Interreg Alpine Space

EUROPEAN UNION

AlpLinkBioEco

European Regional Development Fund

Linking BioBased Industry Value Chains in Alpine Region

CiaoTech PNO

CONNECTING AMBITIONS

ALPLINKBIOECO –

"BENEFITS AND OPPORTUNITIES OF BIO-BASED ECONOMY VALUE CHAINS"

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List of acronyms and definitions

Acronym	Definition
Actor	A company or single organization
AS[1]	**Alpine Space:** 7 Countries, of which 5 EU Member States (Austria, France, Germany, Italy and Slovenia) and 2 non-EU countries (Liechtenstein and Switzerland), and 48 Regions. **AUSTRIA** (Burgenland, Kärnten, Niederösterreich, Oberösterreich, Salzburg, Steiermark, Tirol, Vorarlberg, Wien); **FRANCE** (Auvergne-Rhône-Alpes, Bourgogne-Franche-Comté, Provence-Alpes-Côte d'Azur); **GERMANY** (Baden-Württemberg, Bavaria); **ITALY** (Bozen (Autonomous Province), Friuli Venezia Giulia, Liguria, Lombardy, Piedmont, Trento (Autonomous Province), Valle d'Aosta, Veneto; **LIECHTENSTEIN**; **SLOVENIA**; **SWITZERLAND** (Aargau, Appenzell Ausserrhoden, Appenzell Innerrhoden, Bern, Basel-Landschaft, Basel-Stadt, Fribourg, Geneva, Glarus, Graubünden, Jura, Lucerne, Neuchatel, Nidwalden, Obwalden, Schaffhausen, Schwyz, Solothurn, St. Gallen, Thurgau, Ticino, Uri, Valais, Vaud, Zug, Zürich
Actor Value Chain or VC	An existing or potential commercial relationship between two actors.
Bio-based economy	The production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, biobased products and bioenergy', including both traditional and emerging sectors, i.e. 'agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries[2].
Biomass	Biomass is defined as "the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste"[3].
Cluster	An organized group of actors
Cluster Value Chain	A sequence of actors or industries, showing the added value from a starting raw material to the end product for the consumer
KPI	Key Performance Indicators
LCA	Life Cycle Assessment
PP	A Project Partner within this project
Region	Regions within the project and which are represented by the Project Partners (namely 8 regions of the AS, i.e. Canton of Fribourg, Baden-Württemberg, Autonomous Province of Trento, Lombardy, Austria, Auvergne-Rhone Alps, Slovenia, Bavaria). It is worth to mention here the white paper also include the whole Switzerland as it includes 26 out of the 48 regions of the AS.
Sector	An industry area; of special relevance for this project are "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma", "Chemistry".
SME	Small & Medium enterprise

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1. Introduction

1.1 AlpLinkBioEco project in a nutshell

A key objective of the AS is the transition from fossil economy to bio-based economy. To achieve this objective, the AS regions have significant biomass resources, strong industry sectors and knowledge centres. Unfortunately, no holistic cross-regional approach exists to connect all relevant actors VC. The biggest obstacle is for different actors from very diverse sectors to cooperate transnationally/regionally along various sectorial bio-based VCs. The AS regions have a common challenge to bring together bio-feedstock producers, intermediates processors, product developers and end users to address pressing societal needs with novel cross-regional and sectorial VCs for implementing a bio-based economy.

In this context the AlpLinkBioEco project aims to develop a cross-regional bio-based economy strategy that includes a roadmap and demonstrators for intelligently assessing, selecting and creating innovative VCs. The project shall analyse the different regions and the Clusters with respect to their size and value in the Sectors "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma" and "Chemistry". To reach the ambitious final objective the following specific objectives will be reached during the project:

- to map existing resources, actors and relevant policies to set-up a cross-regional database. This will allow to identify the missing links within the VCs and boost the synergies between small and large actors and enhance the economic sustainability to ensure local employment;
- to manually develop a methodology (VC generator) to match actors demand-oriented in new VCs. The VC generator is developed manually, tested and automated throughout the project to generate numerous potential new VCs;
- to generate new business opportunities within and/or across the regions using the links as shown in the new VC's descriptors.

The project targets all relevant stakeholders including policy makers, cluster initiatives, sectoral agencies, research centres and Universities, all enterprises including SMEs, interest groups including NGOs and individual actors, who can benefit from the specific tools and engagement in the novel VCs.

The project concentrates on bio-based economy and industry. Consequently, biodegradability will be reported, but they are not selection criteria for actors, VC's, and sector VC's, discussion, funding and recommendations. Since the Cluster analysis was not available during the preparation of the White Paper, the Sector analysis using the industry clusters will be a specific topic of the Cluster analysis and shall amend the White Paper.

The White Paper will show examples of best practice. Since the sectors are very wide and complex, the examples are not necessarily representative for the sectors, but they show different approaches of best use of bio-based materials in the respective Sectors.

The analysis of the Sectors within the regions will show "white spots" which are recorded and used for recommendations for policy makers and stakeholders.

1.2 Purpose of the document

The purpose of the document is to create awareness of benefits and potential opportunities that a bio-based economy can bring among stakeholders of the AS regions, to give suggestions on how generate new business opportunities and to give recommendations for stakeholders. It aims at encouraging an exchange of information and helps making an analysis to identify collaborative ventures across the alpine regions. It can be used by policy makers, entrepreneurs, cluster managers and companies. It includes facts and figures, best practice cases including business success stories, prerequisites for SMEs to implement bio-based economy principles, analysis of the current size of bio-based industry within the sectors "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions (where possible) and comparison with the overall economy within the sectors and regions. The whitepaper gives input for the implementation of novel bio-based value chains in the AS.

1.3 Executive summary

- ***Chapter 2***, "*Benefits and opportunities of the bio-based economy within the sectors "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions*", aims to map existing resources to identify the missing links within the VCs that will allow to generate new business opportunities within and/or across the regions. The study underlines that **wood** is one of the most abundant resources in the regions, with more than 35 million m^3 of harvested wood each year. **Agriculture** also cover an important role with roughly 1,400,000 employees and a revenue of about € 140 billion. The **packaging** industry in regions employ more than 230,000 people (due to difficulties to find data for **Packaging for Food and Pharma**, data about packaging as total are mostly reported). **Chemistry** (due to difficulties to find data for the **bio-based chemistry**, data about chemistry are mostly reported) is a well-developed sector in the regions with more than 3000 companies.

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- In ***chapter 3*** an overview is provided on how how bio-based economy is currently implemented, i.e. existing best practices (one for each sector, i.e. ***Tecnaro GmbH*** for **Wood**, ***Frumat*** for **Agriculture**, ***Azienda Agricola Chiesa Virginio*** for **packaging** specifically for food, and Green Sugar AG for **chemistry**), covering the area of regions. Details are provided about the actors, the resources, the value chains and how the initiative has been established. Since the sectors are very wide and complex, the examples are not necessarily representative for the sectors, but they show different approaches of best use of bio-based materials in the respective sectors. Best practices have been chosen for their relevance towards indicators that allow to measure, monitor and assess the progress of the bio-based economy. Four type of indicators have been considered according to their sector/objectives: **Economic, Process, Environmental, Societal**.
- Measuring, monitoring and assessing the progress of the bio-based economy in Agricultural, Wood, Packaging for Food and Pharma and Chemistry VCs in the regions allows to study how the bio-based economy is evolving. For this purpose, in ***chapter 4***, four type of indicators have been considered: **Economic, Process, Environmental**, **Societal.** Indicators have been be applied to the best practices in Wood, Agriculture, Packaging for Food and Pharma and Chemistry. For each of the sectors conclusions are reported.
- Opportunities, resources, activities, actors and best practices mapped in the previous section have used in ***chapter 5*** to describe/model how an ideal value chain should be structured in terms of actors and processes in the bio-based economy within the sectors "**Agriculture**" (Agro), "**Wood**", "**Packaging for Food and Pharma**", "**Chemistry**" in the regions. Moreover, the added-value of clusters to create new business opportunities within and/or across the regions has been highlighted, as already extensively addressed by two *Interreg* projects, that are ***S3-4AlpClusters*** and ***DanuBio ValNet***.
- In ***chapter 6***, activities carried on by actors of the bio-based economy within the sectors "**Agriculture**" (Agro), "**Wood**", "**Packaging for Food and Pharma**", "**Chemistry**" in the regions have been mapped to highlight which are the "white spots" within the sectors in the regions to identify business opportunities to build new VCs. Moreover, clusters, networking opportunities and policies at regional level within the sectors have been identified to show "white spots" which are recorded and used for recommendations for policy makers and stakeholders. The overview shows that bio-based policies and networking opportunities related to the Agricultural, Wood, Packaging for Food and Pharma and Chemistry sectors are mostly missing in the regions, highlighting "white spots".

2. Benefits and opportunities of the bio-based economy within the sectors "Agriculture" (agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions

Aim of chapter 2 is to map existing resources of the bio-based economy within the sectors in the regions to identify the missing links within the VCs. Missing links will allow to generate new business opportunities within and/or across the regions. The analysis takes into account Regions within the project and which are represented by the Project Partners (namely 8 regions of the AS, i.e. Canton of Fribourg, Baden-Württemberg, Autonomous Province of Trento, Lombardy, Austria, Auvergne-Rhone Alps, Slovenia, Bavaria) with respect to their size and value in the Sectors "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma" and "Chemistry". Moreover, the study includes the whole Switzerland as it comprises 26 out of the 48 regions of the AS. The analysis of the Sectors within the regions will show "white spots" which are recorded and used for recommendations for policy makers and stakeholders.

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2.1 Market and social opportunities for the Wood sector

The 58 % of the harvested European wood biomass is processed by EU forest-based industries, which represents approximately 7 % of EU manufacturing GDP and nearly 3.5 million jobs[4]. The regions contribute with more than 35 million m^3 of harvested wood per year as explained in the following. In **Baden-Württemberg**, 11 million m^3 of timber are cut every year. About 4.8 million m^3 of wood are cut in **Bavaria's** area each year. The annual wood use in **Upper Austria** was 3.04 million m^3 in 2017. In **Slovenia** more than 6 million m^3 of wood are harvested every year (inclusive of firewood). Forests of the **Autonomous Province of Trento** produce a biomass of about 337,000 m^3 of wood per year. In **Lombardy**, the **Alta Lombardia** Wood consortium produces annually 147,000 tons of processed wood. **Auvergne-Rhône-Alpes** produces an annual harvest of about 5.2 million m^3 of wood. In **Switzerland** in 2016, 4.68 million m^3 of timber were harvested. In the **canton of Fribourg** 250,000 m^3 of wood are harvested every year. Overall, in EU-28 about 450 million of m^3 wood are harvested every year[5].

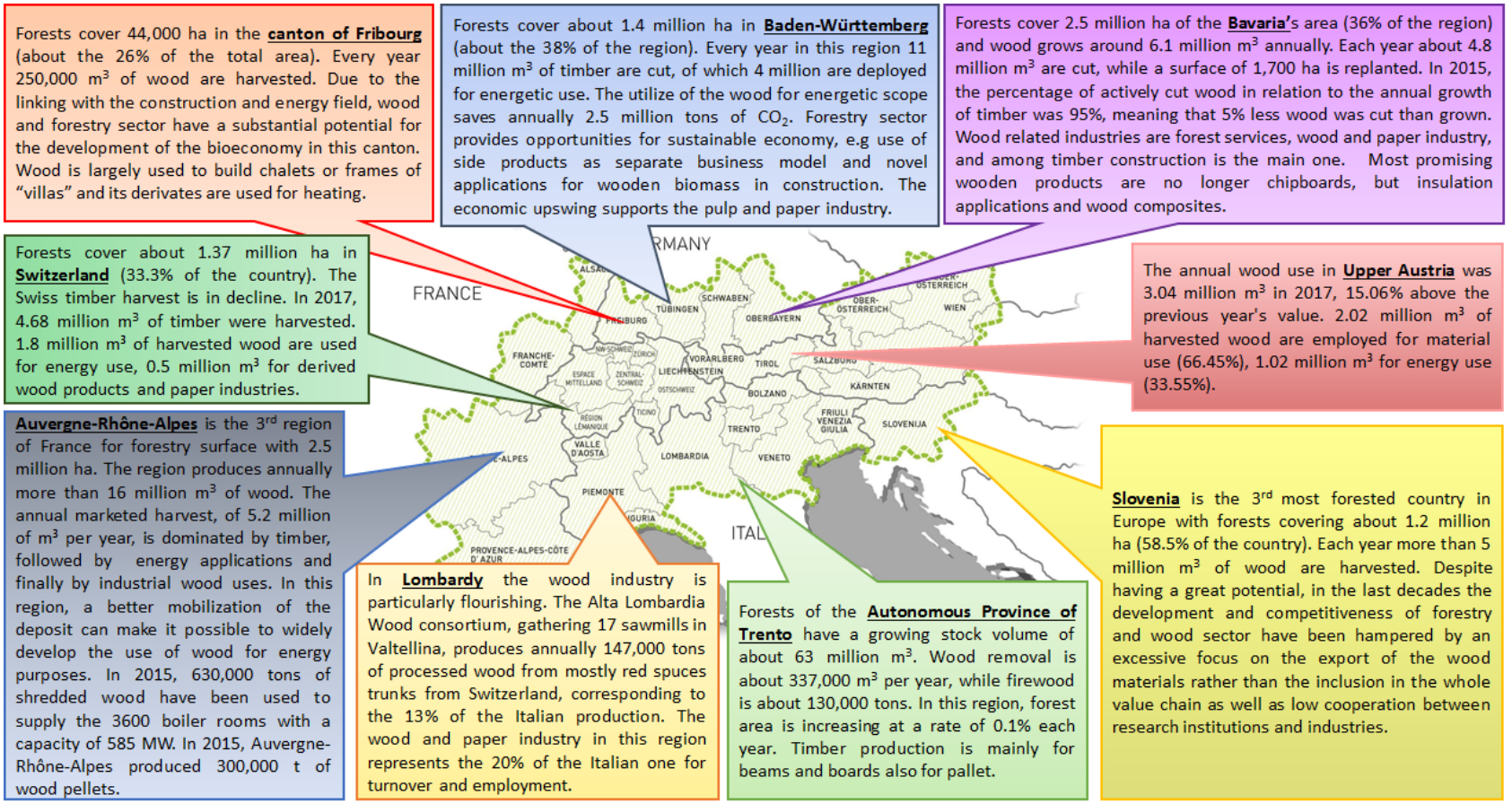

***Figure 1**: Benefits and opportunities of the bio-based economy for Wood sector in Switzerland[6,7] Canton of Fribourg[8], Baden-Württemberg[9,10], Bavaria[11,12,13,14], Austria[15], Slovenia[16], Autonomous Province of Trento[17], Lombardy[18,19]and Auvergne-Rhône-Alpes[20].*

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2.2 Market and social opportunities for the Agriculture (Agro) sector

Overall, in Europe the Agriculture sector alone is responsible for about the 39% of the turnover of the EU bio-based economy, generating around € 390 billion per year. In Europe, the 72% of the total employment of the bio-based market (about 9,900,000 employees) comes from the Agriculture sector[21]. The regions have the potential to contribute with roughly 1,400,000 employees and a revenue of about € 140 billion. In **Bavaria**, the Agriculture and Food industry is strongly developed with 900,000 employees, € 121 billion generated in sales. In **Upper Austria** agriculture and forestry generated an annual gross regional product of about € 2.78 billion and counted about 130,000 employees (in 2015). In **Slovenia,** the Agricultural sector has an annual gross value added that amounts to € 750 million and over than 77,000 employees. In **Autonomous Province of Trento** the first-stage processing industry in agriculture annually accounts for € 303 million. In **Lombardy** the agri-food industry accounts for € 8.3 billion and more than 124,000 employees. **Auvergne-Rhône-Alpes** has a strong food-processing industry with about 4,500 businesses, 40,000 jobs and € 7.7 billion of revenue. In **Switzerland,** the GDP for Agriculture sector was about € 4.25 billion, with 156,000 employees in 2015. In the **canton of Fribourg**, the GDP of the primary sector is € 320 million with about 16,000 full time employees in the agro-food sector (2015).

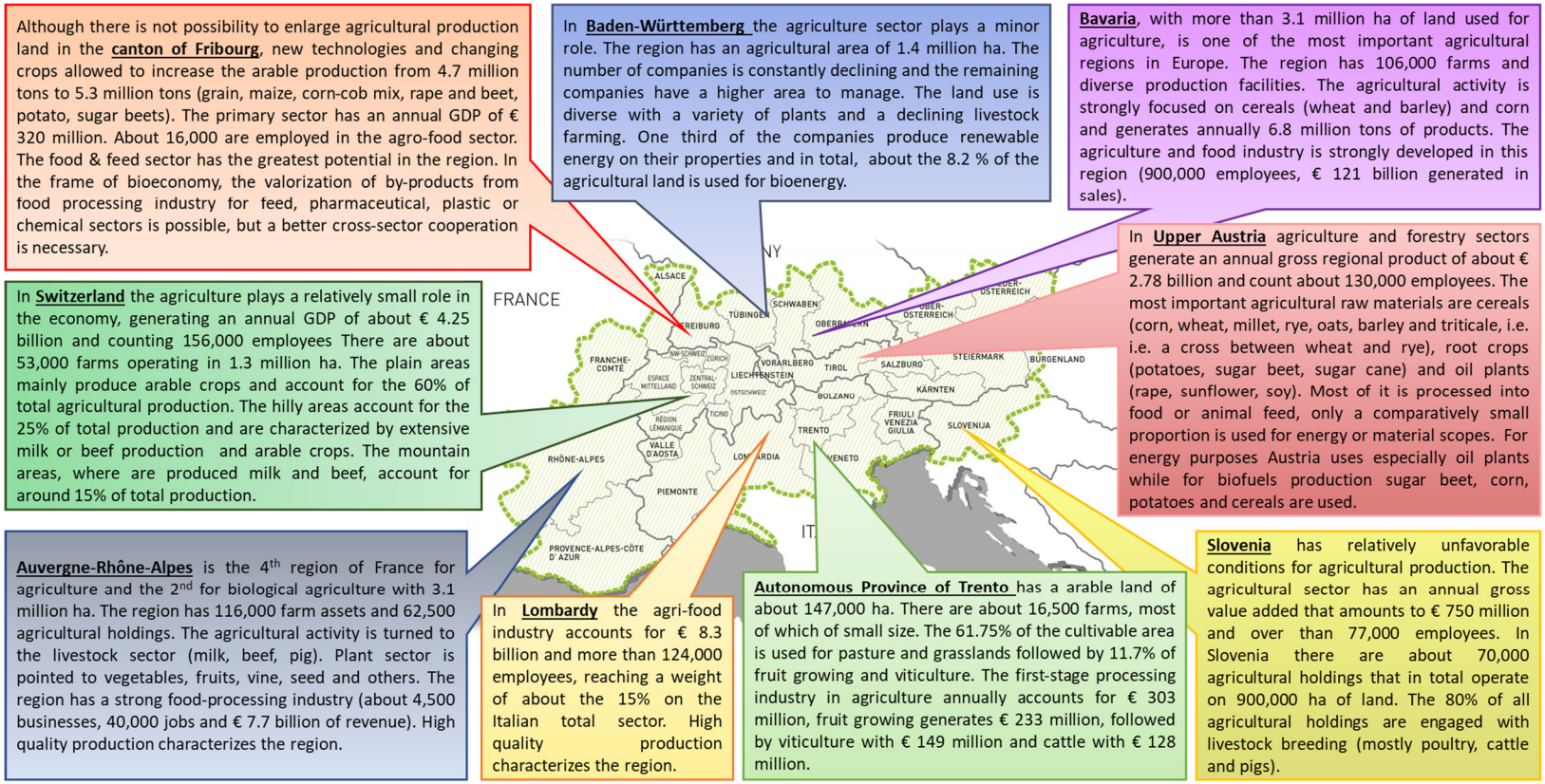

***Figure 2**: Benefits and opportunities of the bio-based economy for Agriculture sector in Switzerland[22], Canton of Fribourg[23], Baden-Württemberg[24], Bavaria[25], Austria[26,27], Slovenia[28], Autonomous Province of Trento[29], Lombardy[30] and Auvergne-Rhône-Alpes[31].*

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2.3 Market and social opportunities for the Packaging for Food and Pharma

Due to difficulties to find data for bio-based Packaging for Food and (especially) Pharma, data about packaging as total are mostly reported in this paragraph. In 2015, the production capacities for bio-based and biodegradable plastics (of which about the 40% is used for rigid packaging), accounted for nearly 1% of total global plastics production, and the market share of bio-based and biodegradable plastics is expected to reach the 2.5% of fossil plastics production by the 2020[32]. Data for the packaging as total are difficult to find at EU level representing a white spot. At regional level, the Packaging sector roughly employees more than 230,000 people. In **Baden-Württemberg** region there are 2,219 firms and 42,858 employments operating in bio-based packaging. The Packaging industry in **Bavaria** employs more than 75,000 people in 578 companies, the challenge now is to capitalise on expertise to make a step towards the bio-based packaging. **Upper Austria** is the 1st Austrian region for bio-based packaging manufacturing, with 426 firms and 9,300 employees. Production of biopolymers and bioplastics in **Slovenia** is rather scarce, in 2014 a total of 14,191 were employed in 1.992 firms. In the **Autonomous Province of Trento**, packaging and packaging material industry are highly considered within the agri-food sector, representing one of the four main sectors for bio-based economy. In the sector of bio-based Packaging, **Lombardy** is one of the top Alpine regions offering many job opportunities with 3,096 firms and 60,291 employees. In **Auvergne-Rhône-Alpes** the bio-based Packaging sector accounts 2,764 firms and 34,819 employees. The plastics sector plays a significant role in bio- based economy growth in the **canton of Fribourg** where 560 full time employees are involved in the manufacturing of bio-based plastic products.

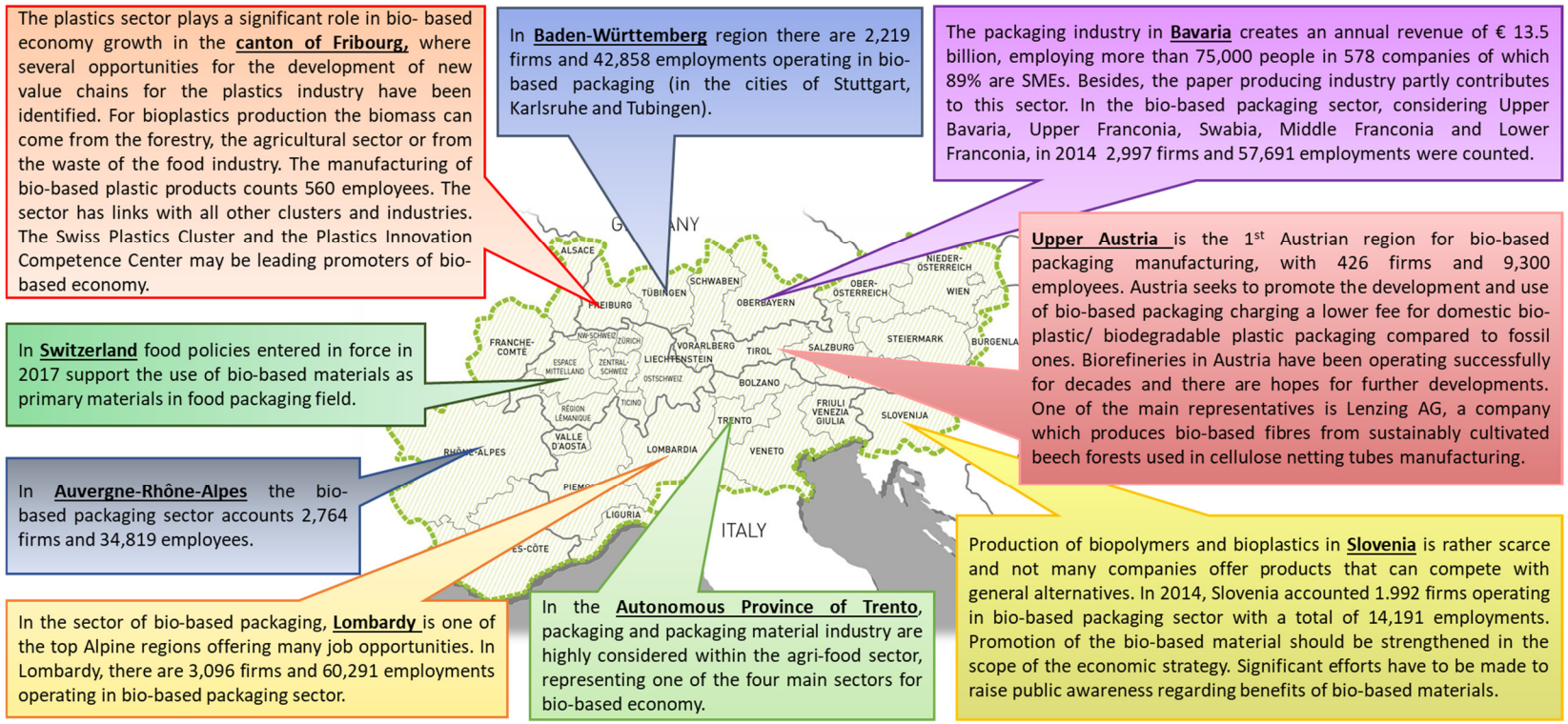

***Figure 3**: Benefits and opportunities of the bio-based economy for Packaging for Food and Pharma sector in Switzerland[33], Canton of Fribourg[23], Baden-Württemberg[34], Bavaria[26,35], Austria[34,36], Slovenia[34], Autonomous Province of Trento[37], Lombardy[34] and Auvergne-Rhône-Alpes[31].*

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2.4 Market and social opportunities for the Chemistry sector

Due to difficulties to find data for the bio-based chemistry, data about Chemistry are mostly reported in the following paragraph. In Europe, the bio-based chemicals production has a share is the 3% of the total market[38], and the chemicals and pharmaceuticals bio-based industry generates an annual turnover of about € 162 billion, with 350,000 employees[39]. Data for the bio-based chemicals production in the regions are difficult to find at regional level, representing a white spot, anyway more than 3000 companies work in the regions in the Chemistry sector, showing a high potential. The chemical and pharmaceutical industries play a key role **Baden-Württemberg,** creating about 72,000 jobs that are the 4.8% of the total industrial employment in the region**.** The chemical industry in **Bavaria** is well developed with about 230 companies, mostly SMEs, with more than 55,000 employees. In 2017, the sector created an annual revenue of € 16.3 billion. In **Austria** the chemical sector in 2016 generates a production value of € 14.8 billion with about 250 companies and around 44,500 employees. In **Slovenia**, chemical industry is one of the main pillars of the economy, generating € 5.4 billion of sales in 2016 with 780 companies and 28,000 employees. The chemical industry contributes to the growth of **Autonomous Province of Trento** generating about € 360 million every year in export. In **Lombardy** there are more than 1,000 chemical companies with 33 thousand employees. **Auvergne-Rhône-Alpes** is 1st French region in chemical production with more than 500 companies and 32,500 employees. Chemical, pharmaceutical and biotech industry in **Switzerland** is highly developed with its 250 companies and 70,000 employees. In the **canton of Fribourg,** the sector of the chemical and pharmaceutical products counts about 3,200 employees.

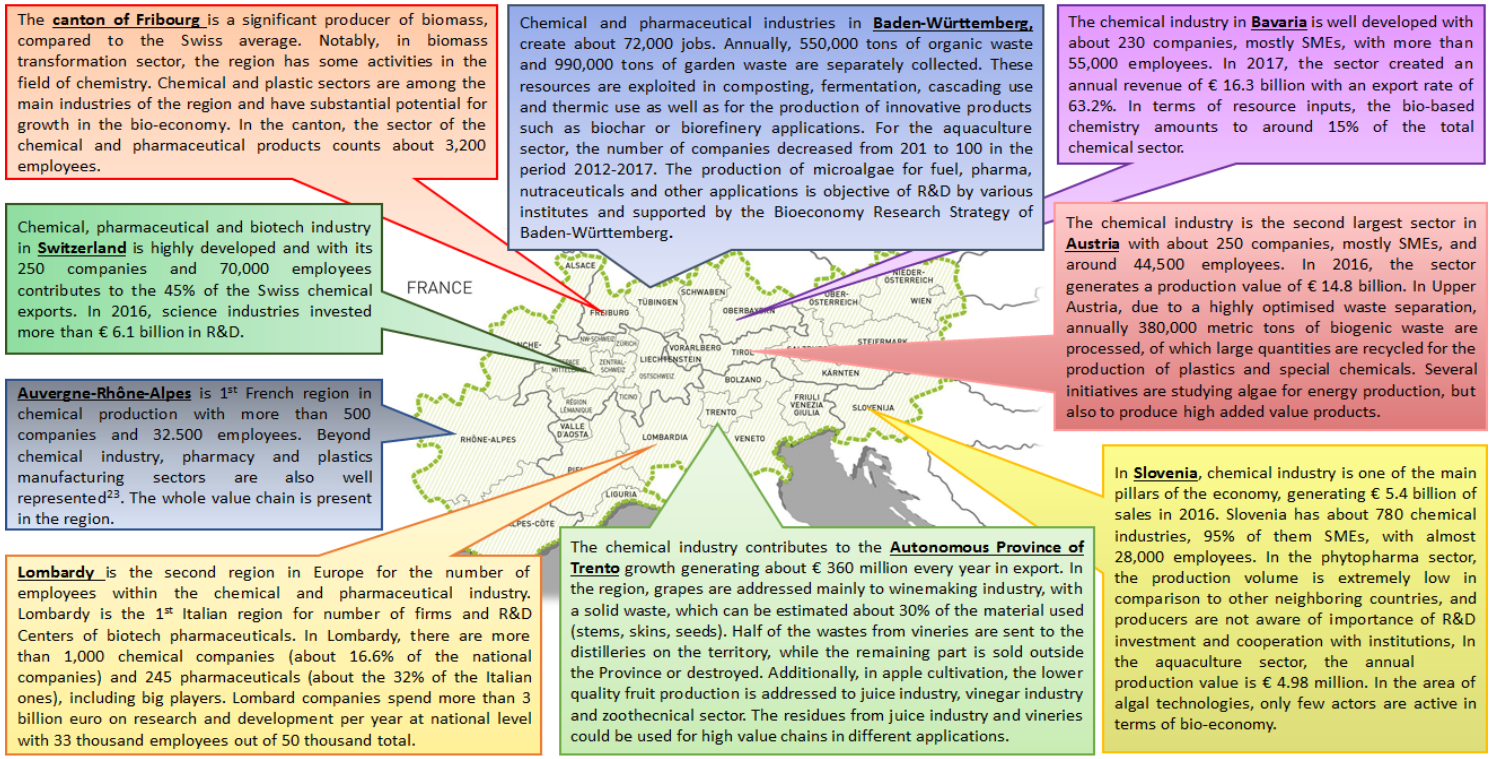

***Figure 4**: Benefits and opportunities of the bio-based economy for Chemistry sector in Switzerland[40], Canton of Fribourg[23], Baden-Württemberg[41,9], Bavaria[42], Austria[43], Slovenia[40,44], Autonomous Province of Trento[37], Lombardy[45] and Auvergne-Rhône-Alpes[46].*

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3. Existing best practice in bio-based economy within the sectors "Agriculture" (agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions and key success factors

While in chapter 2, opportunities for the bio-based economy in the AS have been identified, in chapter 3 an overview is provided on how bio-based economy is currently implemented, i.e. existing best practices (one for each sector), covering the geographical area of the regions. Details are provided about the actors, the resources, the value chains and how the initiative has been established. Since the sectors are very wide and complex, the examples are not necessarily representative for the sectors, but they show different approaches of best use of bio-based materials in the respective sectors. More examples about existing best practices for the four sectors of the AS are reported in *Annex I*.

Best practices have been chosen for their relevance towards indicators that allow to measure, monitor and assess the progress of the bio-based economy. Four types of indicators have been considered according to their sector/objectives:

- **Economic:** e.g. Increasing the business and the turnover, R&D Funding (public or private);
- **Process:** e.g. Production and share of new bio-based products, win of award and competitions;
- **Environmental:** e.g. Reducing dependence on non-renewable resources, mitigating and adapting climate change;
- **Societal:** e.g. Ensuring security, creating jobs and maintaining competitiveness;

In order to identify such indicators a literature research have been performed and a collection of indicators that can be used for the bio-based economy sector is reported in *Annex II*. Moreover, an explanation on how the reported best practices meet those indicators is reported in chapter 4.

3.1 Best practice in the Wood sector

Case study: Tecnaro GmbH

Tecnaro's best practice has been chosen for its relevance towards economic, process, environmental and societal indicators that allow to measure, monitor and assess the progress of the bio-based economy in the Wood sector as reported in section 4, table 1.

Tecnaro used by Gucci, ECO PUMP,

Figure 5: Tecnaro used by Gucci. Picture: Sergio Rossi, Gucci Group.

Within the Wood sector, **Tecnaro GmbH,** located in the Baden-Württemberg (Germany), represents a best practice. Founded in 1998, Tecnaro is a German company which develops, produces and markets bio-based and biodegradable materials. The business is focused on three different material families: Liquid Wood ARBOFORM®, Wood Plastic Composites ARBOFILL® and Biopolymer Compound ARBOBLEND®. ARBOFORM® and ARBOBLEND® consist of biopolymers like the wood constituent lignin or of lignin derivatives and/or other biopolymers like Polylactic Acid, Polyhydroxyalkanoates etc. used as a binder for natural fibers. Because of its lignin matrix, ARBOFORM® is claimed to be as highly constant in quality as the cellulose for papermaking. The disposal of ARBOFORM® products is the same as for naturally grown wood, i.e. natural decay or incineration. The amount of CO_2 emitted in the process is no more than was previously fixed from the atmosphere by the plants while growing. ARBOFORM® is thus claimed to be GHG neutral.[47]

Key success factors:

- Strategic location in Baden-Württemberg, a region covered for the 38% by forest and where more than 11 million m^3 of timber are cut every year.
- Reply to a growing demand for bio-based material, particularly in southern Germany [48].
- Multiple end-of-life options for the materials: other than being biodegradable, Tecnaro's products are recyclable and can be converted into energy at the end of their life cycle, that are added properties compared to other bio-based materials.
- Development of a large portfolio of materials (more than 3,500 material formulas and hundreds of series products made from the bio-based ARBOFORM®, ARBOFILL® and ARBOBLEND® materials) with optimised properties for industrial plastics processing. These features make possible the use of the materials in a wide range of processes and applications, and therefore attract different costumers' categories.
- Cooperation with a sales partner, ALBIS Plastics GmbH (https://www.albis.com/en), a world leader in the distribution and compounding of plastics material.

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Additional success factors:

- Establishing of closed CO_2 cycles (i.e. the renewable raw materials used to produce biomaterials absorb CO_2 during their growth phase and bind it beyond their use phase. If the products biodegrade are converted into energy at the end of their life cycle only as much CO_2 is released as the plants absorbed beforehand[49]).
- Production of biodegradable material made by 100% renewable raw materials (e.g. ARBOFORM® is produced mixing lignin, a by-product of the pulp industry, with natural fibres (flax, hemp or other fibre plants) and natural additives).

3.2 Agriculture

Case study 2: FRUMAT company

Frumat's best practice has been chosen for its relevance towards Economic, process, environmental and societal indicators that allow to measure, monitor and assess the progress of the bio-based economy in the Agricultural sector as reported in section 4, table 2.

Figure 6: Apple skin by Frumat

Frumat, a company located in Bolzano (Italy), is specialized in the recycling of biological industrial waste for the creation of eco-sustainable products. The company was founded in 2008 by a special intuition of the owners, determined to promote a sustainable lifestyle and a production with low environmental impact. Today the company is considered one of the most dynamic ones in the industrial waste recycling sector, both in the Bolzano area and on the national scene, with its wide range of eco-sustainable products and its know-how acquired over the years. Frumat is able to propose a large number of eco-sustainable products for the Italian and international market. The creations proposed by Frumat are obtained through the processing apple cores and skins. The main creations of the company are: i) apple card, obtained through a special processing of industrial biological waste/apple peels and cores, of three different types, i.e. graphic paper, tissue and paper for packaging; ii) the so-called Apple Skin, obtained through particular methods of recycling and processing of the skins and scraps some fruit, is used for the production of clothes, shoes, luggage and leather goods, but also furnishing accessories, sofas, company gadgets, coatings and much more. Therefore, its creations are used in many different sectors, from furniture to manufacturing industry.

Key success factors:

- Strategic location in Trentino-Alto Adige, where apples represent the second main cultivation of the region. Trentino is responsible of the 65% of the Italian apples production, and only in Bolzano, where FRUMAT is located, about 950,000 tons of apples are produced every year[50].
- Meeting the environmental problem caused by the disposal of the sludge waste from the apple processing industries.
- Conversion of food waste into a new raw material and opportunity for fruit processing industries to receive money instead of paying for waste management costs[51].
- Originality of the apple-based products and good acceptance of the market, especially in those countries, beyond Italy, with a large apple production such as Germany, Switzerland, Austria and France.
- Cooperation with other production partners such as Blasetti, a paper industry, Lediberg, a distributor specialized in paper and leather goods, Roto-Cart, a tissue converter, as well as fashion brands.

3.3 Packaging for Food and Pharma

Case study 3: Azienda Agricola Chiesa Virginio

Azienda Agricola Chiesa Virginio's best practice has been chosen for its relevance towards economic, process, environmental and societal indicators that allow to measure, monitor and assess the progress of the bio-based economy in the packaging (in this case specifically for food) sector as reported in section 4, table 3.

The agricultural company Chiesa Virginio, located in Lombardy, developed a completely natural varnish obtained from tomatoes peels', making it possible to recycle waste from tomato processing industry and generate additional income by producing a bio resin to be used **to coat food cans and replace the chemical paints used today**. The company obtained funding from the EC to build a pilot plant extracting the cutin from the tomato peels. The work capacity of the plant is one hundred kilos of peels per hour. Today the system has been patented and the company is committed to scale up the production. Only in the area of northern Italy, tomatoes harvesting produces about 500 thousand quintals of skins, today about only a tenth can be used in the agricultural company Chiesa Virginio plant's so there is still a lot of work to do. Finally, to close the circle, the skins from which the cutin has been extracted can be used as a material to feed the digesters, because, once deprived of waxy substance on the surface, tomatoes peels are attacked by the bacteria and transformed into energy.

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Figure 7: Natural varnish obtained from tomatoes peels by the agricultural company Chiesa Virginio

Key success factors:

- Reply to the growing issue related to the large volumes of by-products resulting from the manufacturing of food. These by-products pose increasing disposal and potentially serious pollution problems and represent a loss of valuable biomass and nutrients.
- Collaboration with a Public Institute for applied research, expert in the food preservation sector (SSICA)
- Development of a new products, a bio-lacquer, that complies with EU safety and sustainability standards **on food-contact materials** and meets new consumers demand.
- Development of an eco-friendly process for natural varnish production, in which no organic solvents are used
- Cooperation with the whole agro-industrial supply chain (from farm to large retail, passing through lacquer manufacturers and packaging producers)[52].

3.4 Chemistry

Case study: Green Sugar AG

Green Sugar AG's best practice has been chosen for its relevance towards economic, process, environmental and societal indicators that allow to measure, monitor and assess the progress of the bio-based economy in the Chemistry sector as reported in section 4, table 4.

Green Sugar AG is a German research and development company with a focus on product innovations for the use of renewable raw materials. In particular, the company develops **conversion processes for the production of industrially fermentable sugars from lignocellulose-containing residual biomass, accompanied by bio-based product developments.** As a platform technology that produces sugars, Green Sugar provides a key solution to a world looking for alternatives to fossil fuels. The **Green Sugar technology** separates the biomass into its main carbohydrate fractions cellulose, hemicellulose and lignin, which can be used in different downstream processes. In particular, the process starts with a pre-treatment and a two-stage acid hydrolysis of the biomass, which allows a separation of lignocellulosic biomass into its main components cellulose, hemicellulose and lignin. The cellulose and hemicellulose are further processed into monomeric sugars such as glucose, xylose, arabinose, mannose and galactose. The hydrochloric acid is passed in a closed circuit and recovered after the pre-hydrolysis and main hydrolysis via an acid evaporation and reused. The C5 and C6 sugars are separated as end products of the Green Sugar process. These **sugars** serve as **a starting point for bio-based fermentation processes to produce biopolymers, biofuels, biopharmaceuticals**, and special **chemicals based on renewable, non-food-grade biomass residues**. The separated **lignin** is used as an **energy source for electricity and steam production for the biorefinery process.**

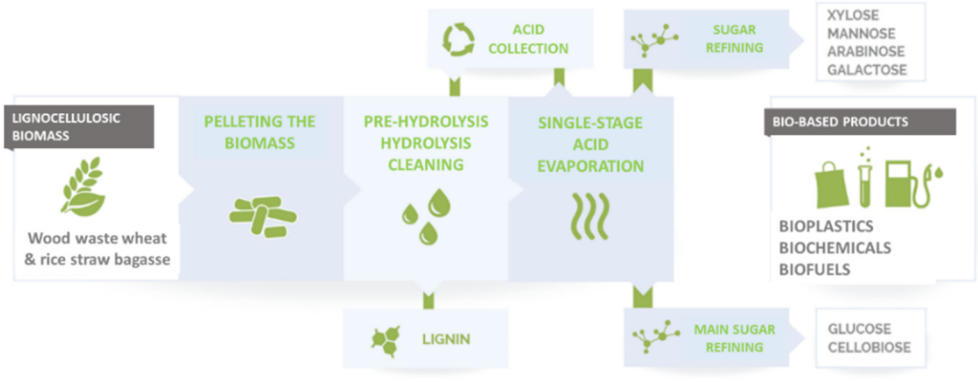

Figure 8: Production of industrially fermentable sugars from lignocellulose-containing residual biomass by Green Sugar AG

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Key success factor:

- Use of lignocellulosic biomass, a side product from Agricultural and Wood sector. The lignocellulosic biomass used in chemical industry has no conflict with the food sector[53].
- High versatility in terms of feedstock type, since all lignocellulosic biomass may function as source for polysaccharides that are required for the Green Sugar saccharification process.
- Establishing integrated value chains and stimulation of economic activities, especially in rural areas, where abundant residual biomass is available.
- Technology partnership with world leading engineering and contracting specialist Linde Engineering Dresden, cooperation for the scale-up of the hydrochloric acid recycling with SGL Carbon and collaboration with Platon Solutions, an innovative German bioplastics design and bioplastics solutions provider.
- Extensive R&D and improvement of the technology, that is today competitive in terms of efficiency and costs[54].

Additional success factors:

- Collaboration with research partners, such as Fraunhofer Institute for Wood Research that addresses current and future-oriented tasks concerning the use of wood and other renewable resources.

4. Key indicators to measure the development of bio-based vcs within the sectors "Agriculture" (agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions

Measuring, monitoring and assessing the progress of the bio-based economy in Agricultural, Wood, Packaging for Food and Pharma and Chemistry VCs in regions allows to study how the bio-based economy is evolving. For the purpose, it is necessary to analyse what indicators would be needed and could be applied to monitor and assess the state and progress of different sectors' contribution to the bio-based economy.

For this study, four type of indicators have been taken into account: **Economic, Process, Environmental**, **Societal** as these indicators could monitor critical issues related respectively to: business and competitiveness, technologies and innovativeness, environment, society. Since the sectors are very wide and complex, indicators have been be applied to the best practices in Wood, Packaging for Food and Pharma and Chemistry. For each of sectors conclusions are reported in the following.

Wood

Case study 1: Tecnaro GmbH

***Table 1**: Key indicators for Best practice 3.1, Wood sector*

sector	Indicator
Economic	***Increasing the business and the turnover:*** TECNAROs' turnover has multiplied by a factor of three from 2010 to 2014. The demand for ARBOFORM and TECNAROs' other products ARBOBLEND and ARBOFILL is exploding.[55] It is worth to mention here the company is among the 8 global major players of the green composites market[56]. ***R&D Funding (public or private):*** - € 276,500 of funding received by EC (H2020-NMP funding program) for the project "BIO4SELF"[57] (2016 - 2019) - € 251,212.50 of funding received by EC (H2020) for the project "ECOBULK"[58] (2017 - 2021) - € 595,023.63 of funding received by EC (BBI funding program) for the project "PULPACKTION"[59] (2016 - 2020) - € 403,125 of funding received by EC (BBI funding program) for the project "LIBRE"[60] (2016 - 2020) - € 237,125 of funding received by EC (H2020 funding program) for the project "GELCLAD"[61] (2016 – 2019) - € 253,500 of funding received by EC (BBI funding program) for the project "FUNGUSCHAIN"[62] (2016 - 2020)
Process	***Production and share of new bio-based products:*** In 2018, Tecnaro GmbH, has doubled the production capacity of its bio-compound in the Ilsfeld-Auenstein facilities by installing a new compounding line with ZE Basic twin-screw extruder of KraussMaffei Berstorff, reaching a maximum output rate of 800 kg/h[63]. Filing of 16 patents. ***Award and competitions:*** TECNARO has already won several awards for sustainability, innovation and future technologies (European Inventor Award 2010, German Industry Award 2009, Werkbund label 2008, Innovation Award of VR Bank 2007, Golden Euromold Award 2000)[64].
Environmental	***Reducing dependence on non-renewable resources***: With ARBOFORM® industry becomes independent from petroleum as a raw material. ***Mitigating and adapting climate change:*** ARBOFORM® can easily be recycled, and even composted or burnt without realising additional CO_2 [47]. Methodology employed for calculation: **LCA assessment**.
Societal	***Creating jobs and maintaining competitiveness***: Tecnaro increased the number of technical staff and the enlargement of the production area by 50% within 2010 to 2014. Number of employees: 30.

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Tecnaro represents the best practice of the Wood VC as its products consist of biopolymers like the wood constituent lignin or of lignin derivatives. Indicators show that in about 30 years of activities the company developed about 3,500 material formulas and hundreds of series products made from the bio-based ARBOFORM®, ARBOFILL® and ARBOBLEND® materials, placing itself among the 8 global major players of the green composites market. In the period from 2010 to 2014 the company multiplied its turnover by a factor of three and enlarged the production area by 50%. Economic and technological performance have been reached while decreasing pressure on environment, i.e. use of petroleum and CO2 emissions.

These encouraging data together with the fact that regions produce about 100 million m^3/year of wood show that the Wood sector offers interesting opportunities for companies willing to invest in the wood bio-based VC.

Agriculture

Case study 2: Frumat

***Table 2**: Key indicators for Best practice 3.2, Agricultural sector*

Sector	Indicator
Economic	***Increasing the business and the turnover:*** The company has an **annual turnover of 0.42 million Euro**[65].
Process	***Production and share of new bio-based products:*** The company was founded in 2008. In 5 year, the amount of organic industrial waste employed for the eco-sustainable manufacturing has increased from 0 to 30 tons/month[66]. ***Award and competitions:*** Frumat has been awarded at Green Carpet Fashion Awards 2018 in the category Technology and Innovation[67].
Environmental	***Reducing dependence on non-renewable resources***: the products contain a high percentage of apple fibres (at least the 50% of the total) obtained by recycling of organic industrial waste[68].
Societal	***Ensuring security:*** The Apple Skin product developed by Frumat can be used for the production of clothes, shoes, luggage and leather goods, and it was recently adopted by two fashion firms, Alma s.p.a. and Matea Benedetti.

Frumat is the company representing a best practice in the Agricultural sector. Indicators show that in 5 year, the company increased the amount of organic industrial waste employed for the eco-sustainable manufacturing from 0 to 30 tons/month (about **360 tons/year**) and reached an annual turnover of 0.42 million Euro in 10 years from its birth.

Considering only in the area of Autonomous Province Trento the amount of agri-food waste (the majority coming from apples and vines) is about **74,000 t/year (meaning that less than 1% of agri-food waste is used by Frumat)**, there is still space for improvement *in the bio-based agricultural VCs*.

Packaging for Food and Pharma

Case study 3: Azienda Agricola Chiesa Virginio

***Table 3:** Key indicators for Best practice 3.3, Packaging sector (case study specific for the Food Packaging sector)*

Sector	Indicator
Economic	***Increasing the business and the turnover:*** Turnover: 4 € Milion/year.[69] ***R&D Funding (public or private):*** - Since 2016, the company has been receiving € 1,135,766.63 of funding by BBI-JU funding program for the 4-year project "AgriMax", in collaboration other 28 partners[70]. - From 01-06-2014 to 31-12-2017 the company has received funding by LIFE Programme by participating at the "LIFE BIOCOPACPlus - BIOCOPAC: Sustainable bio-based coating from tomato processing by-products for food metal packaging". The total budget of the project was 1,018,022.00 €[71].
Process	***Production and share of new bio-based products:*** The Virginio Chiesa plant has a capacity of 100kg/h of skins that are used to produce cutin with an averagely high extraction yield of 10-15%. The heat treatment is carried out at high temperature >120°C) for a short time (≤30') [72]. Filing of 1 patent. ***Award and competitions:*** In 2017, the company was the winner of the Oscar Green, a contest promoted by Coldiretti that awards the best innovation in Agriculture field[73].
Environmental	***Reducing dependence on non-renewable resources***: - reduction of non-renewable raw materials use: 2.5 kg non-renewable material avoided/ 1000 m^2 metal sheet - recycled tomato-based waste employed: 7 kg tomato waste/ 1000 m^2 metal sheet ***Mitigating and adapting climate change:*** - reduction of CO_2 emission: 400 mg CO_2/cans with side stripe - reduction of carbon footprint: 730 mg CO_2 eq/cans with side stripe. It has to be mentioned that a medium sized lacquer manufacturer produces on average 30,000 tons/year. If at least 4,000 tons/year of standard lacquer would be replaced with lacquer derived from tomato, there will be a reduction of CO_2 eq emissions of 2 tons/year. Considering instead that 650 K-tons of metal packaging are used in Italy every year, the reduction of emissions could be impressive, i.e. 1 million kg of CO_2 eq/year

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	- energy from renewable resources: 90 dm^3 biogas/ 150 kg tomato skins - reduction of water use: 7 kg water/ kg tomato skins - consumption of electrical and thermal energy: 68.5 kWh/150 kg tomato skins - reduction of wastes and wastewater: 450 kg wastes/150 kg tomato skins - percentage of recyclability of the product and its end of life, reduction of pollution during the recycling: 50%-70% [74]. Methodology employed for calculation: **LCA assessment**.
Societal	***Ensuring security:*** - The use of a bio-lacquer replacing synthetic lacquers reduces the risk of environmental pollution in the steel recovery phase and thus promotes the recycling of metal containers, allowing the already high recovery percentages to increase even further[72]. - The solution promoted by Virginio Chiesa brings advantage for tomato growers and tomato processors due to value given to their processing waste and a consequent reduction in disposal costs. - Since the metal packaging with bio-based liquor is more easily recyclable thank s to the Virginio Chiesa solution, the metal packaging sector can become more competitive. - The production of a natural lacquer is an advantage for the whole agro-food chain down to consumers because it solves the problems of migration of dangerous synthesized substances from the lacquer into food. Methodology employed for calculation: **Socio-Economic Study**.

Indicators show that the Azienda Agricola Chiesa Virginio represents a best practice in the packaging VC as it is producing an innovative varnish obtained from tomatoes peels **to coat food cans and replace the chemical paints used today in food packaging**. The agricultural company found the way to exploit a processing waste produced from its core business (tomato growth), by giving it value with a consequent reduction in disposal costs and environmental pressure. In fact, the new solution will reduce CO_2 emission and water compared to the conventional varnish productions system by at the same time complying with EU safety and sustainability standards **on food-contact materials**.

The Chiesa Virginio plant can use about **only a tenth of about 500 thousand quintals of skins produced from tomato harvesting in the area of northern Italy**, *showing interesting opportunities for companies willing to invest in the bio-based packaging VC.*

Bio-based Chemistry

Case study 3: Green Sugar AG

Table 4: *Key indicators for Best practice 3.4, bio-based Chemistry sector*

Sector	Indicator
Economic	***Increasing the business and the turnover:*** In 2014, the **total assets of the company amounted at € 316,371**[75]. ***R&D Funding (public or private):*** - Since 2017, for 3 years, the company has been receiving funding by the German Federal Ministry of Education and Research (BMBF) within the framework of the "KMU-NetC" funding program for the HyAlt4Chem project, in collaboration with Fraunhofer Institute for Wood Research WKI, GNS mbH, ORmatic GmbH and the Leibniz Institute for Agricultural Engineering and Bioeconomy ATB[76]. - In the past, from 01-01-2012 to 31-12-2014 the company has received € 179,734 of funding for the European project *Sustainable surfactant production from renewable resources through natural fermentation for applications in natural, organically-certified products* (FP7-SME) in collaboration with other 13 participants[77].
Process	***Award and competitions:*** Due to its innovative strength and social and industrial relevance, the company is currently supported by the Federal Ministry of Research and Development as well as the Saxon Development Bank (SAB) and was able to win leading chemical companies Linde Engineering Dresden and SGL Carbon as technology partners. In addition, the corporate strategy was honoured by the IQ Innovation Award Central Germany[78]. ***Production and share of new bio-based products:*** Filing of 4 patents. The company currently operates a pilot plant and as a next step for the company's development, Green Sugar now plans to build an industrial pilot plant as the basis for national and international commercialization of the technology.
Environmental	***Reducing dependence on non-renewable resources***: Green Sugar has developed a technology, which valorises residual biomass that is often left unused and treated like waste. The focus of Green Sugar is on lignocellulosic biomass since its use in the chemical industry avoids a conflict with the Food sector and promotes food security. Those parts of the plant which are not edible, especially wheat / rice straw, husks, bagasse but also grass, which contain a high concentration of polysaccharides, can be utilized by Green Sugar. Beyond that, forestry waste from the oil palm sector like empty fruit bunches and leaves, tree-tops and trunk waste from the bioenergy sector, as well as timber and residues from the pulp and paper industry are suitable for the Green Sugar saccharification process[78].
Societal	***Creating jobs and maintaining competitiveness***: 11-50 employees.

Green Sugar represents a best practice of the bio-based chemistry VC. Founded in 2007, Green Sugar has developed a proprietary process for the separation of lignocellulosic biomass. The energy self-sufficient process enables the exploitation of the world's most common biomass as a source of raw materials for bio-based chemistry and is not in conflict with agriculture,

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world food, climate change and biodiversity. The process enables the sustainable production of bioplastics, bioethanol, biosurfactants and amino acids. The company currently operates a pilot plant with the intention to scale up to an industrial pilot plant.

Lignocellulosic biomass is one of most abundant biomasses in the regions with 100 million m^3/year of wood produced each year, moreover the Chemistry sector accounts for more than 3000 companies the regions, showing that it offers interesting opportunities for companies willing to invest in the bio-based chemistry VC.

5. How an ideal vc should be structured in terms of actors and processes in the bio-based economy within the sectors "Agriculture" (agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions

5.1 Model value chains and related examples

Opportunities, resources, activities, actors and best practices mapped in the previous paragraphs can be used to describe/model how an ideal VC should be structured in the bio-based economy within the sectors "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the AS regions. The following Figures report the VCs model drawn for each sector referring to best practices already implemented in regions. Since the sectors are very wide and complex, the examples are not necessarily representative for sectors, but they show different approaches of best use of bio-based materials in the respective Sectors.

Wood VC

According to best practices described above, e.g. **Tecnaro**, sustainable biomass can be fractionated in plant for sugar and lignin recovery, converted into bio-based materials and used to develop final products such as elastomer foams for tube insulation, rigid polyurethane foam panels for insulation, polymer compounds intended for injection moulding, high-purity sugars for novel end-use cases. Other VCs in Wood sector within regions can be established as demonstrated by other bests practices set-up by actors of the regions, e.g. insulated panels can be obtained from wood, super-compressed cork, etc, and customized for doors producers, green building industry, pellet and energy industry, as **Galante wood technology** (located in Autonomous Province of Trento) is already doing. Dried wood can be converted into wood wool for logistic companies and retailers by shredding the wood and manufacturing the final product, according to the work performed by **Lindner Suisse GmbH** (Switzerland).

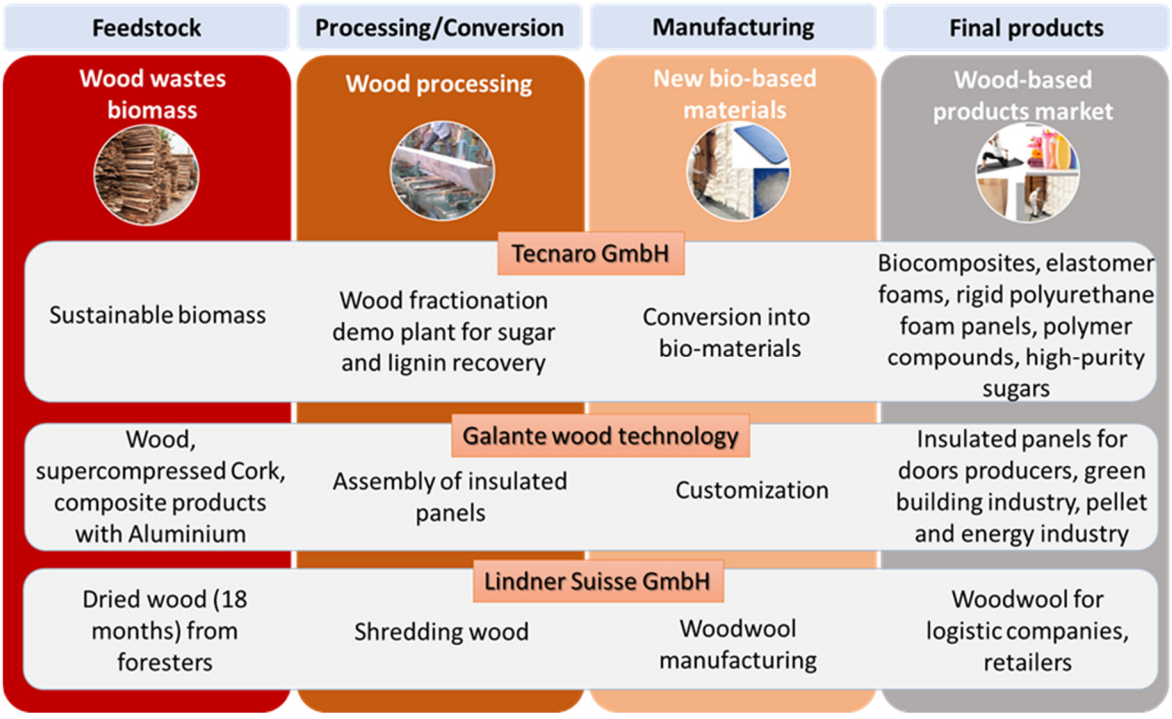

***Figure 9**: Wood Model VC*

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Agriculture VC

Apple skins and seeds provided by producers and converters can be used to obtain apple paper for packaging, Apple Skin for fashion industry, furniture producers, automotive, transportation, as already demonstrated by FRUMAT. Also, in this sector other VCs have been demonstrated by other actors. This is the case of grape and dried marks from wine producers that can be used to produce bio-textile for fashion industry, furniture producers, automotive and transportation as already done by **Vegea**, (located in Autonomous Province of Trento) or fresh unsold commodities can be reused to produce jams and marmalades for Ho.re.ca., supermarkets, as done by **Menz&Gasser** (located in Autonomous Province of Trento).

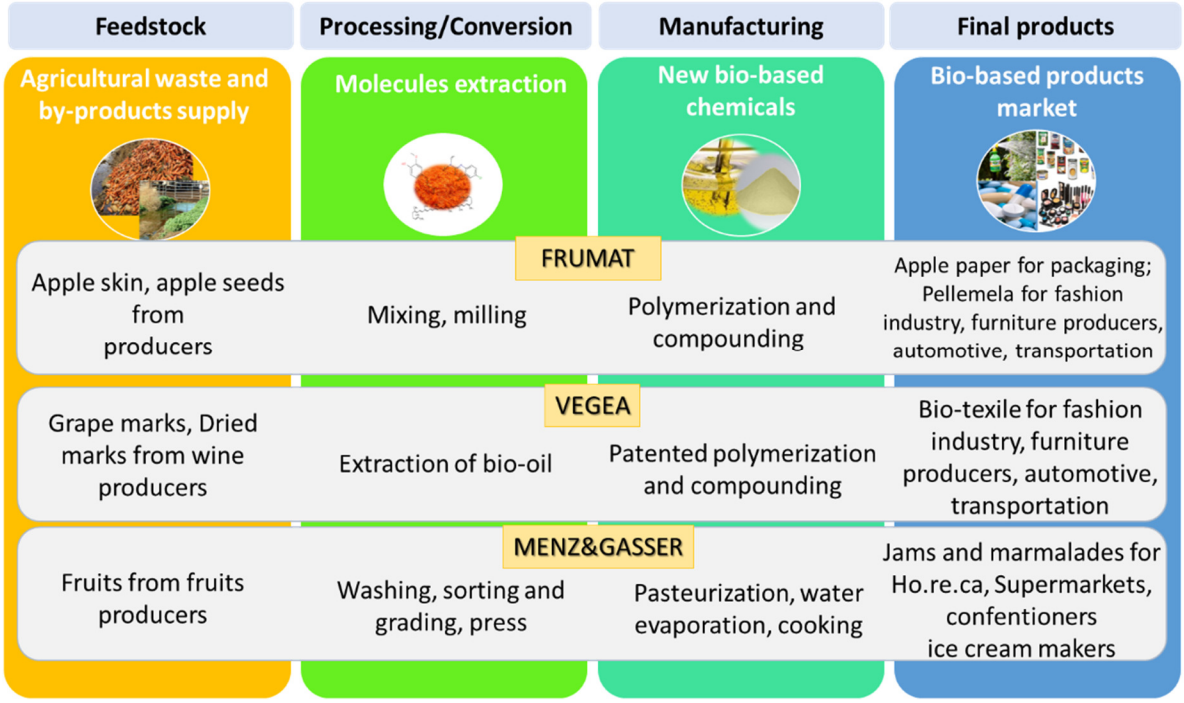

Figure 10: *Agriculture Model VC*

Packaging for Food and Pharma VC

Cutin extracted from tomatoes peels can be used to produce biolacquer to be applied to coat food cans and replace the chemical paints. Moreover, the skins residue from the extraction process can be used to feed the digester where the bacteria can act to produce energy, this is the model VC to describe the best practice reported above for the **Azienda Agricola Chiesa Virginio**. Another example of VC is represented by **Mugu srl** (located in Lombardy); they start from fungal mycelium grown on solid and liquid agro and wood residues to produce bio-based plastic containers and box. Also, as demonstrated by **Evergreen**, in Slovenia, food waste/ waste from food industry can be processed in order to obtain protein and ecoflower pots, picnic sets for gardeners and end-users.

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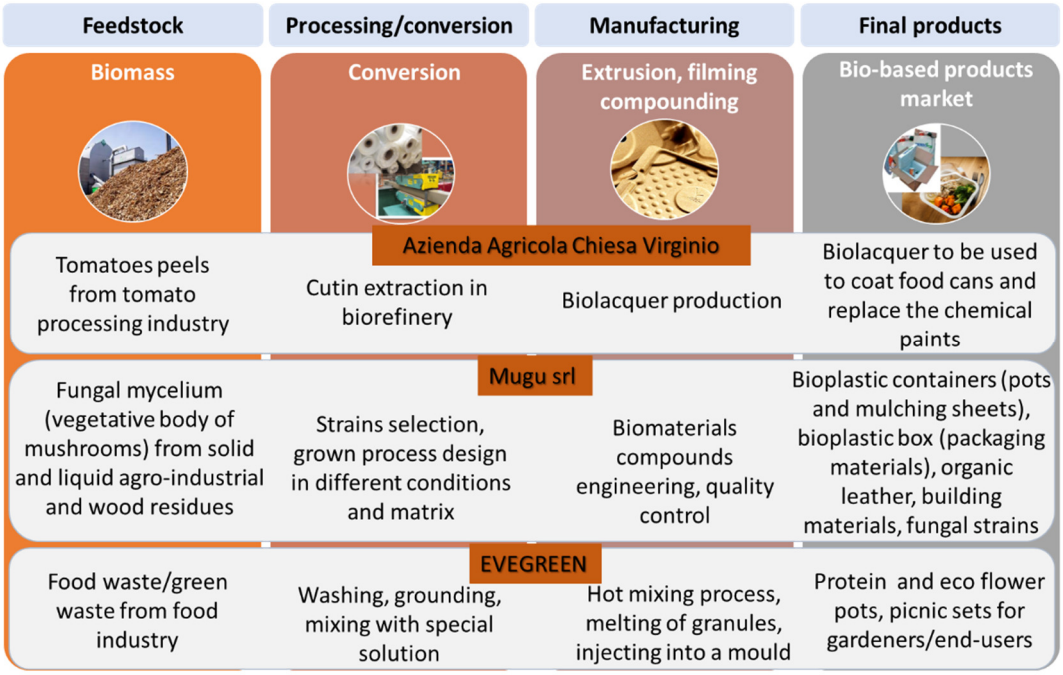

***Figure 11**: Packaging for Food and Pharma sector Model VC*

Chemistry VC

Green Sugar AG demonstrated a new bio-based VC in the Chemistry sector by processing wood waste, wheat & rice straw bagasse to obtain bio-based plastics, fuels and chemicals. Other VCs in chemical sector within regions can be established and demonstrated by other bests practices set-up by actors of regions, as the case of **Novis waste valorization GmbH,** located in Baden-Württemberg region, that is dealing with the waste-incineration slag from plants to recover metals and ores for the metal processing industry. A VC to obtain lignosulfonate for animal farming, cement industry, plaster and particle board industry has been demonstrated by **Burgo Group**, in Veneto. Oil/Ricinus oil from tropical trees can be converted into polyurethane binders for construction industry, as already done by **Conica AG** (Switzerland). In the case of **Conica AG**, the imported castor oil maybe replaced by another natural source (but further RD is necessary.)

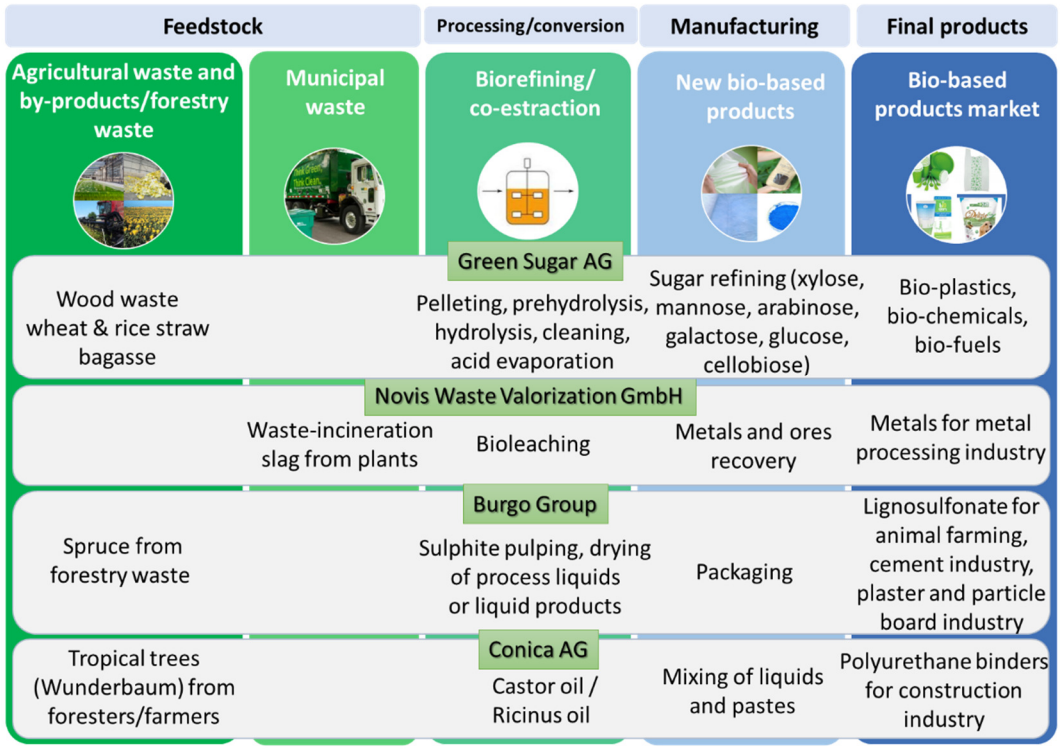

***Figure 12:** Model Bio-based Chemistry VC*

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All the proposed VCs show some relevant aspects; in particular, they highlight:

- How, starting from unexploited feedstocks, it is possible to develop different VCs where different actors, with different profiles, can establish new business opportunities;
- How the same process step can be performed by different companies/organizations;
- How the resources/biomasses can be processed to obtain different kind of products;
- How, starting from one type of biomass, it is possible to reach different markets;
- How the cooperation in VCs is fundamental in order to complete the VC and to make the final product suitable to be marketed.

The VC models give an idea of how it is necessary to increase the production of some biomass or to explore the use of new resources in order to guarantee a commensurate procurement; therefore, they allow the companies to find a solution/process that can be applied to new resources. All the mentioned companies/case studies can inspire entrepreneurs, clusters, companies, new projects in replicating the processes and in the developing/implementing new VCs within the sectors "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions.

5.2 The role of the Clusters to generate new business opportunities in the bio-based economy within the sectors "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions

Clusters play a fundamental role in generating new business opportunities within and/or across the regions in the Agricultural, Wood, Packaging for Food and Pharma and Chemistry sectors. The crucial role of Clusters is being extensively addressed by two *Interreg* projects, that are **S3-4AlpClusters** and **DanuBio ValNet**. In particular, the projects research show how the Clusters represent: local concentrations of capacities, entrepreneurial resources, mid grained level of aggregation, cross-sectoral connectivity, actors of the quadruple helix.

Clusters VCs embrace all relevant actors (from raw materials to the end products for consumer) of the innovation process and they provide important information about needs, opportunities and ongoing transformations. In addition, Clusters are often stretched over several regions where they can facilitate links among actors through interregional cooperation. Clusters are ideal vehicles to transmit transformation processes to the business level and to give them real impact in terms of innovation within enterprises, new VCs and jobs in innovative new fields with high growth potential.

Furthermore, Clusters can be understood as regional concentrations of economic activities in related industries connected through local links, have long been known to be a feature of market economy. Cluster organisations can help firms to better engage with other local actors within their cluster and to organise collective action to strengthen the local VCs. And they can reduce the transaction costs for firms, especially SMEs, in building links to firms and collaboration actors in other locations. Clusters have a distinct geographic dimension, reflecting the dynamics of local spill-overs. They are also deeply embedded in a broader geographic context as they are connected to other clusters with complementary strengths in regional, interregional or global VCs.

According to explanations reported above, active clusters analysis is the proven tool to bring actors together to respond quickly and agilely to local market needs.

In this context of particular importance is a VC generator, developed to match actors demand-oriented in new VC, enabling clusters activities for novel business opportunities.

However, there is a lack of experience among the regions on how to use clusters and how to develop implementation tools to fully benefit SMEs. In addition, alignment between and knowledge about other regions' strategies are very limited. Moreover, the Cluster initiatives focusing on bio-based industries are facing significant challenges as they operate within an emerging industry with specific demands that cannot be properly addressed by traditional networking and matchmaking. [79, 80]

6. Challenges and gaps the bio-based economy within the sectors "Agriculture" (agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions

In this section, the activities carried on by actors of the bio-based economy within the sectors "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions have been mapped. More detailed information on this are reported in *Annex III*. After analysing resources and actors' activities, it is possible to identify and highlight which are the "white spots" within the sectors in the regions. They represent the business opportunities where the companies can invest and where the clusters can build links to fill in the gaps to build new VCs.

A goal-oriented cooperation between the various actors not only at sectors level but also policy level is necessary to establish a future holistic cross-regional approach to connect all relevant actors in cross-regional and sectorial VCs for implementing a bio-based economy. It also requires initiatives and awareness raising, to communicate the future importance of the bio-based

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economy to all actors and to bring this issue to the political agenda. In this context clusters and networking opportunities are of outmost importance, so aim of this chapter is also to identify clusters, networking initiatives and policies at regional level within the sectors and to identify challenges and gaps to show "white spots" which are recorded and used for recommendations for policy makers and stakeholders.

6.1 Analysis of the different regions with respect to their size and value in the Sectors "Agriculture", "Wood", "Packaging for Food and Pharma"

In general, **Agriculture** **is one of the most developed sectors** (according to turnover generated and number of persons employed, as reported in paragraph 2.2), especially in Autonomous Province of Trento, Lombardy, Auvergne-Rhone Alps and Bavaria. In the **Autonomous Province of Trento**, the agricultural residuals (from apples and vines) and the animal manure, the wastewater and dry sludge represent the most abundant resources; the animal manure is mainly used in Biogas plant[37]. In the **Lombardy region,** the wastewater/ sewage sludge, corn silage, autumn-winter cereal silage, livestock animal waste, grass, flour products, glycerin, vegetable oils and urban waste of organic nature are the most abundant resources which are treated and used for biogas production[81]. The **Auvergne-Rhone Alps region** produces biomass especially animal dung, intermediate cultures between two main crops and waste from the agro-food industries[31]. In **Bavaria** cereals (wheat and barley), corn, silage maize and manure are mainly exploited for the Biogas production[82].

The **Food and Feed Industry** is strictly related to the **agricultural** industry, and besides other regions, is well developed in **Bavaria**[82] where, from food waste, it is possible to produce different kind of bio-based products, for instance biogas or bio-based packaging. In **Lombardy**[81], the Food sector represents one of the main relevant pillars of the regional development strategy. It is working to valorize the waste streams which are generated during harvesting, storage and transport prior to primary processing (primary stream), during primary processing within the agro-food industry (secondary stream) and during production or consumption by end users (tertiary stream).

All the regions are active within the **Wood sector** and the available resources are mostly the same for all the regions. They are mainly from conifers but hardwoods could be more exploited as more significant feedstocks. Presently it is very significant the production of semi-finished products in Alpine area like boards. Building industry related to solid beams and laminated timber is also very important. Residual biomass from sawmill processing, end-of-life wood, waste from wood industry could be a relevant feedstock. For instance, in the **Canton of Fribourg** they are used as feedstocks for manufacturing products of wood, bark, straw and plaiting materials, moreover, the lignin extracted from the starting biomass is used for bioplastic production; or in **Autonomous Province of Trento** the timbers are largely used for pallet industry, which can also exploit minor quality wood, while the wood industry residuals are mainly used for bioenergy production, even if sometimes it is used as mulching and as bedding for cattle; **Lombardy** region owns some expertise also in the **paper manufacturing** from wood waste; or in **Slovenia** the wood-based products are exploited for energy applications [8, 31, 37, 41, 82, 83, 84, 85].

In some of the regions, waste from **Agriculture** and **Wood** are used to produce energy, this is the case of **Lombardy**[81]**, Switzerland**[86], **Baden-Württemberg** and **Autonomous Province of Trento** since they are able to exploit different kind of feedstocks to produce energy. In particular, wood waste, agricultural biomass, animal waste, household and industrial waste are exploited for biogas and bioenergy production. For example, the **Baden-Württemberg** companies are producing electricity, heat and fuel from different sources; or the Switzerland is already producing wood-based, thermal and electric energy.

As for the Wood sector, also **Packaging** sector activities (due to difficulties to find specific data for Packaging for Food and Pharma, data about Packaging as total are mostly reported in the following) are widespread among regions. Biomass and waste from agriculture, Wood and Food industry are used for bio-based packaging and polymers production. For instance, the **Canton of Fribourg**, **Bavaria** and in **Switzerland** companies produce packaging material for the food industry (according to the analysis of sectors reported in Annex III and the sources reported at the end of the paragraph); or in **Baden-Württemberg** the companies are using bio-based polymers for specific packaging applications. [8, 31, 37, 41, 82, 83, 84, 85]

According to the research carried out, the **Chemistry** (due to difficulties to find data for the bio-based chemistry, data about Chemistry are also reported in the following) is developed in all the regions, especially in **Austria** and **Bavaria** regions. In **Austria,** the fine chemicals production is well developed, such as acetic acid, furfural, magnesium lignin sulfonate, Omega 3 fatty acids, succinic acid which can find applications in different fields like food, refining and printing industries. [83] In **Bavaria**, the Chemistry industry is one of the most powerful bio-based economy. The biomasses are used for the production of fine chemicals which can find application in drug production, biocatalysts, biofilms and bio-based packaging for food and pharma.[82]

This overview allows to identify "white spots", where is it possible to build new business opportunities.

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6.2 “White spots” in bio-based economy within the sectors “Agriculture” (Agro), “Wood”, “Packaging for Food and Pharma”, “Chemistry” in the regions

In **Baden-Württemberg, Wood** sector represents a chance for the sustainable economy, in fact side-streams products of wood industry can be used as separate business model and wood biomass can find new applications in construction sector other than for energy production. For pulp and paper, general economic upswing enhances the industry. Bio-based refineries do not exist in Baden-Württemberg on an industrial scale[41].

The sector with the greatest potential in the region of **Fribourg** is food & feed (strictly related to the **agricultural** industry). The food processing industry has the potential to valorize all the by-products or wastes they produce (biomass). Nowadays, these by-products are transformed into animal feed or biogas, or they are burned. The construction and energy sector have substantial potential in the development of the bio-based economy in the canton of Fribourg. Much of this potential is linked to the **Wood** sector, new applications and developments have to be found to value biomass even more in the construction industry. The **Packaging sector** plays a significant role in the development of the bio-based economy in the canton of Fribourg. The biomass in the production of bioplastics can come from the **Wood** sector (e.g., lignin), from the **Agricultural** sector with the use of starch or sugar, or from the waste of the food industry (e.g., animal proteins)[8].

In **Autonomous Province of Trento**, **wood** and **agricultural** waste and byproducts can be further exploited. Currently half of the wastes from wineries are sent to the distilleries on the territory, while the remaining part is sold outside the Province or destroyed. The lower quality fruit production is addressed to juice industry, vinegar industry and zoothecnical sector. As reported in the paragraph above, waste from the wood industry are mostly used to produce energy. The residues from juice vineries and wood industry could be used for high value chains in different applications[37]. This is probably due to the lack of chemical companies involved in processing/reusing of those materials. Furthermore, there is a lack of knowledge of the chance of NVC as it has been assessed from the project CirculAlps.

In **Bavaria,** as reported above, waste **wood** and **agricultural** waste are mostly used to produce energy. In this region, only few value chains that cross industries and only low cascaded usage of raw material could be identified, probably due to missing economic incentives and subsequent consequences on logistics [82].

Lombardy in its Regional Strategy for bio-based economy already identified some “white spots” such as creation of integrated biorefineries in the territory to obtain high added value products (e.g. **chemicals**) starting from **wood** and **agricultural** waste; development of new bio-based products (e.g. **Packaging for Food and Pharma**) (obtained partially or totally from materials of renewable origin); scale-up R&D activities to pilot plants and demonstrators[84].

The potential exploitation of **wood** biomass is still high in **Slovenia**, due to abundance of land covered with forests. This can be incorporated in the field of production of **packaging for food and pharma** and added value **chemicals** (drugs for Phyto pharmacy, food additives), and **wood**-based efficient construction[85].

In **Austria**, as a result of the decline in livestock breeding and dairy production, the potential of grassland biomass (grass, clover, alfalfa etc.) and grassland (fallow land) as a " new **agricultural** raw material" for a bio-based industry increased. Large amounts of biogenic residues (**wood** waste, production waste, etc.) are thermally utilized in installations approved for this purpose. **wood** and **agricultural** waste can be used to produce bio-based materials[87] such as **packaging for food and pharma** and added value **chemicals**.

In **Auvergne-Rhône-Alpes**, the abundant regional **wood** resource remains underexploited[20], despite being the 3rd AS region in terms of forestry surface. Better mobilization of the wood deposit can make it possible to widely develop the use of wood as energy, in accordance with the ambitious objectives of the multiannual energy program[Errore. Il segnalibro non è definito.] but also the production of **packaging for food and pharma** and added value **chemicals.**

6.3 The Clusters initiatives in the AS

In the following an overview of clusters supporting bio-based economy in Agriculture, Wood, Packaging for Food and Pharma and Chemistry sectors in the AS regions is reported. For each region, detailed tables with name of the clusters and the sector in which they are acting are reported in *Annex IV*. The overview will allow to identify “white spots” in cluster activities which are recorded and used for recommendations for policy makers and stakeholders.

The major clusters of the **Canton of Fribourg** are directly or indirectly active in the bio-based economy. These clusters embrace activities regarding biomass production, biomass processing and bio-industry products. The **Agricultural** sector is included in the Food & Nutrition Cluster, the **chemical** and **packaging** (as whole, as specific information about packaging for food and pharma are difficult to find) sectors are partially included in the Swiss Plastic Cluster, and the **Wood** sector is included in the Energy & Construction Cluster.

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The overall cluster landscape in **Baden-Württemberg** is not focusing on the new bio-based economy, even if strong clusters exist, within which bio-based products are included. Several clusters in the primary biomass sector for **wood** exist in the region but non for **Agriculture**. The remaining clusters can partially cover the bio-based economy VCs related to Packaging (not specifically for food and pharma) and Chemistry sectors but they are not specifically focusing on the usage, refinery or final application of renewable biomass. These clusters with their associated partners would further benefit from an intensified bio-based approach.

There are few cluster initiatives in **Autonomous Province of Trento,** but more Association and Cooperation initiatives at local and national level to which the industries and companies participate (Federlegno, Federforeste, Coldiretti, Forest Consortium, Confindustria) exist. In general, the interventions are more oriented at the single value chain level or district, also considering the dimensions of the territory.

Lombardy Region promotes and supports **Chemistry** through Lombardy Green Chemistry Association-LGCA[88] and **Agriculture** through Cluster Alta Tecnologia Agrofood Lombardia[89].

In **Upper Austria** there is 1 cluster supporting the Food sector (strictly related to **Agriculture**), 1 cluster supporting **Wood** sector and 1 cluster supporting plastics (**Chemistry**)[83].

In **Auvergne Rhone Alps Regions**, there are a significant number of clusters and enterprises that are making direct use of bio-based applications, in particular, 3 clusters are supporting **Agriculture** and 4 **Chemistry** (polymers, plastics and chemistry).

The "**Bavarian Cluster Initiative**"[90] already contains important bioeconomic parts. The Bavarian cluster policy promotes 17 statewide platforms in the high-tech industry and in traditional sectors as initiative of the Ministry of Economy, that comprise around 8,500 companies and 1,100 individual projects. Those are intended to promote a cross-industry and cross-cluster cooperation besides a cooperation between companies and research institutions. In particular, the fields of **Wood** and **Chemistry** (including materials) are addressed, each by a specific cluster organization[91].

In terms of bioeconomy and bio-clusters it should be pointed out that in **Slovenia**, despite its potentials (solid resource base, vibrant SME sector with comparatively strong orientation towards bio-based products, strong research and innovation activity in bio-based economy sectors and public financing thereof), bio-based economy is not yet mainstreamed as a policy priority. No bio-based clusters in a strict sense of the term exist in Slovenia. A number of clusters gathering R&D institutions and corporate sector have been emerged in the country since late 1990s, with a strong Government support, in particular 2 clusters supporting **Agriculture** (farm and food), 2 **Wood** and 2 **Chemistry** (plastics and materials).

6.4 Networking opportunities in the AS

In order to help actors and Clusters to generate new business opportunities within and/or across the regions by creating links among actors in the VCs, an analysis of the networking opportunities available in the regions in the Agriculture, Wood, Packaging for Food and Pharma and Chemistry sectors has been performed. The analysis shows that very few opportunities are available within the regions or across different regions (or they are not well publicized through regions, web and clusters initiatives, making them difficult to find), highlighting “white spots”.

Opportunity	Description
EUSALP - EU STRATEGY FOR THE ALPINE REGION	EUSALP regularly organise different events: EUSALP Public Event; Workshop; General Assembly meeting; Executive Board meeting; Board AGLs meeting; Action Group Meeting; Virtual meeting. Events related to the economy within the sectors “Agriculture” (Agro), “Wood”, “Packaging for Food and Pharma”, “Chemistry” can be eventually found to the following link: https://www.alpine-region.eu/events/upcoming2 .
Wood portal https://www.legnotrentino.it/it/	**Wood Portal** (Legno Trentino) is a web platform managed by the Chamber of commerce to share information about products, companies, wood auctions, events and other relevant news regarding the wood sector in **Autonomous Province of Trento**.

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6.5 Policies in the AS

An overview of the bio-based economy policies and strategies in the regions related to the Agricultural, Wood, Packaging for Food and Pharma, and Chemistry sectors, is given in the following allowing to identify missing ones. In **Bavaria**, an official Bavarian bio-based economy strategy was expected to be published in 2019, but a delay is foreseen due to changes in responsibilities within the Government. In **Austria**, the bio-based economy strategy is part of the Austrian climate and energy strategy. In **Slovenia** the bio-based economy is only indirectly perceived in the country's strategies and program orientations. In **Lombardy** the **"Regional Strategy for bio-based economy"** is one of the objectives of territorial governance that is being implemented. In **Auvergne-Rhône-Alpes** exist various programs and plans linked to forestry and the bio-based economy, regional policies for agriculture and regional policies for waste and biowaste. **Switzerland** does not have a specific bio-based economy strategy but has some policies and acts regulating the Agricultural, Packaging and Wood sectors. At local level, **Baden-Württemberg** has its own bioeconomy strategy since June 2019. The **autonomous provinces of Trento** and **Fribourg** do not have a dedicated bio-based industry strategy so far, they have some programmes, initiatives or strategies including some actions that foster bio-based economy. This overview shows that comprehensive bio-based policies related to the Agricultural, Wood, Packaging for Food and Pharma and Chemistry sectors are mostly missing in the regions and most of the time the bio-based economy is part of other strategies or policies, highlighting "white spots".

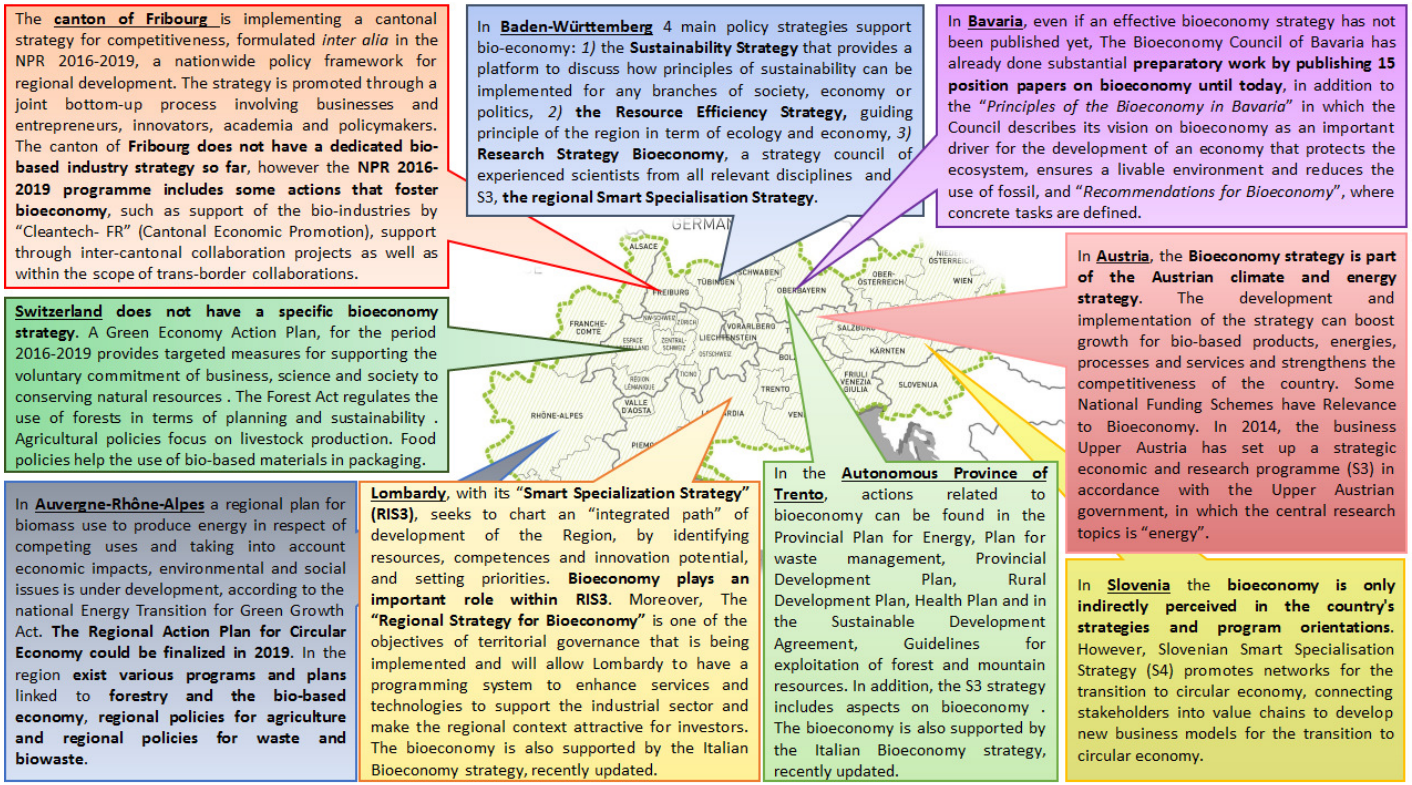

***Figure 13**: Benefits and opportunities of the bio-based economy for Chemistry sector in Switzerland, Canton of Fribourg, Baden-Württemberg, Bavaria, Austria, Slovenia, Autonomous Province of Trento, Lombardy and Auvergne-Rhône-Alpes.* [8, 31, 37, 41, 82, 83, 84, 85, 86]

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7. Recommendation on how to implement vcs in bio-based economy within the sectors "Agriculture" (agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions

The analysis carried out through this document highlights how the bio-based economy within the sectors "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions shows a great potential to be exploited but still there are "white spots". The analysis allowed to identify the missing links within the VCs that can be used to boost synergies between small and large actors and enhance the economic sustainability to ensure local employment and to generate new business opportunities within and/or across the regions using the links as shown in the new VC's descriptors.

To this end the "white spots" identified in previous sections are recorded and used for recommendations for policy makers and stakeholders.

For the Wood sector

- Wood is one of the most abundant resources in the regions, with about 35 million m^3 of harvested wood each year. In all the regions, the most used resources are softwoods from conifers while, although fine innovative applications on hardwoods already exist, the exploitation of hardwoods could be increased and improved. Beams and boards are the most common products and residues from wood industry could be much more exploited. An increased cultivation of other species (i.e. poplar, cork oak in the suitable areas) can be an opportunity. Much information on new wood VC is necessary and the synergies with some projects (CirculAlps) represent a chance.
- In some of regions **wood** biomass is used to produce energy, this is the case of **Lombardy, Switzerland**, **Baden-Württemberg, Slovenia** and **Autonomous Province of Trento, Bavaria and Austria**. Some regions already implement activities also to use wood biomass in added value applications. For instance, in the **Canton of Fribourg** wood biomass is used as feedstocks for manufacturing products, or also the lignin is used for bioplastic production; in **Lombardy** is used in the **paper manufacturing** from wood waste; ***Companies*** *should consider shifting the utilisation of low quality wood or industrial by-products resources from energy towards chemicals and materials by creating higher added value (e.g. products for Packaging for Food and Pharma sector and for Chemistry sector). Using biomass in these new ways has the potential to generate higher value returns than when using it primarily to produce energy;* ***Policy makers*** *should consider to support this shifting with funds and/or tax incentives in order to launch small scale pilot projects for the utilisation of local biomass resources, to meet local community need.*
- In **Baden-Württemberg,** ***companies*** *should consider finding new applications for wood biomass in construction sector other than for energy production and investing in novel infrastructures/facilities for processing biomasses* as *Bio-based refineries do not exist in Baden-Württemberg on an industrial scale, representing a "white spot".* ***Policy makers*** *should support new biorefineries with funding and/ or tax incentives.*
- In **Bavaria,** ***Policy makers*** *should consider supporting cross-cluster and cross-industry value chains as well as the cascaded usage of raw material with funding and/or incentives.*
- In the region of **Fribourg**, ***companies*** *should consider finding new applications and developments to valorise biomass even more in the construction industry.*
- In **Autonomous Province of Trento**, residues from wood are currently not used for high value chains in different applications, probably due to the lack of chemical companies involved in processing/reusing of those materials, this is a "white spot" and ***companies*** *should consider investing in processing/reusing of wood materials*. More knowledge is necessary to boost the new value chains.
- **Lombardy,** in its Regional Strategy for bio-based economy, has already identified some "white spots" such as the creation of integrated biorefineries in the territory in order to obtain high added value products starting from **wood**; ***companies*** *should consider investing in new biorefineries and scale-up R&D activities to pilot plants and demonstrators*.
- **Slovenia**, where there is an abundance of land covered with forests, ***companies*** *can consider using* ***wood*** *to build wood-based efficient construction.*
- In **Auvergne-Rhône-Alpes**, better mobilization of the wood deposit can make it possible to widely develop the use of wood as energy and/ or in higher added value applications, *Investing in novel infrastructures/facilities for deposit. This can be done through the development of direct forms of cooperation of smallholders such as cooperatives, consortia as well as mediated collaboration through public or public controlled agencies.*

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- In **Switzerland**, timber harvest is in decline, therefore ***companies*** *should consider investing in processing/reusing of wood materials in added value products.*

- Examples of best practices in the bio-based economy in the Wood sector are provided to the companies and they can be replicated in within and/or across the regions: ***companies*** *should consider fractionating hard wood biomass in plant for sugar and lignin recovery, to be used to develop final products such as elastomer foams for tube insulation, rigid polyurethane foam panels for insulation, polymer compounds intended for injection moulding, high-purity sugars for novel end-use cases as* ***Tecnaro*** *did. A best practice is also from companies which produce insulated panels, increasing energy efficiency of buildings, and which use natural insulation material like cork. The applications could be for green building industry. The residues of the process could be used for the inner requirement of energy or they could become a feedstock for companies producing pellet for example.* ***Galante wood technology*** *is a quite good example by this point of view. Finally, companies can also convert wood into wood wool for logistic companies and retailers by shredding the wood and manufacturing the final product, following the example of* ***Lindner Suisse GmbH***.

For Agricultural sector

- Regions contributes to Agriculture sector with roughly 1,400,000 employees and a revenue of about € 140 billion. In general, **Agriculture is one of the most developed sectors**, especially in **Autonomous Province of Trento, Lombardy, Auvergne-Rhone Alps and Bavaria**. In some of regions waste from Agriculture are used to produce energy, this is the case of **Lombardy, Switzerland, Baden-Württemberg and Autonomous Province of Trento Baden-Württemberg Switzerland Bavaria**. As for the Wood sectors, ***companies*** *of the Agricultural sector should consider shifting the utilisation of agricultural resources from energy towards chemicals and materials by creating higher added value (eg. products for Packaging for Food and Pharma sector and for Chemistry sector). Using biomass in these ways has the potential to generate higher value returns than when using it primarily to produce energy;* ***Policy makers*** *should consider to support this shifting with funds and/or tax incentives in order to launch small scale pilot projects for the utilisation of local biomass resources, to meet local community need.*

- In the **Lombardy region,** the wastewater/ sewage sludge, corn silage, autumn-winter cereal silage, livestock animal waste, grass, flour products, glycerine, vegetable oils are the most abundant resources which are currently used for biogas production. Also, an important resource is represented by waste generated from food waste during harvesting, storage and transport prior to primary processing (primary stream), during primary processing within the agro-food industry (secondary stream) and during production or consumption by end users (tertiary stream). These resources can be used obtain high added value products through biorefineries, ***agricultural companies*** *should consider investing in new biorefineries and scale-up R&D activities to pilot plants and demonstrators*.

- *In* ***Auvergne-Rhone Alps region, companies*** *should consider using biomass from animal dung, intermediate cultures between two main crops and waste from the agro-food industries to obtain high added value products.*

- *In* ***Bavaria, companies*** *should consider using biomass from cereals (wheat and barley), corn, silage maize and manure and food waste.* In **Bavaria,** as reported for the Wood sector, **agricultural** waste is mostly used to produce energy. This is probably due to the fact that only few value chains that cross industries and only low cascaded usage of raw material could be identified; this is probably due to an insufficient network of economic actors on one side but also to the *Renewable Energy Sources Act* (EEG: Erneuerbare-Energien-Gesetz) which gives advantage to energetic use. ***Policy makers*** *should consider increasing the number of networking opportunities among economic actors of the sector in the region as well as increasing the public funding in order to extend the material usage not only to energetic usage, for instance by combining the production of biogas with other biorefinery processes.* ***Clusters*** *play a fundamental role in generating new business opportunities within and/or across the regions in the Agricultural sector.*

- *In* ***Autonomous Province of Trento****,* ***companies*** *should consider investing in processing/reusing of wastes from vineries and lower quality fruit or side-streams from agri-food industry to develop new value chains*

- In **Austria**, as a result of the decline in livestock breeding and dairy production, the potentials of grassland biomass (grass, clover, alfalfa etc.) and grassland (fallow land) as a " new **agricultural** raw material" for a bio-based industry increased and ***companies*** *should consider using this biomass to obtain high added value products.*

- In **Canton of Fribourg**, the food & feed sector has the greatest potential in the region. In the frame of bio-based economy, the valorisation of by-products from food processing industry for feed, pharmaceutical, plastic or chemical sectors is possible, but currently a cross-sector cooperation is missing, identifying a “white spot”; ***Policy makers*** *should consider increasing the numbers of networking opportunities among economic actors of the sectors in the regions.* ***Clusters*** *play a fundamental role in generating new business opportunities within and/or across the regions in the Agricultural sector.*

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- In **Baden-Württemberg, Switzerland and Slovenia** Agriculture plays a relatively small role, anyway ***companies*** *of the Agricultural sector should consider using almost entire agricultural biomass in the production, making it a waste-free process: e.g. to extract high added value compounds from biomass and using biomass after extraction as a material to feed the digesters for producing energy for the whole plant/farm.*
- Examples of best practices in the bio-based economy in the Agricultural sector are provided to the companies and they can be replicated within and/or across the regions: *Apple skins and seeds provided by producers and converters can be used to obtain apple paper for packaging, leather for fashion industry, furniture producers, automotive, transportation, as already demonstrated by* ***Frumat****; grape and dried marks from wine producers can be used to produce bio-textile for fashion industry, furniture producers, automotive and transportation as already did by* ***Vegea****; or fresh unsold commodities can be reused to produce jams and marmalades for Ho.re.ca., supermarkets, as done by* ***Menz&Gasser****.*
- Bio-based Packaging for pharma industry is a less developed sector*, companies should consider investing in this sector as it offers new business opportunities.*

Packaging sector for Food and Pharma

- Data for the Packaging sector for Food and Pharma (especially for pharma) as total are difficult to find both at EU level and at regions level, representing a white spot. Also, data show that only in some of the regions, biomass and waste from Agriculture, Wood and Food industry are used for bio-based packaging and polymers production. For instance, in the **Canton of Fribourg**, **Bavaria** and in **Switzerland** companies produce packaging material for the Food industry; or in **Baden-Württemberg** the companies are using bio-based polymers for specific packaging applications. Upper Austria is the 1st Austrian region for bio-based packaging manufacturing. This means that *further investments are needed* ***by companies*** *in the bio-based Packaging sector for Food and Pharma in the regions* even if incentives and necessary conditions for these investments are often missing.
- In **Switzerland,** food policies entered in force in 2017 support the use of bio-based materials as primary materials in food packaging field, ***policy makers*** *should consider supporting the bio-based Packaging sectors for Food and Pharma in regions with similar policies.*
- **Austria** seeks to promote the development and the use of bio-based packaging charging a lower fee for domestic bio-plastic/ biodegradable plastic packaging compared to fossil ones, ***policy makers*** *should consider supporting the bio-based Packaging sectors for Food and Pharma in regions with similar policies.*
- The **Packaging sector** plays a significant role in the development of the bio-based economy in the **Canton of Fribourg**. The biomass in the production of bio-based packaging can come from the **Wood** sector (e.g., lignin, cellulose and other chemical compounds) and from the **Agricultural** sector with the use of starch or sugar, or from the waste of the Food industry (e.g., animal proteins), ***companies*** *in other regions should consider to use agricultural and wood biomass within the regions* (as reported in the recommendations for Wood and Agriculture) to develop bio-based packaging for food and pharma.
- In the sector of bio-based Packaging, **Lombardy** is one of the top Alpine regions offering many job opportunities. *New biorefineries could provide biomass from Wood and Agricultural sector to develop bio-based Packaging for Food and Pharma sector.*
- Production of biopolymers and bioplastics in **Slovenia** is rather scarce, *further investments are needed* ***by companies*** *in the bio-based Packaging sector for Food and Pharma in the regions.*
- Examples of best practices in the bio-based economy in the Packaging sector for Food and Pharma are provided to the companies and can be replicated in within and/or across the regions: *Cutin extracted from tomatoes peels can be used to produce biolacquer to be applied to coat food cans and replace the chemical paints. Moreover, the skins residue from the extraction process can be used to feed the digester where the bacteria can act to produce energy, as* ***Azienda Agricola Chiesa Virginio*** *is already doing; by starting from fungal mycelium grown on solid and liquid agro and wood residues, bio-based plastic containers and box as did by* ***Mugu srl****. Also, as demonstrated by* ***Evergreen****, in Slovenia, food waste/ waste from food industry can be processed in order to obtain protein and ecoflower pots, picnic sets for gardeners and end-users.*

Chemistry sectors

- Data for the bio-based chemistry in the regions are difficult to find at regions level, representing a white spot, anyway regions have a good track record in chemistry production and some of the regions already have substantial potential for growth in the bio-based chemistry. The chemical industry in **Bavaria** is well developed, the bio-based chemistry amounts to about 15% of the total chemical sector. The chemical industry is the second largest sector in **Austria**. In **Slovenia**, chemical industry is one of the main pillars of the economy. In the **canton of Fribourg,** chemical and plastic sectors are among the main industries of the region and have substantial potential for growth in the bio-based economy. **Lombardy** is the second

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region in Europe for the number of employees within the chemical and pharmaceutical industry. **Auvergne-Rhône-Alpes** is 1st French region in chemical production. Chemical, pharmaceutical and biotech industry in **Switzerland** is highly developed. ***Companies*** *should consider using this leading position in Chemistry sector to move forward bio-based chemistry (and exploit the new business opportunities bio-based chemistry id offering) by using the biomass from the Agricultural and Wood sectors to develop high added value products.*

- Examples of best practices in the bio-based economy in the Chemistry sector for Food and Pharma are provided to the companies and they can be replicated in within and/or across the regions: *wood waste wheat & rice straw bagasse can be processed to obtain bio-based plastics, fuels and chemicals* as did by ***Green Sugar AG***; ***Novis waste valorization GmbH*** *is dealing with the waste-incineration slag from plants to recover metals and ores for the metal processing industry; Oil/Ricinus oil from tropical trees can be converted into polyurethane binders for construction industry, as already done by* ***Conica AG*** *(Switzerland). In the case of* ***Conica AG****, the imported castor oil maybe replaced by another natural source (but further RD is necessary.)*

For policy makers

- *Implementation of regionally bio-based economy policies in the Agricultural, Wood, Packaging for Food and Pharma and Chemistry sectors.*
- *Developing coordination mechanisms to harmonize policies developed by different regions and among different sectors within the sectors in the regions.*
- *National funds for incentives to local governments in order to launch small scale pilot projects for the utilisation of local agricultural and wood biomass resources, in order to meet local community need.*
- *Tax incentives to support bio-based VS in the Agricultural, Wood, Packaging for Food and Pharma and Chemistry sectors.*

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Annex I: Other relevant best practice within the sectors “Agriculture” (Agro), “Wood”, “Packaging for Food and Pharma”, “Chemistry” in the regions

Best practices have been chosen for their relevance towards indicators that allow to measure, monitor and assess the progress of the bio-based economy within the sectors “Agriculture” (Agro), “Wood”, “Packaging for Food and Pharma”, “Chemistry” in the regions. Four type of indicators have been considered according to their sector/objectives:

- **Economic:** e.g. Increasing the business and the turnover, R&D Funding (public or private);
- **Process:** e.g. Production and share of new bio-based products, win of award and competitions;
- **Environmental:** e.g. Reducing dependence on non-renewable resources, mitigating and adapting climate change;
- **Societal:** e.g. Ensuring security, creating jobs and maintaining competitiveness;

In order to identify such indicators a literature research have been performed and a collection of indicators that can be used for the bio-based economy sector is reported in *Annex II*.

Wood

Case study 2: Scheufelen GmbH

Scheufelen GmbH (Lenningen, Metropole Region Stuttgart, Germany) is the Europe's **market leader for coated premium papers,** therefore being a best practise in the Wood sector. It restarted operations on July 2018 in the premises and with all brands and assets of former Papierfabrik Scheufelen GmbH + Co. KG, with a total head count of 85 experienced papermakers, a strong R&D team and a total production capacity of 300,000 tons of paper. In selecting raw materials, tools and equipment, they strive to use alternatives that are as environmentally friendly as possible. Respected brands have been developed to reintroduce quickly renewable, cost efficient and environmentally sound sources of fibre into paper making without compromising paper quality. Relevant products on the market are: Phoenolux - Scheufelen's bright white coated board, graspaper - Grass paper for graphic applications, phoenograss - An exclusive combination of grass paper with the high white fresh fibre board phoenolux, greenliner - Suitable for container board and liner, bvs - Scheufelen's standard coated paper, bro - Coated paper designed specifically for web offset. Moreover, together with the affiliated Packaging Campus Lenningen, a cooperation with Hochschule für Medien, Stuttgart, Scheufelen sets a new standard in helping brand owners, packaging converters and graphical printers to bring truly sustainable and renewable fibre solutions to their packaging needs.

Case study 3: METabolic Explorer

METabolic Explorer in less than 20 years, by using industrial biochemistry, created the basis for producing products essential to daily life without oil and with a superior performance, with over 500 patents worldwide. In particular, in the frame of funded project (VALCHEM), the company is developing a **monopropylene glycol (bio-MPG) and lignin-based performance chemicals from wood.** The obtained performance-lignin is intended to replace similar-in-application fossil components in high-value added reactive resins and composites. **The largest markets for MPG are unsaturated polyester resins, paints and coatings, industrial applications and personal care**.

Agriculture

Case study 2: AGRANA Stärke

AGRANA Stärke Gmb produces a range of conventional and organic fertilisers, including lawn fertiliser, based on the by-products associated with the production of sugar and starch. An example of this is BioAgenasol®, a slow-release organic fertilizer, containing a percentage of organic matter of about 85-90% (raw materials OGM free, such as wheat, corn, sugar beets and potatoes grown in Austria) and 5.5% nitrogen.

Case study 3: Mogu srl

Mogu srl (IT - Lombardy) developed a technology that employs fungal mycelium - the vegetative body of mushrooms - to transform and bind agricultural by-products into strong, functional, natural materials. Such technology can be used in a wide range of industries, including, to name few, product design, architecture, fashion, automotive, construction, horticulture, packaging & more.

Packaging for Food and Pharma

Case study 2: Goglio

Goglio, is leader in flexible packaging, rigid plastic accessories such as valves, spouts and packaging machines. Among its products, Goglio produce compostable packaging system and in 2015, working together with Caffè Molinari and Innovia Films,

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Goglio launched into the market a compostable and bio-based integrated coffee packaging system with a bio degassing valve, sourced from wood.

Case study 3: BioBag Austria

BioBag Austria, based in Linz / Austria, is one of the pioneers in the sector of **biodegradable and compostable materials,** as well as its products. Together with different partners, the products are developed according to customer requirements. Under the motto "Great festivals without leftovers", **compostable catering articles are also exported to many countries**. Several **municipalities and world companies** such as McDonald's, Warner Brothers, the US Navy or the organizers of the Olympic Games, EXPO's, or the World Cup 2005 in Turin, **have placed confidence in the products of this company.** Under the motto "in the cycle of nature", it should succeed together to reduce the plastic waste mountain and the use of fossil raw materials. Among the products they developed: **Organic waste collection,** with the compostable starch sack, is ideal for the collection of biogenic kitchen waste and will fit into any kitchen, made from renewable resources for biowaste separation; **organic packaging and industrial systems**, compostable BIO carrier bags made from renewable raw materials; **organic household**, compostable cling film made from renewable biodegradable raw materials; **organic catering,** innovative, biodegradable and compostable cling film.

Bio-based Chemistry

Case study 2: Novamont

Novamont, by using innovative and proprietary technologies reconverts sites that are no longer competitive, or have been abandoned, into innovative laboratories and industrial plants to create integrated biorefinery within the territory. Novamont has plants and/or laboratories in Novara (Piedmont, IT), near Rovigo (Veneto, IT) Terni, Piana di Monte Verna, Patrica and Porto Torres (Italy, non-Alpine Region). In some regions, it has its own cultivation in order to exploit inusual bioresources like thistle (Cynara cardunculus L.), and the used model could be applied on other species in Alpine area. Novamont produces and sales only bio-based products, among the most important it is worth to mention:

- **MATER-BI:** an innovative family of biodegradable and compostable bioplastics. Materials in MATER-BI are obtained, from starches, cellulose, vegetable oils and their combinations and has applications in numerous sectors, such as packaging, farming, shopping bags, differentiated waste collection, etc.
- **MATROL-BI:** is an experimental line of rapidly biodegradable bio lubricants and greases, which are obtained from renewable resources. In the event of accidental dispersal into the environment, MATROL-BI biodegrades in a few days, leaving no traces.
- **CELUS-BI:** is an innovative family of ingredients for the cosmetics and personal care sector. Its applications are found in moisturising creams, shampoos, foundation and lipsticks [92].

Case study 3: GREENSEA SAS

With an original collection from a variety of different environment, a global sourcing of macroalgae through professional partnerships and a production capacity of up to 60,000 litres for microalgae, GREENSEA SAS is the company dedicated to the production of marine ingredients, whether from macroalgae and microalgae. Greensea has its own Research and Development laboratory and works on many innovative projects through partnerships in a vast international network of research facilities. The company has 25 years of experience in microalgae cultivation and processing of algae for innovative ingredients for several markets, is able to integrate activities "from the culture tube to the commercial ingredient" and owns a large collection of microalgae and cyanobacteria including many exotic or extremophiles strains.

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Annex II: Methods and Indicators that can be used to measure the development of bio-based VC the bio-based economy within the sectors “Agriculture” (Agro), “Wood”, “Packaging for Food and Pharma”, “Chemistry” in the regions

Table 2 reports a collection from literature of the main indicators can be used to measure progresses in the the bio-based economy within the sectors “Agriculture” (Agro), “Wood”, “Packaging for Food and Pharma”, “Chemistry” in the regions, dealing with specific sectors and categories, i.e.

- Environmental: Resources, Land use, Climate changes impact;
- Societal: Actors, Employment, Safety and security;
- Economical: Financial/Business, Funding;
- Process: Value chains, bio-based products.

For each category, the main objective is reported together with the related indicators that, if well used, can give a measure of how the category is progressing towards the bio-based economy within the sectors “Agriculture” (Agro), “Wood”, “Packaging for Food and Pharma”, “Chemistry” in the regions .

Table 5: *Key indicators to be used to measure the development of bio-based economy within the sectors Agriculture, Wood, Packaging for Food and Pharma and Chemistry in the region* [93,94,95]

Sector	Indicators category	Objective	Specific Indicators
Environmental	Resources	Reducing dependence on non-renewable resources	- Fossil fuel use (tons, % - of all fuels) - Mapping of biomasses (tons/geographical distribution) - Biomasses availability (tons) - Complexity of the supply (% of tons waste versus % of tons used as biomass) - Resources productivity and efficiency (%) - Natural resources index (tons/geographical distribution) - Recovery rates from waste materials (%) - Share of raw materials in the timber industry processed with biotechnological methods (%) - Share of agricultural waste recycled with biotechnology methods (%) - Share of processed municipal solid domestic waste (%) - Share of biomass in total volume of raw materials recycled in the chemical and petrochemical industry (%)
	Land use	Managing natural resources sustainability	- Area of organic farming (ha) - Yield of biotech crops (tons) (canola, soy, corn, sugar sorghum, sugar beet, etc.) - Indirect land use/embodied land for agriculture and forestry products (ha) - Area of soils subjected to bioremediation (ha) - Proportion of degraded land (%) - Abandoned and marginal lands to be used for feedstocks cultivations (ha) - Use of pesticides and other chemicals (kg/ha)
	Climate changes impact	Mitigating and adapting climate change	- Share of renewable energy compared to primary production (%) - Purification polluted surface and ground water, soil with preparations for biodegradation (%) - CO_2 emissions (%) - Share of irrevocable consumption in volume of used water (%) - Greenhouse gas balance (tons CO_2 eq) (emissions and sequestration)
Economical	Financial/Business	Increasing the business and the turnover	- Number of start-up companies working on bio-based economy solutions and number of companies getting to the industrial scale (number #) - Return on investment (ROI) (€) - Turnover (€) - Presence of multinationals (number #) - Gross domestic production (GDP) - Gross and/or local value added (G/LVA) - Eco-innovation index
	Funding	R&D Funding (public or private)	- Public and private financial support (€) - Investments in research and innovation (€) - Investments for ecosystem services (€)

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Societal	Training	Professionals Training	- Number of research institutions (structural units), which researches bio-based economy (number #) - Number of schools that train specialists for bio-based economy (number #) - Number of objects of innovative infrastructure that promote the development and commercialization of biotechnology and bio-based economy (number #)
	Employment	Creating jobs and maintaining competitiveness	- Potential of the workforce, in terms of number of enabled people and skills (number #) - Contribution to regional employment (number #) - Employment in the bio-based economy sectors, i.e. Wood, Agriculture, Packaging, Bio-based Chemistry (number #) - Number of employed persons in rural and urban areas (number #) - Contribution to the GDP - Female Employment in bio-based economy sectors, (% of female employment) - Male Employment in bio-based economy sectors, (% of male employment)
	Safety and security	Ensuring security	- Conditions of supply of commodities (addressing safety regulation, yes or not) - National supply security and self-reliance (Import/Total energy use)
Process	Value chains	Development of the "production–processing-realization" chain	- Complexity of the value chains (number of stakeholders involved) - Use of biotechnology in aquaculture (feed, medicines, etc.) (% to the base period) - Use of biotechnology in bio-based chemistry (% to the base period) - Share of the biological treatment facilities in the total (%), to be used in different value chains - Technology transfer among different actors and value chains (number of stakeholders involved)
	Bio-based products	Production and share of new bio-based products	- Share of bio-based plastics and polymers in total consumption of polymer products (%) - Production of biofuels (bioethanol and biodiesel), biogas, solid biofuels (tons) - Production of bio-based products(tons) - Production of electricity from renewable sources (T-watt) - Registered original biopharmaceuticals (number #) - Patents developed: (number #)
	Innovation	Award and competitions	- Numbers of Award and competitions won

Besides the indicators, it is fundamental to assess the impact of the bio-based VC in terms of sustainability. The following table reports the main sustainability assessment methods that can be used to measure progresses in the bio-based economy within the sectors "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions.

Table 6: *Methods for the sustainability assessment of bio-based vc within the sectors Agriculture, Wood, Packaging for Food and Pharma and Chemistry in the regions* [96]

Sector	Method	Action
Economical	Cost-benefit analysis (CBA)	Monetary valuation of gained benefits. Monetized impacts are especially suitable to policy making.
	Input-output (IO) methods	Economic tables are commonly available for IO-analysis and are well and reliably documented. Preciseness is better if markets are well-known. Especially suitable for industry once cost structure and profitability is applied.
	Life cycle costing (LCC)	Economy is often of high interest to any decision maker and economic information supports social impact assessment too.
Environmental	Life cycle analysis (LCA) methods	Comprehensive consideration of all inputs and emissions of a product during its life-cycle. Inclusion of indirect emissions, such as those from steel or fossil fuel production. Standardized method and comprehensive databases are available.
	Material flow analysis (MFA)	Focus on loads of materials needed in production of a specific (end) product enables identification of inefficient material uses and production phases. Can be comprehensive, yet simple to operate.
	Environmentally extended IO	Environmental extension of IO is obtainable from commonly available statistics.
Societal	Social life-cycle assessment (SLCA)	Social aspects are often connected to economic and ecological issues. Hence, much data are available.

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Any	Multi-criteria analysis (MCA)	Number of approaches available. Enables thorough evaluation and balancing between alternatives with respect to indicators, dimensions and stakeholders via outranking, weighting, voting, for example. Inclusion of intangible and highly subjective aspects is possible.

However, it should be taken into account that the definition of "bio-based economy" within the sectors "Agriculture" (Agro), "Wood", "Packaging for Food and Pharma", "Chemistry" in the regions is not well established yet, being subject of a scientific debate. Therefore, the list of indicators and methods still needs some definition/improvement. The experts should well define which sectors the bio-based economy includes and which are the specific objectives for each sector. In this way, specific indicators can be fixed in order to analyse the complex and polydimensional bio-based economy system, especially at regional level, and to develop future perspectives.

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Annex III: Sectors, resources and activities in the Alpine Space

Nine regions of the Alpine Space have been taken under study, i.e. Canton of Fribourg, Baden-Württemberg, Autonomous Province of Trento, Lombardy, Austria, Auvergne-Rhone Alps, Slovenia, Bavaria and Switzerland. The following tables report the **sectors developed** in each of the regions taken under study (Table 7a), the **resources available** (Table 7b) and the **activities are being performed** (Table 7c).

The Table 7a reports which are, for each region under study, the developed sectors. In particular, the absence of stars means the absence of stated activities for the specific sector; it has not been possible to assess them by analysing the documents taken under study (reported as references). One star indicates the presence of activities for a specific sector, in this case it has been possible to assess them. When the sector is assessed as the most active/dominant in the region, it is indicated with two stars.

***Table 7a**: Developed sectors in nine regions of the Alpine Space*

	Canton of Fribourg [8]	Baden-Württemberg [41]	Autonomous Province of Trento[37]	Lombardy [84]	Austria [83]	Auvergne-Rhone Alps [31]	Slovenia [85]	Bavaria [82]	Switzerland [86]
Agriculture/ Food and feed Industry	*	*	**	**	*	**	*	**	*
Algae/Aquaculture		*	*	*	*	*	*		
Chemistry Industry	*	*	*	*	**	*	*	**	*
Construction Industry	*	*	**	*	*	*	**	*	*
Energy Industry	*	**	*	**	*	*	*	*	**
Forestry	*	*	*	*	*	*	*	*	*
Municipal waste			**	*				*	
New Packaging Industry	*	*	*	*	*	*	*	*	*
Paper Industry				**	*	*	*	*	*
Plastic Industry	*			*	*	*	*	**	
Textile Industry		*	*	**	*	*		*	
Transportation/Mobility Industry			*	*			*		*

By analysing in dept documents/reports (reported as references), it has been possible to identify which are the resources available in each region for each sector. This kind of analysis allows to highlight the exploitable potential of the Alpine Space.

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Table 7b: *Resources available in the nine regions of the Alpine Space*

	Canton of Fribourg [23]	Baden-Württemberg [41]	Autonomous Province of Trento [37]	Lombardy [81,84]	Austria [83]	Auvergne-Rhone Alps [31]	Slovenia[97, 85]	Bavaria [82]	Switzerland [86]
Agriculture	- Biomass	- Bio-waste	- Agricultural residuals (mainly from apples and vines) - Animal manure wastewater and dry sludge	- Wastewater/ sewage sludge - Corn silage - Autumn-winter cereal silage - Livestock animal waste - Grass, flour products, glycerine, vegetable oils and urban waste of organic nature	- Biowaste and green waste - Giant china reed - Waste water/sewage sludge) - Manure, slurry	- Biomass - Animal dung -Intermediate cultures between two main crops - Waste from the agro-food industries	- Grass based biomass - Arable land	- Manure - Cereals (wheat and barley) and corn - Silage maize	- Arable land
Algae/ Aquaculture		- Microalgae biomass	- Waste of trout farms		- Microalgae	- Micro and Macro algae	- Algae[98]		
Chemistry Industry	- Biomass	- Biomass	- Residues from grape industry and other cultivation	- Vegetable raw material [45]	- Biogenic materials	- Biomasses	- Aromatic plants and medicinal plants	- Medicinal plants and herbs[99]	- Biomass
Construction Industry	- Biomass and Wood	- Wooden biomass[100]	- Wood	- Wood[101]	- Timber[102]	- Wood	- Waste from construction - Wood	- Wood	- Timber[103] - Biomass[104]
Energy Industry	- Biomass and wood derivates such as pellets	- Wood and biogas for bioenergy production	- Residual biomasses from forestry, agricultural cultivation, first-stage wood processing and wood industry	- Corn silage, cereal silage, animal waste, vegetable oils, grass, flour products, urban waste for producing biogas	- Organic residues - Raw wood - Oil plants (such as rape, soya, sunflower) - Sugar cane and sugar beet Corn, potatoes and cereals	- Biomass from wood and biowaste	- Manure, - Landfill gas - Agricultural crops - Wastewater[105]	- Biomass	- Wood - Household and industrial waste

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					- Miscanthus giganteus				
Food and feed Industry	- Restaurant waste, food shop waste		- Food waste		- Food waste - Kitchen and green waste composted in home gardens	- Biomass	- Biodegradable waste from food processing - Organic kitchen waste - Waste from public utilities - Bio-waste	- Food wastes	- Biomass [104]
Forestry	- Products of wood, cork, straw	- Timber	- Residues from forest harvesting - Residual biomass from sawmill processing	- Wood biomasses	- Wood (without bark) - Conifer wood - Deciduous wood - Raw wood	- Wood/ timber - End-of-life wood - Hedges, alignment plantations	- Wood and wood by-products - Waste from wood processing	- Wood	- Wood and timber [103]
Municipal waste			- OFMSW (Organic Fraction of Municipal Solid Wastes)	- Urban waste	- Sludge			- Municipal waste	
Packaging Industry	- Biomass	- Use of bio-based polymers		- Wood biomass [101]	- Biobased fibres from sustainably cultivated beech forests	- Biomasses	- Biomasses	- Wood biomass	- Biomass
Paper Industry				- Wood Waste	- Wood-based cellulose fibres (forestry sources) [102]	- Wood biomass	- Paper waste - Wood biomass	- Wood biomass	- Wood biomass [103]
Plastic Industry	- Food, forestry and agriculture waste			- Biomasses	- Organic waste - Natural fibre - Wood[102]	- Biomasses	- Plastic waste from household	- Biomass	
Textile Industry		- Biomass	- Grape marc and apple skins	- Waste clothes/ waste textiles	- Paper and cellulose fibres [102]	- Biomass		- Biomass	
Transportation/Mobility Industry			- Agri-food waste	- Agriculture and wood biomasses			- Biomasses		- Agriculture and wood biomasses

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As done for the resources, an in dept analysis of the activities are being performed in each region has been conducted. It has led to the exploration of the processes/value chains developed by the Alpine Space organisations and of what is possible to do with the available resources.

In the end, by merging the information from the Table 7a, 7b and 7c, it is possible to have a helicopter view on what is available in the Alpine Space in the Bioeconomy sector.

Table 7c: *Activities performed in the nine regions of the Alpine Space*

	Canton of Fribourg [8]	Baden-Württemberg [41]	Autonomous Province of Trento [37]	Lombardy [81, 84]	Austria [83]	Auvergne-Rhone Alps [31]	Slovenia [85]	Bavaria [82]	Switzerland [86]
Agriculture/Food	- Biomass production - Biobased products (meat product, dairy products, fruits and vegetables)	- Arable production (grain, maize, corn-cob mix, rape and beet, potato, sugar beets) - Bio-waste and biogenic resources production	- Production of grapes and apples (pasture and grasslands followed by permanent or ligneous crops) - Use of animal manure in Biogas plant - Wastes from wineries are sent to the distilleries on the territory, while the remaining part is sold outside the Province or destroyed - The lower quality fruit production is addressed to juice industry, vinegar industry and zootechnical sector	- Wastewater treatment - Biogas production	- Rapeseed oil is mainly used for the production of biodiesel - Sugar cane and sugar beet are mainly used for the production of biofuels, as well as corn (also corn spindles as a by-product of corn grain production), potatoes and cereals - Industrial use of Miscanthus is still in its infancy - in fuel production as well as in fuel use - Raw material processing into food or animal feed	- Biomass production	- Arable land is used for food or animal feed production - Biogas production	- Biogas production - Biobased products from biomasses	- Energy and fuels production from waste [103] - Use of biomass in food processing

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Algae/Aquaculture		- Microalgae cultivation - Industrial production of microalgae for various applications such as fuel, food, feed, pharma, nutraceuticals and others	- Omega 3 extraction from trout farms waste		- Gasification of the algae biomass in biogas plants - Production of high-quality vegan oil from algae biomass	- Algae for biomass production	- Biofuels production from algae [98]		
Chemistry Industry	- Biomass transformation for: biopolymer and phytopharma production; Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms; Manufacture of other chemical products	- Biochar and Biorefinery applications	- Valuable chemical compounds (polyphenols) production from grapes residue	- Value-added substance extraction from vegetable raw materials [87]	- Fine chemicals production in biorefinery - Acetic acid for the food industry - Furfural (a chemical used as a solvent in lube oil refining, among others) - Magnesium lignin sulfonate for the production of refractory bricks - Omega 3 fatty acids production from algae - Succinic acid on a plant basis, which is used to produce dyes and inks for printer cartridges or for printings on cardboard	- Products for pharma and plastic industries	- Medical products for pharma and cosmetic sectors	- Fine chemicals for drug production, biocatalysts, biofilms and biodegradable plastics	- Pharmaceutical products from biomass

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Construction Industry	- Use of wood to build chalets or frames of "villas", to replace steel structures or as insulation material and to produce certain construction material	- Wooden biomass for buildings [100]	- Wood use for building and energy efficiency	- Wood-based buildings construction [101]	- Wood-based buildings construction [101]	- Wood-based buildings construction	- Wood-based buildings construction	-Wood-based buildings construction	- Timber-based buildings construction [103] - Use of biomass in building materials [104]
Energy Industry	- Wood derivatives, such as pellets, are already used to heat individual houses or in central heating	- Energy production from timber sources - Electricity, heat and fuel production from biogenic sources	- Energy production using predominantly thermochemical processes and anaerobic digestion - Biomethane, biogas, electric energy and compost production from OFMSW	- Renewable energy production from biogas	- Energy or material production - Biogas or sewage gas production by fermentation of organic residues to generate heat and electricity - Biofuels production from sugar (cane or beet) and from corn, potatoes and cereals - Biodiesel production from rape	- Bioenergy production from biomass - Heat production from wood sources	- Briquettes and pellets production for heating - Use of biogas as source of energy [105]	- Biofuel and biomass production from biomass	- Wood-based, thermal and electric energy production - Fuels production from wood material and waste [103]
Forestry	- Sawmilling and planning of wood - Manufacture of products of wood, cork, straw and plaiting materials - Use of lignin for bioplastic production	- Wood Sawmilling	- Productions of timber, beams, and boards also for pallets - Production of residual biomass from sawmill processing - Bioenergy production (HDP or pellet) from Wood industry residuals, - Wood industry residuals used as	- Energy production from wood biomasses	- Production of itaconic acid from wood, which can serve as basis for rubber, paints and coatings	- Joinery, sawing and woodworking	- Wood-based products for energy applications	- Sawmills, - Wood products industry - Paper production and processing - Wooden furniture - Timber construction - Insulation applications and wood composites production - Production of polymers on basis of Lignin	- Wood-based products - Energy production from wood biomass [103]

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			mulching and as bedding for cattle					- Surface treatments based on natural resins	
Municipal waste			- Separate collection of waste - Biomethane, biogas, electric energy and compost production from OFMSW in the anaerobic bio-digester	- Management and recovery of biodegradable waste - High level of recycling and recovery in the management of sewage sludge	- Bioenergy production from urban waste			- Extraction of lignin from municipal waste for energetic usage	
Packaging Industry	- Biobased packaging for food industry	- Biobased polymers production for specific packaging applications		- Wood-based packaging production [101]	- Packaging production from sustainably cultivated beech forests	- Bio-based packaging from biomasses	- Biopolymer production	- Biobased packaging production for food industry - Biobased coatings, paints and films production	- Biobased packaging for food industries
Paper Industry				- Paper manufacturing	- Wood-based cellulose fibres are used for the production of many bio-based products (textiles, carpets, automotive products, furniture materials, hygiene and cosmetic products, technical textiles) [102]	- Paper board manufacturing from wood	- Wood-based paper production	- Paper manufacturing from wood	- Wood-based paper production [103]
Plastic Industry	- Biobased paints production			- Biodegradable plastics production from biomasses	- Natural fibre reinforced plastics based on	- Bioplastics production	- Biobased products from plastic waste	- Biodegradable plastic production from biomass	

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	- Biobased plastic derivatives supplied to construction sector - Bioplastics with high bacterial resistance production for medical and Food sector				hemp or fennel fibres - Bioplastics production from wood - Plastics production from organic waste - Production of composites made of cork with small amounts of polymer-based binders [102]	from biomasses			
Textile Industry		- Biobased textile & clothing production, also for automotive sector	- Food waste, such as grape marc and apple skins, conversion into textile	- Waste clothes are reused or inserted into new clothes - Reuse of wasted textiles as secondary raw materials in the built environment, becoming a material insulator to be used during the construction of buildings	- Textiles manufacturing from paper and cellulose fibres [102]	- Biobased textiles production from biomasses		- Biobased textiles production from biomasses	
Biogas /Biofuel			- Biomethane is used to feed busses for public transportation	- Biofuel and biodiesel production from biomasses			- Biogas or biofuel use in transport sector		- Biofuels production from biomass

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Annex IV: List of Clusters in the bio-based Economy in the Agricultural, Wood, Packaging for Food and Pharma and Chemistry sectors

Canton of Fribourg

Table 8: *Clusters in Canton of Fribourg*

Clusters	Sector
Energy & Construction Cluster (ECC)	Energy and construction sectors
Food & Nutrition Custer (FNC)	Food & feed sector
Swiss Plastics Cluster (SPC)	Chemical and polymer sectors

Baden-Württemberg

Table 9: *Clusters in Baden-Württemberg region*

Clusters	Sector
Cluster Verpackungstechnologie – International Packaging Institute (IPI)	Packaging
Forst und Holz Allgäu-Oberschwaben	Wood
ForstBW	Wood
Fotec – Netzwerk Funktionale Oberflächen	Material science/Polymers
Holzkette Schwarzwald e. V.	Wood
IHK-Chef Arbeitskreis "Druck, Verpackung, Medien"	Packaging
INNONET Kunststoff®	Plastics, bio-based materials
KunststoffDIALOG Wirtschaftsraum Heilbronn	Plastics
Packaging Excellence Region Stuttgart e.V	Packaging
Packaging Valley Germany e.V.	Packaging
proHolz Schwarzwald	Wood
proHolzBW	Wood
Regioholz Nordschwarzwald	Wood

Autonomous Province of Trento

Table 10: *Clusters in Autonomous Province of Trento region*

Clusters	Sector
Green Innovation Factory	Clean tech
Habitech	Energy and Environment

Lombardy

Table 11: *Clusters in Lombardy region*

Clusters	Sector
Lombardy Green Chemistry Association-LGCA	Green chemistry
Cluster Alta Tecnologia Agrofood Lombardia	Agro-food

Upper Austria

Table 12: *Clusters in Austria region*

Clusters	Sector
Lebensmittel Cluster	Food
Möbel- und Holzbau Cluster	Wood
Kunststoff Cluster	Plastics

Auvergne Rhone Alps Regions

Table 13: *Clusters in Auvergne-Rhône-Alpes region*

Clusters	Sector
Axelera	Chemistry and Environment
Céréales Vallées	Agriculture
cluster bio	Organics food
Elastopôle	Rubber and Polymers
Plastipolis	Plastics

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Techterra	Technical textiles
Terralia	Agri and agrofood, Plant technologies

Slovenia

Table 14: *Clusters in Slovenia region*

Clusters	Sector
MATerials as end PROducts (coordinated by MATPRO)	Materials
Plasttechnics cluster of SloveniaConstruction Cluster of Slovenia Plasttechnics	Plastics Construction
SRIP Factories of the Future (Coordinated by Jožef Stefan Institute)	Farm
SRIP Smart buildings and homes including wood value chain (Coordinated by TECES)	Wood
SRIP Sustainable food production (Coordinated by Chamber of Commerce and Industry -GZS/ZKP)	Food
Wood Industry Cluster	Wood

Bavaria

Table 15: *Clusters in Bavaria region*

Clusters	Sector
Chemie-Cluster Bayern GmbH (München)	Chemistry
Cluster Neue Werkstoffe – Bayern Innovativ GmbH (Nürnberg)	Materials
Cluster Biotechnologie – BioM GmbH (Martinsried)	Biotechnology
Cluster-Initiative Forst und Holz in Bayern GmbH (Freising)	Wood
Umwelttechnologie-Cluster-Bayern e.V. (Augsburg)	Environment

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