Center for Competitiveness
University of Fribourg
Switzerland

Regional Status Report "Status of cluster development with focus on Bioeconomy": Canton of Fribourg (Switzerland)

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List of Abbreviations

AMI	Adolf Merkle Institute
CHF	Swiss Franc
EC	European Commission
ECC	Energy & Construction Cluster
FNC	Food & Nutrition Cluster
FTE	Full-time equivalent
FSO	Federal Statistic Office
GDP	Gross domestic product
IEA	International energy agency
LQ	Location quotient
NPR	Nouvelle politique régionale
NOGA	General classification of economic activities
RCS	Région Capitale Suisse
R&D	Research and Development
SPC	Swiss Plastic Cluster
USDA	United States Department of Agriculture

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Introduction

This study is part of the project "*linking BioBased Industry Value Chains Across the Alpine Region*", launched by the sub-group "*Cluster & Bioeconomy*" within the frame of EUSALP AG2. The aim is to describe the economic structure of the region (canton of Fribourg) and more specifically to identify the economic activities linked to the bioeconomy, the main clusters comprising the areas linked to the bioeconomy, the economic policy and strategic initiatives taken so far to promote the bioeconomy and the main further steps to be taken by the clusters as well as by private and public institutions to develop the business opportunities in the field of the bioeconomy. The mandate of the study is to provide a stocktaking of the situation and not to propose a detailed governmental economic policy program, even though the results indicate that it may be appropriate to consider some policy actions to promote the development of the bioeconomy in the canton of Fribourg.

The report comprises three chapters. The first chapter presents the main features of the bioeconomy. This part is important due to the diversity of definitions related to the concept of the bioeconomy. We present the three main categories of activities (biomass production industries, biomass transformation industries and biobased products industries) that constitute the bioeconomy. We also identify the industrial sectors attached to each of the three categories according to the official NOGA classification used in Switzerland. The second chapter identifies the economic activities and clusters of the canton related to the biobased economy. The report shows the main industrial activities shaping the economic structure of the canton. Then, the report identifies the main industrial activities having a current and a potential impact in the three main categories of bioeconomy activities. The main industrial activities are highlighted according the importance of the employment and to their degree of specialization. This approach identifies the clusters of the region as well as the specialized industries of the cantonal bioeconomy and draws out the main value chains that interlink these activities. The identification of the current and of the potential bioeconomy activities within the region also permits the identification of the business opportunities offered in a broader geographical scope (cross-regional value chains). The third chapter presents a stocktaking of the situation in the canton of Fribourg according to a matrix provided by the contracting group of this study. We provide a SWOT analysis of the canton of Fribourg as a basis to consider further actions to implement a specific strategy fostering the bioeconomy in the canton through, inter alia, the existing clusters active in the canton. Due to the convergence of

technologies and to the multidisciplinarity of the industrial activities of the bioeconomy, the report recommends a strengthening of the interactions between the existing clusters and actors located in the canton – the development of cross-industry value chains – under the frame of a strategic policy aimed at promoting the bioeconomy within the cantonal boundaries.

1. Key features regarding the bioeconomy

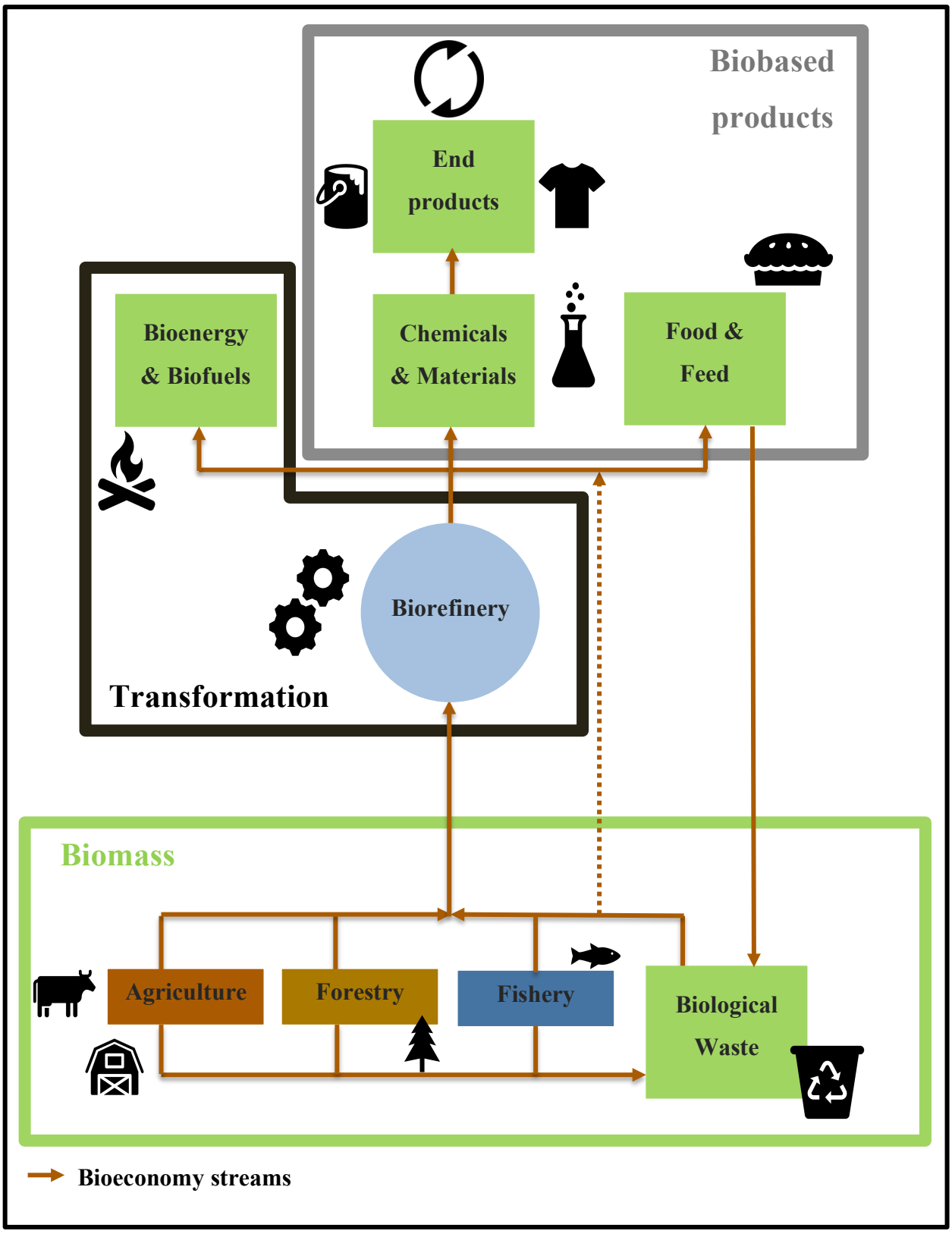
1.1 Definition of the bioeconomy

There are many definitions of the bioeconomy. The bioeconomy, or biobased economy, can be defined as an industry where the primary resources necessary to produce materials, chemicals and energy come from renewable biological resources (McCormick *et al.*, 2013). According to one definition, "The Bioeconomy refers to the sustainable production and conversion of biomass into a range of food, health, fiber and industrial products and energy. Renewable biomass encompasses any biological material (agriculture, forestry and animal-based including fish) as a product in itself or to be used as raw material." (ETPs, 2015). A consensus has developed around the definition adopted by the European Commission: "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" (EC, 2017; see also Scarlat *et al*., 2015). The differences between these definitions are slight, but depending on the definition used, different economic sectors might be included or excluded in the field of the bioeconomy. Most of the literature related to this issue is based on the European Commission's definition, and it will be the one used throughout this report as well.

Figure 1 shows the production chain of the bioeconomy and the different kinds of output that can be produced in it. It is closely linked with the will of governments worldwide to promote the transition toward a "green economy". It is therefore implied that the bioeconomy should be sustainable and use resources in a responsible way.

Governments operating at the regional and national levels have recently started to release programs or guidelines concerning their bioeconomies. The European Commission (EC, 2012) and the U.S government (The White House, 2012) both launched a plan to promote and develop the bioeconomy in 2012. Other European countries, such as Germany in 2015 (BMBF, 2015) and Spain in 2016 (MdEC, 2016), launched a 2030 program to develop their bioeconomy at the national level. The regions of Flanders in Belgium and Baden-Wurttemberg in Germany have also launched a regional strategy to develop their respective bioeconomies (De Besi *et al.*, 2015).

Figure 1. Production chain of the bioeconomy



Source: Center for Competitiveness

The scope of these programs can vary. However, most of these programs focus on research and development with the provisioning of funds for research programs in sectors related to the bioeconomy. Some organizations, both private and public, have been created to link the different actors of the biobased economy and help them create cross-industry value chains.

Switzerland, however, did not launch a regional or a global plan but introduced some initiatives aimed especially at promoting research and development efforts in the bio technology industry. As an example, the NRP66 Resource Wood program aimed at increasing the use and availability of wood resources and expanding its uses (Resource Wood, 2017). The "Stratégie énergétique 2050", whose aim is to guide the transition toward national low-carbon electricity production, has also implemented some financing schemes to facilitate the production of energy from renewable sources. The generation of energy with biomass is included in this project, whose objective is to make its production increase fourfold until 2050 (SFOE, 2015).

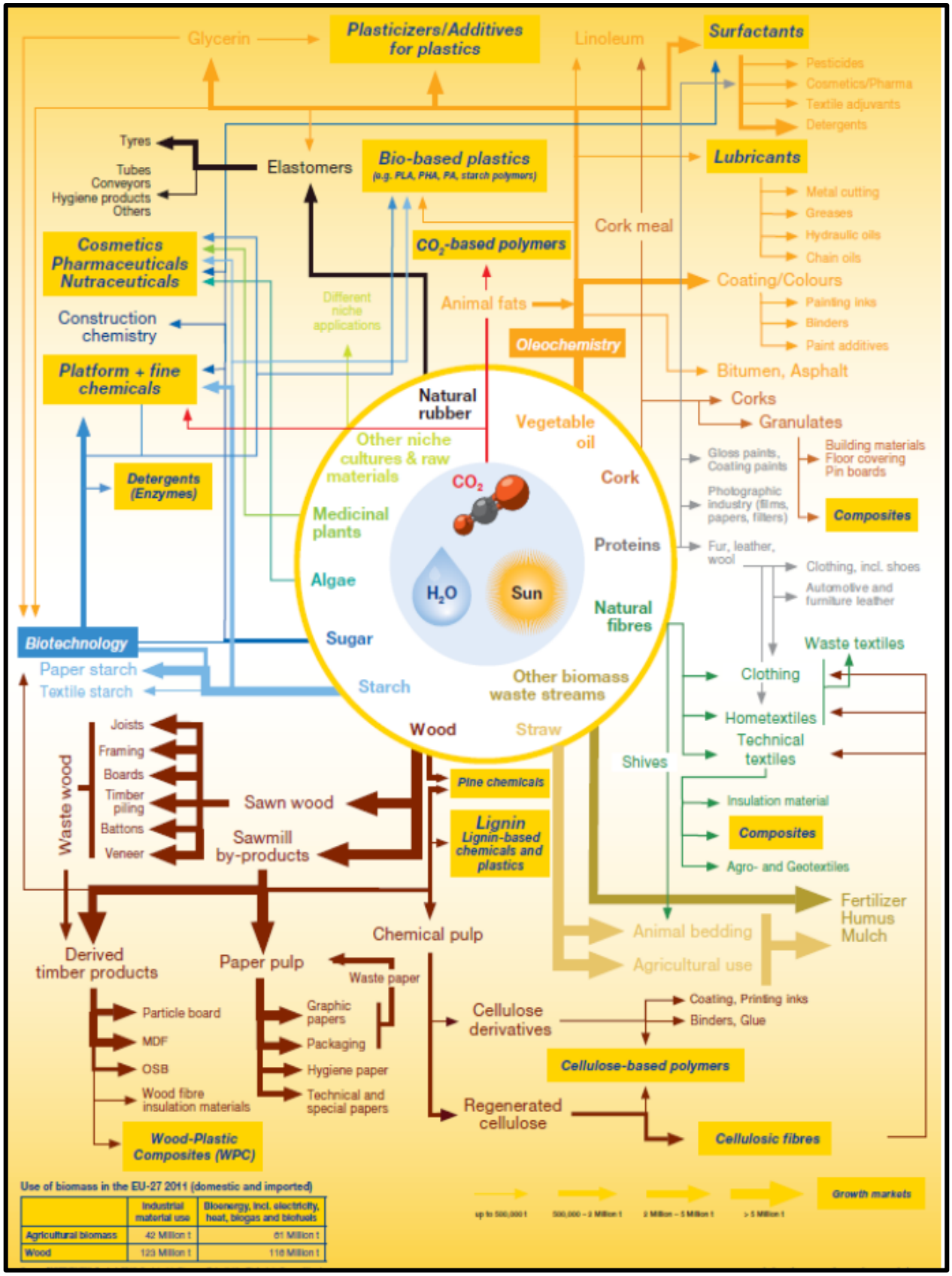
1.2 Subdivisions of the bioeconomy

The bioeconomy is quite a broad topic, and, as explained above, it has different definitions. Considering the definition of the European Commission, we identified a list of industrial sectors, according to the Swiss general classification of economic activities (NOGA), whose scope (entire scope or some parts of it) is considered part of the bioeconomy.

The bioeconomy can be divided into three general categories (*Figure 1*). These categories are biomass production, its transformation and, finally, the production of biobased products. The first category (the biomass) encompasses all productions of natural resources that are used in the bioeconomy. The biomass can be a direct product from the agriculture, forest, or fishing industries, or it can be waste originating from every step of the production cycle. Other sources, such as algae or insects, are also considered biomass. As it can be seen in *Figure 2*, there are multiple ways to use and transform biomass.

This biomass is then transformed (processing) into either energy, food, feed, chemicals or consumer products. The unit transforming the biomass is called a biorefinery. The definition according to the IEA: "*Biorefining is the sustainable processing of biomass into a spectrum of Biobased Products and Bioenergy. Biobased products being: chemicals, materials, human*

Figure 2. Industrial material use of biomass in Europe



Source: Parisi, C. and Ronzon, T. (2016)

food and animal feed. Bioenergy being: fuels, power and/or heat" (IEA Bioenergy, 2015). The biorefinery is a crucial part of the value chain because it transforms the biomass or extracts components from it to make them usable for the biobased industries. However, the industries transforming the biomass can also be the direct manufacturers of a final product. This means that the boundary between the transformer industry and the biobased industry can be somewhat blurry. *Figure 2* illustrates the different components of the biomass that can be transformed by biorefineries into biomaterials. These biomaterials are then used as energy or are processed into biobased products. It can be seen in *Figure 2* that there are numerous possibilities and ways to use the biomass.

The last category encompasses the biobased products: the biomass, or the transformed biomass, is processed or manufactured into a final product. The main industries are food-processing, chemical, pharmaceutical, and textile industries. Nevertheless, they are many other sectors producing biobased products (ETPs, 2015). The definition of what exactly are biobased products may vary again between countries and institutions. The Europeans, the IEA and the American authorities diverge on their exact definitions of biobased products. The first two consider food & feed products as biobased products, whereas the United States Department of Agriculture[1] does not. We will rely on the definition of the European Committee for standardization and include the food & feed sector as a biobased product industry. They define biobased products as: "*[...] products wholly or partly derived from biomass, such as plants, trees or animals (the biomass can have undergone physical, chemical or biological treatment)"* (European Committee for standardization, 2014).

We established the list of sectors related to the bioeconomy on the basis of the NOGA classification, which is defined by the Swiss statistical office as follows: "*The general classification of economic activities (NOGA) is a basic working tool for structuring, analysing and presenting statistical information. It allows classification of the statistical units' 'businesses' and 'local units' according to their economic activity and to aggregate them in coherent groups. It is used to reproduce reality as faithfully as possible, in an exhaustive and sufficiently detailed way to fulfil different objectives*." (FSO, 2008). The sectors identified as being part, either fully or partially, of the bioeconomy are divided

[1] "[...] manufacturing goods from biological products, renewable resources, domestic or agricultural or forestry material. The USDA excludes food, feed, and fuel when referring to the biobased products industry." (United States Department of Agriculture, 2016).

according to the three categories of the value chain previously identified (biomass production, its transformation and biobased product manufacturing).

The economic sectors that produce biomass directly are listed in T*able 1* (biomass sector industries). The list comprises sectors of NOGA section A: *Agriculture, Forestry and Fishing*. These sectors are the direct and largest suppliers of biomass for the bioeconomy. Industrial sectors such as *Manufacture of food products*, whose wastes provide biomass, are listed under the category biobased products industries and not under the biomass sector industries because their main activities are not to supply biomass but to supply industrial products.

Table 1. Production chain of the bioeconomy

NOGA code	Industry name
011	Growing of non-perennial crops
012	Growing of perennial crops
013	Plant propagation
014	Animal production
015	Mixed farming
016	Support of agriculture and post-harvest crop activities
021	Silviculture and other forestry activities
022	Logging
023	Gathering of wild-growing non-wood products
024	Support services to forestry
031	Fishing
032	Aquaculture

Note: industry definition based on NOGA 2008.
Source: Center for Competitiveness

Regarding the sectors listed in *Table* 1, it is important to consider that the biomass streams originate from direct production of corn or soy, for example, or it can be extracted from some biological waste such as straw or animal waste. Restaurants or shops can also supply a certain quantity of biomass with their unsold products or waste. Other sources, such as algae or insects, do not have a specific category, and it was not possible to identify in which NOGA category they are registered. Moreover, because these activities do not represent a large share of the economy, it was not crucial to know under which exact categories they are listed.

Table 2 shows the sectors that are part of the transformation process of the bioeconomy. They include the transformation of wooden products, which can be used directly as such (paper, for

example) or can be transformed into other products. Numbers 201 and 205 are part of the NOGA classification 20: *Manufacture of chemicals and chemical products*. These sectors may have been inserted into the transformation category as well as in the biobased product category. We classified them in the "transformation" category because they reflect biorefineries (production of goods that are then transformed into biobased products). This includes the production of biofuels or basic chemicals produced with biomass. The last two categories are where the production of energy and heat with biomass is included.

Table 2. List of transformation sector industries

NOGA code	Industry name
161	Sawmilling and planing of wood
162	Manufacture of products of wood, cork, straw and plaiting materials
171	Manufacture of pulp, paper and paperboard
172	Manufacture of articles of paper and paperboard
201	Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms
205	Manufacture of other chemical products
206	Manufacture of man-made fibers
351	Electric power generation, transmission and distribution
353	Steam and air conditioning supply

Note: industry definition based on NOGA 2008.
Source: Center for Competitiveness

Table 3 shows the sectors that produce or can potentially produce biobased products. The food-processing industry (numbers 101 to 110) transforms primary biomass into consumable products. Tobacco products (120) are produced with a renewable crop and are therefore biobased products. This list also includes the manufacturing of textiles and apparel from leather and natural textile fibers. Sectors number 202, 203 and 204 encompass products that are made by the chemical industry. Even if the majority of the industry does not produce biobased products, there is a substantial part of the industry's production that is biobased (e.g., bio-lubricants, bio-cosmetics, bio-cleaning products). The European Commission has estimated that 12.3% of the chemical industry's production is of biobased products (EC, 2016). The pharmaceutical industry, NOGA codes 211 and 212, is also a producer of biobased products. As for the chemical sector, only part of the industry is making biobased products. The manufacture of rubber products is part of the bioeconomy, as rubber can come from biomass (rubber tree) and therefore be biobased. The same scheme applies for the

manufacture of plastic products, in which there are numerous possibilities to produce biobased plastics (bioplastics). The production of bioplastics was estimated to account for 1% of the annual production of plastic in 2016 (European bioplastics, 2016). The manufacture of clay building material can also be included in the list of biobased product industries, as biomass is already used to produce certain construction materials. The production of furniture made from wood or biomass is also considered part of the bioeconomy, since some products are made from wood or biomass.

Table 3. List of biobased product industries

NOGA code	Industry name
101	Processing and preserving of meat and production of meat products
102	Processing and preserving of fish, crustaceans and molluscs
103	Processing and preserving of fruit and vegetables
104	Manufacture of vegetable and animal oils and fats
105	Manufacture of dairy products
106	Manufacture of grain mill products, starches and starch products
107	Manufacture of bakery and farinaceous products
108	Manufacture of other food products
109	Manufacture of prepared animal feeds
110	Manufacture of beverages
120	Manufacture of tobacco products
131	Preparation and spinning of textile fibers
132	Weaving of textiles
133	Finishing of textiles
139	Manufacture of other textiles
141	Manufacture of wearing apparel, except fur
142	Manufacture of articles of fur
151	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery and harnesses; dressing and dyeing of fur
152	Manufacture of footwear
202	Manufacture of pesticides and other agrochemical products
203	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
204	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
211	Manufacture of basic pharmaceutical products

212	Manufacture of pharmaceutical preparations
221	Manufacture of rubber products
222	Manufacture of plastic products
233	Manufacture of clay building materials
310	Manufacture of furniture

Note: industry definition based on NOGA 2008.
Source: Center for Competitiveness

2. Economic activities of the canton of Fribourg related to the biobased economy

2.1 The canton of Fribourg

The canton of Fribourg is one of the 26 official regions of Switzerland. It is located in the west side of the country and has physical borders with the canton of Vaud and the canton of Bern. The canton of Fribourg has the particularity of finding itself between the French- and German-speaking parts of Switzerland. Thanks to this particular location, the canton of Fribourg is bilingual, with approximately two-thirds of its population being French speakers and one-third German speakers. Switzerland covers an area of 41,290 square kilometers and had, as of 2015, a population of 8.3 million inhabitants. Its capital and fifth largest city is Bern, while the largest city and the economic center of the country is Zürich. The canton of Fribourg covers an area of 1,671 square kilometers and has, as of 2017, a population of 311,800 inhabitants (SStat, 2017). Its largest city and the regional capital is the city of

Figure 3. The canton of Fribourg in Switzerland

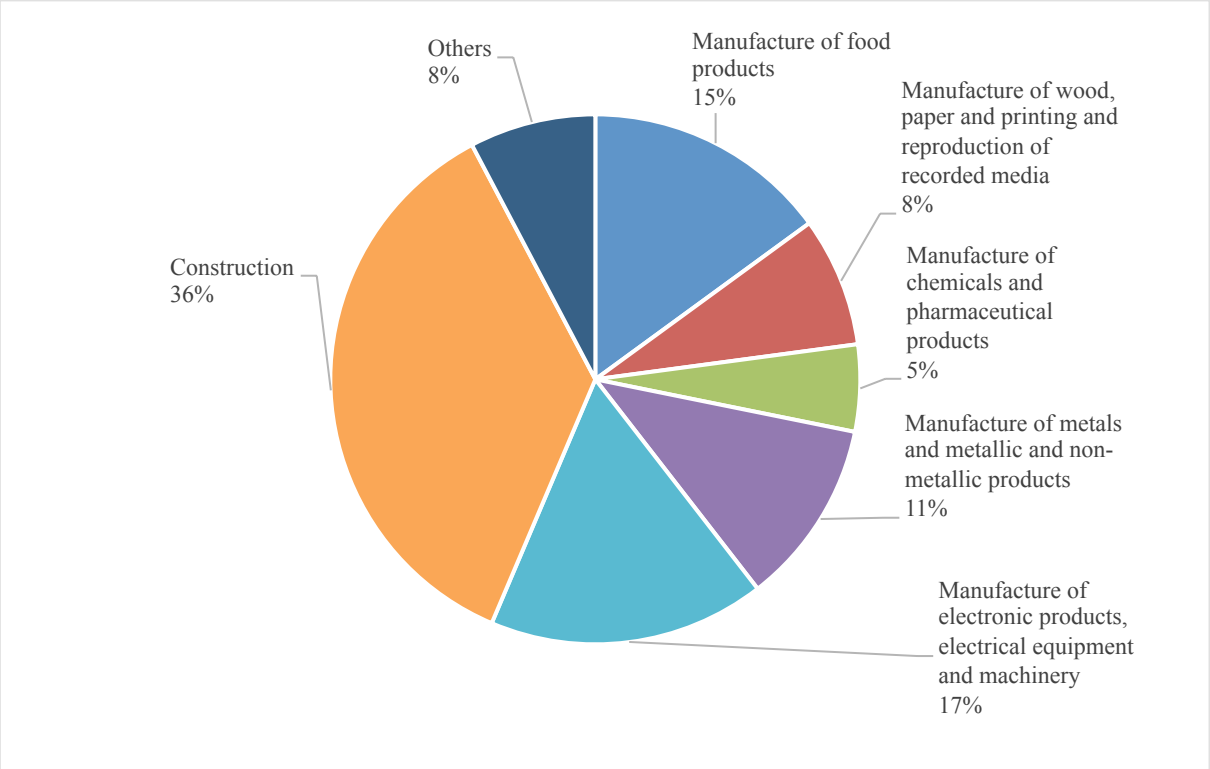
Source: adapted from https://en.wikipedia.org/wiki/Lausanne#/media/File:Switzerland_adm_location_map.svg

Fribourg. Since 2009, Switzerland has been ranked as the most competitive economy in the world by the Global Competitiveness report (WEF, 2016).

2.2 Economic composition of the region

As of 2016, the canton of Fribourg had a GDP of 17,957 million CHF. The GDP per capita was 57,630 CHF, compared to the national average of 77,943 CHF.[2] The composition of the GDP of the region is 2% of the primary sector, 33% of the secondary sector and 65% of the tertiary sector. If considered by employment share, the primary sector represents 6% of the total, the secondary sector 30% and the tertiary sector 64%. The share of the primary and secondary sectors in the economy is slightly higher than the Swiss average in the GDP and in

Figure 4. Share of industries composing the secondary sector of the canton of Fribourg in FTE (2014p).



Note: FTE: Full-time equivalent; p: provisory data for 2014; industry definition based on NOGA 2008.
Source: Gugler, P. Lepori, D. Resbeut, M. (2017), Economic performance, Structure and Comparative Advantages of the Canton of Fribourg (CH), Center for Competitiveness, University of Fribourg, Switzerland

[2] For a full report of the economic performances of the canton of Fribourg, please refer to: Gugler, P. Lepori, D. Resbeut, M. (2017), Economic performance, Structure and Comparative Advantages of the Canton of Fribourg (CH), Center for Competitiveness, University of Fribourg, Switzerland.

in the employment.

The agriculture sector is by far the largest employer in the primary sector, with a share of 96% of total employment. As can be seen in *Figure 4*, the secondary sector in the region of Fribourg is diversified. The two main industries are the construction sector and the manufacture of electronic products, together accounting for just over 50% of total employment. The third sector in terms of employment is the manufacture of food products. It represents 15% of the total employment in the secondary sector. The other industries represent a lower share of the secondary sector: the manufacture of metals and metallic and non-metallic products (11%); the manufacture of wood, paper and printing and the reproduction of recorded media (8%); and the manufacture of chemicals and pharmaceutical products (5%). The tertiary sector is, like the secondary sector, diverse and therefore composed of diverse industries. The three main industries are: wholesale and retail, with a share of 21%, public administration and education, with a share of 18%, and human health and social work activities, with a share of 17%. Other notable services industries are professional, scientific and technical activities, with a share of 10%, and accommodation, food and service, with a share of 7%. All the other industries have a share of less than 6% of the total employment.

Table 4 shows the six most important and specialized groups of industries of the canton of Fribourg in terms of value added and employment.[3] Some of these groups may comprise a combination of primary, secondary and tertiary economic activities. Their composition can be found in annex B. The largest group in terms of employment is construction. It represents 13.13% of the total employment of the canton and 7.34% of its value added. However, its share of total exports is negligible, as it mainly serves the local market. The group of agriculture and food products is quite similar, with a 10.83% share of the total employment and 5.31% in terms of value added. It registers 10.14% of the total exports (excluding the export of manufactured measuring instruments, watches and jewelry products) of the Fribourg canton[4]. The sub-sector of machinery and equipment represents an employment share of

[3] The source of Figure 4 and Table 4 is: Gugler, P. Lepori, D. Resbeut, M. (2017), Economic performance, Structure and Comparative Advantages of the Canton of Fribourg (CH), Center for Competitiveness, University of Fribourg, Switzerland.

[4] These sectors registered 72.15% of the value of exports of the canton of Fribourg in 2015. They are excluded because they mainly reflect the results of one international company, which is located in the canton of Fribourg but whose exported products are not produced in the canton. See Gugler, P.

6.58% and a value added share of 8.74%. It registers 32.35% of the total exports of the canton of Fribourg (excluding the export of manufactured measuring instruments, watches and jewelry products). The sub-sector of chemical and pharmaceutical products registers 2.18% of the total employment and 4.24% of its value added, but it also represents more than one-third of exports, with a share of 35.38% (excluding the export of manufactured measuring instruments, watches and jewelry products). Two smaller sub-sectors are wood-products and metals, which respectively represent 1.74% and 2.05% of the value added of the canton of Fribourg.

Table 4. Employment, value added and canton's exports of the more specialized groups of industries for the canton of Fribourg (2014p).

Sub-sectors of related activities	Employment (FTE) in % (of total)	Value Added in % (of total)
Sub-sector of agriculture and food products	10.83%	5.31%
Sub-sector of wood products	2.14%	1.74%
Sub-sector of machinery and equipment	6.58%	8.74%
Sub-sector of metals	2.66%	2.05%
Sub-sector of chemical and pharmaceutical products	2.18%	4.24%
Sub-sector of construction	13.13%	7.34%

Note: FTE: Full-time equivalent; p: provisory data for 2014; industry definition based on NOGA 2008.
Source: Gugler, P. Lepori, D. Resbeut, M. (2017), Economic performance, Structure and Comparative Advantages of the Canton of Fribourg (CH), Center for Competitiveness, University of Fribourg, Switzerland

To sum up, we may identify four important groups of industrial activities: the food industry, linked to the agriculture sector; the construction industry, linked to several sectors such as wood, metals, energy; the chemical/pharmaceutical sector, comprising the plastic industry; and the machinery equipment sector. Three of these core activities constitute the main existing clusters that have been initiated over the last 10 years: the Swiss plastic cluster (SPC, created in 2005), the Energy & Construction Cluster (ECC, created in 2009) and the Food & Nutrition Cluster (FNC, founded in 2015). All these clusters are regrouped under the INNOSQUARE CLUSTERS institution, which aim is to ensure the sustainable growth of the clusters it manages.[5]

Lepori, D. Resbeut, M. (2017), Economic performance, Structure and Comparative Advantages of the Canton of Fribourg (CH), Center for Competitiveness, University of Fribourg, Switzerland, p. 13.

[5] More information about INNOSQUARE CLUSTER can be found at:

2.3 The bioeconomy in the canton of Fribourg

The presence of bioeconomic activities in the canton of Fribourg may be identified according to the three categories presented above (biomass production, biomass transformation and biobased products).[6] We will also consider the location quotient (LQ) of each industry to identify the most-specialized industries compared to the national average.[7] We will then identify the sectors presenting the highest development potentialities as well as their main technological and industrial linkages, which are important for the development of the value chain of the bioeconomy. The list of sectors identified under the three categories cannot be considered absolutely exhaustive, since all sectors producing or using, for example, some primary resources may fall within the scope of the bioeconomy (e.g., restaurant waste, food shop waste). But their economic weight and potential in the bioeconomy are low, so they do not need to be added.

2.3.1 The relevant industries in the bioeconomy

a.) Biomass production

Compared to the Swiss average, the canton of Fribourg is a significant producer of biomass due to the importance of its agricultural sector and, to a lesser extent, its forest-based industry.

Table 5 identifies three industries that have a high LQ and high share of employment in the region. The first industry is the cultivation of non-perennial crops, with an LQ of 2.70 and an employment of 1,094 FTE. The second industry is animal production, with an LQ of 2.23 and a total of employment of 4,258 FTE. The third industry is mixed farming, which is the combination of the industries just stated. This industry registers an LQ of 2.58 and employs 688 FTE. These findings reflect the relative importance of the agriculture in the region

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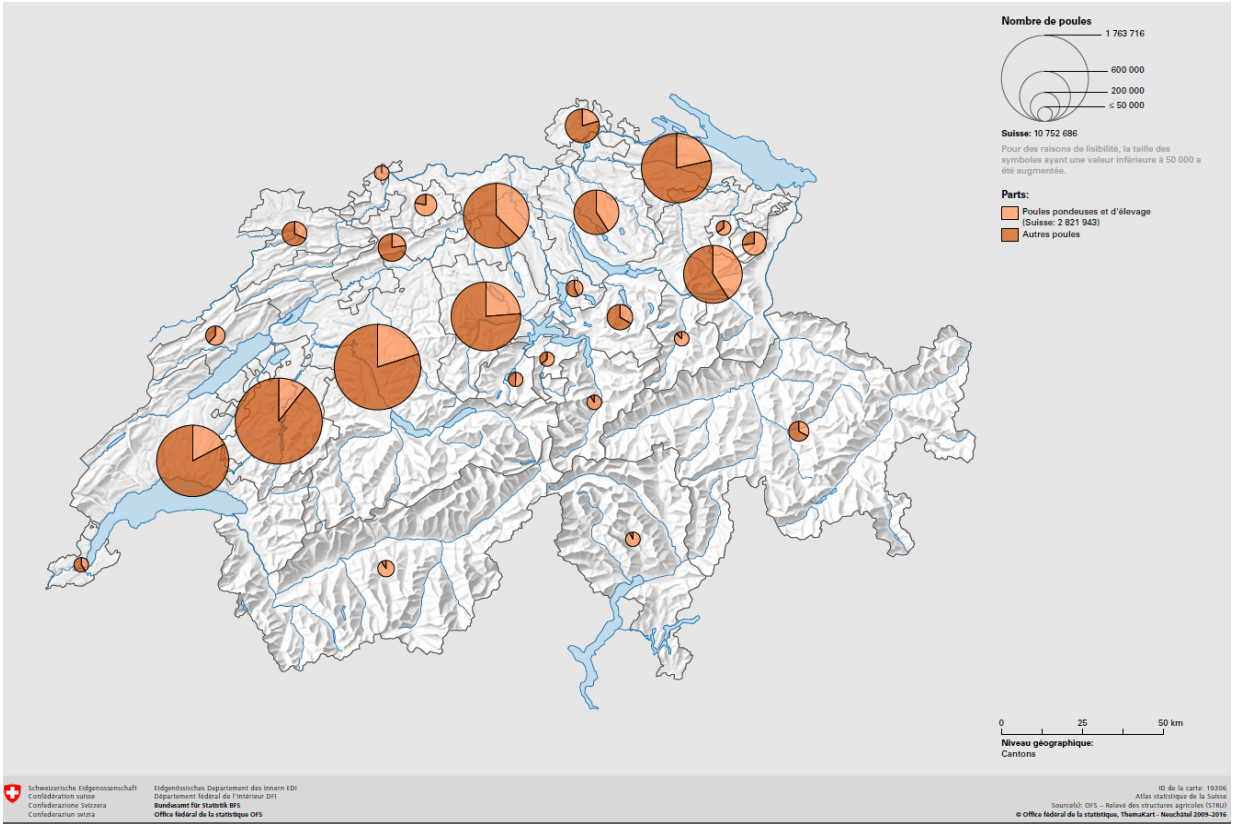
http://clusters.innosquare.com/en/

[6] The data for every industry can be found under Appendix A.

[7] "*The LQ reflects the degree of concentration/specialization of an industry in a given region compared with its concentration in the national economy (Resbeut and Gugler, 2016; Delgado et al., 2014). "An LQ above 1 means that the industry is more concentrated in the selected region than it is on the national level. This study uses a cutoff of 1.15, instead of 1, in order to determine if an industry shows a particular concentration. This cutoff is set to take into account the specificities of the distribution of economic activities in Switzerland*" (Gugler, P. Lepori, D. Resbeut, M. (2017)).

compared to the national level. The strength of the agriculture sector is even more pronounced in the production of animals.

Figure 5. Number of poultry per Swiss Canton



Source : https://www.atlas.bfs.admin.ch/maps/13/map/mapIdOnly/0_de.html

As seen in *Figure* 5, the canton of Fribourg is the first producer of poultry on the national level, followed by the neighboring canton of Bern, and it ranks third in cattle farming, with the neighboring region of Bern being first. The region of Fribourg is therefore a large producer of agricultural products and, therefore, of biomass. All the by-products of agriculture from poultry and cattle farming (e.g., feathers and poultry or cattle manure) can be used in the bioeconomy.

Silviculture and other forest activities (LQ of 1.86 and FTE employment of 151) is also a sector offering a potential supply of biomass. The by-products of wood have a high potential in the bioeconomy to produce energy, paper or cellulose derivatives.

As it might have been expected, fishing-related activities are rare in the region, as it is the case in Switzerland as a whole. The potential of biomass from this source is therefore negligible.

Other biomass streams originate from industries whose main business is not the production and use of their waste. Therefore, they are listed in the following categories either of transformation or of biobased product manufacturing.

Table 5. LQ and employment (in FTE) for the biomass sector industries

NOGA code	Industry name	LQ	FTE
011	Growing of non-perennial crops	2.70	1094
012	Growing of perennial crops	0.38	103
013	Plant propagation	1.58	50
014	Animal production	2.23	4258
015	Mixed farming	2.58	688
016	Support of agriculture and post-harvest crop activities	2.41	116
021	Silviculture and other forestry activities	1.86	151
022	Logging	0.00	0
023	Gathering of wild-growing non-wood products	0.00	0
024	Support of services to forestry	1.48	101
031	Fishing	1.04	5
032	Aquaculture	0.62	4

Note: LQ: location quotient; FTE: Full-time equivalent; industry definition based on NOGA 2008.
Source: adapted from: Gugler, P. Lepori, D. Resbeut, M. (2017), Economic performance, Structure and Comparative Advantages of the Canton of Fribourg (CH), Center for Competitiveness, University of Fribourg, Switzerland

b.) Transformation of biomass

Table 6 presents the main industries that may eventually transform the biomass. Biomass transformation represents only one type of activity among others for most of these industries. There are no data measuring the volume of biomass transformed in the canton.

Table 6 shows that there are two transformation industries that have a high LQ and a considerable share in FTE employment. The sawmilling and planing of wood has an LQ of 2.53 and represents 205 FTE employment. The manufacture of products of wood, cork, straw and plaiting materials has an LQ of 1.66 but represents 1,602 FTE employment. This means that the wood transformation sector is specialized and quite active in the canton, with a significant number of jobs. The wood industry is globally part of the bioeconomy, as the resources it uses are renewable.

The manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary form has a low LQ (0.37) and represents 74 FTE employment. We classified these sectors under "transformation sector industries", whereas the production of plastic goods (LQ of 0.94 and 560 FTE employment) is classified under "biobased production industries" in *Table 7*. It has to be highlighted that the production of bio-plastic or derivate products is a sector of the bioeconomy offering a high innovative and market potential.

Table 6. LQ and employment (in FTE) for the transformation sector industries

NOGA code	Industry name	LQ	FTE
161	Sawmilling and planing of wood	2.53	205
162	Manufacture of products of wood, cork, straw and plaiting materials	1.66	1602
171	Manufacture of pulp, paper and paperboard	0.00	0
172	Manufacture of articles of paper and paperboard	0.97	188
201	Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms	0.37	74
205	Manufacture of other chemical products	0.46	110
206	Manufacture of man-made fibers	0.00	0
351	Electric power generation, transmission and distribution	0.67	451
353	Steam and air conditioning supply	0.43	10

Note: LQ: location quotient; FTE: Full-time equivalent; industry definition based on NOGA 2008.
Source: adapted from: Gugler, P. Lepori, D. Resbeut, M. (2017), Economic performance, Structure and Comparative Advantages of the Canton of Fribourg (CH), Center for Competitiveness, University of Fribourg, Switzerland

Electric power generation, transmission and distribution registers a low LQ (0.67) but represents a non-negligible share of employment in FTE, with 451. This category comprises the production of biogas. The canton of Fribourg and its neighboring regions have roughly 10% of the Swiss installed production capacity of biogas and are therefore important actors in the production of bioenergy at the national level (Greenwatt Groupe E, 2016).

c.) Biobased products

Table 7 lists all industries that manufacture or may manufacture bioproducts according to their LQ and their employment level. The food industry is one of the main economic actors

producing bioproducts in the canton. The high LQ levels of the sub-sectors illustrate a strong specialization of the firms and, therefore, the strength of the food cluster. The processing and preserving of meat and the production of meat products (NOGA 101) as well as the manufacture of dairy products (NOGA 105) register an LQ of 4.15 and 7.21, respectively. Their FTE employment is 1,670 and 1,687, respectively. These two industries combine a high level of employment and a high LQ. They are closely related to the industry of animal production, which constitutes an important economic activity in the canton, as shown above. Another relevant actor with high LQ but lower FTE employment is the processing and preserving of fish, crustaceans and molluscs (4.08 and 67 FTE), which is not a major industry in Switzerland as a whole due to its localization. Another relevant actor is the processing and preserving of fruits and vegetables (3.12 and 139 FTE). On the other hand, the manufacture of bakery and farinaceous products and the manufacture of other food products have rather moderate LQs of 1.15 and 1.35, respectively, but their share of employment is substantial, with 767 and 641 FTE employment, respectively.

The manufacture of paints, varnishes and similar coatings, printing inks and mastic is notable, with an LQ of 1.73 and an FTE employment of 204. It is possible to produce paints and varnishes that are produced only with biomass and are therefore biobased products.

The manufacture of basic pharmaceutical products registers an LQ slightly higher than 1 and 292 FTE employment. Concerning the manufacture of pharmaceutical preparations, the LQ is low (0.55), but the FTE employment is 495. This might be explained by the strong representation of pharmaceutical industries in other regions (e.g., in the canton of Basel). Even though the LQ is relatively low, there might be some potential for the development of biopharmaceutical products.

The manufacture of plastic products has an LQ slightly lower than 1 (0.94), but it represents 540 FTE employment. As explained before, this industry is part of the Plastic Cluster and has strong potential (innovation and development of new products) in the field of the bioeconomy.

The last industry is the manufacture of furniture. It has an LQ of 1.31 and represents 368 FTE employment. It is closely linked with all the wood processing and the transforming value chain, as a share of the industry's production is based of wood. It is therefore closely linked with NOGA categories 021, 161 and 162.

The other industries exhibited in the table have low LQs and a low share of employment. Therefore, they have lower potential concerning the development of the bioeconomy in the region of Fribourg.

Table 7. LQ and employment (in FTE) of biobased product industries

NOGA code	Industry name	LQ	FTE
101	Processing and preserving of meat and production of meat products	4.15	1670
102	Processing and preserving of fish, crustaceans and molluscs	4.08	67
103	Processing and preserving of fruit and vegetables	3.12	139
104	Manufacture of vegetable and animal oils and fats	0.00	0
105	Manufacture of dairy products	7.21	1689
106	Manufacture of grain mill products, starches and starch products	0.44	17
107	Manufacture of bakery and farinaceous products	1.15	767
108	Manufacture of other food products	1.35	641
109	Manufacture of prepared animal feeds	0.90	41
110	Manufacture of beverages	0.44	61
120	Manufacture of tobacco products	0.00	0
131	Preparation and spinning of textile fibers	0.00	0
132	Weaving of textiles	0.01	0
133	Finishing of textiles	0.11	3
139	Manufacture of other textiles	1.29	141
141	Manufacture of wearing apparel, except fur	0.59	72
142	Manufacture of articles of fur	0.00	0
151	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery and harnesses; dressing and dyeing of fur	0.69	21
152	Manufacture of footwear	0.00	0
202	Manufacture of pesticides and other agrochemical products	0.00	0
203	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	1.73	204

204	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	0.37	63
211	Manufacture of basic pharmaceutical products	1.11	292
212	Manufacture of pharmaceutical preparations	0.55	495
221	Manufacture of rubber products	0.13	5
222	Manufacture of plastic products	0.94	560
233	Manufacture of clay building materials	1.05	21
310	Manufacture of furniture	1.31	368

Note: LQ: location quotient; FTE: Full-time equivalent; industry definition based on NOGA 2008.
Source: adapted from: Gugler, P. Lepori, D. Resbeut, M. (2017), Economic performance, Structure and Comparative Advantages of the Canton of Fribourg (CH), Center for Competitiveness, University of Fribourg, Switzerland

d.) Complementary and supporting institutions

The canton of Fribourg benefits from the presence of its cantonal University as well as its University of Applied Sciences[8] providing curricula in many disciplines related to the bioeconomy. The University of Fribourg offers teaching programs in chemistry and biochemistry that have linkages with the bioeconomy. The School of Engineering and Architecture of Fribourg is also active in strategic areas such as chemistry and has strong linkages with the Swiss industry. It has developed various institutes that offer businesses the opportunity to create partnerships. The institutes that can potentially support the development of the bioeconomy in the canton of Fribourg are, for example, ChemTech (institute of chemical technology); Energy (institute of applied research in energy systems); iPrint (institute for printing); and iRAP (institute for applied plastic research). The ChemTech institute is cooperating with actors in the food business to help them valorize bio-waste. Other major institutions that can play a role in the development of the bioeconomy are the INNOSQUARE CLUSTERS and the Adolf Merkle Institute (AMI), which focuses its activities on research and education in the domain of soft nanomaterials. The strengthening of research in the field of agriculture in Posieux (Agroscope) by the federal authorities offers potential synergies with the other complementary and supporting institutions. All these institutions have significant potential to strengthen R&D, particularly in cross-industrial technologies, as well as the technological transfers leading to commercial output in the

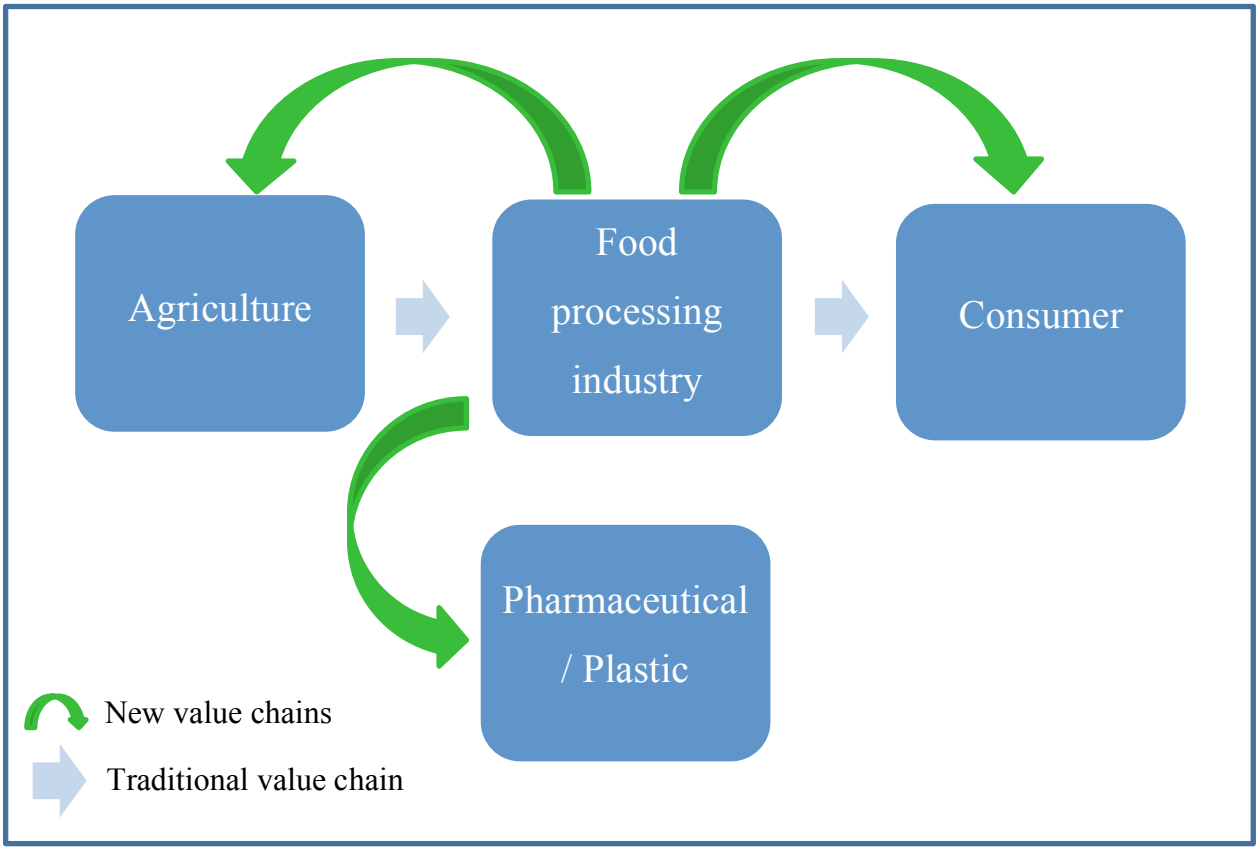
[8] School of Engineering and Architecture of Fribourg

canton. In that respect, the above-mentioned clusters are central networks in order to develop bioeconomic activities in the canton of Fribourg. Their role is to induce partnerships among private enterprises and these research and education institutions.

2.3.2 Value chain and potential of the bioeconomy in the canton of Fribourg

The previous chapter provides a picture of the main industries of the canton of Fribourg that are active or may develop activities in the bioeconomy.

Figure 6. Value chain of the food processing industry in the bioeconomy

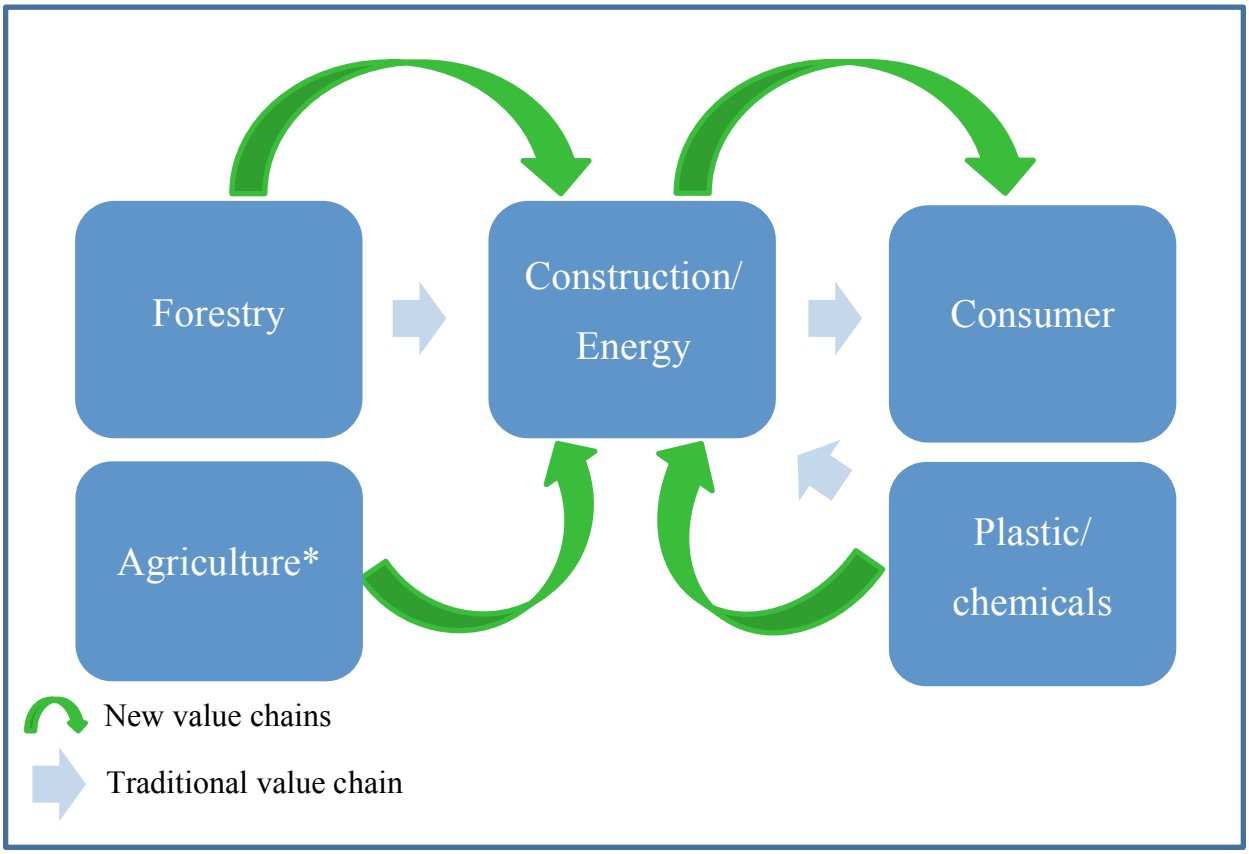


Source: Center for Competitiveness

The sector with the greatest potential in the region of Fribourg is food & feed. A cluster already exists, namely, the Food & Nutrition cluster. As seen before, the two main segments of agriculture are the growing of non-perennial crops and animal production. Animal production is destined on one hand to the dairy products industry (for cattle farming) and, on the other hand, to the processing and preserving of meat. The food processing industry, in the frame of the bioeconomy, has a double potential. The first is to develop new products in their respective industry, since consumers are requesting more products that are healthier or that

benefit their well-being. Secondly, they have potential concerning the valorization of all the by-products or wastes they produce (biomass). These by-products are, for the moment, transformed into animal feed or biogas, or they are burned. By-products may, however, be rich in proteins or nutrients and may have a higher value added in the pharmaceutical, plastic or chemical sectors. This means that there is a need for inter-sectorial cooperation to create better processes or develop new products. However, it is also important to create cross-sector cooperation (e.g., with the plastic cluster or the pharmaceutical industry). *Figure 6* shows this process of creation of new value chains in the bioeconomy and how some new openings are appearing for the food processing industry.

Figure 7. Value chain of the construction industry in the bioeconomy



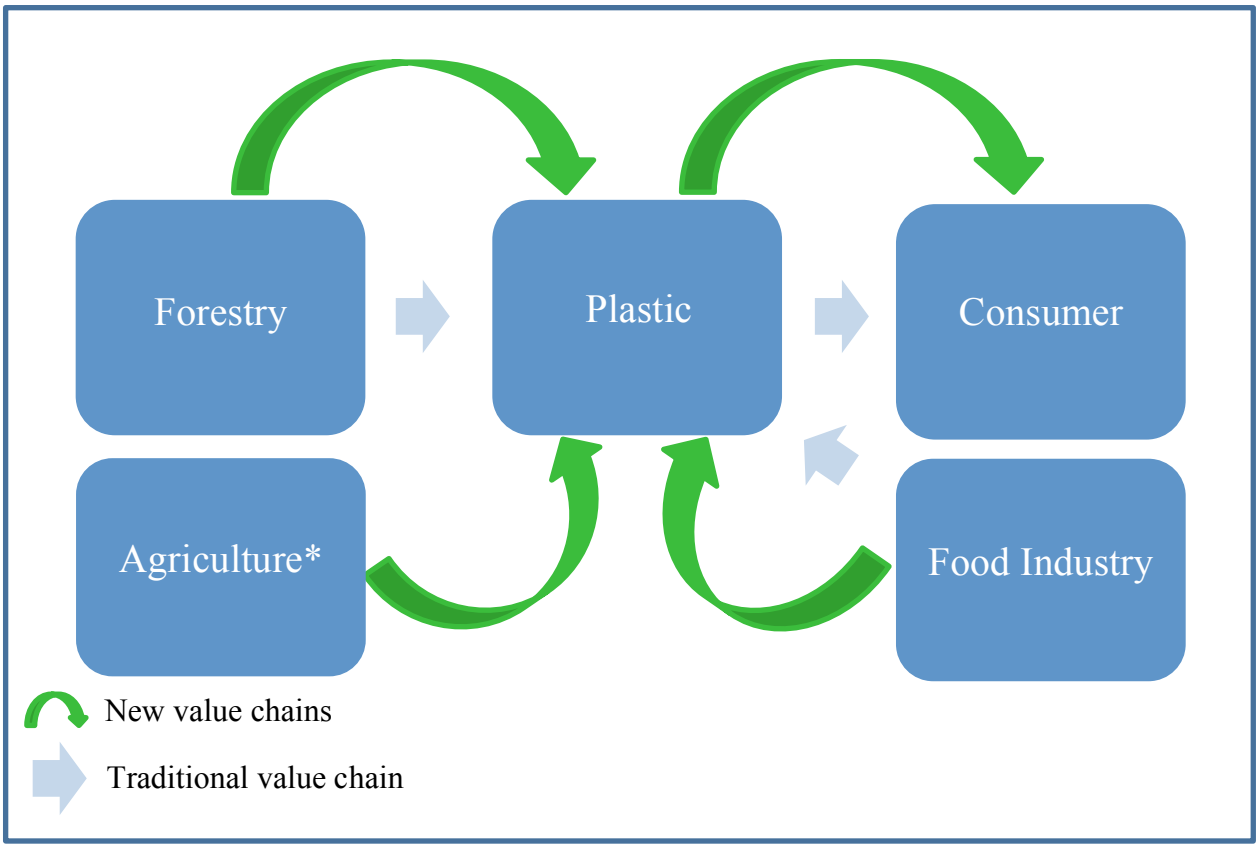
*biomass from non-food crops or non-edible by-products of agriculture (e.g., straw)
Source: Center for Competitiveness

Being a considerable producer of bio-waste, the food industry has the possibility to create a cross-industrial value chain to valorize its waste and create value added.

The construction and energy sector have substantial potential in the development of the bioeconomy in the canton of Fribourg. As seen in *Figure 7*, much of this potential is linked with the wood and forestry sector. Wood is historically used in the construction sector to build

chalets or frames of "villas". There are, however, multiple possibilities to use wood or wood derivatives in the construction sector (e.g., to replace steel structures or as insulation material). Concerning energy, wood derivatives, such as pellets, are already used to heat individual houses or in central heating. It is also possible to make biobased products from agricultural biomass. For example, it is possible to manufacture insulation from hemp or straw. New applications and developments have to be found to value biomass even more in the construction industry. The chemical and plastic industries can supply new biobased products to the construction sector (e.g., biobased paints, biobased plastic derivatives). As one of the main economic sectors in the region, the development potential of the Energy & Construction Cluster in the bioeconomy is large and there are numerous possibilities to develop cross-sectoral cooperation with the other clusters of the canton of Fribourg.

Figure 8. Value chain of the plastic industry in the bioeconomy



*biomass from non-food crops or non-edible by-products of agriculture (e.g., straw)
Source: Center for Competitiveness

Figure 8 represent the possibilities of development of new value chains for the plastic industry in the frame of the bioeconomy. As stated in the previous paragraph, the bioplastic industry can serve the same markets as the traditional plastic industry. There is, however, a

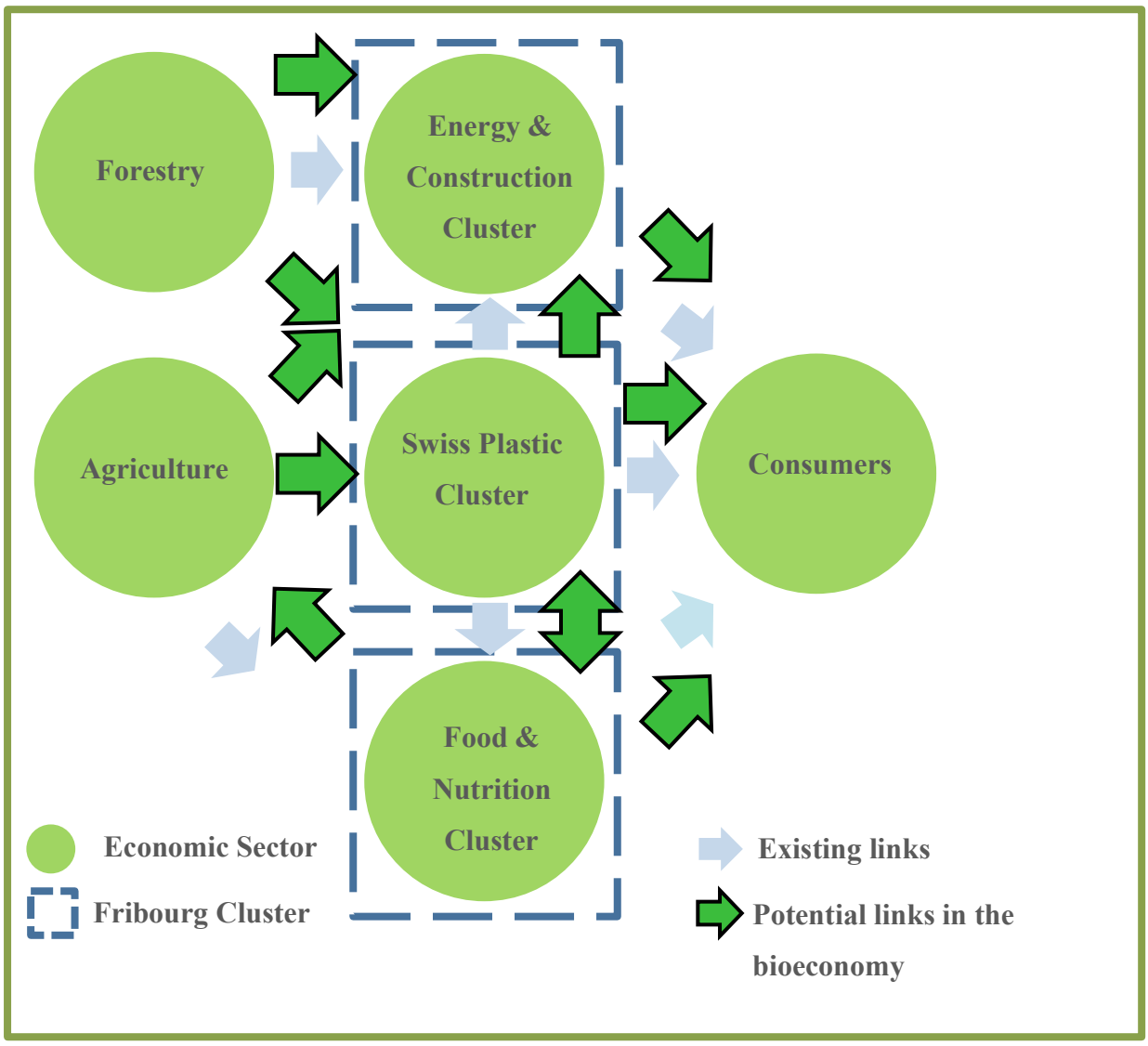
specific focus on the medical sector and the food industry, as they have specific needs that the bioplastic industry could serve well (e.g., bioplastics with high bacterial resistance). The biomass in the production of bioplastic can come from the forestry sector (e.g., lignin), from the agricultural sector with the use of starch or sugar, or from the waste of the food industry (e.g., animal proteins). The plastic sector plays a significant role in the development of the bioeconomy in the canton of Fribourg. It has links with all the other clusters and industries. The Swiss Plastic Cluster may also be a leading instigator of innovation in the bioeconomy of the canton of Fribourg.

The development of the bioeconomy will create new linkages between industries and sectors. It will durably modify the structure of the value chain of all the industries involved in the bioeconomy. *Figure 9* gives insight into the new links the bioeconomy will create. The primary sector on one side will have the possibility to find new commercial opportunities thanks to the bioeconomy. The agricultural and forestry sectors, which are major economic actors in the canton of Fribourg, will have the possibility to develop new value chains in the frame of the bioeconomy by supplying and making profits from biomass that was not previously considered valuable. The three clusters present in the canton of Fribourg have, as stated previously, development possibilities in the bioeconomy. The plastic industry can develop new products in cooperation with the food and construction industries. The possibilities for bioplastics serving the pharmaceutical and medical sector are also substantial. The food processing industry, which is facing intense competition (from within and without the country), can also create value by developing unique products and serving new markets. The energy and construction sectors will also find economic opportunities through the development of biobased products. Stronger regulation concerning the environmental efficiency of buildings and increasing public awareness concerning ecological problems will affect traditional construction materials. Although the construction sector will face challenges in adapting itself, there will be growth opportunities in the development of biobased products related to the construction and energy sectors.

The bioeconomy can be a strong catalyst to develop and foster new economic linkages between a broad range of industries and economic sectors. The value chain of the bioeconomy is changing away from that of the traditional economy (and might even been seen as disruptive), as sectors focused on business-to-consumer operations can now develop business-to-business operations (e.g., the food processing industry) or become suppliers/clients of new industries. This transformation has an impact on every actor involved in the bioeconomy from

the primary sector to the consumers, but it offers far more opportunities than threats to the industries of the canton of Fribourg.

Figure 9. Clusters of the region of Fribourg: Their integration in the frame of the bioeconomy



Source: Center for Competitiveness

3. Regional biobased industry strategy

3.1 The bioeconomy within the frame of the cantonal economic development policy

The bio-economy represents an important asset for the regional competitive advantage of the economic development of the canton of Fribourg. As shown in the previous chapter, some important economic activities, firms and institutions located in the canton are already involved in the bioeconomy and/or possess significant innovative and market potentialities in the field of the bioeconomy.

The initiators of "*S3-4AlpClusters*" asked us to fulfill a standardized matrix reproduced in *Table 8*. The major clusters and competence centers of the canton are directly or indirectly active in the bioeconomy. These clusters as well as the competence centers embrace activities regarding biomass production, biomass processing and bio-industry products. The food & feed sector is included in the Food & Nutrition Cluster, the chemical and polymer sectors are partially included in the Swiss Plastic Cluster, and the energy and construction sectors are included in the Energy & Construction Cluster. We can identify enterprises that are competing in all sectors mentioned in the table. Major players in the bio-economy are active in the fields of agro-business, comprising agriculture and food production, and in other sectors, such as chemical/pharmaceutical, energy, construction, wood products and textiles. Knowledge high schools and institutes are particularly involved in the areas of the primary biomass sector, the food and feed sector, the chemical sector (comprising polymers and phyto-pharma), and the energy and the construction sectors. The biomass supply is mainly provided by the primary sector, the food and feed sector, and the pulp and paper sector. The chemical sector (including the polymer and phyto-pharma sectors) also has an available supply of biomass in the region of Fribourg. The main competitive biobased industry products on the market are supplied by the food/feed, chemical, polymer, phyto-pharma, energy and construction sectors. Concerning funding and policies, there are no specific policies aimed solely at the bioeconomy; rather, there are more-general policies/funding (see *Table 8* for details).

Table 8. Current situation of the bioeconomy in the canton of Fribourg

Key asset	Primary Biomass sector	Food & Feed	Pulp & Paper	Chemi-cals	Poly-mers	Phyto-pharma	Textiles & Clo-thing	Energy	Cons-truction
Cluster Organization		X		X	X			X	X
Enterprises	X	X	X	X	X	X	X	X	X
Policy makers	*	*	*	*	*	*	*	*	*
Knowledge Institutes	X	X		X	X	X		X	X
Biomass supply	X	X	X	X	X	X			
Competitive biobased industry product on the market		X		X	X	X		X	X
Funding	**	**	**	**	**	**	**	**	**
Policies, programs and regulations	***	***	***	***	***	***	***	***	***

Note: Marked with an X if available/applicable, left empty if not; Primary biomass: agriculture, wood, biogenic waste, blue biomass
* Federal and Cantonal Institutions
**In general, no specific funding related to any of the specific sectors mentioned in the table, but other kinds of funding through inter alia the NPR program (see below).
*** no specific program related to any of the specific sectors mentioned in the table
Source: Center for Competitiveness

The canton of Fribourg does not have an official so-called "S3 policy". However, the canton supports innovation and knowledge building according to its economic competitiveness strategy. The cantonal competitiveness strategy is formulated in the program for the 2016-

2019 phase of the New Regional Policy (*Nouvelle Politique Regionale* - NPR) (Etat de Fribourg, 2016). The economic strategy of the canton promotes innovative clusters and competence centers within the frame of its policy to foster the competitive advantage of its territorial capital and the competitiveness of the firms located within the cantonal boundaries. The clusters are the Energy and Construction cluster, the Swiss Plastic Cluster, the Food and Nutrition cluster and IT Valley. The main competence centers (CCs) are Robust and Safe Systems, Plastics Innovation, biofactories and iPrint (digital printing). These innovative and industrial bodies are active under the umbrella of the Bluefactory and in other innovation centers, such as the private Marly Innovation Center and Le Vivier. The cantonal government was one of the key initiators of the creation of the Bluefactory, and it invested in this project.

Table 9. Enforcement program of the NPR 2016-2019

Cantonal strategy:

- Business innovation*
- Territorial innovation*
- Touristic innovation

Inter-cantonal strategy:

- Program CEDP-SO*
- Région Capitale suisse*
- Bi-cantonal and proximity intercantonal*

Cross-border strategy*

Collaboration with RegionS (Innoreg FR) *

Note: * programs having a potential impact on the bio-economy

Source : Etat de Fribourg, 2016, p. 34.

The canton of Fribourg does not have a biobased industry strategy so far. However, the program regarding the enforcement of the NPR 2016-2019 comprises several actions that may impact the innovative and entrepreneurial activities in the field of the bioeconomy (*Table 9*). For example, some bio-industries' activities and innovations may be supported through "Cleantech-FR" (Cantonal Economic Promotion) as well as within the framework of the main clusters organized within "the umbrella" of Innosquare (Bluefactory). Some parts of the cantonal support take place in the context of inter-cantonal collaboration projects (regional

policy of the cantons located in West-Switzerland[9] – CDEP-SO – and Région Capitale Suisse-RCS) as well as within the scope of trans-border collaborations (Interreg). For example, both the RCS and

Table 10. Policy instruments/funding of the canton of Fribourg under the Programme NPR 2016-2019

Name and objectives of policy instruments	Mode of delivery / funding	Amount of funding (CHF)	Duration
Name: Business innovation platform Objectives: Support the innovation capacities of SMEs; Support the creation of high added value firms; Support Cleantech projects within firms	Non-returnable grant	3400000	2016-2019
Name: Cluster development Objectives: Intensify cluster collaboration; Increase critical mass of clusters; Increase the international visibility of clusters; Foster the role of clusters for technology transfer	Non-returnable grant	1400000	2016-2019
Name: Inter-firm projects Objectives: Intensify innovation within technology platforms; Intensify technology transfer	Non-returnable grant	1800000	2016-2019

Source: Michael Keller, Interview 27th of March 2017, according to a classification based on: http://ec.europa.eu/regional_policy/sources/docgener/evaluation/pdf/expost2013/wp2_final_en.pdf and Etat de Fribourg (2016)

[9] Politique régionale des cantons de Suisse occidentale.

Interreg have projects related directly or indirectly to the bio economy. The RCS's projects cover inter alia the fields of health industries, renewable energies and agro-business. Some of Interreg's projects focus specifically on the bio-economy. Some support to the bio-economy is granted from projects unrelated to the NPR strategy. For example, the Biofactory Competence Center (BCC) located at Bluefactory received a starter-fund (2012-2015).

Table 10 provides a list of the major types of innovation supports granted by the canton of Fribourg according to targets that may have an impact on the bio-economy. To sum up, the canton of Fribourg implements a competitive strategy that may generate positive externalities on the development of the bioeconomy within the boundaries of the canton, but so far, the canton has not adopted any targeted actions aimed at fostering and upgrade specifically the development of the bioeconomy.

3.2 Competitive Dashboard of the canton in the field of the bio-economy

The economic structure of the canton of Fribourg is shaped by significant industrial activities and knowledge institutions offering important potentialities pleading for the promotion of the bioeconomy in the canton. Therefore, it is important to contemplate and draw up a development strategy targeting the bioeconomy based on a SWOT analysis (*Table 11*). This approach, which integrates the endogenous strengths and weaknesses and the exogenous opportunities and threats of the canton in the area of the bioeconomy, provides a scoreboard for a cantonal stocktaking and an ex ante evaluation of the situation.

Table 11. SWOT analysis

Strengths	Weaknesses
- Relative importance of the primary sectors (particularly the agriculture sector) as biomass source and biomass transformation - Importance of the food sector as biomass source and biomass transformation (slaughterhouses, agro-business) - Strong clusters and competence centers in strategic activities where the bioeconomy can be developed: food cluster, plastic cluster, construction & energy cluster, I-print	- Production side of bio-products; lack of a critical mass that could absorb the biomass produced in the canton; most parts of the value creation opportunities are currently not valorized in the canton - Except for plastic and a few other industries, the relative weak presence of big chemical and pharmaceutical enterprises reduce the opportunities to develop chemical and pharmaceutical bio-products - Lack of dynamism in the creation

CC, etc. - Presence of co-located clusters and of co-located industries related to the bioeconomy - Strong educational high schools - Strong presence of fundamental research institutes (university) and applied research institutes in several bio disciplines (as in chemical sciences and nanotechnologies) - Close collaboration between the business community and the cantonal government (previous positive experience of public private partnership projects) - Good geographical location inside the country	and development of start-ups in the bioeconomy compared to other regions (Zurich) - Weak linkages and interconnections among enterprises as well as among enterprises and institutions within clusters and competence centers and between clusters and competence centers. - Lack of an inter-cluster and inter-industry organization aimed at valorizing the whole bioeconomy value chain within and outside the canton - Lack of cantonal strategy in the field of the bioeconomy
Opportunities	**Threats**
- Growing commercial opportunities in the field of the bioeconomy (food, feed, chemical products, bioenergy) - Development of private innovation centers such as the Marly Innovation Center and Le Vivier - Strengthening of the federal research institute on animal production in the canton (Agroscope) - European and other programs providing research funds in the field of the bioeconomy - Development of inter-cantonal projects (e.g., Région Capitale Suisse) and of cross-border projects (e.g., Interreg)	- Faster development of efficient policies and strategies in other cantons to promote the bioeconomy and to attract key players in this field - Specialization of high-value activities (biobased products industry) in other cantons, reducing the opportunities to create and attract specialized firms in this area

3.3 Road-map towards a cantonal strategy fostering the bio-economy

Source: Center for Competitiveness

As stated above, the canton of Fribourg does not have a biobased industry strategy so far. A recent study funded by the European Union shows that most governmental initiatives to set up specific strategies to foster the bioeconomy are still in a starting phase (BioStep, 2016). Of course, important horizontal policies enforced at the federal level (e.g., laws and actions related to renewable energies, food securities, and environmental sustainability) and at the cantonal level (e.g., land planning) are governing issues impacting the bioeconomy. The development of the bioeconomy – pushed not only by purely economic goals but also by important socio-economic considerations – should be in the agenda of a specific cantonal economic strategy.

The SWOT analysis of the canton of Fribourg in the field of the bioeconomy provides interesting insights pleading for a more active economic strategy to promote the bioeconomy in the canton of Fribourg. A policy supporting the development of the bioeconomy would benefit many important sectors of the canton, including the agriculture and forestry, agro-business, chemical product, energy and construction sectors. Furthermore, the bioeconomy value chain comprises all kinds of enterprises, from the very small enterprises (farms, start-ups, etc.) to the major national and international companies. The promotion of the bioeconomy's sciences would boost high schools and research institute programs. In that respect, the bioeconomy may contribute to an efficient eco-system within the boundaries of the canton. Important sectors (in terms of specialization and/or employment) could be attached to the existing clusters and would benefit from and create positive externalities among the industrial and innovative activities deployed within the boundaries of the canton.

The train is entering Fribourg's rail station. Missing this train would lead to a loss of opportunities regarding innovations, start-up creations, new market development, and the valorization of the activities of important sectors of the canton. The bioeconomy cannot be restricted to the narrow view focusing on the efficient use of agricultural wastes for marginal transformation into energy and simple products. The bioeconomy is at the center of the actions fostering the convergence of the "nano-bio-info-cogno"[10] technologies fostered by "industry 4.0". The bioeconomy is following a societal and economic trend towards a greener,

[10] Nanotechnologies, biotechnologies, information technologies and cognitive sciences.

more responsible and fairer economy. It is therefore a trend that will last, and having a head start would give the region of Fribourg a competitive advantage over the other Swiss and European regions.

It is not the mandate of this report to propose a comprehensive study identifying the major steps and targets aiming to adopt a bioeconomy strategy for the canton of Fribourg. However, based on the observations, interviews and the results of this report, we highlight the main stepping stones to be considered in the perspective of a cantonal promotion of the bioeconomy involving all stakeholders from agricultural smallholders to big agro-business enterprises and from the clusters and innovation centers to civil society. *Table 12* provides the main targets to be contemplated if a bioeconomy strategy is to be considered in the canton of Fribourg.

Table 12. Main strategic stepping stones to foster the bioeconomy in the canton of Fribourg

- Promote innovation in the field of the bioeconomy
- Promote R&D projects directly linked to the convergence of "nano-bio-info-cogno"[11] technologies fostered by "industry 4.0".
- Promote efficient knowledge transfer networks in the field of the bioeconomy
- Encourage private investment through venture capital
- Encourage the creation of start-ups aiming to develop bio-industry products (particularly the chemical and pharmaceutical sectors)
- Upgrade labor knowledge in the fields of the bioeconomy (high school curricula, apprenticeships, etc.)
- Implement an inter-cluster approach in accordance with the interdisciplinary and cross-sectoral features of the bio-economy
- Favor public-private partnerships to implement concrete actions fostering the bioeconomy
- Organize efficient coordination for the different policy actions related to the bioeconomy

[11] Nanotechnologies, biotechnologies, information technologies and cognitive sciences.

- Strengthen partnerships with Federal Institutions, particularly regarding R&D and education (e.g., in the field of agriculture)
- Communicate that innovation in the bioeconomy is an important goal of the canton (through several actions such as a "bioeco innovation" award)
- Improve the knowledge and active participation of the demand side
- Consider opportunities for inter-cantonal and cross-border collaboration but take the lead in major projects (to avoid a folding seat approach).

Conclusion

The world's resources are limited, and as new countries are now emerging and consuming more, traditional resources are becoming scarce. For economic growth and our way of living staying as it is, it will be necessary to develop more sustainable and renewable ways of producing. The development of the bioeconomy is one of the solutions to these problems. Because producing with biomass and using the natural resources we consume in a more efficient manner would help us lower the pressure on our economic society. The bioeconomy offers important business opportunities for the future. Firms may develop their activities with the creation of new products and processes by addressing new needs or addressing existing needs differently.

Defining the bioeconomy is crucial to understanding what its scope and underlying potential are. Dividing the bioeconomy into three different sub-categories allowed us to better understand the global value chain, the interactions between the industries and the growth possibilities that the bioeconomy is opening. We decided to list all the industries that were, or might be, active in the bioeconomy under the three following categories: the biomass sector industries, which regroup mostly primary sector industries, but not only; the transformation sector industries (biorefineries), which are a central element of the bioeconomy's value chain because they transform the biomass into transformable resources; and the biobased product industries, which are responsible for taking these transformed resources and manufacturing components or final goods from them. The distribution of all the industries composing the bioeconomy (using the NOGA classification) under these three categories gave us good hindsight on what interactions are or may take place at the different steps of the value chain.

In the second chapter, we showed the general economic structure of the canton of Fribourg. This allowed us, in connection with the first chapter, to identify the presences of industries with potential in the bioeconomy. The canton of Fribourg has a strong presence in the biomass production industry, with the agricultural (especially milk and meat production) and forestry sectors being well represented in the region. Concerning the transformation sector, the canton of Fribourg has a large wood transformation industry and some activities in the field of chemistry. The biobased products sector showed that the canton is a major player in the food-processing industry with an even greater specialization in meat and dairy product processing. The other main industries of the canton of Fribourg are the chemical, construction, and plastic sectors. All these industries have substantial potential for growth in the bioeconomy. As shown at the end of the second chapter, the clusters all have links to the bioeconomy, and they have the opportunity to develop new links between them thanks to the opportunities offered by the bioeconomy.

The bioeconomy has significant growth potential in the Canton of Fribourg. Important research and education institutions as well as numerous firms are active in this field. However, the canton has not yet implemented any specific strategy aimed at fostering and developing the bioeconomy. According to the results of this study, we strongly advise the consideration of all the actions and measures that should be taken to strengthen the development of the bioeconomy in the canton of Fribourg. Measures that should be taken include the promotion of innovation in the field of the bioeconomy and encouragement of the creation of start-ups to improve cross-regional cooperation in matters of bioeconomy.

The different regional actors active in the bioeconomy should also invest more in the development of cross-sectorial cooperation to develop products tailored to the needs of the consumers. The positive spillovers of such interactions would go far beyond the field of the bioeconomy and would benefit other segments of the economy. This cooperation between the clusters can help the industries react faster to changes and become more multidisciplinary thanks to the bioeconomy.

As stated above, the bioeconomy is at the center of the actions shaped by the convergence of "nano-bio-info-cogno"[12] technologies fostered by "industry 4.0". The bioeconomy is addressing societal and economic needs towards a greener, more responsible and fairer

[12] Nanotechnologies, biotechnologies, information technologies and cognitive sciences.

economy. It is therefore a trend that will last, and having a head start would give the region of Fribourg a competitive advantage over the other Swiss and European regions. The potential of the canton of Fribourg to develop its bioeconomic sector is therefore high, but its development should be done in cooperation with neighboring regions (either in Switzerland or in the Alpine arc). This would help situate the canton as a central and essential actor in the value chain of the bioeconomy, giving it a strong growth potential.

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Appendices

Appendix A: LQ and employment (in FTE) of all industries for the canton of Fribourg (2014p)

NOGA-3	Industry name	LQ	FTE
011	Growing of non-perennial crops	2.70	1094
012	Growing of perennial crops	0.38	103
013	Plant propagation	1.58	50
014	Animal production	2.23	4258
015	Mixed farming	2.58	688
016	Support activities to agriculture and post-harvest crop activities	2.41	116
021	Silviculture and other forestry activities	1.86	151
023	Gathering of wild growing non-wood products	0.00	0
024	Support services to forestry	1.48	101
031	Fishing	1.04	5
032	Aquaculture	0.62	4
072	Mining of non-ferrous metal ores	0.00	0
081	Quarrying of stone, sand and clay	1.03	124
089	Mining and quarrying n.e.c.	1.01	9
091	Support activities for petroleum and natural gas extraction	0.00	0
099	Support activities for other mining and quarrying	0.00	0
101	Processing and preserving of meat and production of meat products	4.15	1670
102	Processing and preserving of fish, crustaceans and molluscs	4.08	67
103	Processing and preserving of fruit and vegetables	3.12	139
104	Manufacture of vegetable and animal oils and fats	0.00	0
105	Manufacture of dairy products	7.21	1689
106	Manufacture of grain mill products, starches and starch products	0.44	17
107	Manufacture of bakery and farinaceous products	1.15	767
108	Manufacture of other food products	1.35	641
109	Manufacture of prepared animal feeds	0.90	41
110	Manufacture of beverages	0.44	61

120	Manufacture of tobacco products	0.00	0
131	Preparation and spinning of textile fibres	0.00	0
132	Weaving of textiles	0.01	0
133	Finishing of textiles	0.11	3
139	Manufacture of other textiles	1.29	141
141	Manufacture of wearing apparel, except fur apparel	0.59	72
142	Manufacture of articles of fur	0.00	0
143	Manufacture of knitted and crocheted apparel	0.11	1
151	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery and harnesses; dressing and dyeing of fur	0.69	21
152	Manufacture of footwear	0.00	0
161	Sawmilling and planing of wood	2.53	205
162	Manufacture of products of wood, cork, straw and plaiting materials	1.66	1602
171	Manufacture of pulp, paper and paperboard	0.00	0
172	Manufacture of articles of paper and paperboard	0.97	188
181	Printing and service activities related to printing	1.26	697
182	Reproduction of recorded media	0.33	1
192	Manufacture of refined petroleum products	0.08	2
201	Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	0.37	74
202	Manufacture of pesticides and other agrochemical products	0.00	0
203	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	1.73	204
204	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	0.37	63
205	Manufacture of other chemical products	0.46	110
206	Manufacture of man-made fibres	0.00	0
211	Manufacture of basic pharmaceutical products	1.11	292
212	Manufacture of pharmaceutical preparations	0.55	495
221	Manufacture of rubber products	0.13	5
222	Manufacture of plastics products	0.94	560
231	Manufacture of glass and glass products	2.82	330
232	Manufacture of refractory products	1.83	6
233	Manufacture of clay building materials	1.05	21
234	Manufacture of other porcelain and ceramic products	0.49	15
235	Manufacture of cement, lime and plaster	0.00	0
236	Manufacture of articles of concrete, cement and plaster	2.03	336
237	Cutting, shaping and finishing of stone	1.63	121
239	Manufacture of abrasive products and non-metallic mineral products n.e.c.	0.14	7
241	Manufacture of basic iron and steel and of ferro-alloys	0.47	21
242	Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	0.97	59
243	Manufacture of other products of first processing of steel	3.12	102
244	Manufacture of basic precious and other non-ferrous metals	0.35	33
245	Casting of metals	1.25	154
251	Manufacture of structural metal products	2.49	1226
252	Manufacture of tanks, reservoirs and containers of metal	0.01	0

253	Manufacture of steam generators, except central heating hot water boilers	17.07	18
254	Manufacture of weapons and ammunition	0.00	0
255	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	1.59	182
256	Treatment and coating of metals; machining	0.93	1003
257	Manufacture of cutlery, tools and general hardware	0.48	157
259	Manufacture of other fabricated metal products	0.27	63
261	Manufacture of electronic components and boards	1.91	1041
262	Manufacture of computers and peripheral equipment	0.04	1
263	Manufacture of communication equipment	1.08	108
264	Manufacture of consumer electronics	0.11	2
265	Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks	0.59	1107
266	Manufacture of irradiation, electromedical and electrotherapeutic equipment	1.97	733
267	Manufacture of optical instruments and photographic equipment	0.03	3
268	Manufacture of magnetic and optical media	0.00	0
271	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	0.07	26
272	Manufacture of batteries and accumulators	0.00	0
273	Manufacture of wiring and wiring devices	0.18	24
274	Manufacture of electric lighting equipment	0.31	20
275	Manufacture of domestic appliances	0.45	49
279	Manufacture of other electrical equipment	0.34	99
281	Manufacture of general-purpose machinery	3.17	1316
282	Manufacture of other general-purpose machinery	0.79	588
283	Manufacture of agricultural and forestry machinery	0.70	22
284	Manufacture of metal forming machinery and machine tools	0.71	254
289	Manufacture of other special-purpose machinery	0.55	355
291	Manufacture of motor vehicles	0.00	0
292	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	1.91	62
293	Manufacture of parts and accessories for motor vehicles	0.04	3
301	Building of ships and boats	0.54	7
302	Manufacture of railway locomotives and rolling stock	0.00	0
303	Manufacture of air and spacecraft and related machinery	0.01	1
304	Manufacture of military fighting vehicles	0.00	0
309	Manufacture of transport equipment n.e.c.	0.00	0
310	Manufacture of furniture	1.31	368
321	Manufacture of jewellery, bijouterie and related articles	0.22	29
322	Manufacture of musical instruments	0.57	9
323	Manufacture of sports goods	0.83	13
324	Manufacture of games and toys	1.16	9
325	Manufacture of medical and dental instruments and supplies	0.38	141
329	Manufacturing n.e.c.	0.36	40
331	Repair of fabricated metal products, machinery and equipment	0.90	391
332	Installation of industrial machinery and equipment	2.00	122
351	Electric power generation, transmission and distribution	0.67	451

352	Manufacture of gas; distribution of gaseous fuels through mains	0.32	12
353	Steam and air conditioning supply	0.43	10
360	Water collection, treatment and supply	1.59	82
370	Sewerage	1.06	117
381	Waste collection	2.15	231
382	Waste treatment and disposal	1.09	75
383	Materials recovery	0.66	76
390	Remediation activities and other waste management services	0.00	0
411	Development of building projects	1.65	64
412	Construction of residential and non-residential buildings	1.34	3208
421	Construction of roads and railways	0.94	472
422	Construction of utility projects	1.15	95
429	Construction of other civil engineering projects	2.11	119
431	Demolition and site preparation	1.79	272
432	Electrical, plumbing and other construction installation activities	1.24	3484
433	Building completion and finishing	1.41	2335
439	Other specialised construction activities	1.41	2161
451	Sale of motor vehicles	0.84	186
452	Maintenance and repair of motor vehicles	1.32	2193
453	Sale of motor vehicle parts and accessories	1.04	228
454	Sale, maintenance and repair of motorcycles and related parts and accessories	1.12	111
461	Wholesale on a fee or contract basis	1.75	148
462	Wholesale of agricultural raw materials and live animals	1.28	204
463	Wholesale of food, beverages and tobacco	1.05	916
464	Wholesale of household goods	0.94	1562
465	Wholesale of information and communication equipment	0.50	217
466	Wholesale of other machinery, equipment and supplies	0.77	721
467	Other specialised wholesale	0.80	1135
469	Non-specialised wholesale trade	2.35	489
471	Retail sale in non-specialised stores	1.11	2071
472	Retail sale of food, beverages and tobacco in specialised stores	1.36	796
473	Retail sale of automotive fuel in specialised stores	1.27	239
474	Retail sale of information and communication equipment in specialised stores	0.80	261
475	Retail sale of other household equipment in specialised stores	0.90	736
476	Retail sale of cultural and recreation goods in specialised stores	1.03	586
477	Retail sale of other goods in specialised stores	0.99	2104
478	Retail sale via stalls and markets	1.27	29
479	Retail trade not in stores, stalls or markets	0.87	173
491	Passenger rail transport, interurban	0.32	252
492	Freight rail transport	0.22	22
493	Other passenger land transport	1.02	965
494	Freight transport by road and removal services	1.37	1470
495	Transport via pipeline	0.40	3
501	Sea and coastal passenger water transport	2.80	9
502	Sea and coastal freight water transport	0.03	1
503	Inland passenger water transport	0.33	16

504	Inland freight water transport	0.00	0
511	Passenger air transport	0.01	3
512	Freight air transport and space transport	0.79	14
521	Warehousing and storage	1.66	276
522	Support activities for transportation	0.31	381
531	Postal activities under universal service obligation	1.18	878
532	Other postal and courier activities	0.24	47
551	Hotels and similar accommodation	0.58	1003
552	Holiday and other short-stay accommodation	0.62	45
553	Camping grounds, recreational vehicle parks and trailer parks	1.82	34
559	Other accommodation	7.16	45
561	Restaurants and mobile food service activities	1.04	3027
562	Event catering and other food service activities	0.64	270
563	Beverage serving activities	0.90	225
581	Publishing of books, periodicals and other publishing activities	0.62	249
582	Software publishing	0.64	7

591	Motion picture, video and television programme activities	0.59	91
592	Sound recording and music publishing activities	1.68	50
601	Radio broadcasting	0.04	3
602	Television programming and broadcasting activities	0.08	10
611	Wired telecommunications activities	0.57	310
612	Wireless telecommunications activities	0.10	10
613	Satellite telecommunications activities	1.31	12
619	Other telecommunications activities	1.16	49
620	Computer programming, consultancy and related activities	0.41	907
631	Data processing, hosting and related activities; web portals	1.05	204
639	Other information service activities	0.45	15
641	Monetary intermediation	0.41	1283
642	Activities of holding companies	1.38	83
643	Trusts, funds and similar financial entities	2.73	10
649	Other financial service activities, except insurance and pension funding	0.55	115
651	Insurance	0.47	509
652	Reinsurance	0.04	5
653	Pension funding	0.24	24
661	Activities auxiliary to financial services, except insurance and pension funding	0.33	119
662	Activities auxiliary to insurance and pension funding	0.96	763
663	Fund management activities	0.14	58
681	Buying and selling of own real estate	1.10	176
682	Renting and operating of own or leased real estate	0.25	42
683	Real estate activities on a fee or contract basis	0.76	708
691	Legal activities	0.68	449
692	Accounting, bookkeeping and auditing activities; tax consultancy	0.73	862
701	Activities of head offices	0.85	1099
702	Management consultancy activities	0.79	936

711	Architectural and engineering activities and related technical consultancy	0.84	2391
712	Technical testing and analysis	1.17	277
721	Research and experimental development on natural sciences and engineering	0.69	404
722	Research and experimental development on social sciences and humanities	0.66	24
731	Advertising	0.47	209
732	Market research and public opinion polling	0.29	22
741	Specialised design activities	0.69	236
742	Photographic activities	0.68	60
743	Translation and interpretation activities	1.05	66
749	Other professional, scientific and technical activities n.e.c.	1.29	206
750	Veterinary activities	1.33	171
771	Renting and leasing of motor vehicles	0.25	12
772	Renting and leasing of personal and household goods	1.17	60
773	Renting and leasing of other machinery, equipment and tangible goods	0.73	60
774	Leasing of intellectual property and similar products, except copyrighted works	0.07	1
781	Activities of employment placement agencies	0.45	186
782	Temporary employment agency activities	0.98	1950
783	Other human resources provision	0.00	0
791	Travel agency and tour operator activities	0.67	203
799	Other reservation service and related activities	0.79	81
801	Private security activities	0.43	171
802	Security systems service activities	1.49	39
803	Investigation activities	0.36	1
811	Combined facilities support activities	0.75	298
812	Cleaning activities	0.83	1116
813	Landscape service activities	1.11	693
821	Office administrative and support activities	0.51	42
822	Activities of call centres	0.00	0
823	Organisation of conventions and trade shows	0.56	65
829	Business support service activities n.e.c.	1.73	294
841	Administration of the State and the economic and social policy of the community	1.22	2965
842	Provision of services to the community as a whole	1.06	2078
843	Compulsory social security activities	3.79	250
851	Pre-primary education	0.16	40
852	Primary education	1.42	2434
853	Secondary education	1.27	2077
854	Higher education	1.56	2407
855	Other education	1.02	889
856	Educational support activities	0.29	5
861	Hospital activities	0.76	3351
862	Medical and dental practice activities	0.85	1469
869	Other human health activities	0.95	1526
871	Residential nursing care activities	1.11	2702

872	Residential care activities for mental retardation, mental health and substance abuse	1.15	153
873	Residential care activities for the elderly and disabled	1.47	1372
879	Other residential care activities	2.02	485
881	Social work activities without accommodation for the elderly and disabled	1.08	363
889	Other social work activities without accommodation	0.83	1210
900	Creative, arts and entertainment activities	0.64	297
910	Libraries, archives, museums and other cultural activities	0.82	192
920	Gambling and betting activities	1.00	74
931	Sports activities	0.79	517
932	Amusement and recreation activities	1.12	123
941	Activities of business, employers and professional membership organisations	0.66	244
942	Activities of trade unions	0.93	53
949	Activities of other membership organisations	0.98	1328
951	Repair of computers and communication equipment	0.08	2
952	Repair of personal and household goods	0.78	86
960	Other personal service activities	1.08	1427

Note: FTE: Full-time equivalent p: provisory data for 2014; industry definition based on NOGA 2008 (classification of economic activities).
Source: Gugler, P. Lepori, D. Resbeut, M. (2017), Economic performance, Structure and Comparative Advantages of the Canton of Fribourg (CH), Center for Competitiveness, University of Fribourg, Switzerland

Appendix B: Industries composing the sub-sectors defined in table 8 for the canton of Fribourg (2014p).

NOGA-3	Industry name	EPT
Sub-sector of agriculture and food products		
012	Growing of perennial crops	103
014	Animal production	4258
015	Mixed farming	688
016	Support activities to agriculture and post-harvest crop activities	116
031	Fishing	5
032	Aquaculture	4
101	Processing and preserving of meat and production of meat products	1670
102	Processing and preserving of fish, crustaceans and molluscs	67
103	Processing and preserving of fruit and vegetables	139
105	Manufacture of dairy products	1689
107	Manufacture of bakery and farinaceous products	767
108	Manufacture of other food products	641
109	Manufacture of prepared animal feeds	41
462	Wholesale of agricultural raw materials and live animals	204
463	Wholesale of food, beverages and tobacco	916
472	Retail sale of food, beverages and tobacco in specialised stores	796
750	Veterinary activities	171
Sub-sector of wood products		
021	Silviculture and other forestry activities	151
023	Gathering of wild growing non-wood products	0

024	Support services to forestry	101
161	Sawmilling and planing of wood	205
162	Manufacture of products of wood, cork, straw and plaiting materials	1602
310	Manufacture of furniture	368
Sub-sector of machinery and equipment		
261	Manufacture of electronic components and boards	1041
262	Manufacture of computers and peripheral equipment	1
263	Manufacture of communication equipment	108
264	Manufacture of consumer electronics	2
265	Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks	1107
266	Manufacture of irradiation, electromedical and electrotherapeutic equipment	733
267	Manufacture of optical instruments and photographic equipment	3
271	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	26
273	Manufacture of wiring and wiring devices	24
274	Manufacture of electric lighting equipment	20
279	Manufacture of other electrical equipment	99
281	Manufacture of general-purpose machinery	1316
282	Manufacture of other general-purpose machinery	588
284	Manufacture of metal forming machinery and machine tools	254
289	Manufacture of other special-purpose machinery	355
293	Manufacture of parts and accessories for motor vehicles	3
303	Manufacture of air and spacecraft and related machinery	1
325	Manufacture of medical and dental instruments and supplies	141
331	Repair of fabricated metal products, machinery and equipment	391
332	Installation of industrial machinery and equipment	122
466	Wholesale of other machinery, equipment and supplies	721
721	Research and experimental development on natural sciences and engineering	404
Sub-sector of metals		
241	Manufacture of basic iron and steel and of ferro-alloys	21
242	Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	59
243	Manufacture of other products of first processing of steel	102
244	Manufacture of basic precious and other non-ferrous metals	33
245	Casting of metals	154
251	Manufacture of structural metal products	1226
252	Manufacture of tanks, reservoirs and containers of metal	0
253	Manufacture of steam generators, except central heating hot water boilers	18
255	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	182
256	Treatment and coating of metals; machining	1003
257	Manufacture of cutlery, tools and general hardware	157
259	Manufacture of other fabricated metal products	63
Sub-sector of chemical and pharmaceutical products		
201	Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	74

202	Manufacture of pesticides and other agrochemical products	0
203	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	204
204	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	63
205	Manufacture of other chemical products	110
206	Manufacture of man-made fibres	0
211	Manufacture of basic pharmaceutical products	292
212	Manufacture of pharmaceutical preparations	495
221	Manufacture of rubber products	5
222	Manufacture of plastics products	560
231	Manufacture of glass and glass products	330
236	Manufacture of articles of concrete, cement and plaster	336
Sub-sector of construction		
411	Development of building projects	64
412	Construction of residential and non-residential buildings	3208
421	Construction of roads and railways	472
422	Construction of utility projects	95
429	Construction of other civil engineering projects	119
431	Demolition and site preparation	272
432	Electrical, plumbing and other construction installation activities	3484
433	Building completion and finishing	2335
439	Other specialised construction activities	2161
711	Architectural and engineering activities and related technical consultancy	2391
712	Technical testing and analysis	277

Note: FTE: Full-time equivalent p: provisory data for 2014; industry definition based on NOGA 2008 (classification of economic activities).

Source: Gugler, P. Lepori, D. Resbeut, M. (2017), Economic performance, Structure and Comparative Advantages of the Canton of Fribourg (CH), Center for Competitiveness, Un