptake of compound feed has increased and is estimated to demonstrate a healthy growth rate. Besides improving nutritional value, **compound feed is gaining importance for their role in meat quality improvement**. Farm animals in Europe consume an estimated 478 million tonnes of feed a year, of which about 156 million tonnes are produced by compound feed manufacturers. The compound feed production of Europe can be broken down to mainly pig feed (35%), feed for broilers and laying hens (33%), and cattle feed (25%).[372]

The European compound feed market is concentrated with a couple of big players capturing a major share of the market. However, some of the players have been growing their businesses in Europe by acquiring or merging with the manufacturers in the foreign market. Prominent players on the market include Cargill, Biomin, Incorporated, Alltech, Kemin Industries, Inc, and ADM Animal Nutrition.[373]

When it comes to regulations, the only independent spokesman of the European Compound Feed Industry at the level of the European Institutions is the **European Feed Manufacturers' Federation** (FEFAC). It's role is to:

- Represent, defend and promote the interests of the European compound feed and premix industry with the European Institutions, international bodies (such as IFIF) and stakeholders platforms;
- Develop professional rules and good manufacturing practices including the sourcing of feed materials that ensure the quality and the safety of compound feed and premix;
- Encourage the sustainable development of livestock production responding to the market requirements, so as to maximise market opportunities for compound feed and premix companies, etc.[374]

At the 29th FEFAC Congress on 25 September 2020 FEFAC launched its Feed Sustainability Charter 2030 as **the European feed industry response to the EU Green Deal Objectives affecting EU feed and livestock production. The Charter contains concrete feed sector actions at EU and national level featuring animal nutrition solutions that can help increase the sustainability of livestock farming operations.**[375]

9.2.2 Conclusions

[372] https://www.alltech.com/sites/default/files/2019-01/GFS_Brochure_2019_English%20FINAL.pdf
[373] https://www.mordorintelligence.com/industry-reports/european-compound-feed-market-industry
[374] https://fefac.eu/about-us/mission/
[375] https://fefac.eu/home/fefac-feed-sustainability-charter-2030/

In the context of WaysTUP! Project, analysis of Food industry is relevant to Pilots 1, 2 and 3 since they are producing edible products. On the other hand, Feed industry is relevant only to Pilots 1 and 3 since end products of these Pilots are intended for animal feed. Analysis of these industries should provide valuable insights to these WaysTUP! Pilots that will help them with drafting their business strategies.

Food industry

The whole food industry refers to **the entire food supplying industry** from farming and food production, packaging and distribution, to retail and catering. Therefore, in order to do a comprehensive analysis of this industry, major markets of the food value chain are examined **Agri-food market, Food processing market and Food service market**, as well as EU policies and regulations related to food. Future trends that are influencing Europe's food sector should also be taken into consideration.

The Europe Food Processing Machinery market is estimated to witness a grow in the future period (with Germany which dominates the European market), thanks to numerous market driver factors. Drivers of this market are rising global demand for food and rising demand for processed foods among many other.

On the other hand, **Food Services Market is expected to decline in the future** due to economic slowdown across countries because of the COVID-19 outbreak. The European foodservice market is the second most significant area in the world for foodservice operators.

Feed industry

According to global feed industry analysis, Europe is the second-fastest-growing region. **Europe Compound Feed Market is expected to grow at a CAGR of 4.3% in the next five years. Spain dominates the market.** Also, the demand for meat protein is growing in the European region particularly in Germany, Spain, Russia and United Kingdom. The European compound feed market is concentrated with a couple of big players capturing a major share of the market.

When it comes to regulations within feed industry, **European Feed Manufacturers' Federation has a top priority as it develops professional rules and good manufacturing practices**

including the sourcing of feed materials that ensure the quality and the safety of compound feed and premix.

We also need to emphasize the importance of Feed Sustainability Charter 2030 that has been developed as **the European feed industry response to the EU Green Deal Objectives affecting EU feed and livestock production.**

9.3 Chemical Industry

9.3.1 Market analysis

The European chemical industry is a solution provider for a competitive, low carbon and circular economy in Europe and beyond. It is a wealth generating sector of the economy, and a vital part of Europe's economic infrastructure.[376] According to the **European Chemical Industry Council** or Cefic (the main European trade association for the chemical industry) the **chemical industry generates 1.1% per cent of EU gross domestic product (GDP).** This industry counts 1,71 million workers and sales of EUR 565 billion (2018), which means that it is one of the biggest industrial sectors and a dominant source of direct and indirect employment in many regions.[377]

However, even though nowadays chemical industry contributes approx. 15% of GDP, industrial investment is falling. As investment share in main production declines, and Europe is losing ground in technological capability. **Currently, European value chains are at risk**.[378]

An updated profiles of the chemical industry in the EU28 and in each country separately, is available here.

Industry is the biggest customer for EU chemicals. Graphic below shows customer sectors of the EU chemicals industry in 2017.

[376] https://www.chemlandscape.cefic.org/country/eu/
[377] https://www.chemlandscape.cefic.org/country/eu/
[378] https://www.chemlandscape.cefic.org/country/eu/

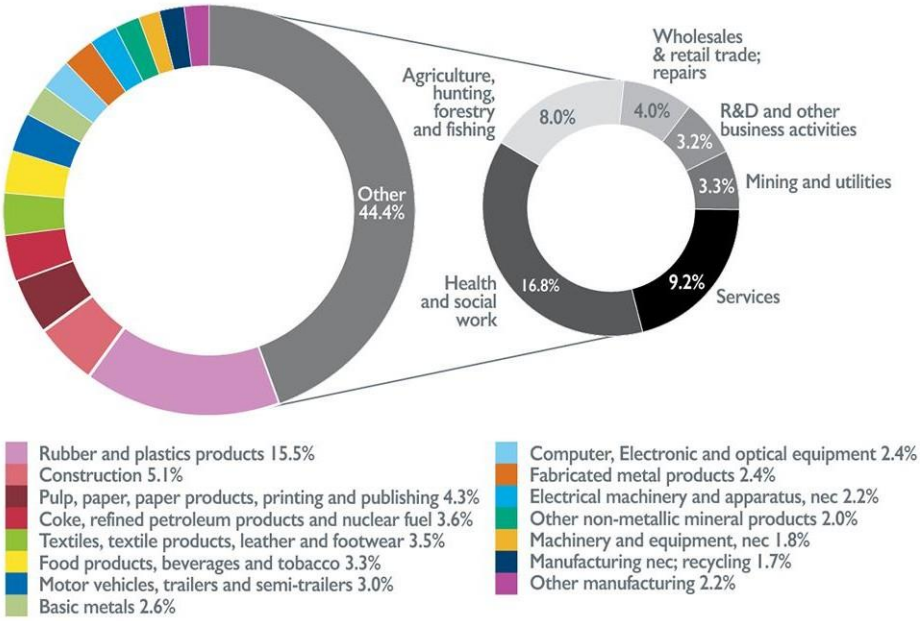

Figure 46 Customer sectors of the EU Chemicals industry (2017)

Source: European Chemical Industry Council (Cefic)

In the present circumstances, the European chemical industry is facing uncertainty, and there are no indications that the main parameters will recover in the close future. **Increasing protectionism all over the world is negatively impacting industrial and economic activity**. Moreover, the **regulatory uncertainty because of Brexit** and growing trade wars between the US and its key partners are weakening investor confidence. Also, since there is no growth in other manufacturing industries, it contributes to weaker demand in chemicals.[379]

The EU chemical production slightly declined in the first half of 2019. Total sales (domestic sales and exports) remained at the previous years' level.[380]

[379] https://www.chemlandscape.cefic.org/country/eu/
[380] https://www.chemlandscape.cefic.org/country/eu/

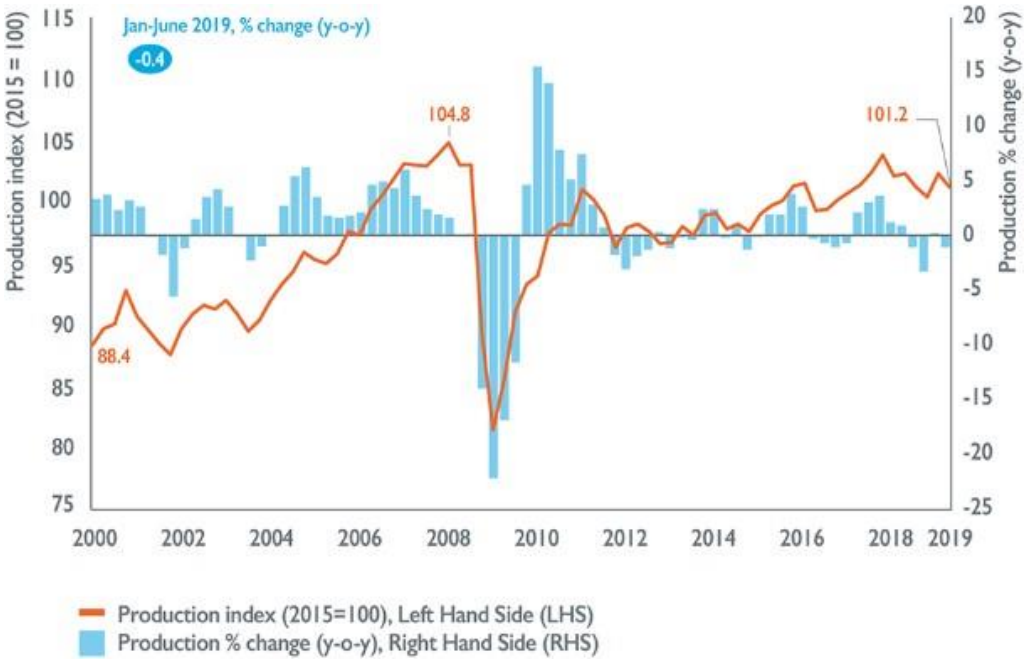

Figure 47 EU Chemical Industry production (2000-2019)

Source: European Chemical Industry Council (Cefic)

Looking at the situation worldwide - the world chemicals sales were EUR 3,347 billion in 2018, up 2.5% from EUR 3,266 billion in 2017. This is not a significant growth. With EUR 1,198 billion in 2018, **China is still the largest chemicals producer in the world**, contributing 35.8% of global chemicals sales in 2018. **The EU chemical industry ranks second by sales, slightly ahead of the United States**. Including non-EU countries, total European chemicals sales reached EUR 694 billion in 2018, or 20.7% of world output. But China has passed Europe to top the global sales ranking.

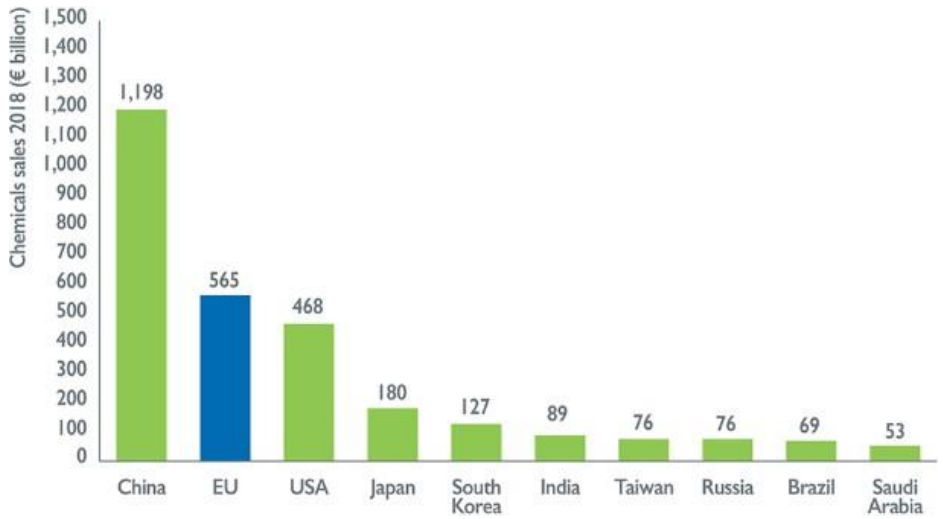

Figure 48 Chemicals sales by country (2018) - top 10

Source: Cefic Chemdata International 2019

Demand for chemicals is still strong in China and India, but it grows slowly in Europe and North America, where Europe sells most of its chemicals. Nevertheless, thanks to their technological capabilities and innovative products, especially in consumer chemicals, automotive, electronics, food and nutrition, European chemical producers are anticipated to benefit through increased exports or via local investments. EU chemical industry reached a significant extra-EU net trade surplus of EUR 48.1 billion in 2018.[381]

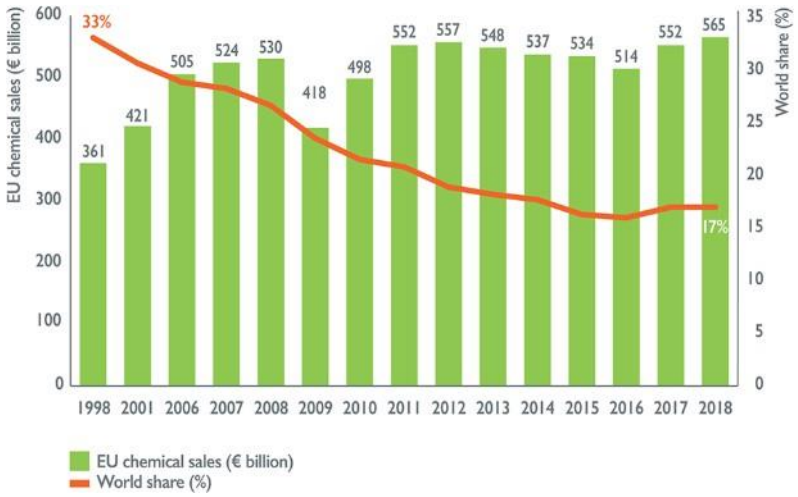

Figure 49 EU share of global chemicals market

Source: Cefic Chemdata International 2019

[381] https://www.chemlandscape.cefic.org/country/eu/

According to the Accenture's market study, by 2030 the **top seven European chemical markets** and their projected chemical use are:

- Healthcare: EUR 120 billion
- Services: EUR 70 billion. Services such as: wholesale and retail trade for recreational products, sanitation/sewage, hotel/restaurant uses, R&D chemicals, etc.
- Agriculture: EUR 31 billion
- Construction: EUR 30 billion
- Motor vehicles: EUR 28 billion
- Food and beverages: EUR 18 billion
- Industrial equipment: EUR 18 billion[382]

By 2030, world chemicals sales are expected to reach EUR 6.6 trillion. **The EU chemical industry is estimated to fall into third place** behind China, (with nearly 50% of the world market), and the US.

On the other hand, the chemical industry in Europe is still characterized by high market share in specialty **chemicals and pharmaceutical ingredients**, which **is expected to continue to grow** in the future.[383]

9.3.2 Conclusions

We recognized **chemical industry as potential end market** where end products **of Pilots 5 and 6** can be distributed to their potential customers. Therefore, insights from the analysis of European markets related to chemical industry should be particularly significant to Pilots 5 and 7. They can adjust their market strategies and overall business approaches based on our conclusions.

Chemical industry contributes to the great share of EU GDP, however, **European value chains are at risk currently** because of increasing protectionism and regulatory uncertainty caused by Brexit. Nevertheless, the EU chemical industry still ranks second by sales, behind of China which records the strongest demand for chemicals.

Forecasts predict that by 2030 European chemical markets with the greatest performance would be **healthcare, services and agriculture**, respectively.

9.4 Biofuel industry

[382] https://www.chemanager-online.com/en/news-opinions/headlines/european-chemical-industry-year-2030
[383] https://www.chemlandscape.cefic.org/country/eu/

9.4.1 Market analysis

From the global perspective, biofuel production and consumption in the United States, the European Union and Brazil appear to be shifting gears. As WaysTUP! Pilots are focused on production and distribution of their end products in Europe, biofuel market of this region will be further analyzed.

Europe biofuel market is expected to rise at a CAGR of more than 4% during the forecast period of 2020-2025. The growth of European biofuels market is primarily supported by different policies and regulatory frameworks in this area, availability of feedstocks, and several incentives provided by governments in the region. Factors that drive the European market include increasing concerns about the environment, fuel diversity, peak oil, energy security, and sustainability. On top of that, in 2019, the European Union and Climate Change Package (CCP) with Fuel Quality Directive (FQD) announced **the mandatory goals for 2020 is a 20% binding target for renewable energy in the overall energy mix of the EU and a 10% renewable energy blending target (energy basis) for the transport sector**. However, there are also certain restraints regarding biofuel production - the initial cost of providing energy in such a way is much higher than fossil fuels.[384]

Europe is the most significant consumer of **biofuels in the form of biodiesels and ethanol**. Biodiesel remains the vital fuel for heavy-duty vehicles used on the road, in construction, agriculture, and mining, and by other heavy industries with improving engine efficiency, offsetting increased demand tied to economic growth. It represents about 75% of the total transport biofuels market.

If we analyze European biofuel market across countries, we can see that **Germany is the largest consumer of biofuel in the EU and it is estimated to be the largest biofuel market in the future**. Germany mostly exports biodiesel, but imports ethanol, mainly from Argentina and Indonesia. Factor that contributes to the biofuel market growth in the country refers to the fact that Germany is the third-largest producer of wood pellets in Europe. And since the Germany government does not support wood pellets to be used in the generation of electricity, it can be used to produce biofuels in the country.[385]

Besides Germany, **the main European centers of biofuels production are located in Spain, Sweden, and France.** The U.K and Italy biofuel and biodiesel market are also fast developing. Italy biofuel and biodiesel markets are expected to record the highest growth in the

[384] https://www.mordorintelligence.com/industry-reports/europe-biofuel-market
[385] https://www.mordorintelligence.com/industry-reports/europe-biofuel-market

upcoming period. The Italian biodiesel operators include two categories: oilseed crushers and biodiesel producers.[386]

European Biofuels Market segmented by countries is presented below, covering the 10-year timeframe between 2016 and 2026.

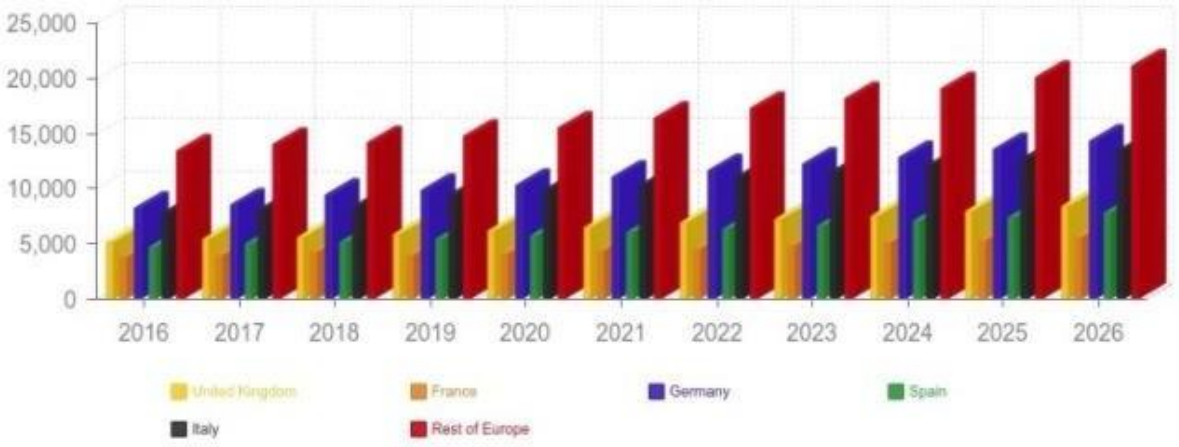

Figure 50 Europe Biofuels Market, By Geography (in $ Million)

Source: Inkwood Research

In the Netherlands, consumption of biofuels increases with higher mandates, but the leading share of the combined mandate (biodiesel and bioethanol) is filled with double-counting, waste-based biodiesel.

There is a gradual reduction of the cap on crop-based biofuels in the United Kingdom, which means that waste biodiesel is likely preferred above domestically produced wheat and sugar beet ethanol or any other biofuels.

When it comes to Greece, this country is not among the most prominent countries on the European biodiesel market. However, **biodiesel production capacities in Greece are very high**. Optimization of the use of residues and processing of by-products could also be crucial to improve biodiesel economics.[387]

Increase biodiesel uses for heating applications may also provide more market opportunities in Europe. The introduction of a 'policy mix' with tax exemptions & mandatory targets will enable to create more certain market conditions.

[386] https://www.inkwoodresearch.com/reports/europe-biofuels-biodiesel-market/
[387] https://biodieselgreece.blogspot.com/2016/03/swot-analysis-of-biodiesel-market-in.html

Furthermore, According to European Biodiesel Board (EBB), EU biodiesel consumption is expected to increase 3% as a result of mandate increases in several Member States (Croatia, Finland, Hungary, Ireland, Italy, the Netherlands, Poland, Slovakia, and the United Kingdom) and a rebound in the Czech Republic.

Some of the key players in Europe biofuel market include, UPM-Kymmene Oyj, Green Fuel Nordic Oy, Svenska Cellulosa AB, Preem AB, SunPine AB, Galp Energia, SGPS, S.A., Biomethanol Chemie Nederland B.V., Beta Renewables S.p.A., Borregaard ASA and others.

9.4.2 Conclusions

Pilots 5 and 6 are producing sustainable bio-solvents, and both of them focus on bioethanol production. Therefore, these Pilots should target biofuel industry as their potential end market. That said, capturing trends within this industry is valuable for these Pilots as it can help them with their entrance to biofuel markets and further positioning.

Europe is the most significant consumer of biofuels in the form of biodiesels and ethanol. Europe biofuel market is expected to rise in the next five years, primarily because of **supportive policies and regulatory frameworks** in this area. **Germany is the largest consumer of biofuel in the EU** and it is estimated to be the largest biofuel market in the future. Besides Germany, **the main European centers of biofuels production are located in Spain, Sweden, and France.**

Pilot 6 will take place in L'Alcudia, Spain, while Pilot 5 will be located in Athens, Greece. Even though, we've found out that **Greece is not among the most prominent countries on the European biodiesel market, biodiesel production capacities in Greece are very high**.

9.5 Bio-Fertilisers

9.5.1 Market analysis

A biofertilizer (also bio-fertilizer) is a substance which contains living micro-organisms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant.[388] Biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth-promoting substances. The microorganisms in biofertilizers restore the soil's natural nutrient cycle and build soil organic matter. Through the use of biofertilizers, healthy plants

[388] https://en.wikipedia.org/wiki/Biofertilizer

can be grown, while enhancing the sustainability and the health of the soil. Biofertilizers can be expected to reduce the use of synthetic fertilizers and pesticides, but they are not yet able to replace their use.[389]

The global biofertilizers market size was valued at USD 1.0 billion in 2019 and is anticipated to witness a CAGR of 12.8% from 2020 to 2027. The increasing usage of microbes in biofertilizers shows the potential of sustainable farming methods and food safety. The rising concern about food safety is expected to drive the market for biofertilizers in the future.[390]

Nitrogen-fixing biofertilizers had the largest market share of 71.2% in 2019, in terms of volume. This market domination is attributed to **correction of heavily contaminated soil and water reserves caused by the worldwide usage of synthetic fertilizers for decades**. biobased fertilizers provide high phosphorus content to the soil (and several other essential minerals), fixed nitrogen presence and these factors are necessary to plant growth. Moreover, use of biofertilizers impacts on the healthy development of plants without any adverse effect on human health or on the environment.[391]

Nitrogen-fixing bacteria are most commonly utilized biofertilizers as plants do not have the ability to convert atmospheric nitrogen into fixed nitrogen, and it is crucial for their growth. Azotobacter, Rhizobium, and Azospirillum are the majorly used bacteria for nitrogen fixation in seed and soil treatment applications. Nitrogen-fixing Rhizobium can develop endosymbiotic association with the roots of legumes, which paves its way for use as biofertilizers in the cultivation of leguminous crops. Aerobic nature of Azotobacter along with its neutrality in alkaline soil has increased its application scope in the cultivation of crops including maize, wheat, cotton, mustard, and potato.[392]

However, Bacillus, Pseudomonas, and Aspergillus are the majorly used bacteria for providing phosphorous macronutrients to plants. These biofertilizers are able to **hydrolyze organic and inorganic phosphates from insoluble compounds through the involvement of soluble bacteria.** Across Asia Pacific, countries such as India, Australia, China, and Thailand predominantly depended on synthetically formulated phosphate fertilizers. Major agricultural input companies have their decades-old facilities in the region serving the region's local farming base with synthetic fertilizers, which slightly acts as a restraining factor for phosphate solubilizing products across Asia Pacific.[393]

[389] https://en.wikipedia.org/wiki/Biofertilizer
[390] https://www.grandviewresearch.com/industry-analysis/biofertilizers-industry
[391] https://www.grandviewresearch.com/industry-analysis/biofertilizers-industry
[392] https://www.grandviewresearch.com/industry-analysis/biofertilizers-industry
[393] https://www.grandviewresearch.com/industry-analysis/biofertilizers-industry

Besides from nitrogen-fixing biofertilizers and phosphate solubilizing products, which are the two majorly demanded products worldwide, multinational companies operating in this area are also focusing on mass commercializing potassium mobilizing biofertilizers, zinc solubilizing products, and NPK consortia liquid products. Silicate bacteria are among the most common potassium solubilizing bacteria, which includes Bacillus glucanolyticus, B. mucilaginous, B. circulans, and B. edaphicus.[394]

When it comes to the crop type insights, the cereals and grains segment held the largest volume share of 76.4% in 2019. Cereals and grains production demand a substantial quantity of biofertilizer for healthy development. Studies conducted worldwide indicated that cereal and grain crops reflected high development and growth with Azotobacter inoculation which aided in reducing nitrogen requirement by crops. Further, for healthy development of wheat, phosphate solubilizing bacteria and Azoteobacter inoculation proved highly efficient biofertilizers in terms of crop yield. Utilization of these for cereal and grain cultivation results in high vegetation growth, and high photosynthesis activity.[395]

Oilseeds and pulses are anticipated to record the fastest growth, in terms of volume, with CAGR of 12.2% in the biofertilizers market from 2020 to 2027. Growing demand for soybean, sunflower, and groundnuts across the globe are considered to the key benefiting factor behind the product's application in oilseeds and pulses sector. Further, with multiple microbiological advancements in determining the suitable composition of biofertilizers for application in wheat cultivation among major cereals & grains cultivation, the demand is projected to reflect high growth over the forecast period worldwide.[396]

In terms of volume, **seed treatment application dominated the market** with a share of 73.2% in 2019, majorly driven by the benefits of induced nutritional values in the seeds. Aggressive consumption of synthetic fertilizers and a multitude of other crop care chemicals such as pesticides and insecticides over the past couple of years have led to a substantial deterioration in soil quality across all major agrarian economies. However, several governments have imposed regulations on agricultural sector across all developing and developed economies taking into consideration the environmental hazards caused due to excessive use of chemical products in farming, which is projected to reflect a positive growth trend for biofertilizers in various seed and soil applications across the globe.[397]

Seed inoculation or seed treatment is one of the most significant points of application globally. Seed treatment includes dipping of the desired seeds in a mixture of phosphorus

[394] https://www.grandviewresearch.com/industry-analysis/biofertilizers-industry
[395] https://www.grandviewresearch.com/industry-analysis/biofertilizers-industry
[396] https://www.grandviewresearch.com/industry-analysis/biofertilizers-industry
[397] https://www.grandviewresearch.com/industry-analysis/biofertilizers-industry

and nitrogen fertilizers. Later, the seeds are sun-dried and subsequently sown in the fields. The inoculant coating made on the seeds enables quick and healthy growth of the plants. The key objective of incorporating biofertilizers during seed treatment is majorly to induce essential nutrients such as sulfur, zinc, nitrogen, and phosphorus, which enhance the nutritional value of vegetables & fruits and cereals & grains.[398]

North America dominated the market with a share of 32.6%, in terms of revenue, in 2019. According to The World of Organic Agriculture in 2017, around 0.8% of the total agricultural land was used for organic farming in North America, which is expected to reach around 5% by the end of 2020. Increasing government interventions in farming practices held in the region led to significant changes in agricultural trends & methods across the US and Canada. With stringent regulations in place, over 19,017 farming communities are practicing organic farming in the region to ensure sustainable long-term business.[399] Favorable regulatory scenario, especially in North America and Europe is expected to be a key driving factor for the market for biofertilizers over the next couple of years across these regions.

Europe was the second-largest consumer of biofertilizer and held a 30% share of the global biofertilizer market in 2019. Owing to the imposition of stringent regulations on the use of chemical fertilizers in Europe, the use of chemical fertilizers tends to be replaced by biological fertilizers. The European Union is continuously encouraging the use of biofertilizers since they are cost-effective, advising the farmers to optimize the application of chemical fertilizers or replace them wholly or partly with eco-friendly ones to result in better economic return. The EU Common Agricultural Policy promotes the adoption and use of bio-based products, along with organic farming, and provides up **to 30% of the budget as direct green payment to farmers to maintain sustainable agricultural practices**. The growth of the European biofertilizer market is mainly due to the rising penetration of biofertilizers in agriculture and the growing demand for organic products.[400]

The demand for biofertilizers in the region has been increasing due to the increasing practice of organic farming. In 2017, the **major countries based on organically farming land** were **Spain** (16.6%), **Italy** (15.2%), **France** (13.9%), and **Germany** (9.1%). In 10 European states, arable land crops accounted for more than 50% of the organic area, followed by permanent crops and permanent grassland. The newly revised regulation in Europe related to organic production encourages the sustainable development of organic produces. According to German league for organic food production (BÖLW), the organic food market in Germany grew to EUR 9 billion in 2016, and at the end of 2016, there were 27,000 organic-production

[398] https://www.grandviewresearch.com/industry-analysis/biofertilizers-industry
[399] https://www.grandviewresearch.com/industry-analysis/biofertilizers-industry
[400] https://www.mordorintelligence.com/industry-reports/europe-biofertilizers-market

holdings in Germany. The rise in demand for organic products is booming due to an increase in consumer awareness about the toxicity of synthetic fertilizers. In addition to this, increasing incomes, along with improved farming practices, make organic yields more robust. Thus, the increasing demand for organic food has increased the area under organic farming, resulting in increased demand for biofertilizers.[401]

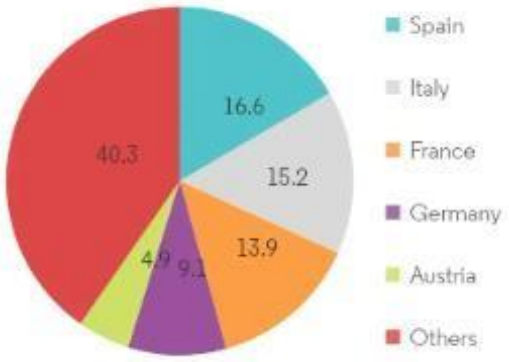

Figure 51 Europe Bio-fertilizers Market: Organic Farming Shares in %, by countries (2017)

Source: FIBIL Statistics, Mordor Intelligence

The **Spanish market majorly influences the European region**. The Spanish biofertilizers market was estimated to value USD 91.4 million in 2018. Researchers from the Centre for Plant Biotechnology and Genomics (UPM-INIA), Madrid, developed a **method to obtain clean organic fertilizers that can regenerate degraded soil caused by overharvesting**, in 2015. They have developed a technology to produce a biofertilizer from the chitin of the exoskeletons of crustaceans and insects. These innovations are further driving the biofertilizers market in Spain. The rise in the cost of synthetic fertilizers also has, in turn, led to the high usage of bio-based fertilizer products in Spain.[402]

Investments in R&D and the introduction of new products are the primary strategies adopted by all major companies involved in the biofertilizer market.[403] Prominent players on the European biofertilizer market are: Symborg SL., Gujarat State Fertilizer & Chemicals (GSFC), Lallemand, Novozymes, Biomax, Agri Life, Ajay Bio-Tech Ltd. and Antibiotice S.A.[404]

9.5.2 Conclusions

Markets of bio-fertilisers is analyzed in order to help Pilot 7 to gain an overview of its potential end industry.

[401] https://www.mordorintelligence.com/industry-reports/europe-biofertilizers-market
[402] https://www.mordorintelligence.com/industry-reports/europe-biofertilizers-market
[403] https://www.mordorintelligence.com/industry-reports/europe-biofertilizers-market
[404] https://www.marketdataforecast.com/market-reports/europe-bio-organic-fertilizer-market

The **global biofertilizers market is expected to grow** in the next seven years due to growing need of correction of heavily contaminated soil and water reserves caused by the worldwide usage of synthetic fertilizers for decades. **Oilseeds and pulses** are anticipated to record the fastest growth. In terms of volume, **seed treatment application dominated the market** with a share of 73.2% in 2019, majorly driven by the benefits of induced nutritional values in the seeds. It is one of the most significant points of application globally.

The EU Common Agricultural Policy promotes the adoption and use of bio-based products, along with organic farming, and provides up to **30% of the budget as direct green payment to farmers to maintain sustainable agricultural practices. Spain, Italy, France and Germany** are recorded to be the major countries based on organically farming land. Therefore, these countries **are probably open to importing quality biofertilizers** from other countries worldwide. All major companies involved in the biofertilizer market invest in research and development in order to improve their current products and to generate new products.

9.6 Other Potential End-users/Industries of interest

Following our methodology, after the elaboration of all the industries representing target markets of WaysTUP! Pilots, we utilized Pilots' feedback from the questionnaire in order to identify other potential industries of their interest. NTUA Partner emphasized biogas industry as one of their current markets in relation to the technology that they are using. As we haven't mentioned this industry in report yet, this chapter will be dedicated to it.

Biogas industry

Biogas is a renewable energy gas resource comprising methane and carbon dioxide. It is produced from the anerobic digestion using microorganisms and from the decomposition of organic waste. Biogas is used as a fuel for the electricity generation and also utilized to produce heat for the space heating and cooking applications.[405]

By feedstock, European Biogas Market is segmented to organic waste (food waste, paper waste, slaughterhouse waste etc.), sewage sludge, energy crop and others. The most favorable resources for the biogas production are energy crops and organic waste. Rising waste generation from urban centers coupled with shifting trends toward resource recovery will propel the industry growth in coming years.[406]

[405] https://www.gminsights.com/industry-analysis/europe-biogas-market
[406] https://www.gminsights.com/industry-analysis/europe-biogas-market

Geographically, **Germany biogas market has the biggest share in the European Biogas Market.**[407] Germany biogas market is expected to growth significantly because of supportive regulatory schemes toward utilization of biogas for electricity production. In 2017, the government of Germany introduced Renewable Energy Sources Act which aims toward prioritizing renewable based electricity generation. Easy availability of feedstock coupled with declining cost of biogas production technologies will further enhance the industry growth. On the other hand, the **UK biogas market** is estimated to witness growth of over 10% by 2025. Government supported investment programs and feed-in-tariff schemes will further enhance the business landscape in coming years. **Other major biogas producing countries in the region are Italy, France, and Switzerland**.[408] In addition, other European countries have announced nationally determined targets toward clean fuel adoption which will further complement the business landscape.

Prominent market players include EnviTec Biogas, Weltec Biopower, Scandinavian Biogas Fuels International, Gasum, Agrinz Technologies, PlanET Biogas Global, Viessmann Group, Agraferm Technologies AG, BDI - Bioenergy International GmbH, Xergi, AB Holding and Engie.[409]

9.7 Industry Trends Under COVID-19

Each industry that has been analyzed within this chapter needs to be examined from the aspect of COVID-19 pandemic in order to understand all the sudden issues that appeared as a result of this large-scale health crisis. According to our previous analysis of trends under COVID-19, most industries are facing certain challenges and demand restrictions. However, some actors on the market can benefit from the current situation, since there are markets on which pandemic have a positive impact – such as insect edible market.

Impact of COVID-19 on the plastics market

Shipping complications, cancellations, and work from home rules are cascading throughout the plastics industry value chain as a result of the COVID-19 pandemic and, in turn, is expected to **negatively impact the global plastics market growth** over the near future.[410]

[407] https://www.statista.com/statistics/985862/turnover-biogas-industry-eu/
[408] https://www.psmarketresearch.com/market-analysis/biogas-market
[409] https://www.gminsights.com/industry-analysis/europe-biogas-market
[410] https://www.grandviewresearch.com/industry-analysis/global-plastics-market

On the other hand, we are witnesses that **plastic products actually help to fight the pandemic.** Currently, medical devices and personal protection equipment are being produced with all available capacities. Also, anti-bacterial vinyl flooring in hospitals, cleaning equipment and packaging for soaps, disinfectants, and food, are plastic products that play a significant role in the time of pandemic. Plastic packaging is extremely important to secure the functioning of our supply chains for food and other essential goods that could have been broken up during this crisis. Furthermore, it has been noted that even some companies that were not previously involved in the manufacture of personal protection equipment or medical devices are now changing their production lines to provide these much-needed goods.[411]

The European plastics converting industry will continue its transition to a circular economy that has been institutionalized in the Circular Plastics Alliance. However, considering the current state, some flexibility in achieving certain deadlines by 2025 need to be considered during this COVID-19 crisis.

Impact of COVID -19 on the food and feed industry

COVID-19 affects the feed industry in different ways. On the grocery and retail side, **panic buying and hoarding are encouraging the sale of frozen foods, canned goods, meat and dairy products**, which could be good for some; nevertheless, the foodservice industries will definitely be hit hard as institutions temporarily close and diners shy away from public spaces. Another challenge that feed industry faces are **supply chain disruptions**. While the virus has only begun to impact some regions, down-chain suppliers in key sectors are struggling to meet demand. This is quickly becoming evident with micro-ingredients, such as vitamins and minerals. The closure of factories and ports would make an even harder situation for the supplies. That said, the animal feed industry is expected to brace for higher commodity costs due to limited availability and delayed deliveries.[412]

A closer look to the updated impacts of COVID-19 on the global feed sector can be found here.

Impact of COVID -19 on the chemical market

[411] https://www.plasticsconverters.eu/post/how-plastic-products-contribute-to-the-fight-against-covid-19
[412] https://www.feedstrategy.com/blog/4-ways-covid-19-may-impact-feed-production/

The chemical industry has been noticing the adverse effects of the COVID-19 outbreak. Many production facilities of several end-user industries have faced **heavy losses and temporarily shutdowns.** With this, the demand for chemicals used in these facilities has been declined. However, with the outbreak of this pandemic, a **rise in the demand for packaging materials** has been increased to prevent the contamination of food, medicine, personal care, and medical products thereby creating a significant demand for chemicals involved in the packaging industry.[413] Also, another market driver is a **sustainable demand for antimicrobial additives to stop the growth of microbes**.

Currently, high demand for textile fabrics for health and hygiene measures presents a major market opportunity. Also, new entrants and existing players are focusing on mass production of chemicals for sanitizers.[414]

Impact of COVID -19 on the biofuel market

The impact of Covid 19 is particularly acute in oil product markets, as restrictions on international travel and regional and local movement prevent people and goods from circulating freely, which takes a heavy toll on transport fuel demand.

In Europe, restrictions on movements and social contact have spread almost as fast as the virus itself, e.g. disrupting industrial production and lowering trade and shipping activities. Moreover, the peak is yet to come, as officials warn that the number of cases will continue to grow.

It is hard to measure an impact on the global biofuels market. However, it is expected that biodiesel and bioethanol demand will getlower.[415]

9.8 Conclusions

Chapter 9 refers to **plastic, food and feed, chemical and biofuel industries**, as well as **biofertilizer market** since end products of WaysTUP! Pilots will be mainly distributed on these

[413] https://finance.yahoo.com/news/worldwide-chemical-industry-affects-covid-115854912.html
[414] https://www.marketresearchfuture.com/covid-19-analysis/covid-19-impact-chemicals-materials-market-9548
[415] https://ihsmarkit.com/research-analysis/how-covid19-will-affect-global-biofuels-demand.html

markets where their key end users are present. Therefore, these markets are recognized as key drivers of the future WaysTUP! Pilots' value chain growth and development.

Chapter 9.1 is dedicated to **European plastic industry** and related to WaysTUP! Pilot 4. Key finding of our analysis include that Germany, Italy, France, Spain, United Kingdom and Poland cover almost 80% of the European demand and that the packaging market is among the highest applications of bioplastic materials. This is relevant for **Pilot 4** as it aims to provide monomers and PHAs, and long chain dicarboxylic acid to bioplastics for packaging. Packaging is the largest end-use market of European Plastics Industry and is expected to grow in the upcoming period, together with the whole European plastic industry.

Chapter 9.2 refers to **Food and Feed industry** that are related to **Pilots 1,2 and 3**.

Since Pilot 1, 2 and 3 are producing end products that are intended for human food, information about current state and future trends in the European food industry can contribute to their future market positioning.

Even though, analysis of the whole food industry requires very broad and comprehensive exploration of lots of food-related markets, we tried to provide basic insights and focus on the most relevant facts.

Germany which dominates the European Food Processing Machinery market that is expected to grow in the future due to rising global demand for food. However, Food Services Market is expected to decline in the future due to economic slowdown across countries because of the COVID-19 outbreak. By further examination of other sources provided in the chapter 9.2, Pilots will be able to identify which markets across the European food industry offer most opportunities.

Feed industry is recognized as end industry for **Pilots 1 and 3**. Hence, in order to help them with their realization we identified key insights from this market, in the European region.

Europe is the second-fastest-growing region of the global feed industry. The demand for meat protein is growing particularly in Germany, Spain, Russia and United Kingdom.

From the perspective of regulations within feed industry, European Feed Manufacturers' Federation is the most relevant institution which develops professional rules and good manufacturing practices. T

he latest document that has a huge importance for the whole European feed industry is Feed Sustainability Charter 2030.

Chapter 9.3 is dedicated to **chemical industry**, as it is related to **Pilots 5 and 6** of our Project. The final realization of their end products (biosolvents) is possible on European chemical

market. In order to prepare Pilots 5 and 6 for their entrance to this market, we capture current situation and future trends of European chemical market.

Significant European industry is not in a good condition currently, but it is still very powerful on the global level, right behind the most dominant player - China. European value chains are at risk because of increasing protectionism and regulatory uncertainty caused by Brexit. Nevertheless, recovery is expected in the upcoming period and chemical markets with the most potential are healthcare, services and agriculture, respectively.

Chapter 9.4 refers to **biofuels industry** as **Pilots 5 and 6** are most likely going to place their end products biosolvents, especially bioethanol, to European biofuels markets.

Europe is the most significant consumer of biofuels in the form of biodiesels and ethanol. European biofuels market will grow in the future, thanks to supportive policies and regulatory frameworks. The most prominent countries in this area are Germany, Spain, France and Netherlands. This fact sounds promising for Pilot 6, which is located in Spain.

Pilot 5 is located in Greece, where, as we concluded, biodiesel production capacities are very high.

Chapter 9.5 refers to **Bio-fertilisers market** that is relevant to **Pilot 7**, that produces biochar.

Trends within Bio-fertilisers market will directly influence the success of Pilots' 7 biochar market realization.

The global biofertilizers market is expected to grow in the future period, while seed treatment application is estimated to maintain the market dominance, thanks to the high nutritional values in the seeds.

EU supports sustainable agricultural practices, financially and by its policies. Spain, Italy, France and Germany are countries that are dedicated the most to organically farming land in comparison to the other European countries. It suggests that most opportunities regarding distribution of biofertilizers products lies within these countries.

Chapter 9.6 is dedicated to **Biogas industry** as it is recognized as current market (among others) in relation to the technology that they are using, of one of the **Pilot 5** Partners.

By analyzing this industry, we found out that the most favorable resources for the biogas production are energy crops and organic waste. Also, in the European Biogas Market Germany biogas market has the biggest share, which is expected to grow in the future. The main reason for this is probably because the government of Germany adopted Renewable Energy Sources Act which aims toward prioritizing renewable based electricity generation.

Other major biogas producing countries in the region are UK, Italy, France, and Switzerland.

Chapter 9.7 captures **industry trends under Covid 19**. The purpose of this chapter is to find out how this global health crisis will impact industries analysed and therefore affect WaysTUP! Pilots.

Impact of Covid 19 on the plastic industry is twofold. First, restrictions and work from home measures negatively impact plastics industry value chain. However, since plastic products can actually help to fight the pandemic, production of plastic goods is increasing.

Impact of Covid 19 on the food and feed industry is also twofold. On one hand panic buying and hoarding are boosting the industry. One the other hand, foodservice industries are suffer losses because of lockdowns and other government measures.

Feed industry faces are supply chain disruptions. The closure of factories and ports will lead to higher commodity costs due to limited availability and delayed deliveries.

COVID -19 brings heavy losses and temporarily shutdowns of many production facilities of several end-user industries, and it negatively affects the chemical market. Nevertheless, there is a rise in the demand for packaging materials and a sustainable demand for antimicrobial additives to stop the growth of microbes.

When it comes to the impact of COVID -19 on the biofuel market - decrease of transport fuel demand due to restrictions on movements negatively impacts biofuel market.

10. Competitive Landscape

A competitive landscape analysis should provide a complete description of the potential competitors of a company and their relative position at a particular market. This strategic marketing concept includes exploration of rivalry that businesses and their products face at the markets.

However, in our case, currently it is not possible to do a comprehensive direct competitor analysis because WaysTUP! Pilots' products are still in preparation phase – therefore, their final products are not on the market since they haven't been made yet. We are lacking information such as product quality, price or business models that Pilots will use, and such information are crucial for the comparison between market competitors. Nevertheless, what we can do in this stage, is **an initial scanning of competitive landscape**. The purpose of this approach is twofold. First, we will **identify who are the most prominent players on the Pilots' potential markets**, that are actually Pilots' future competitors. Second, we will try to understand **main attributes of competitors' market strategies, vital strengths of their products, as well as their current weaknesses**. By knowing this information, Pilots will be able to brainstorm about what could be their potential advantages in comparison to their future competitors, as well as what characteristics of their businesses should be improved.

Initial scanning of competitive landscape should start by defining relevant markets for WaysTUP! Pilots. However, since we have already identified relevant markets in the previous chapters within different market break-ups related to technologies that Pilots use, their end products and targeted end-industries, the aim of this chapter will be to further analyze several major players operating on these markets. The analysis will include products that competitors offer and their main strengths, competitors' current market strategies and issues they are facing or business areas they need to improve. This information is valuable for Pilots because it supports decision makers when defining and evaluating their strategies.

10.1 Competitors Segmentation (based on Technological Process, End-Product, End-Industry)

10.1.1 Pilots' Competitors based on technology type

No. Of Related Pilot	Technology type – Related Market

1, 4, 5, 6	FERMENTATION - European fermented ingredient market			
Competitor	**Products – categorized into groups**	**Main Strengths of products**	**Current Strategy**	**Weakness/Current issue/Area to improve**
Ajinomoto Foods Europe SAS France	Enzyme Preparations; Sweeteners; Savory Seasonings; Umami	Sodium, Sugar and Fat Reduction; Texture Improvement; Binding; Key Ingredient Reduction; Taste Improvement	Rely on our large portfolio of ingredient; Several dozen R&D bases in fourteen countries perform lateral technological collaboration to achieve highly specialized solutions for global markets.	Company does not conduct online orders; None of their products are certified as Kosher.
Chr. Hansen Holdings AS Denmark	Food cultures & enzymes, Natural colors, Products related to plant and animal health, Probiotic supplements	They are pioneering microbial science to improve food, health and productivity for a sustainable future.	Company invests in greener production and it made a strong climate commitment by joining the UN initiative to limit the global temperature rise to 1.5°C. Company's 2025 Strategy is available here	Process of bringing products to market is not fast enough.
Kerry Group Ireland	Taste, Food, Nutrition, Function, Foodservice, Beverage, Pharma and Biotechnology	Sugar reduction in drinks, Creating coffee with NON-GMO grass-fed dairy, Improving the quality and durability of burger buns, Delivering taste experience for meat	Creating better tasting, more authentic and nutritious food and beverages. Their consumer-led approach means they predict growth opportunities earlier to innovate faster.	The foodservice channel in the region was significantly impacted by Covid-19 in the first half of 2020, as most operators were temporarily closed for an extended period of time. Recovery

		alternatives		followed when restrictions began to lift.
2	**EXTRACTION - Global Extraction Solvents Market**			
Merck KGaA Germany	Healthcare, Life sciences, Performance materials	Specialized and high-quality products	Risk diversification strategy with three distinct business sectors, and theyavoid overexposure to any single customer, industry, or geography; Always pushing the boundaries to find new solutions and drive innovation; Mergers and acquisitions (M&A) are an important driver of their long-term value creation strategy with a focus on innovation-driven technology.[416]	Their e-commerce platform can be further developed
2	**EXTRACTION - European food flavor market**			
Firmenich SA Switzerland	PERFUMERY, INGREDIENTS (synthetic and natural) AND FLAVORS: Sweet flavors across various categories (Dairy, Dietary & Nutrition, Bakery & Cereals,	Organic, healthy products, high-performance flavors, great taste	Consistent innovation to anticipate what the consumer needs Find out more here.	Areas to improve in the future: Create a Firmenich Sustainability Academy to train 100% of their workforce on social and environmental topics; Extend

[416] https://www.merckgroup.com/en/annualreport/2019/combined-management-report/fundamental- information-about-the-group/strategy.html

	Confectionery, Pharmaceuticals, Desserts); Beverages; Savory			their apprenticeship programs to all geographic regions etc.
Symrise AG Germany	NUTRITION, SCENT & CARE, FLAVORS: Culinary, Snacks, Sweet, Dairy, Beverages	Healthy, natural, high quality, exciting	1. Deliver unparalleled consumer insights 2. Pioneer with cross-divisional research and development teams 3. Work with the right suppliers in the right way 4. Best quality production processes	Areas to improve in the future: Increase transition from a product developer and manufacturer to a comprehensive solution provider through digitized and networked processes.
3	**LARVAL BREEDING - Global Insect Feed Market**			
Multibox United Kingdom	Insects are processed into fish or animal feed and a number of grades of fertiliser.	Good nutrient value, no cost to the environment	*Our aim is to be the lowest cost producer selling into a commodity market. We've partnered up with Europe's finest and brightest to enter new geographies with our proven insect technology and deliver market lead insect research to commercialise new verticals.*	It's difficult to find appropriate waste producers, investors and insect farmers/ entomologists who are interested in becoming consultants of a company
nextProtein France	NextProtein - A dry protein powder used as a feed ingredient for aquaculture, pet food and other	High-yield quality of the Black Soldier Fly; Products are approved by the EU for aquaculture	NextProtein is backed by a range of high-profile European investors	Company is trying to shift towards a full circular economy, moving away from the industry standard of using cereal

	animal feed. NextOil - A lipid product for use as a feed ingredient for aquaculture and other animal feed. NextGrow - A natural fertilizer made from Black Soldier Fly frass and their organic waste, for use in agriculture.	feed, and can be used for feedstocks for the poultry and pork industries and for pet food.		by-products as a main feed source for the insects to focus instead on wasted fruits and vegetables, in order to reintegrate them into their food systems.[417]
Protix The Netherlands	Proteinx – Pet food and aquaculture Lipidx – insect oil Pureex – ingredient that can be used as base for wet pet food Flytilizer – fertilizer Oerei – feed for chickens Friendly fish – insects in aquaculture	Nutritional, functional properties, structure-forming capabilities; healthy and natural; hypoallergenic and fresh ingredient	Protix invests in technology supporting sustainable growth. Science is at the core of what they do, and they have a strong focus on research and engineering to continuously further improve quality, controllability, efficiency and overall competitiveness. Also, Protix has forged key partnerships over the last years.	/
7	**SLOW PYROLYSIS - Global Bio-Oil Market**			

[417] https://kawa-news.com/en/a-french-tunisian-startup-changes-the-future-of-sustainable-agriculture-with- insect-proteins/

Biopetrol Israel	Synthetic oil, Gas and Solid residue	Process of high utilization of the organic matter that is in the sewage sludge produces oil and gas in larger quantities and of better quality.	BioPetrol's Strategy – Three Potential Products/Services: 1. Disposal of Sewage Sludge 2. Synthetic Crude Oil 3. Selling the Technology	Biopetrol Ltd. is still at the early stage of development.
Neste Oil Rotterdam The Netherlands	Renewable Road Transport, Renewable Aviation, Renewable & recycled plastics, Renewable chemicals, Marine, Base Oils, Fossil products	Top quality Group III base oils, Eco-friendly products, safe, reliable	As part of Neste's renewed strategy, the company introduced two new ambitious climate targets: - To reduce customers' greenhouse gas emissions with its renewable and circular solutions by at least 20 million tons CO2eq annually by 2030 - To reduce the carbon footprint of Neste's production ahead of EU's climate and energy targets.[418]	Company has already created lots of powerful strategic partnerships, but it is always looking for more. Therefore, this can be recognized as an area to improve in the future.
Ital Bi Oil Srl Italy	Biodiesel	Eco-friendly	Ital Green Energy Srl, in line with company policies aimed at producing in strict respect for the environment, has	In order to exploit the potential deriving from the growth of the market, management

[418] https://www.neste.com/releases-and-news/climate-change/neste-sets-new-strategic-climate-targets- reduce-own-and-customers-emissions

			started the production, of about 1.6 million MW/h of green energy per year in three plants that use exclusively biomass.[419]	considers it useful to expand the existing plant. The current production capacity of 550 Ton/24h will be increased to 1000 Ton/24h.

Table 11 Pilots' Competitors based on Technology type

10.1.2 Pilots' Competitors based on end products

[419] https://gruppomarseglia.it/settore-energia/

No. Of Related Pilot	End Product – Related Market			
1	GELATINE - Global Gelatin Market			
Competitor	**Products – categorized into groups**	**Main Strengths of products**	**Current Strategy**	**Weakness/Current issues/Area to improve**
Gelita AG Germany	Gelatine; Collagen peptides; Fats, proteins, minerals; Hemostats	Natural, pure and allergen-free clean-label ingredients	Innovation Strategy: Company re-invests 50% of innovation generated gross margin back into innovations; Company scouts for new technologies and business models; builds and foster partnerships and alliances with customers, suppliers, institutes and academic Research Centers.	Challenges growing companies such as Gelita face: - Balancing quality and growth - Retaining top talent
Tessenderlo Group Belgium	Agriculture, Valorizing bio-residuals and Industrial solutions	High quality, Environmentally friendly, Sustainable and innovative products	Company aims to minimize their ecological footprint and to maximize the contribution of their products in the evolution towards achieving a green economy.	Area to improve: -To expand the product portfolio and applications offerings to strengthen position in specialty niche markets -To build a global network of connected technical experts

				-To continuously improve the cost efficiency of their production processes etc.
2	**Coffee-Oil - Global Flavor Market**			
Nature Flavors California	Extracts & flavorings, Fragrances, Syrups, Baking ingredients, Drinks	Innovative, natural and organic	Continuously shop the world over in order to find the most unique and purest raw ingredients so that they can bring you new products	Due to Covid-19, they are experiencing longer than usual shipping times
Coffee Flavor Oils Florida	Candy Flavor, Coffee Bean Flavor, PG Based, Vanilla Powder, Tea Leaf Flavor, Chocolate Flavor	Coffee Bean Flavor are great for flavoring candy, fudge; there are 100% natural produsts Cocktail Flavors are Non-Alcoholic	Shipping Strategy	Only online sales; Company ships to almost any country but the shipping fees are about $45 USD for 4 kilos. Duration is usually 14 days to the door, usually 10 of those days are actual transit.
3	**Insect protein - Insect Protein Market**			
Swarm Nutrition GmbH Germany	Insect Bars - Mixed, Red Berries, Chia Hazelnut, Raw Cacao	High-quality, protein-containing and natural, tasty	SWARM started with the concept to bring insect protein to those who value its benefits the most: athletes. But now, it aims to be more than just a novel sports food - to disrupt food industry.	Area to improve: expand to new markets

Ÿnsect France	For aquaculture, pets, plants	High quality, Essential nutrients for human, animal and plant health, Organic, Eco-friendly, Safe, Sustainable	They cultivate boldness and creativity, while remaining focused on execution and driven by a culture of results. At Ÿnsect, they are constantly adapting to changing environments.	Constantly looking for balance, internally, but also between environments and their stakeholders.
4	**Monomers and PHAs - Global Biodegradable Plastics Market**			
Biome Bioplastics United Kingdom	High temperature, Non-woven, Cords, Flexible films, Coating, Custom blends	Natural, Heat resistance, Biodegradable and compostable, Resistance to water, grease, gasoline and oil, give good strength, flexibility and tear resistance	Continual product innovation; Backed by an extensive patent base and industry knowledge, company often work with otheir customers on collaborative projects to deliver market-changing opportunities.	/
Arkema France	Acrylics, Coating resins, Electroactive polymers, Fluorochemicals, Fluoropolymers, Glass coating, Functional polyolefins, Hydrogen peroxide, Hydrazine hydrate, Molecular sieves	No added APEOs (alkyl phenol ethoxylate); No added formaldehyde or formaldehyde donors; Low levels of volatile organic compounds (VOC); Low level of	Strategic vision includes: expansion in high growth regions and bolt-on acquisitions program	Regarding Covid-19*: It is essential that we adapt our inventory, our operational spending, and our investments, intelligently and determinedly and without delay. As part of our responsible approach, we must also start to prepare for life*

	etc.	residual monomers; etc.		*after the crisis and to consider the way we operate, particularly as lockdown eases.*[420]
5, 6	**BIOSOLVENTS - Global Bio-Solvents Market**			
LyondellBasell The Netherlands	Chemicals, Polymers, Advanced Polymers Solutions, Fuels	High purity synthetic ethanol; Eco-friendly; Sustainable	*We operate a worldwide product stewardship program that aims to make health, safety, and environmental protection an integral part of the development, manufacture, distribution, use, recycling, and disposal of all our products*. More info here.	Company has ambition to: - Increase its investment in the recovery and recycling of plastic, and accelerate solutions to end plastic waste. - Reduce its CO2 emissions by 15% per ton of product produced relative to 2015 levels by 2030. - Advance diversity, inclusion and equity in the workplace[421]
Solvay Belgium	Amines, Antioxidants and Stabilizers, Barium and Strontium	Solvents: Biodegradable, low VOC, non-toxic and eco-	G.R.O.W. strategy (Growth, Resilient Cash, Optimize, Win) -prioritize investments	*Solvay wants to grow with its customers. We want to be faster, simpler and more*

[420] https://www.arkema.com/en/arkema-group/strategy/interview-with-thierry-le-henaff/#ground
[421] https://www.finanznachrichten.de/nachrichten-2020-09/50812549-lyondellbasell-sustainability-report- sets-ambitious-plastic-waste-targets-008.htm

	Derivatives, Composites, Flavors and Fragrances, Fluorine and Lithium Derivatives, Solvents (Flame Retardants, Fluorinated Chemicals, Green Solvents, Hydrocarbon, Oxygenated Solvents) etc.	friendly Flavors and Fragrances: ensure food safety, GMO-free, HACCP conformity, non-allergen, and Kosher or Halal certifications according to customer needs	in high margin MATERIALS businesses with high growth potential -maximize cash flow generation from their CHEMICALS businesses -optimize their SOLUTION businesses to unlock value and increase returns -creating winning team and operation model	*customer-centric so that employees can devote more time with clients - breaking down silos and working side-by-side to co-innovate solutions.*[422]
7	**BIOCHAR - European Biochar Market**			
Carbon Gold United Kingdom	Biochar products: Compost, Fertiliser, Soil Improver	100% organic, boosts plant health, improves water efficiency, environmentally positive, reduces disease impact	Diversification strategy	Looking for strategic investment partners.
Sonnenerde Austria	Nature in the garden, Organic, Terra Preta, High beds, Lawns, Vegetables, Flowers, Trees, Composting etc.	Organic, Healthy, High quality, Easy to process, Visually appealing, Good-smelling, Ecologically valuable	Company is creating video tutorials and publishing them on their youtube channel, making closer relationships with their customers; They also have strong social media presence	Factory was closed temporarily due to Covid-19 crisis

Nordgau Carbon Germany	Nordgau Carbon Terr (biochar for mixing with manure or compost for use as a soil improvement medium)	High quality (contains 89% carbon), Improves soil fertility, Increases the retention capacity of humus-poor and sandy soils, Active contribution to climate protection	Nordgau Carbon sells most of its biochar to the local farming industry but also to customers in neighboring countries. Nordgau Carbon holds the European certificate of sustainably produced biochar (EBC).	/
Carbon Cycle Germany	Biochar in poultry/cattle/pig farming; Compost	High quality biochar that has many benefits: the loss of nutrients and nitrate leaching is reduced, the use of fertilizers is considerably reduced, groundwater is protected, and soil fertility is sustainably improved.	Carbon Cycle sells its biochar to the farming industry in several EU countries. The biochar has been approved as a soil additive and as animal feed. Carbon Cycle holds the European certificate of sustainably produced biochar (EBC).	/

Table 12 Pilots' Competitors based on End Products

[422] https://www.solvay.com/en/our-company/our-strategy

10.1.3 Pilots' Competitors based on end industry

No. Of Related Pilot	End Industry – Related Market			
4	PLASTIC INDUSTRY - European Plastic Packaging Market			
Competitor	**Products – categorized into groups**	**Main Strengths of products**	**Current Strategy**	**Weakness/Current issues/Area to improve**
Alcion Plasticos, S.L Spain	Plastic packaging for agrochemicals, industrial and cosmetic products	Environmentally-friendly, High quality - certified solutions, immediate delivery, raw materials used comply with REACH regulations. Impermeability to solvents; Resistance to high temperatures; Prevents permeation of steam and oxygen; Protection against UV rays.	*Our R+D+I department works together with our customers to find the perfect and tailored solution for their product combining design, functionality, technical quality and safety. We work under the premises of ISO 166002, strictly complying with the standards required by such certification.*[423]	/
Amcor Limited Switzerland	Packaging for food, beverages, healthcare, home care, personal-care, pet-care, specialty cartons, technical	Durable, high performance, unique	Amcor do not lack innovation or talent. They have made it a strategy to constantly change to make it better for the customer's and for	Amcor Limited can tackle the Threats of New Entrants by innovating new products and services, building

[423] https://alcion.com/en/rigid-plastic-packaging-tailored-made-for-the-industry/

	applications		the environment. They have committed to increased production of recyclable material to the customers, reusing recyclable material, and working with others to increase rates of recycling.[424]	economies of scale so that it can lower the fixed cost per unit, building capacities and spending money on R&D. It can tackle the Bargaining Power of Buyers by building larger base of customers.[425]
1, 2, 3	**FOOD INDUSTRY - Europe Food Market**			
Cosun Corporate The Netherlands	Product range extends from potato fries and sugar syrup to other foodstuffs, such as ingredients for cakes, ice cream, meat substitutes and fruit juices; it also includes animal feed, detergents, wallpaper paste and cosmetics.	High quality, Innovative, Sustainable	Cosun has a clear ambition for 2030: *we intend to be 100% plant based, 100% circular and 100% transparent. Drawing on the strengths of our five business groups – Aviko, Duynie, Sensus, Suiker Unie and SVZ – we are delivering solutions that benefit everyone, everyday. Our business groups offer a wide range of distinct products and services.*[426]	Continuous attention and safety measures are required to reduce the number of incidents. Company has stepped up fire prevention and other safety measures at factories and will continue to invest in prevention.[427]
Vion Food	Food service	Organic, Safe,	Vion's strategy	The highest

[424] https://freemanagementresources.com/amcor-ltd-business-strategy/
[425] http://fernfortuniversity.com/term-papers/porter5/asx/815-amcor-limited.php
[426] https://www.cosun.com/#about
[427] https://www.cosun.com/wp-content/uploads/2020/05/annualreport_2019_EN.pdf

Group The Netherlands and Germany	(deep frozen products and processed products), Industry (beef and pork), Retail (pre-packaged, products, processed products, sliced products)	Healthy, Good taste and quality	prioritises five topics: food safety, animal welfare, sustainable farming, traceability and product integrity and fair pricing.	priority is managing product quality and safety aswell as their worker safety. Procedures are in place,which are monitored and audited by internal and external parties.[428]
1, 3	**FEED INDUSTRY - European Compound Feed Market**			
Avril Group France	Food, Feed, Renewable chemistry, Renewable energy	Healthy, Non-GMO, Safe, and quality	Avril aims, on the one hand, at diversifying its market opportunities by developing the production of oilseed meals which are richer in proteins for livestock feeds; and, on the other hand, to develop new processes and products to use plant proteins in human food.[429]	Area to improve: -Cover their supplies of palm oil by sustainability schemes: certification, voluntary contributions to field projects, RSPO credits; - Ensure the correct management of livestock units within the scope of the Group's responsibility…[430]
Hermetia Germany	Insect protein as feed	Rich in essential amino acids, Eco-friendly, Quality	/	Safety risks, production haws to be alignedwith the safety

[428] https://view.publitas.com/cfreport/vion-annual-report-2019/page/26
[429] https://www.groupeavril.com/en/sustainable-development/better-food-humans
[430] https://www.groupeavril.com/sites/default/files/avril_group_2019_annual_report_b.pdf

				requirements
5, 6	**CHEMICAL INDUSTRY – European Chemical Market**			
AIQBE of Huelva Spain	Substances and materials used in food, healthcare, transport, new information and communications technologies, construction, energy, tourism, agriculture and fisheries etc.	Cleaner fuels, Healthy, Quality	Huelva is configured as a meeting place between the companies that integrate it, either for the exchange of knowledge and industrial experiences, or for the development of common activities and approach and integration in the society in which it is established.	Continuous improvement in the operation of its day to day, both in the environmental aspects, as well as in the maintenance and energy efficiency of each of the plants, without forgetting all aspects related to the prevention of occupational risks and health, human resources and communication, among others.
Haropa France	Haropa represents : 43% of the French refinery capacity; 80% of the French production of additives and base oils; 30% of the French production of biofuels; 35% of the French production of fertilizers; 13% of	Reliable and qualified services; High security and safety; An innovative harbour corridor in order to generate sustainable improvements of quality services for	A strategy that revolves around three priority areas: -Promoting virtuous logistics solutions: promoting a modal shift to limit the emission of greenhouse gases -Reducing the impact of port activities -Integrating the ports into their natural and	For HAROPA, reconciling economic development and the environment is a major challenge.

	the European styrene production capacity; 30% of the French production of ethylene; 50 % of the French production of plastics and elastomers	customers and territories; Eco-friendly.	urban environment [431]	
5, 6	**BIOFUEL INDUSTRY – European Biofuel Market**			
Green Fuel Nordic Oy Finland	Bio-Oil and Bio-Ash	Eco-friendly, quality, innovative	Six main categories: 1. Controlled and efficient growth 2. The most effective bio-refinery projection in cooperation with technology suppliers 3. Top level expertise in bio-oil plant operation 4. Competitive and sustainable resource acquisition 5. Competitive alternative for industrial energy production, with strategic long-term partnerships 6. Commercialisation of new applications for	Negative developments of a macroeconomic nature, such as crises in important sales markets for Green Fuel Nordic Oy, could adversely impact

[431] https://www.haropaports.com/en/rouen/green-port

			liquid bio-oil	
Sekab Sweden	Chemistry: Ethyl acetate, Washer fluid, Technical ethanol, Thermol Biofuel: ED95, Low blending, Masterbatch	Renewable, Certified according to the highest requirements of the market today	Strategically sustainable marketing communication	Covid 19 brings ceratin issues, but company is rapidly adopting to new circumstances
7	**BIOFERTILISERS - Global biofertilizer market**			
Lallemand Canada	Yeast, Bacteria and Specialty ingredients; Business areas: Animal Nutrition Baking Bio-Ingredients Brewing Lallemand Biofuels & Distilled Spirits Health Solutions Oenology Specialty Cultures Pharma Organic Yeast Plant Care Cosmetics & Beauty Vita D	High-value products, Natural, Organic, Safe, Reliability and Flexibility	The key to their success is cooperation – not only cooperation among theirselves, but cooperation with their customers, researchers, suppliers and the key people in the markets their serve.	Area to improve: -Continuously improve product quality -Enhance the productivity -Develop new applications and products -Develop competences and networks
Novozymes Denmark	Industrial enzymes, Microorganisms, and Biopharmaceutical ingredients Business areas:	High-quality, Balancing performance, sustainability and formulation cost, eco-friendly	Focus areas: Differentiate to succeed, Invest in impact, Spearhead new business Four enablers: 1. Reallocate toward	A continuation of the unstable agricultural markets could continue to impact the ag-exposed parts of

	Agriculture, Bioenergy, Food & Beverages, Household care		high-impact innovation 2. Expand emerging-market and commercial activity 3. Simplify, optimize and digitize 4. Thrive in a dynamic organization	their business.
5	**BIOGAS INDUSTRY - European biogas market**			
PlanET Biogas Global Germany	Industrial, Commercial, and Institutional organic waste solutions Product groups: PlanET Vario, PlanET BIGMix, PlanET PreMix, Pumping technology, PlanET eco stirrers, CHP module, Gas storage, Roof structure, Flare, PlanET hygienisation tank	High quality products, Good price - performance ratio and friendly support service	Company consolidates its sustainable growth and biogas excellence via future markets where long-term investments in biogas technology are secure from a political viewpoint and are accepted by society at large.	Area to improve: PlanET Biogas Global attends to any market worldwide and offers various kinds of partner programs for these countries, where they haven't yet set up a subsidiary.
Aikan A/S Denmark	Biogas, Compost	High methane yield, Quality, Eco-friendly	Strategy in line with circular economy principles	Possible challenges: Feedstock unavailability, Regional and seasonal availability of biomass and storage problem, Pressure on transport section (because of biomass moisture,

				transporting wet biomass from the plantation to the production site becomes energetically unfavorable and costly with increasing distance).[432]

Table 13 Pilots' Competitors based on End Industry

10.2 Conclusions

After an initial scanning of competitive landscape, segmented by Pilots' technological processes, end-products and end-industries, we identified some of the most prominent players on the Pilots' potential markets, that present Pilots' future competitors. As we explored their product portfolios and identified main advantages of their products, we are able to present the most desirable product attributes nowadays (regarding targeted markets) and therefore to suggest Pilots to develop their end products in line with these requirements. Moreover, understanding overviews of Pilot competitors' business strategies, and the challenges they are facing, enable us to provide initial business guidelines to the Pilots. Below, we drafted our conclusions for each WaysTUP! Pilot.

Pilot 1

Pilot 1 is using fermentation process in order to provide their end products: functional ingredients, gelatin and active peptides, flavours, polyphenols and carotenoids. Therefore, we identified major players on the European Fermented Ingredient Market that are also producing enzymes and flavours. Main strengths of their products include: sodium, sugar and fat reduction, as well as texture and taste improvements. Current strategies they are using suggest that **key to success is large portfolio of products, as well as strong research and development sector in order to achieve highly specialized solutions**. Furthermore, they are paying attention to the ecological footprint of their production. These are the key points that Pilot 1 should take into account. Moreover, **great example of business strategy is a customer-led approach which allows company to predict growth opportunities earlier and to innovate faster.** On the other hand, while analyzing weaknesses of companies – leaders on the European Fermented Ingredient Market, we realized that **it is very important for a**

[432] https://www.eubia.org/cms/wiki-biomass/biomass-resources/challenges-related-to-biomass/

company to develop online and offline sales channels (and make their products available to larger customer groups), and to try to make a process of bringing products to market as fast as possible.

Competitive analysis segmented by end products, led us to the Global Gelatin Market, where we identified two prominent players – Gelita AG from Germany and Tessenderlo Group from Belgium. They insist on **producing high quality, natural products that can be allergen free**. Their business strategies are in line with the green economy, and the main challenges they are facing are about balancing quality and growth, and retaining top talent. They are also **focused on the cost efficiency improvement of their production processes**.

From the end industry point of view, we've analysed Food and Feed industry. Among already mentioned qualities that products should have, prominent players from the European food and feed markets insist on the **product safety**. Therefore, production processes need to be aligned with the safety requirements. Also, one of the priorities of their strategies is **fair pricing.**

Pilot 2

Analyzing competitive landscape from the technology type point of view, that refers to extraction process, we found out that companies operating on the Global Extraction Solvents Market and European Food Flavor Market use **risk diversification strategy with a number of distinct business sectors**, and they avoid overexposure to any single customer, industry or geography. They are also relying on the **constant innovation to anticipate customer needs**.

On the other hand, we realized that **Pilot 2 is providing a unique end-product (biomass from the coffee ground), and that they have no direct competitors on the European market**. In terms of competition, Veolia company is the only major waste management company that can be considered. However, in order to find out desirable qualities of the coffee oil, we identified prominent players on the Global Flavor Market that provide coffee bean flavor. Their products are **innovative, natural and organic**. Also, they are using shipping strategy in order to make their products available to the customers worldwide. Moreover, **they continuously shop all around the world in order to find the most unique and purest raw ingredients so that they can develop new products.** According to identified weaknesses of the examined companies, we realized that it is very important for a company to **develop online and offline sales channels.**

Examination of the questionnaire we distributed to Pilot 2 gave us important insights regarding the main **challenges they are facing - legislative framework and market prices**. These challenges can be overcome in the future phases of Pilot 2 implementation.

Pilot 2 has already secured a large feedstock in supply from Costa and Nestle and they are able to process it and turn it into biomass. This is the first-mover advantage.

Pilot 3

Analysing situation on the Global Insect Feed Market we realized that **products made of insects** such as dry protein powder used as a feed ingredient and insect oil **should be approved by the responsible EU body (due to respect of safety measures)**. They should also be **healthy, tasty, eco-friendly and to have good nutrient value**. Companies on the market, that rear insect as animal feed or human food in Europe, as *Ynsect* (France), *Multibox* (United Kingdom), *Protix* (Netherlands), *nextProtein* (France), *Hipromine* (Poland) or *Hermetia Baruth* (German) can be viewed **as direct competitors** to Pilot 3, Key aspects of their business strategies include **developing key partnerships, investing in technology** supporting sustainable growth and having a wide range of high-profile European investors. On the other hand, challenges they face include expansion to new markets, finding balance internally and between environments and their stakeholders, finding appropriate waste producers, investors and insect farmers/entomologists who are interested in becoming their consultants. Examination of our questionnaire distributed to Pilot 3 implied that **the main challenge with larval biomass is to introduce it as a new ingredient of the animal feed and to standardize the product and take the production to a full industrial scale.** The greatest advantages of Pilot 3 in comparison to its competition are definitely the **development of their know-how and efficiency of industrial production.**

Pilot 4

Since Pilot 4 is using fermentation as it's technological process to produce its end products, we analysed business strategies of prominent European companies that use the same technology type. They emphasize importance of **research and development activities in order to continuously improve their production**. Also, they had certain issues regarding Covid-19, therefore we highly recommend development of mitigation measures in order to be prepared for such crisis in the future.

In terms of end products, we identified few prominent players on the Global Biodegradable Plastics Market. Their **products are natural, provide heat, water and tear resistance, give good strength, flexibility and have low level of residual monomers**. Also, their strategies involve continual product innovation, expansion in high growth regions, bolt-on acquisitions programs and collaborative projects with customers. On the other hand, identified main challenges are mostly related to Covid 19.

However, a great **challenge** for Pilot 4 is linked to the necessity to create a **clear and stable legislative framework**, an essential element to encourage investment. The diffusion of **high-**

quality standards for circular and bio-based products is **still not sufficient and demand support measures** that allow innovative and sustainable products to compete with existing ones need to be implemented. The **lack of homogeneity of the authorization approach** regarding End Of Waste criteria is another important challenge to face in the future (which is essential to utilize biowaste as secondary raw material for new biobased products). **Customer education** in the field of organic cosmetics is also highlighted as an obstacle and it is imperative to deal with **social awareness** in this field. Working to raise awareness of the general public, a path is being built towards **solving the problem of accepting higher prices** for green and sustainable products. Nevertheless, **Pilot 4's main market advantages** include long experience in bioplastics for different sectors in the value chain, possession of the pilot plant equipment to modify the materials and process them to obtain samples or prototypes. **Knowledge of materials characterization, properties, and the best end of life (recycled, composted), together with the emphasis on quality research and development, marketing, and a worldwide network of contacts, puts Pilot 4 in a great starting position**.

Pilot 5

We analysed prominent players on the Global Bio-Solvents Market and found out that their products are **eco-friendly, non-toxic, biodegradable, sustainable and have low VOC**. Furthermore, their strategies are centered around the prioritization of investments in high margin materials businesses with high growth potential and creation of great team and operational model. Their aim is to become more customer-centric.

From the end industry aspect, we analysed major players from the chemical and biofuel industry. They are focused on **shifting their businesses according to green and circular economy principles.** Main obstacles are related to negative developments of macroeconomic nature, such as crisis in important sales markets.

Also, as one of the Pilot 5 partners, NTUA, emphasized biogas industry as an important field, we also analysed European biogas market. Key players on this market aim to provide high quality products with good price-performace ratio and friendly service. They are also choosing their future markets by exploring where long-term investments in biogas technology are secure from political viewpoint and are accepted by society at large. Possible challenges that these companies face include feedstock unavailability, regional and seasonal availability of biomass and storage problem among others.

Our findings regarding Pilot 5 from the questionnaire distributed for the purposes of investigation Pilots' obstacles and potential advantages, are presented below.

As **the biggest challenges** about the Pilots' market, **the efficiency** of the process in terms of end product yield, **the economic viability** of the biorefinery approach, and **end product**

characteristics in relation to market demand are stated in the questionnaire. Also, as a common potential risk, legal and regulatory barriers related to biowaste volarization were suggested again. Considering the bioeconomy trend, it is easy to conclude that biosolvent **market is not saturated** at all, and competitors are few on the market. **Main competition** are still the companies that produce fossil fuel-based solvents, and they are dictating the market prices. A big **advantage** for the Pilot, which will ensure a strong market position and profitability of production, is the **use of bio-waste as a resource to produce added-value products** that can substitute fossil-based products.

Pilot 6

Pilot 6 uses simultaneous saccharification and fermentation as technology processes to produce biosolvents/bioethanol. Also, we have recognized chemical and biofuel industries as its end industries – industries in which most of their end users are present. That said, same markets that are investigated for the purpose of Pilot 5 competitor analysis were in the focus of Pilot 6 competitor analysis.

Products produced by prominent players on the Global Bio-Solvents Market are **eco-friendly, non-toxic, biodegradable, sustainable and have low VOC**. Furthermore, these companies have business strategies that are centered around the prioritization of investments in high margin materials businesses with high growth potential and creation of great team and operational model. Their aim is to become more customer-centric so that employees can devote more time with clients.

Main strategies of the major companies operating within Pilot 6 end industries are focused on **strategically sustainable marketing communication and effective bio-rafinery projection.**

Pilot 6 recognize challenge of the pricing pressure of conventional (petrol-based) solvents, since the Pilots' purpose is not commercial. Pilot aims to reduce rejection to zero waste and move towards less hazardous solvents like ethanol and ethyl lactate.

Pilot 6 emphasizes its main advantages such as the production of high-value "green" product lines, continuously available feedstock, current process/technology development stage, and own patented process.

Pilot 7

Competitive landscape analysis segmented by technology type led us to Global Bio-Oil Market. Prominent players operating on that market produce top quality Group III base oils, and characterize their products as eco-friendly, safe and reliable. Their **business strategies are aiming to creating business in line with green economy.** These companies have a lot of **powerful strategic partnerships** and are always looking for more.

Major players on the European Biochar Market are producing **100% organic, healthy, easy to process products that are visually appealing, good-smelling and ecological valuable**. These companies are usually using **diversification strategy** and are always looking for strategic investment partners. They are also working hard to **build a strong relationship with their customers** by creating video tutorials on their youtube channel and communicating with their end users on a daily basis through social media channels.

Based on our competitive analysis segmented by end industry, we explored Global Biofertilizer Market and found out that prominent players on this market are producing high value, natural, safe, reliable, flexible, sustainable and eco-friendly products. Usually the key to their success is **cooperation** – internal, but also external (with their customers, researchers, suppliers etc.). On the other hand, the main challenge they are facing is related to unstable markets due to Covid 19 and other factors.

Based on the questionnaire we distributed, the main **challenge for Pilot 7** will be to **educate the market** about biochar's great potential in many industries and **raise awareness** about the importance of **sustainable and eco-friendly production.** Since the Pilot will be producing biochar from the sewage sludge, it is easy to present feedstock sustainability and constant availability on the market. This is also the main **competitive advantage** of the Pilot, together with **a clean production** process and **zero-emission operation.**

11. Potential opportunities within geographical areas of pilots' interest

After analyzing Questionnaires and inputs received by the Pilots, it became obvious that the **EU market is still not saturated enough with sustainable end products that Pilots are offering**. At this point, it is very important to focus on finding the right position for every Pilot on the EU market and look for opportunities to expand to other geographical areas and markets. The biggest **challenges that Pilots are facing are related to the legislative framework of bio-sustainable production, European regulations of the green economy, and the competitiveness of ecological products on the market.** In order to see the full potential of their end products, develop strong business structures and reach sustainable income and production, **companies are strongly advised to consider following current industry trends** regarding **cross-sectoral** and **cross-industry collaboration**, including smart specialization as a starting point.

11.1 Smart Specialisation

As a regional (European) policy framework, **Smart Specialisation**[433] was developed to support the **defragmentation of investment efforts** and earlier policy frameworks, and help Europe set the standards of a new (greener) economy, which made it a very important concept and policy agenda for science, technology, and innovation. This agenda will be of great help to Pilots to **develop their business models** to the level of material sustainability and **increase revenue** while continuing to contribute to the preservation of the environment and improve awareness of the citizens and local communities on urban bio-waste as a local resource.

Rather than encouraging specialization along pre-determined paths, the smart specialization approach recognizes that new or unexpected discoveries of activities might emerge within given parts of an innovation system, leading to **"specialized" diversification**. Having that in mind, this form of 'research and innovation' approach could lead Pilots to the discovery of new spheres of sustainable products usage and exploitation.

11.2 Cross-sectoral and cross-industry collaboration

[433] https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation- Towards-the-Circular-Economy-vol.1.pdf

Cross-sectoral linkages play a central role in industrial transformation and the development of emerging industries because they are expected to favor knowledge spillovers and innovation. The development of emerging industries is often driven by cross-cutting technologies, creativity and service innovation, and societal challenges such as the need for eco-innovative and resource-efficient solutions.[434]

Environmental industries are, in fact, deeply associated with several other industries. Innovations in the fields of pollution management, cleaner technologies, and renewable energy sources, products, and resource management trigger changes in the value chain of many other industries.

Clusters, as a type of uniting companies and organizing mutual (cross-sectoral) cooperation, **facilitate cross-sectoral and cross-regional collaboration**, thanks to their model of governance that is based on vertical and horizontal cooperation and their embeddedness in regional business and innovation ecosystems, but also their integration in global value chains. Cluster organizations could effectively influence the degree of participation of European industries into global value chains, which is why **it is strongly recommended for different companies to combine their knowledge, technologies, and efforts** - in this particular case, regarding sustainable end eco-friendly production.

Although **the association and cross-sectoral linking** will make a great difference in overcoming current obstacles, some of them will still remain daunting. They range from current product design to cultural resistance, to 'subsidized' commodity and energy prices. **Some of these barriers may fade on their own, with time**. Others could require specific new frameworks - in terms of corporate governance, cross-industry collaboration, technology, or regulation. Still, **corporate unions and clusters are the best way to step forward in improving the current situation,** taking into account all global trends in terms of industrial dynamics, cross-sectoral trends, and global value chains.

For example, **traditional cross-sectoral linkages along the value chain of the Advanced Packaging industries** (e.g. with the food and beverage sectors) **have weakened**, but stronger linkages are emerging with other sectors, especially in the upstream stages of the value chain, reflecting the introduction of advanced materials (eco-packaging), advanced machinery (digital printing), intelligent manufacturing and smart packaging.

As previously said, smart specialization is an important first step on the way to cross-sectoral collaboration, because it gives companies new perspectives and inspires them to explore their knowledge, and find potential linking points with companies from different sectors, to

[434] https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation- Towards-the-Circular-Economy-vol.1.pdf

join forces. After this complex and demanding process of mind and production shifting and establishing partnerships, **cross-industry collaboration is the next step**. Some of the main obstacles, such as restrictive regulations or the lack of an environmental protection system in society, can only be overcome in cooperation with local, regional, and state policies, conducted by the government.

11.3 Coffee oil

Most of the beneficial compounds inside coffee remain intact after brewing a cup of coffee (except for the water-soluble, like caffeine), and that fact offers a great opportunity for these compounds to be reclaimed from waste coffee.[435] Since a large quantity of by-products is generated during the production of coffee, their recycling is becoming more and more important on many levels.

Coffee oil, extracted from fat that coffee ground contains, became an **important resource for further production**, and it gives an excellent opportunity to connect companies from different industries and be an important link for cross-sectoral collaboration.

Nowadays, many cosmetic companies are using oils extracted either from green or roasted coffee beans as a component of their beauty products, but **current coffee oil prices are expensive and volatile for formulators.** This could be one of the main reasons to introduce Recycled coffee oil as a competitive and sustainable resource.

Ongoing researches (lead by Innohealth Group in Madrid) showed that **coffee oil is able to absorb UV radiation in the UVB range**, which causes the greatest damage to the human skin while having a safe tanning effect. This means it can be used as a component of sun care cremes and lotions. Also, data showed a significant **positive effect of the oil as anti-aging** as it presented a significant antioxidant activity as well as Nrf2 induction which are directly involved in the response to oxidative stress.

All of the above can be a good starting point for **Pilot 1** to consider specializing in this direction. **Besides producing sustainable solutions for the food and beverage industries, dyes, and pigments to bioplastics, cosmetic usage of recycled coffee oil can be an important path to entering new markets and connecting with other industries**.

10 of the world's biggest cosmetic companies are located in France (such as "Biotherm", "Vichy", "Nuxe", "Yves Rocher", "La Roche-Posay", "Loreal", "Bioderma" etc) and they all strive to offer new products to their customers, to be competitive and innovative. Integrating

[435] Article: "Cross-Sector Partnerships for Sustainability: How Mission-Driven Conveners Drive Change in National Coffee Platforms" Iteke van Hille

recycled coffee oil, with all its benefits for human skin, into beauty products can be the right answer to rising consumer demand for natural and sustainable products.

11.4 Food and Feed

With the target to recycle 65% of municipal waste by 2035, EU members are eager to find new ways of obtaining, processing, and implementing biowaste as feedstock in many different industries. **Sustainable agriculture, food, nutrition, and natural resources management are the biggest links in this chain**.

Recent EU circular economy policies promote recovery and recycling of excess nutrients from agricultural, industrial, and urban waste streams into products that can be used as agricultural fertilizers. **Organic waste-based fertilizers can be processed in several ways to increase the retention of nutrients and ensure they are suitable for agricultural application while minimizing environmental impact**. Feedstock material such as meat by-products, fish by-products and spent coffee grounds are already considered as a great alternative to chemical and other conventional fertilizer components. Turning food waste into organic fertilizer creates economic and environmental benefits, which can improve soil health, help reduce erosion, and improve water quality.

Having all that in mind, **joining multiple stakeholders into clusters is a necessary step** forward to bringing the stated benefits to life. Since agriculture is the largest receiving sector for organic fertilizers, cross-sectoral collaboration, on this particular matter, should start with education. At first, focused on end-users: farmers and other significant actors in the food industry, and later on, education activities should be continued with a wider audience, in order to raise social awareness of the importance of implementing a separate bio-waste collection system.

There are many potential obstacles regarding reusing municipal waste that companies are not able to overcome by themselves, so they must be supported by the government, subvention policies, and regulations.

11.5 Insect Protein

Although the edible bug market slowly gains traction with consumers, still **the biggest opportunities for insect farmers exist as a protein replacement for animal feed.** Insects offer a less expensive alternative to conventionally sourced protein - they are easy to grow and high in protein and digestible fat. Insects can recover nutrients from food waste and bring them back into the food-value chain, thereby contributing to a circular economy.

When it comes to larval biomass, there are **two major market opportunities for cross-sectoral collaboration within the food industry: agriculture and aquaculture**.

As already stated, agriculture is more and more turning its focus on sustainable and environmentally friendly production. For many years, animal manures were used as fertilizers, but the main problem is methane emitting, which is bad for the environment. **Insect's frass is proven to be good organic fertilizer**, not in any way harmful to the environment or to the crops grown in the field.[436]

Aquaculture is a big market for insect biomass producers. Nowadays, fishmeal is typically made from wild-caught fish and fish by-products, and at the same time, fish stocks are becoming increasingly unreliable due to warming oceans, overfishing, and catch restrictions. Fish from aquaculture accounts for 23% of the total fish consumed, which means only one-third of the production of farmed fish is employed directly for human intake, using the remaining fish as a meal in other farming activities.

Legislative constraints could be the main factor for limiting the growth of the larval biomass potential. Currently, insects are defined in the EU as a novel food and most countries are authorizing imports and sales of insect-based products.[437] Regarding aquaculture, the **EU normative has only recently allowed introducing feeds derived from some insects into animal diets** (EU Rer. 217/893). This regulation has permitted the use of processed animal proteins (PAPs) from insects in the diet of farmed fish limited to seven species (Hermetia illucens, Musca domestica, Tenebrio molitor, Alphitobius diaperinus, Acheta domesticus, Gryllodes sigillatus, and Gryllus assimilis). The biggest animal breeders and growers (in aquaculture) are located in Spain, the UK, France, Italy, and Greece, and these countries could be important partners in the field of establishing a completely new insect's protein market.

11.6 Bioplastics

Demand for bioplastic is rising in every major industry in the world, and with more sophisticated biopolymers, applications, and products emerging, the market for bioplastics is continuously growing and diversifying. Thanks to its diversity, **bioplastic** can be considered as **the material of the future**, since it can be used in almost every industry.

436 www.researchgate.net/publication/251383042_Positive_and_negative_impacts_of_insect_frass_quality_on_soil_nitrogen_availability_and_plant_growt

437 https://www.researchgate.net/publication/311796026_European_law_on_insects_in_food_and_feed

Therefore, opportunities for cross-sectoral collaboration, which can lead to overtaking the worlds' polymer market, are enormous. Following global megatrends and emerging industries, it is easy to see where **potential linking points** can be made:

Packaging - bioplastic packaging is already the largest segment of the European bioplastic market and includes bags for compost, agricultural foils, horticultural products, nursery products, toys, and textiles. Also, it is often used for disposable cups and plates, salad bowls, clingfilm, and all kinds of food containers. Sophisticated bioplastic packaging for food products has greatly improved the shelf life of the food and its use helps brands to connect with their customers by showing they are conscious of their environmental footprint - plant-based polymers are able to fully compost at the end of their useful life.

Electronic industry - consumers' electronic industry only recently started to address the sustainability of the materials it uses in its products. So far, their contribution to environmental preservation was focused on producing more energy-efficient devices and more efficient recycling options for electronic waste. This is a **whole new world of possibilities for bioplastic** - to provide the electronic industry with an excellent opportunity to improve their environmental credentials as they can be injection molded with similar characteristics to traditional plastics without modifying any machinery.

Medical industry - biodegradable bioplastics stitches, are now being used by medical professionals in hospitals and surgeries all around the world. They became a standard procedure very quickly since they are easy to sterilize, they remain in place until the tissue has healed when they are dissolved by the body leaving no marks behind.

Biodegradable plastics are also being used for medical devices and dental implants, containers for tablets and creams, etc.

Aerospace and Automotive industry - both aerospace and automotive industries invest a significant amount of resources investigating how they can reduce the weight of their vehicles so that fuel consumption and emissions are lower, and plastics are often a solution. Bioplastics that can perform to the same standards as their traditional plastic counterparts are an important resource for this type of cross-sectoral collaboration in the future.

When it comes to ***smart specialization*** in the field of bioplastic, one specific option stands out and it regards the development of PEF (polyethylene furanoate), a new polymer that is expected to enter the market in 2023. PEF is comparable to PET but 100 percent bio-based and is said to feature superior barrier and thermal properties, making it an ideal material for the packaging of drinks, food, and non-food products.

11.7 Biosolvents

Solvents play a major role in the chemical industry, as a **vital ingredient of chemical processes and products**. They are used in a wide number of industrial applications including agrochemicals, pesticide delivery, paints & coatings, household and industrial cleaners, and pharmaceuticals, and synthetic chemistry.

The bio-based solvents market is growing fast, as many countries are **changing their regulations and legislative frameworks toward a greener economy and sustainable production.** Therefore, sustainable solvents suppliers are facing a fast-growing demand for bio-based solutions across many industries. Currently, one of the major opportunities (and it will be increasing in the future) lies in the **transportation and logistics industry**, as biofuels are slowly taking over the market.

Biofuels (bioethanol and biobutanol), which are produced from natural materials have emerged as promising transportation fuels because of their sustainability and environmental benefits which can reduce the dependency on crude oil reserves. Also, **biofuels do not produce additional carbon emission**, which is a great advantage over conventional fuels. It is estimated that bioethanol will meet approximately 30% of global energy demand by 2050.

The most prosperous cross-sectoral cooperation in terms of bioethanol exploitation can be established with large oil companies, as it serves mostly as a constituent of the mixture with gasoline or as an octane increaser. Many petrol companies already offer “rich” fuels to their customers, and sustainable solvent suppliers are a very important lick in this particular value chain.

Another very common usage of **bioethanol is as a solvent in consumer products** such as perfumes, food coloring and flavoring, alcoholic drinks, and in certain mediation. Many cross-sectoral collaborations can be established, mainly in the chemical industry, where the pursuit of ultrapure and green solvents is never-ending. Having in mind that ethanol is the oldest and most successful bio-based chemical solvent used in commercial production, it can be distributed as a component for industrial production of detergents, cosmetics, lotions, shampoos, soaps, and other consumer products.

11.8 Biochar

Biochar was initially mainly used in agriculture, but the range of uses for biochar now covers a wide range of different fields, giving this raw material an opportunity to be used cascadelly.

It is much too **valuable resource** to be just worked into the soil without having it used at least once for more beneficial purposes – whether as storage for volatile nutrients, as an adsorber

in functional clothing, as insulation in the building industry, as energy storage in batteries, as a filter in a sewage plant, as a silage agent or as a feed supplement.[438]

Therefore, **opportunities for cross-sectoral and cross-industrial collaboration in terms of biochar exploitation are diverse, and a list of potential end-users is very long**.

Considering current market opportunities, most of the potential lies in linking with the building sector, waste and drinking water treatment, textile industry and wellnes and cosmetics industries.

The construction industry has become one of the strongest and fastest growing in the last few decades, and biochar has a variety of potential uses in this sector. Two of biochar's properties (extremely low thermal conductivity and **ability to absorb water up to 6 times its weight**) makes it just the right material for insulating buildings and regulating humidity. Also, **biochar is a very efficient adsorber of electromagnetic radiation**, meaning that biochar-mud plaster, placed in rooms with a large number of electronic devices, is very good at preventing "electrosmog".

Modern textiles already uses biochar as additive for achieving better thermal and breathing properties of the sport apparel, and as a reducer of the development of odours (active clothing and socks).

As said above, biochar adsorbs perspiration and odours, shields against electromagnetic radiation, and removes negative ions from the skin, which makes it more and more popular component of different wellness products (pillows that doesen't build-up heat in summer) and cosmetic preparations (soaps, face creams, therapeutic bath additives).

11.9 Conclusions

Since the biggest challenges that Pilots are facing are related to the legislative framework of bio-sustainable production, European regulations of the green economy, and the competitiveness of ecological products on the market, we tried to give solid answers on what could be the **key opportunities for overcoming market obstacles**. By exploring the potentials of Pilots' end products, we found several important steps that should be taken: **smart specialization** (finding the most demanded and most profitable end product and make ways to specialize in sustainable production within current regulations), **cross-sectoral collaboration and cluster organization** (creating new value chains between different industries and joining forces to bring ecological products as standards to the market), and

[438] Review: The Application of Biochar in the EU: Challenges and Opportunities, Luca Montanarella and Emanuele Lugato

constant education of citizens, regarding the importance of separate bio-waste collection system, environmental preservation, and zero-emission industry.

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Annexes

Annex 1: Questionnaire Design

Part A: General Information	
Pilot Number 1: Food & Feed	
Organisation Name	
Main Contact Point for WP6 Activities: (Name and e-mail)	
Role in the Pilot (You can select more than one role): (Pilot Owner, Feedstock provider / Process partner / End-product partner)	

Part B: Feedstock, Process Technologies, End-products	
B.1. Feedstock	
Please indicate the feedstock provided in the context of the Pilot:	
Please indicate any feedstock that you considering utilizing in the future (if any):	
B.2. Process Technologies	
Please indicate the feedstock processing methods used in the context of the Pilot (processes and technologies):	
Please indicate any feedstock processing methods (processes and technologies) that you considering utilizing in the future (if any):	
B.3. End-products	
Please indicate the end-products	

stemming from the Pilot:	
Please indicate any end-products that you considering utilizing in the future (if any):	
B.4. End-users / potential customers	
Please indicate the current end-users and/or potential customers stemming from the Pilot:	
Please indicate any new potential end-users and/or potential customers stemming from the Pilot (if any):	

Part C: Geographical Scope (Related to the Pilot)	
C.1. Current Geographical Scope	
Please indicate the current geographical areas you are operating in:	
C.2. Future Geographical Scope	
Please indicate any new geographical areas that you would be interested in the future (if any):	

Part D: Market Information (Related to the Pilot)	
D.1. Overall Market	
Which are your major customers:	
What are the biggest market challenges you face:	
Can you identify potential market risks:	
D.2 Competition	
Who are your competitors:	

How much competition is there? Does the market appear to be saturated:	
Do you know which companies are using the same technologies and which companies are producing the same end-products:	
What is your primary competitive advantage:	

Part E: General Comments	
Please indicate any issue that D.6.1 Market Outlook Report should investigate	