2 An Original Business Model: The Integrated Biorefinery

Summary
The biorefinery, considered as a single industrial entity, becomes economically attractive when different factories making up an industrial ecosystem are present on the same site, where the firms supply each other with intermediate products and/or energy and water. The economies of scale resulting from the close proximity of the different players become key competitiveness factors. The biorefinery can thus optimise its procurement and production depending on markets both upstream and downstream of its activity. This economic optimisation must be accompanied, or at least is generally accompanied by environmental optimisation, including the minimisation of waste and of energy consumption and other inputs.

The Bazancourt-Pomacle Biorefinery is one of the largest in Europe. It brings together on the same site a sugar factory and dehydration plant; a joint research centre; a starch and glucose plant; an ethanol producing plant; an industrial demonstrator; a CO_2 collection centre; a production and research centre for active cosmetics ingredients; the pilot plant for the FUTUROL second generation fuel project; and a White Biotechnologies Centre of Excellence, a partnership between three academic institutions.

Whilst it is often suggested that the common good, good sense and a spirit of cooperation were the key factors in the development of the site and its uniqueness, in this chapter we study other significant factors. These factors are linked to the business environment in which the cooperatives operated. They are both exogenous, such as the evolution of the CAP and WTO regulations, but also endogenous, such as increasing financial needs and strategic and industrial trial and error on the part of the players involved. We show, for example, that the current situation of the Bazancourt-Pomacle

(continued)

P.-A. Schieb et al., *Biorefinery 2030*, DOI 10.1007/978-3-662-47374-0_2

integrated biorefinery is to a large degree the result of the strategies implemented to tackle problems linked to competition, regulation, finance and organisation. The decision to diversify, to integrate upstream and downstream activities in the value chain, to use increasingly complex financial arrangements, to build an industrial demonstrator and to increase economies of scale through new partnerships, are all response strategies to stabilise and develop activities.
One section of this chapter studies whether the Bazancourt-Pomacle Biorefinery has enough assets to continue to develop. To do this we make an analysis of its strengths, weaknesses, opportunities and threats, and illustrate our analysis with two applications: that of the threat that certain players may leave the site and the strength of the circular economy facilitated by the biorefinery.

Abstract The innovation strategy developed by the firms present on the Bazancourt-Pomacle site is based on the concept of the territorially integrated biorefinery, in the sense that the synergy between local biodiversity and the optimised use of resources is the basis of research and innovation strategy. This concept is also applied when these firms develop new markets and new products.
Whilst the definition of a refinery may appear obvious to all, the definition of a biorefinery seems more abstract. What is a biorefinery? In what way is it economically relevant? What are the differences between first and second-generation biorefineries? Our first section will attempt to answer these questions.

1 The Concept of Biorefinery

The field of study of the biorefinery is still recent, and this is reflected in its terminology. The biorefinery has no single accepted definition, but rather a series of definitions that enable us to apprehend the subject as well as possible.

1.1 Definitions, Technical Status and Typology

Box 2.1 Examples of Definitions of the Biorefinery
As part of its scientific programme to support the policies of 2008, BIOPOL[1] reviews some of the existing definitions of the biorefinery[2]:

(continued)

[1] Assessment of BIOrefinery concepts and the implications for agricultural and forestry POlicy.
[2] BIOPOL (2008).

Box 2.1 (continued)

– The term "green biorefinery" was defined for the first time in 1997 in Germany.[3] According to this definition, "*'green' biorefineries are complex systems based on ecological technology for comprehensive (holistic), material and energy utilization of renewable resources and natural materials using green and waste biomass and focalising on sustainable regional land utilization*." The expression "*complex systems*" has since been replaced by "*totally integrated systems*."

– According to Kamm et al. (2006) and Kamm et al. (2007), The American Department of Energy (DOE) uses the following definition:

> A biorefinery is an overall concept of a processing plant where biomass feedstocks are converted and extracted into a spectrum of valuable products. Its operation is similar to that of petrochemical refineries.

– The American National Renewable Energy Laboratory (NREL) uses the following definition[4,5]:

> A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuels, power, and chemicals from biomass. The biorefinery concept is analogous to today's petroleum refineries, which produce multiple fuels and products from petroleum. Industrial biorefineries have been identified as the most promising route to the creation of a new domestic biobased industry.

– The International Energy Agency (IEA) describes the biorefinery as "*the sustainable processing of biomass into a spectrum of marketable products (food, feed, materials, chemicals) and energy (fuels, power, heat)*". *This means that biorefinery can be a concept, a facility, a process, a plant, or even a cluster of facilities.*[6]

In simple terms, a biorefinery is an industrial site that transforms biomass in a sustainable way into human and animal food products, biomaterials, biofuel, and chemical products with high value added, such as cosmetics. The aim is to put every part of an agro-resource to either food or non-food use. Thus, with the same inputs, the members of the biorefinery will obtain a much wider range of outputs (Cf. Figs. 2.1 and 2.2).

Another example is wheat, which can be processed to produce starch, glucose, gluten and fibre. These ingredients can then be used for human and/or animal foodstuffs. After that glucose can be used to produce glucose syrup and then, after fermentation, bioethanol to be used in the production of biofuels.

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[3] Kamm et al. (1998).

[4] Kamm et al. (2006).

[5] Kamm et al. (2007).

[6] IEA Bioenergy Task 42 Biorefinery, 2009. Brochure: www.biorefinery.nl/biopol

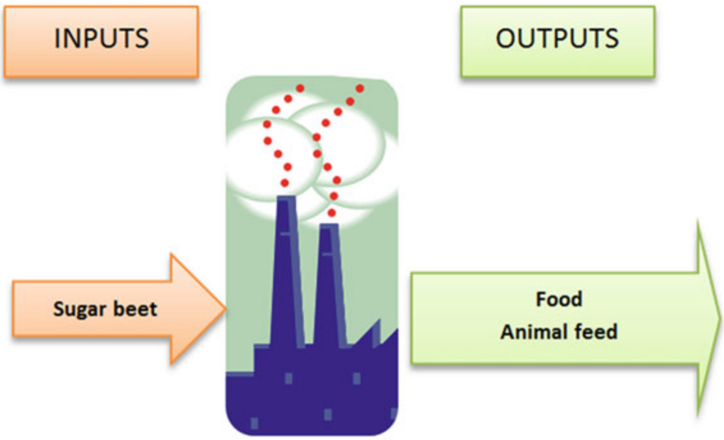

Fig. 2.1 Inputs and outputs of a traditional sugar factory [Adapted from a diagram by STUART, P. (2006). The forest biorefinery: survival strategy for Canada's pulp and paper sector? Pulp & Paper. Canada, June 107 (6)13–16]

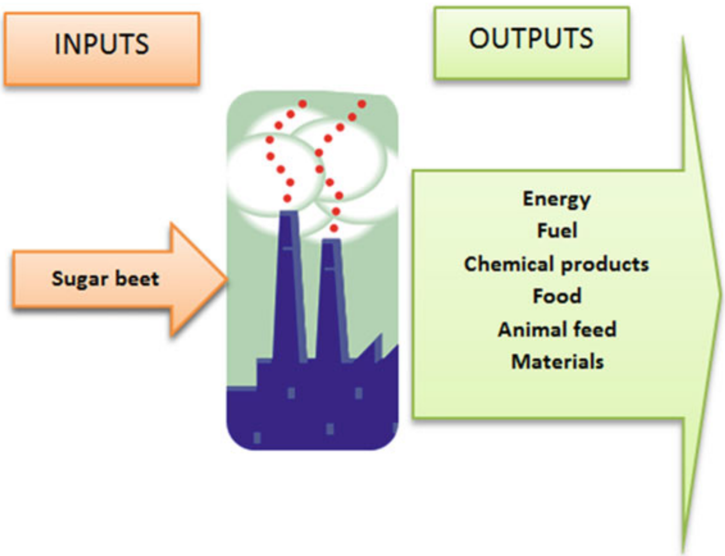

Fig. 2.2 Inputs and outputs of a sugar factory that is part of a biorefinery [Adapted from a diagram by STUART, P. (2006). The forest biorefinery: survival strategy for Canada's pulp and paper sector? Pulp & Paper. Canada, June 107 (6)13–16]

The biorefinery concept is similar to that of the oil refinery, which produces different fuels and other products from oil (Cf. Fig. 2.3). The traditional refinery converts oil into fuel, molecular platforms for the petrochemical industry and chemical specialities such as lubricants and solvents. The biorefinery converts

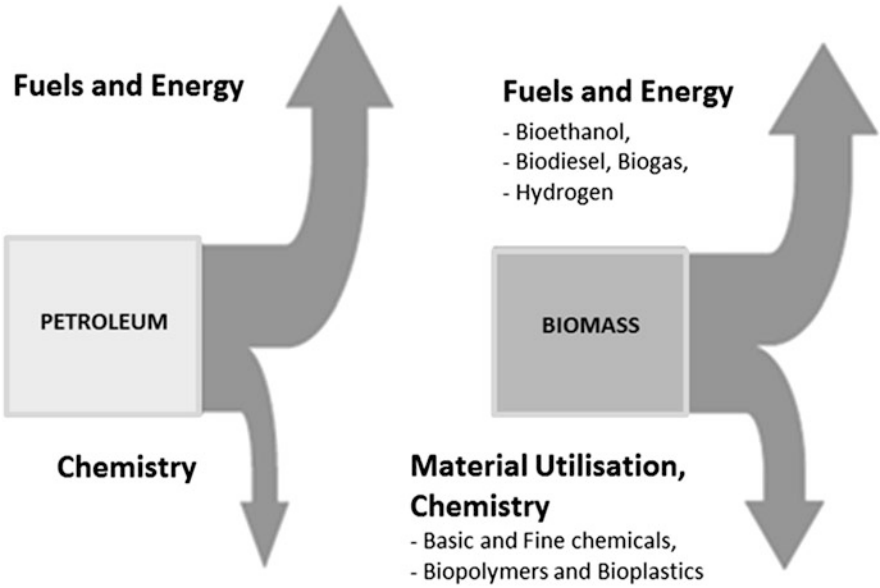

Fig. 2.3 The refinery and the biorefinery (Kamm, B., Kamm, M., Gruber, P. (2012). Biorefineries - Industrial Processes and Products. In: Ullmann's Encyclopedia of Indutrial Chemistry, WILEY-VCH, Weinheim, p 668)

biomass into biofuels, molecular platforms for green chemistry, and into chemical specialities such as biolubricants and biosolvants. The production processes used in biorefineries are the same as those commonly used in oil refineries: raw-material distillation, processing of these materials, separation of the products formed, all of which is carried out using integrated material and energy flows and processes.

The biorefinery competes with the oil refinery as it commercialises similar molecules in terms of properties and/or applications.

By producing bioenergy and biosourced products, the biorefinery takes advantage of all the components and intermediate products and maximises the value obtained from its refining operations.

According to de Cherisey (2010), numerous studies[7] have attempted to classify and map the biorefineries of the world. Biorefineries can be classified on the basis of the raw materials they use

- The cereal biorefinery processes grain and starch.
- The oilseed biorefinery.
- The "green" biorefinery, which processes water-based raw materials.

[7] The European projects Biopol, Biorefinery Euroview and, more recently, Star Colibri.

- The lignocellulose biorefinery, which can process forestry products or straw, corncobs and lignocellulose-rich waste.
- The syngas biorefinery, which produces hydrocarbons or intermediate chemical products by the microbial fermentation of synthesis gas.

However, the concept of biorefinery goes beyond the philosophy of the oil refinery because, when possible, it includes sustainable management practices and a circular economy.

More generally, the concept of biorefinery takes into account all the issues of sustainable development, including environmental, economic and social factors.

1.2 The Viability of the Biorefinery

The biorefinery, seen as a single industrial entity, becomes economically worthwhile when different factories on the same site come together to make up an industrial ecosystem in which the different firms supply each other with intermediate products and/or energy. The economies of scale made possible by the proximity of the various players, in terms of logistics and investment, become key competitiveness factors. The biorefinery can thus optimise its procurement and production in line with the markets upstream and downstream of its activity.

This economic optimisation can be accompanied by an environmental optimisation, including the minimisation of waste, energy consumption and other inputs. The more integrated the biorefinery, the more viable the biorefinery model is (Cf. Box 2.2).

Box 2.2 Levels of Integration and Multi-functionality Already Achieved by Biorefineries ***(After Star-Colibri (2011))***

Degree	Integrated and multifunctional features
Raw materials	Use of all the components of the biomass
	Processing of different components of raw materials in parallel and in an appropriate manner
	Flexible, optimised use of raw materials for primary refining
Process	Link between primary and secondary refining
	Successive steps to the process along the value chain
	Wide range of products
Products	Simultaneous production of chemical products, materials, energy, and when appropriate, by-products for food and animal feed
	Simultaneous production of various materials and/or simultaneous production of different types of energy
	Link between conversion and refining
Industry	Incorporation within the existing value chain
	Selection of location with regard to biomass production and availability

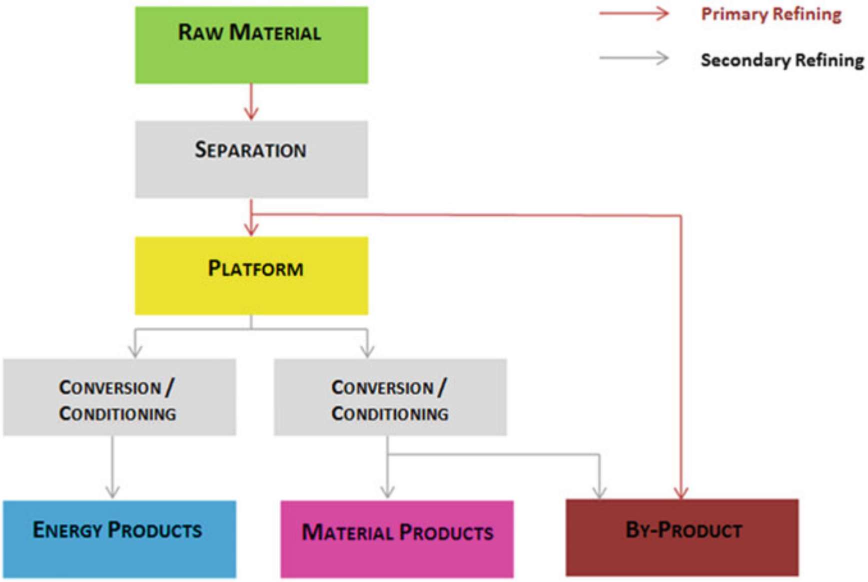

Fig. 2.4 The different components of the primary and secondary refining in biorefinery concept. (IEA Task 42 Biorefinery systemics, 2009; adapted and modified by the FNR) (Peters D., FNR, 2011. The German Biorefinery Roadmap; presentation at the Expert Forum Conference on Biorefineries; Budapest; April 2011)

Most traditional biomass processing plants carry out the initial stage of biomass refining and, in certain cases, a first conversion stage. Integrated biorefineries go further than this, including other conversion stages and thus moving towards sustainable optimisation by maximising their profits and minimising their losses. For example, energy focused biorefineries[8] produce biofuel, electricity and heat from the biomass through primary and secondary refining: the waste from the process is sold as animal feed, or even better transformed into high value-added products, which optimises the biomass both economically and ecologically (Cf. Figs. 2.4 and 2.5).

One of the most exceptional examples of the biorefinery concept is embodied in the Bazancourt-Pomacle site.

1.3 The Bazancourt-Pomacle Biorefinery

The Bazancourt-Pomacle Biorefinery (Cf. Fig. 2.6) is one of the best-known and largest biorefineries in France and indeed in Europe. It is an excellent subject for a

[8] We speak of first generation biorefinery to describe processes using food products such as cereal grain and of second generation biorefinery for processes using lignocellulose materials (straw, agricultural waste, wood, . . .).

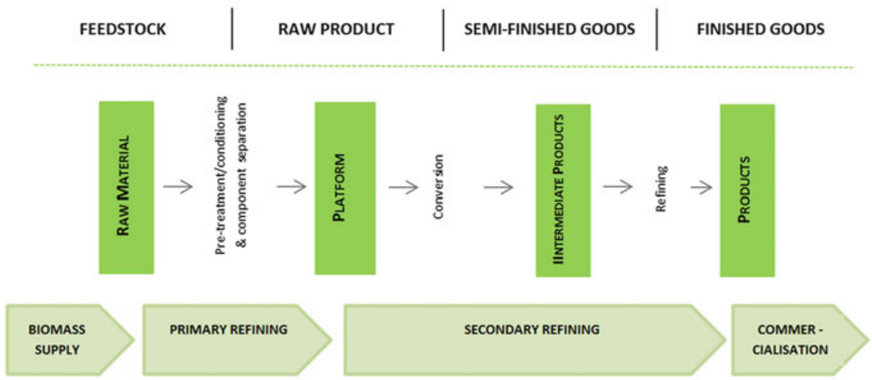

Fig. 2.5 The different components of the overall biorefinery concept (IEA Task 42 Biorefinery systemics, 2009; adapted and modified by the FNR) (Peters D., FNR, 2011. The German Biorefinery Roadmap; presentation at the Expert Forum Conference on Biorefineries; Budapest; April 2011)

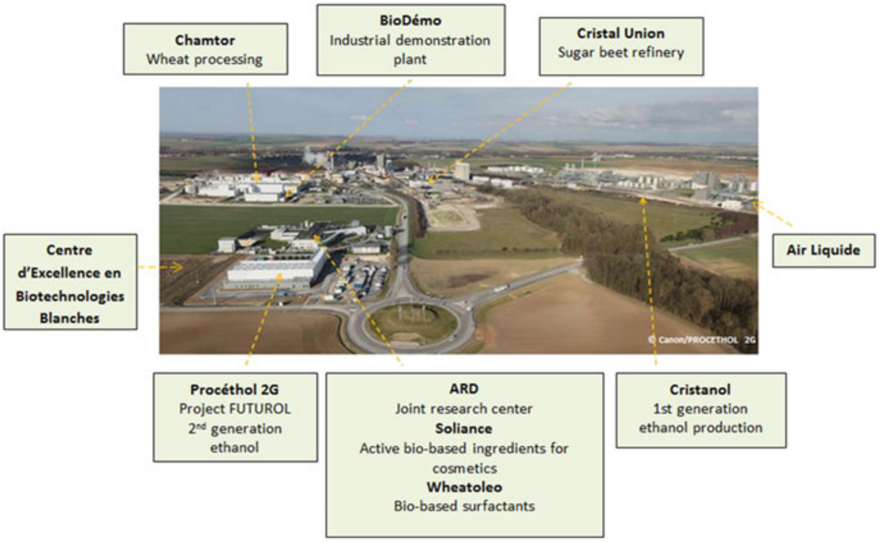

Fig. 2.6 Overall view of the Bazancourt-Pomacle platform

study insofar as it is a concrete illustration of what is often still considered a concept.

The Bazancourt-Pomacle Biorefinery, from the name of the communes in which it is located, is unusual in that it includes an industrial complex and an open innovation platform. It includes on the same site a sugar factory and dehydration plant; a joint research centre; a starch and glucose processing plant; an ethanol production unit; an industrial demonstrator; a CO_2 collection centre; a research and production unit for active cosmetics ingredients; the pilot factory for the FUTUROL second generation biofuel project; and a public research centre named Centre of Excellence for White Biotechnology (CEBB) operated by three academic institutions.

Its principal owners are two major European cooperatives: VIVESCIA (whose holding company is Siclaé) and CRISTAL UNION (Cf. Box 2.1)

Box 2.3 Presentation of VIVESCIA and CRISTAL UNION,[9] 2013 Figures

	VIVESCIA	CRISTAL UNION
People	• 11,443 members, 8500 of whom are active • 3000 member breeders • 2500 farmer customers • 8119 employees in cooperatives and agricultural subsidiaries	• 9300 farmer members in ten different regions of France • 2200 employees on more than 10 sites in France
A leading international group	• Largest cereal cooperative in France, collecting 3.9 million tonnes • 270 collection silos • One million hectares of agricultural land (SAU)[a] • Active on 4 continents, in 25 countries, with 80 factories • World leader in the malt sector • One of Europe's leading milling and baking/pastry-making groups • Second largest maize processor in Europe	• 1.7 million tonnes of sugar produced per year, together with nearly 190,000 tonnes of sugar beet pulp and alfalfa pellets • Ten sugar factories and three major distilleries • 138,000 ha of sugar beet production, nearly 40 % of French production • Second largest French sugar producer and fifth largest in Europe • Partnership for sugar production in Algeria and partnerships for sugar marketing throughout Europe
Financial data	• Turnover: 4.2 billion euros	• Turnover: two billion euros

[a]Surface Agricole Utile

It is the result of a unique development process (c.f. Box 2.2), which started in 1953 with the creation of the Bazancourt sugar factory. This founding event involved a significant degree of risk on the part of the farmers, who put up their farms as security and gave up a year's harvest as the company's capital.

[9] Summary of figures given on the companies' websites http://www.vivescia.com/groupe-en-bref/chiffres-cles and http://www.cristal-union.fr/le-groupe/chiffres-cles/

1.3.1 Key Stages in the Development of the Bazancourt-Pomacle Site

Box 2.4 Key Stages in the Development of the Bazancourt-Pomacle Site

1948 **Distillery**
1953 Bazancourt Cooperative sugar factory[10]
1989 **ARD**, joint research centre (cereals, sugar, alfalfa)
1992 Creation of **CHAMTOR**, initially producing inulin (chicory) and glucose (wheat), then starch and glucose, bought by Pfeifer and Langen in 1994
1994 **SOLIANCE**, creator and manufacturer of active cosmetics ingredients
2005 National launch of competitiveness clusters in Reims and presidential visit of the site to illustrate this new dynamic. Creation of the IAR cluster (Picardy and Champagne-Ardenne regions)
2007 **CRISTANOL**, ethanol and alcohol producer[11]
2009 Acquisition of **CHAMTOR**, starch and glucose producer, from Pfeifer and Langen by CHAMPAGNE CEREALES
2010 **BIODEMO**, ARD's industrial demonstration unit
2011 **PROJET FUTUROL**, second-generation bioethanol pilot factory
BRI, joint open biorefinery platform
2012 **AIR LIQUIDE**, CO_2 liquefaction
Launch of **CEBB** by Ecole Centrale Paris, AgroParisTech and NEOMA Business School[12]
2013 **FONDATION JACQUES DE BOHAN**, foundation dedicated to promoting the biorefinery
Launch of a joint staff restaurant for the different firms on the site
2014 Acquisition of **SOLIANCE** by GIVAUDAN. The site becomes the **REIMS CHAMPAGNE ARDENNE EUROPEAN BIOREFINERY INSTITUTE**[13] (IEB)

[10] Conversion of the distillery into a sugar factory.
[11] From wheat and sugar beet by-products.
[12] Installation of these research chairs in a dedicated building on the biorefinery site planned for 2015.
[13] http://www.institut-europeen-de-la-bioraffinerie.fr

This pioneering initiative was followed up at the beginning of the 1990s (Fig. 2.7) by the simultaneous arrival on site of the CHAMTOR, factory, producing starch and glucose, and the ARD research centre.[14,15,16]

Later, in 2005, when France launched a new industrial policy with competitiveness clusters, actors in Picardy and Champagne-Ardenne united to develop a joint project: "pôle à vocation mondiale Industries et Agro-ressources" (world industry and agro-resource cluster—IAR). The excellent example of Bazancourt-Pomacle was chosen by the President of the French Republic[17] for the ceremony to launch this national policy focusing on cooperation between public and private players to reindustrialise the country.

After this, the development speeded up. In 2007, the launch of new regulations in favour of biofuels stimulated the construction on the site of CRISTANOL, a mixed sugar beet and cereal ethanol producer. A few years later, in 2011, this same encouraging environment led to the setting up of the FUTUROL project[18] by the company PROCETHOL 2G and to the construction of its pilot factory.

Furthermore, since 2012, significant financial support by the local authorities (Champagne-Ardenne Regional Council, Marne Departmental Council and Greater Reims Area), has enabled the launch of a Centre of Excellence for White Biotechnology (CEBB) through the creation of three complementary research chairs.[19] The arrival of higher education institutions has given the site a new dynamic, with academic researchers to initiate essential research into the different activities. The industrial demonstrator BIODEMO,[20] built in 2010, also illustrates this new dimension by giving ARD the ability to develop biotechnological processes on an industrial scale.

More recently, the Jacques de Bohan Foundation has been set up by VIVESCIA and CRISTAL UNION. Its first purpose is to promote the biorefinery concept as an integrated industrial tool for the optimal use of agricultural production. By creating

[14] The département of the Marne demonstrated its commitment alongside the industrial players at this time by financing the ARD research building.

[15] This led to the creation in 1994 of SOLIANCE, creator and producer of active cosmetics ingredients and, in 2010, WHEATOLEO, manufacturer of surfactants.

[16] The people of Champagne very quickly realised that this was a turning point, and sought to support it through research. With this aim in mind, and at the initiative of Albert Vecten, who was at that time President of the Champagne-Ardenne Regional Council, the Paris Reims Foundation was set up in 1990, under the aegis of the Fondation de France. This foundation has more than 1000 individual, local authority and business donors. It supports the agro-bio-industrial dynamic in the Greater Champagne region through the development of a centre for teaching and research excellence in topics such as Europol'Agro research, by hosting researchers and by funding post-doctoral scholarships.

[17] Jacques Chirac.

[18] The first French project for the production of second generation ethanol.

[19] NEOMA Business School Chair in Industrial Bioeconomy, AgroParisTech Chair in Industrial Agro-Biotechnologies, and Ecole Centrale Paris Chair in White Biotechnologies.

[20] Initially for the production of succinic acid in partnership with BIOAMBER.

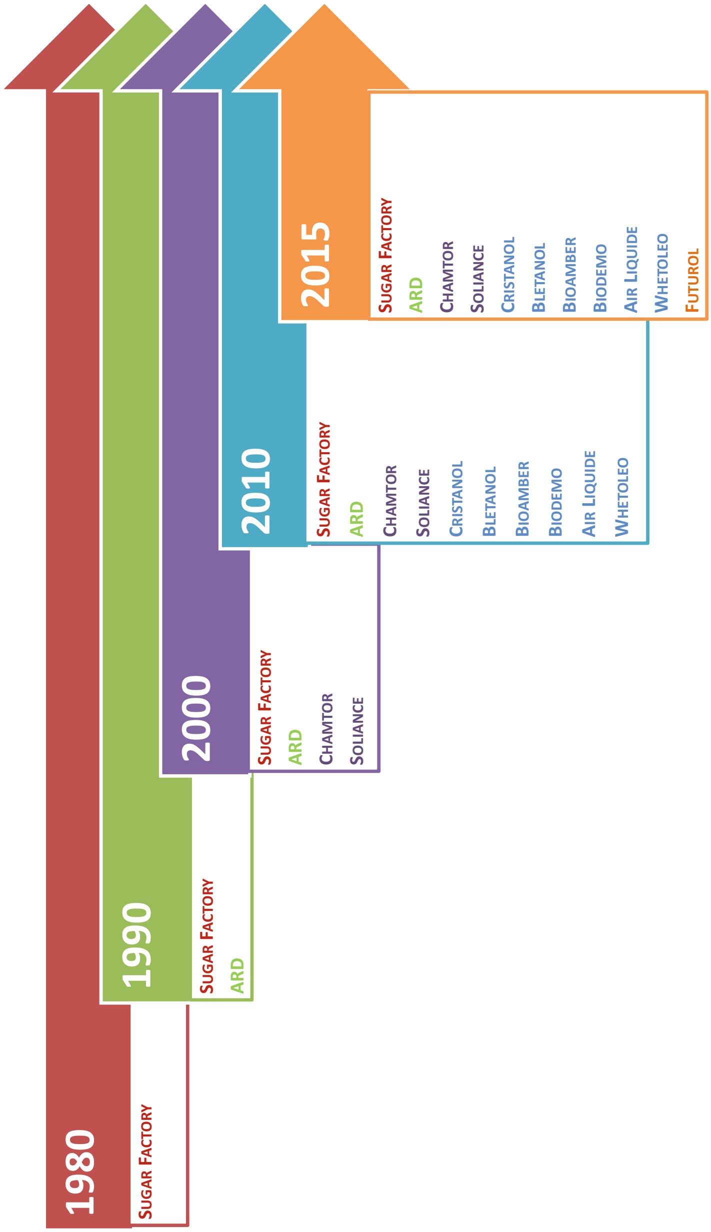

Fig. 2.7 Evolution of the Bazancourt-Pomacle platform between 1980 and 2012 in 10-year periods (It should be noted that BIOAMBER is produced in the bio-demonstrator)

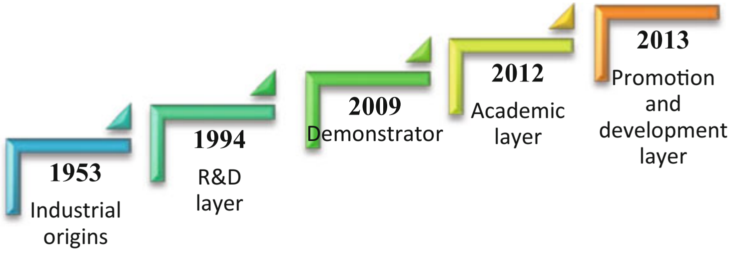

Fig. 2.8 Phases in the development of the Bazancourt-Pomacle Biorefinery from 1953 to 2012

the foundation, these firms demonstrate their open-mindedness and concern for the development and evolution of the bioeconomy (Allais et al. 2013).

These different stages appear as the addition of different layers around an initial core (Fig. 2.8). Four successive phases can be seen in the growth of the Bazancourt-Pomacle site, as it evolved from a mere industrial complex into an integrated, complete biorefinery. This representation is important, insofar as it proves that even though the development of the site was not planned, its current shape did not come about by accident. Indeed, the firms present on the site did not come together by chance but are result of a strategy that sought complementary activities to diversify the food and non-food use of agro-resources. Although its growth was far from homogenous, in the sense that some of the stages took much longer than others, the Bazancourt-Pomacle Biorefinery can claim to have developed in an ordered way, and this is one of its strengths (Lapie et al. 2012).

Thanks to all these initiatives, more than 1000 people are now employed on the Bazancourt-Pomacle site (full-time and seasonal) in addition to at least 600 indirect jobs. They work 24 h a day to process three million tonnes of various types of biomass (mainly sugar beet and wheat, but also alfalfa) on a site covering more than 160 ha (c.f. Table 2.1). Two agro-industrial cooperative groups are very involved on the site: VIVESCIA[21] and CRISTAL UNION[22] (owners of CRISTANOL,[23] CHAMTOR, ARD[24] etc.) Their presence guarantees the site's industrial dynamism, with more than 20 million euros invested annually and a global strategic vision.

The site is unusual in that it constitutes an "ecosystem," in which "symbioses" can develop, exchanges and interaction aimed at optimising its economic efficiency and reducing its environmental impact. The site has reached a critical size making it possible to optimise the basic synergies between the different players (water, steam, energy, waste. . .), and to develop product synergies (flows of materials between the units), and operational synergies (R&D, academic research. . .).

[21] http://www.vivescia.com

[22] http://www.cristal-union.fr

[23] http://www.CHAMTOR.fr

[24] http://www.a-r-d.fr

Table 2.1 Synopsis of firms present on the Bazancourt-Pomacle site[a, b] (2011 data)

Key figures for firms present on the site

Name	Activity	2011 Turnover	2011 Payroll	Date or arrival	2011 Production volume
A.R.D	Research and development	10,144,749	90	1989	Not provided
BIOAMBER	Succinic acid production	395,759	Not provided	2008	Not provided
BIODEMO	Demonstrator	Not provided	Not provided	2009	Not provided
BLETANOL	Cereal cooperative Union	84,406,086	12	2006	Not provided
CHAMTOR	Starch production	153,400,000	198	1992	347,000 t
CRISTAL UNION	Sugar production	200,000,000 (approx.)	279	1948	206,282 t
CRISTANOL	First generation ethanol production	213,553,021	131	2006	2,359,387 hl
FUTUROL/ PROCETHOL 2G	Second generation ethanol industrial pilot scheme	150,060	12	2011	Not provided
SOLIANCE	Cosmetic ingredients production	16,268,033	60	1994	Not provided
WHEATOLEO	Surfactant production	304,914	Not provided	2010	Not provided
AIR LIQUIDE	CO_2 collection	Not provided	Not provided	2009	120,000 t

[a]There is a wheat collection site ACOLYANCE (http://acolyance.fr/) at the platform that partially supplies CHAMTOR, but with no role in the overall symbiosis. This entity is not studied in this book. During their interviews, the authors met Mr Pascal Bailleul, Managing Director of ACOLYANCE, and thank him for the additional information he provided.

[b]The Compagnie Industrielle de la Matière Végétale (Industrial Plant Material Company—CIMV) is also present on the site. Since 2007, CIMV, which was set up in 1998 with head offices in Levallois-Perret, is operating a pilot scheme to test the process for transforming straw into paper pulp

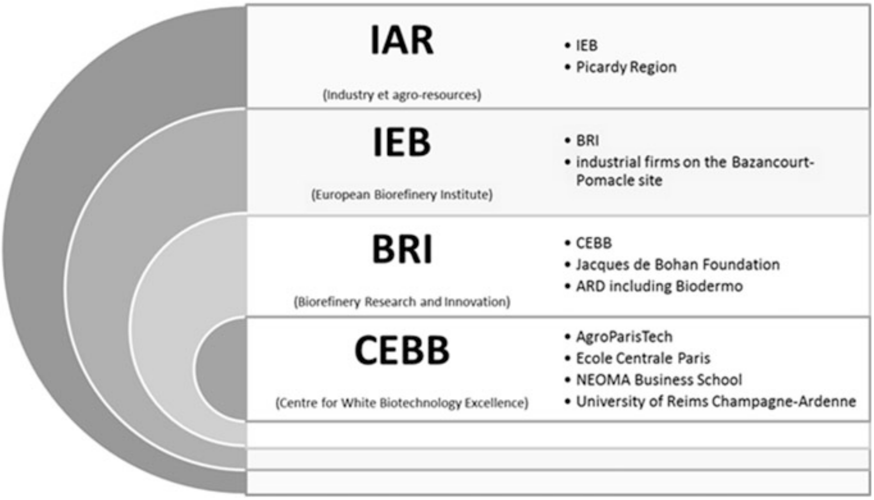

Fig. 2.9 Interaction and cohesion between players on the Bazancourt-Pomacle site [Moreover, the involvement of the local authorities is echoed in their support for the academic chairs and in the setting up of the European Biorefinery Institute (IEB), the new name for the site]

Research is at the heart of the biorefinery's structure. The structure is organised at different levels (Fig. 2.9): academic, research and innovation, and overall site level. The site also interacts with the Industry and Agro-resource Competitiveness Cluster (IAR)[25] (see above), a world-scale cluster that is very dynamic in the Champagne-Ardenne and Picardy regions.

All these dimensions make the Bazancourt-Pomacle site an integrated biorefinery, whose interest lies in the diversity of its outputs, the optimised use of its inputs and its industrial ecology[26] (c.f. Fig. 2.10).

This diversity of outputs observed in the site's overall variety of products is not necessarily present at the level of each individual company. Although some firms on the site specialise in the production of a single type of output (human foodstuffs, animal feed or biofuel),[27] thanks to the biorefinery's ecosystem, others are capable of producing all three types of outputs (c.f. Table 2.2).

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[25] http://www.iar-pole.com

[26] This notion will be discussed in detail in Chap. 3.

[27] This division between human foodstuffs, animal feed and biofuel is commonly made in the literature and refers to the "FFF: Food, Feed, Fuel" debate. To grow their raw materials, biofuels use a little under 6 % of agricultural land, or 1.7 million hectares in 2010, including 1.45 million hectares for biodiesel and 250,000 ha bioethanol. Nonetheless, after 2008 and the dramatic rise in the price of agricultural raw materials, there has been criticism of the competition existing between biofuel production and that of human or animal foodstuffs. This notion of competition for arable land and its potential impact on prices is in fact not clear-cut, as shown in several recent studies (Sources: Press Release by the French Court of Auditors: *Évaluation d'une politique publique: la politique d'aide aux biocarburants [Assessment of a public policy: the policy of support for*

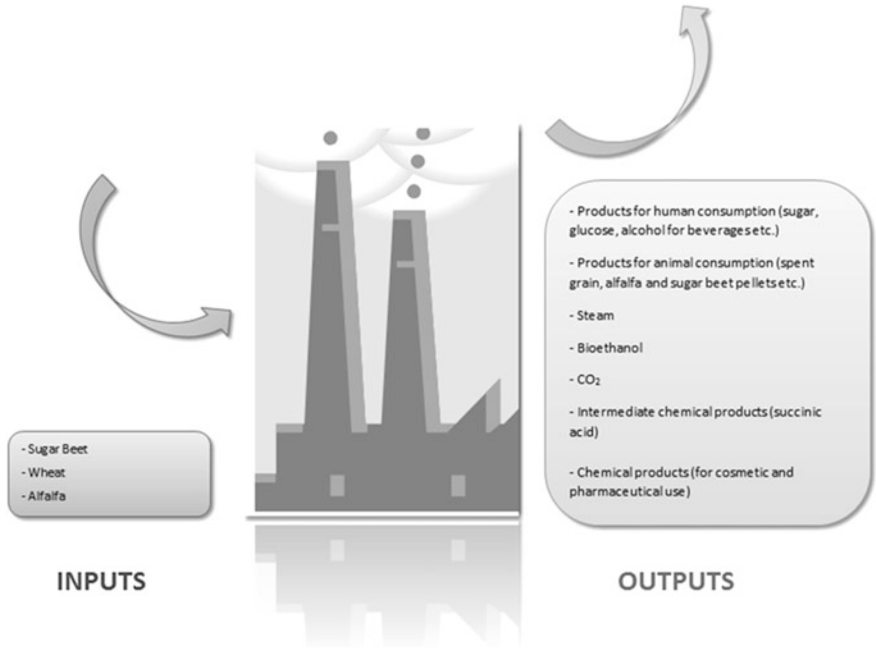


Fig. 2.10 Inputs and outputs of the Bazancourt-Pomacle Biorefinery

Table 2.2 Distribution of CHAMTOR and CRISTANOL production

	CHAMTOR		CRISTANOL	
	Volume 2011	Value 2011 (million euros)	Volume 2011	Value 2011 (million euros)
Human foodstuffs	190,000 t	75.5	670,090 hl	43.8
Animal feed	122,000 t	25	178,554 t	34.7
Biofuel	257,000 hl[a]	11.5	2,359,387 hl	132.5

[a]CHAMTOR does not produce biofuel, but a fermentation substrate (liquid wheat). This product is then sold to Cristanol, which used it to produce 257,000 hl of bioethanol in 2011. This quantity is included in Cristanol's overall production

biofuels], 24 January 2012 and Gohin Alexandre (2013), Le changement d'affectation des sols induit par la consommation européenne de biodiesel: une analyse de sensibilité aux évolutions des rendements agricoles (Changes in land use resulting from European biodiesel consumption: an analysis of sensitiveness to change in agricultural yield, INRA Rennes).

It should be noted that with the arrival of second-generation biofuel, production would be mainly based on agricultural by-products and/or forestry resources. It would thus be possible to produce biofuel without monopolising fertile land that is essential for the cultivation of cereal for human foodstuffs.

The production of the Bazancourt-Pomacle Biorefinery provides an alternative to fossil fuels, and nonetheless maintains its vocation to supply the food markets.

While it is often claimed that the common good, good sense and the spirit of cooperation were the foundations of the different initiatives that led to the development of the site and its originality, other factors obviously played their part.

2 Changes in the Environment that made the Bazancourt-Pomacle Biorefinery

According to Filippi et al. (2008), for several decades French agricultural cooperatives have faced a radically changing environment, including reforms of the Common Agricultural Policy (CAP) and the growing power of the hypermarket sector. The different players on the Bazancourt-Pomacle site have not escaped this trend and face both exogenous (market volatility, CAP, WTO regulations), and endogenous (financial organisation, trial and error) factors of change.

This section will present the changes the cooperatives have had to face, and then describe the strategies used to tackle these regulatory, competitive and industrial mutations.

2.1 Exogenous Factors

Three main exogenous factors have influenced the strategy of firms on the Bazancourt-Pomacle site: World Trade Organisation regulations, reform of the Common Agricultural Policy (CAP), and the volatility of agricultural product prices.

2.1.1 WTO Regulations[28]

The 1947 General Agreement on Tariffs and Trade (GATT) applied to agriculture, but in practice, the contracting parties excluded this sector from application of the principles set out in the general agreement. As the CAP had rapidly generated surpluses, the European Community was asked to dismantle its system of subsidies to avoid harming the American market (Emorine 2006).

The Uruguay round included this sector in multilateral trade negotiations (Bureau et al. 2007). In 1994, the Marrakech agreement gave a new multilateral frame for the progressive deregulation of agriculture. At this time agriculture benefitted from its own agreement, the Agreement on Agriculture.

The WTO member states undertook to apply a programme to reform agricultural policies in force between 1995 and 2000 in developed countries. This programme targeted three main areas:

[28] Source: http://www.europarl.europa.eu

- Access to markets, by imposing the transformation of all protection measures into customs duty (tariff equivalents) and then their gradual reduction (by 36 % over 6 years, 1995–2000, compared with the reference period, 1986–1988).
- Differentiated reduction of subsidy volumes by type of aid, depending on their capacity to distort agricultural markets.
- Reduction of export subsidies over 6 years by 21 % in volume and 36 % in value, compared with the reference period of 1986–1990. This linear reduction was implemented by the European Union in 20 product groups. For processed products, only the reduction in value was applied. Before this agreement, although agriculture was already subject to GATT regulations, export subsidies were regulated by other agreements (Tangermann 2001).

The 1992 reform of the CAP, apart from its internal objectives, also aimed to facilitate the Agreement on Agriculture as part of the Uruguay round. In fact, the EU broadly respected the commitments it made in Marrakech.

Since 1995, the common agricultural policy has been subject to WTO rules.[29] A Dispute Settlement Body (DSB), with a very strict procedure for litigation, was set up to ensure that states who were party to the agreement respected the new multilateral regulations.

2.1.2 The Common Agricultural Policy

Agricultural cooperatives had to adapt to the different phases of CAP reform.

Several key stages can be distinguished:

- In 1962: creation of the CAP, with the initial aims of increasing agricultural productivity, guaranteeing a fair standard of living for farmers, stabilising markets, guaranteeing food supply and ensuring reasonable prices for consumers. Farmers invested massively in new production techniques and new equipment in order to increase their production volumes.
- Production surpluses soon appeared; in 1984, quotas were set up and a policy of subsidy reduction was implemented.
- In 1988: budget discipline with a maximum annual allocation for expenses and obligatory set-aside of land.
- From 1992: new guaranteed low prices to align with global prices.
- In 1999: Berlin agreement, giving European agriculture responsibility for protecting the environment and local territories.
- In 2003: Delinking of subsidies. Subsidies are paid in the form of a single payment per farm based on the average level of subsidies received during

[29] "Within the framework of the General Agreement on Tariffs and Trade (GATT), signed in Geneva in 1947, and the agreement setting up the World Trade Organisation (WTO), signed in Marrakech in 1994, the EU and its member states act in accordance with articles 207 (common trade policy), 217 and 218 (international agreements)."

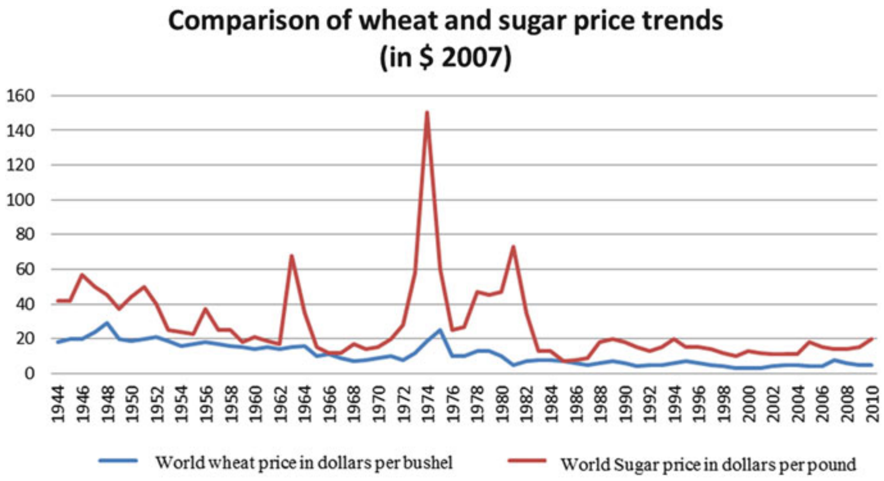


Fig. 2.11 Comparison of wheat and sugar price trends [De Cherisey, Hugues (2010). Panorama et potentiel de développement des bioraffineries. ADEME Study. 221 p.]

three reference years. These subsidies are paid on condition that the farmer respects the environment and animal wellbeing.
– In 2009: End of mandatory set-aside and total delinking of subsidies apart from exceptional cases.
– In 2013: Budget reduction.

This decline in protection, under the pressure of the WTO, led to extremely volatile prices for agricultural products (c.f. Fig. 2.11).

2.1.3 The Volatility of Agricultural Produce Prices

Significant variations in the price of agricultural raw materials have a direct impact on the activity of agricultural cooperatives.

A high level of instability makes prices much more difficult for producers to anticipate. Speculation, in particular, makes pricing more complex and increases the risk to producers' margins.

In such a situation, it is important for farmers and the cooperatives to which they belong to sell their produce on the most profitable markets.

Given the humanitarian stakes (Cf. Fig. 2.12), it is important for nations and international organisations to support the efforts of the agricultural sector to favour food independence and avoid, where possible, periods of under-production. The issue of agricultural produce storage is also important to offset poor harvests.

However, support for the agricultural sector must respect the principle of free competition within the sector, in an increasingly global agro-food industry.

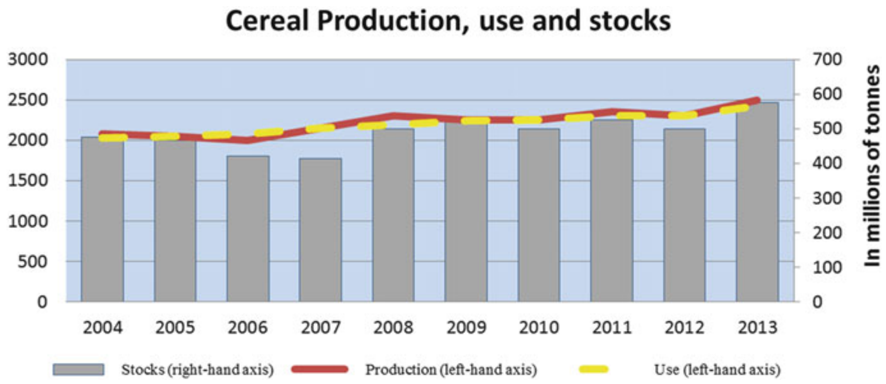


Fig. 2.12 World cereal production and consumption (*Source*: http://www.fao.org/worldfoodsituation/csdb/fr/)

2.2 Endogenous Factors

The previous section described changes in regulations and the market that affect all agricultural cooperatives. Now we turn to the endogenous factors that have affected the Bazancourt-Pomacle Biorefinery. We discuss two key points: the failures it has experienced and the lessons it has learnt from these failures; and problems linked to the heavy investment load that it has had to bear in order to develop.

2.2.1 Trial and Error: Example of the Launch of CHAMTOR and Its Implications[30,31]

Fortunately, the Bazancourt-Pomacle site has experienced more successes than failures during its development. However, it would be unwise to ignore the failures. Failures can be considered a good thing, in that they can point us in a different direction, towards success. We will attempt to illustrate this through the example of the launch of CHAMTOR.

The CHAMTOR plant was built in 1992 on former agricultural land in the commune of Bazancourt, opposite the sugar factory.

The factory's launch was instigated by several personalities who strongly influenced rural life in Champagne-Ardenne, Jacques de Bohan, Alain Delaunoy and Georges Mangeart. Their idea was to have a site to process their produce within the region and to create value added for the agricultural sector by transforming chicory and wheat into sugars: inulin and glucose for the production of blended products for the food industry. They also hoped to obtain inulin quotas that were, at that time, negotiated at European level.

[30] Source: Interviews with the main players on the site.

[31] Source: http://www.siclae.com/actualites/CHAMTOR-20-ans-histoire-futur-construire

The concept was very innovative because the plant was to transform chicory into inulin during the chicory season and then, during the off-season, transform wheat into glucose. The plant was designed and built while the quota negotiations were under way, in the hope of obtaining them. Unfortunately, in 1992, the CHAMTOR adventure did not start too well when the firm failed to obtain the inulin production quotas it had hoped for. It did not have the right to produce, or at least not on the scale for which it had been designed.

After an appeal to the European Commission, it eventually transpired that the process to transform chicory into inulin was extremely complex.[32] Laboratory trials had been very successful, but on the industrial scale, the inulin production process turned out to be a disaster. In fact, the project had progressed from the laboratory to industrial production too quickly, and had ignored the pilot phase.

Despite all the hard work of the staff, the plant did not manage to accelerate production or to find clients, and after 2 years was near to collapse. Realising that the future of CHAMTOR would not be in inulin, the management decided to renovate the factory step-by-step and to specialise in wheat processing. This led to several changes in the shareholders. Initially the project was supported by a Belgian starch producer, Avebe. Then CHAMTOR was bought by the German sugar group Pfeifer and Langen, which took up the challenge of transforming the firm into an efficient, profitable starch and glucose producer.

Through hard work and heavy investment, the factory began to gather momentum, increased its production, obtained market share and forged itself a place in the starch sector.

Then, in 2007, Pfeifer and Langen decided to refocus on its core sector. It sold CHAMTOR to CHAMPAGNE CEREALES. Today,[33] CHAMTOR, via Siclaé, is part of the VIVESCIA group. It processes 450,000 tonnes of Champagne-Ardenne wheat.

Consistent with the notion of an integrated biorefinery, CHAMTOR delivers a fermentation substrate[34] to CRISTANOL by pipeline, equivalent to 250,000 hl of ethanol. Glucose produced by CHAMTOR is also used to develop new molecules. The firm operates in French, European and world markets. Its customers are confectioners, biscuit-makers, industrial bakers, pastry and cake makers, ice-cream manufacturers, major animal and pet-food manufacturers, and paper mills.

So as to avoid repeating early mistakes, the firm sought to smooth the passage from laboratory trials to industrial production. The processes do not take place identically when the molecules are in a larger environment.[35] For this reason, ARD industrialised the laboratory process, investing 21 million euros, in 2011, in an industrial demonstration unit, BIODEMO. Firms can use this unit to produce on a

[32] At the time, it was also necessary to train nearly 200 staff in a new activity.

[33] CHAMTOR is the fourth largest European corn starch producer.

[34] Liquid wheat.

[35] Due to calorific loss among other factors.

preindustrial scale. This is a vital intermediate phase to validate the technology and finalise "process book" as preparation for full industrialisation.

Apart from the consequences of this mistake, which led to success via improved production processes, other endogenous factors drove the cooperatives to review their strategies.

In the next section, we look at the consequences that the heavy investment involved had on the cooperatives' financial structures.

2.2.2 Funding Heavy Investment

As the 2008 financial crisis has made access to capital more difficult, cooperatives have to review their financing and capitalisation strategies. In this area, actors on the Bazancourt-Pomacle site are no exception to the rule. In the following subsection, we will look at the challenges and opportunities engendered by the cooperative business model in terms of financing. Then we will consider the investment made on the Bazancourt-Pomacle site and highlight the importance of bank partnerships.

Challenges and Opportunities of the Cooperative Business Model

According to Chomel et al. (2013), whilst French law provides a precise legal framework for cooperatives, and particularly for agricultural cooperatives, it does not define them. The only definition available is that drawn up in 1995 by the International Cooperative Alliance (ICA). In its Manchester declaration, the ICA defined a cooperative as "an autonomous association of people voluntarily united to satisfy their collective economic, social and cultural aspirations and needs, by means of a jointly-owned, democratically controlled enterprise." According to the same author, this definition is completed by the universal values and principles that characterise cooperatives (c.f. Box 2.3).

Box 2.5 Cooperative Values and Principles According to the ICA (1995)

Values	Principles
• Individual and mutual management and responsibility • Democracy • Equity and solidarity • Members' commitment to ethical principles of honesty, transparency, social responsibility and altruism	• Voluntary membership open to all • Democratic power exercised by the members • Financial contribution by members • Autonomy and independence • Education, training and information • Cooperation between cooperatives • Commitment to the community

Traditionally, cooperatives used retained earnings and members' contributions to finance their activity. Today, like any other firm, cooperatives operate in a very different business environment (c.f. Fig. 2.13). They need more funds to grow and remain competitive, at a time when it is more difficult than ever to obtain funds (Lewi and Perri 2009).

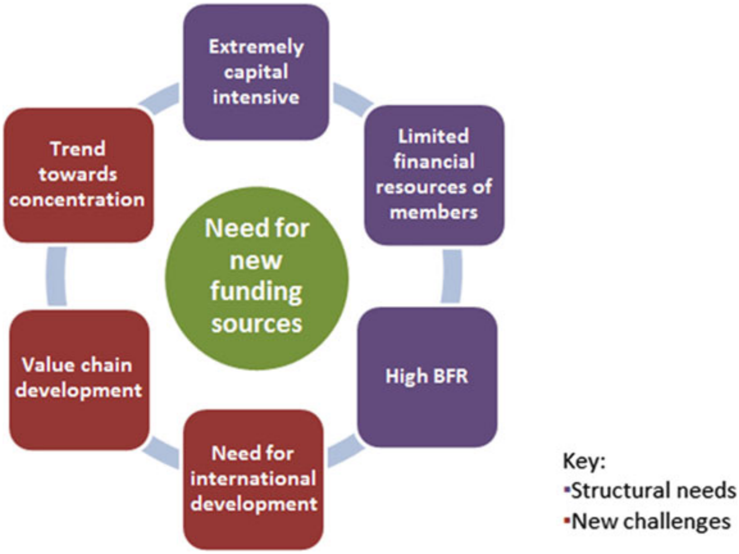


Fig. 2.13 Structural needs and new challenges (After the PWC study (2012), Cartographie et grands enjeux du monde coopératif agricole à l'échelle mondiale)

Funding development is an increasingly difficult challenge and it goes hand-in-hand with more general issues such as expansion and differentiation in the market. However, even though the unique cooperative business model makes access to new funding sources more difficult, it also provides opportunities.

In a 2012 study, Deloitte's identifies the limitations of the cooperative business model (c.f. Fig. 2.14). The study notes that:

– The ownership structure limits access to capital since generally cooperatives do not issue shares.[36] Indeed, such a strategy, which gives outside investors the opportunity to own and control the firm would go against cooperative principles, according to which ownership and control are reserved for the members. This limits the rate of capital funding and the cooperative's ability to grow. Furthermore, although traditional internal funding sources are necessary, they are not always enough to satisfy development requirements, particularly as the fall in the agricultural population makes it impossible to expand the capital. Meanwhile retained income is not always sufficient since it depends on annual profits and in the long term raises the question of funding by the membership.[37]

[36] Avoidance strategies are nonetheless possible, as shown by the examples of TEREOS (stock market listing and open bond issue) and VIVESCIA (closed bond issue).

[37] As the profits are owed to the members, retaining profit is synonymous with looking for funding sources to repay the members.

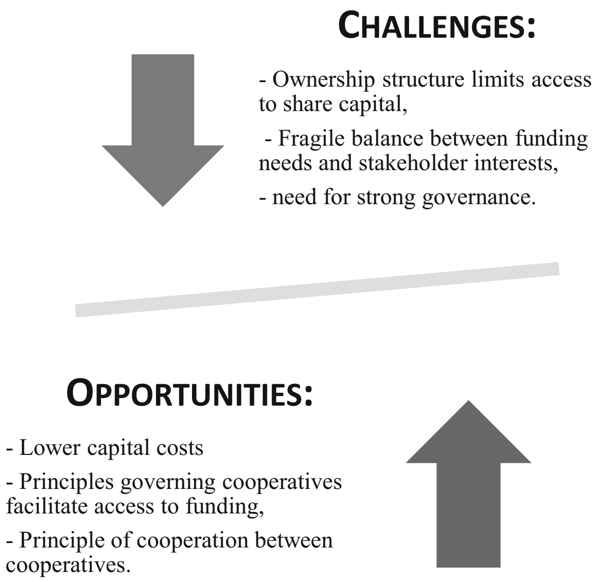


Fig. 2.14 Challenges and opportunities generated by the singularity of the cooperative business model (After the Deloitte Report, 2012, Financer l'avenir: Évolution des stratégies de financement et de capitalisation des coopératives)

– The balance between funding needs and stakeholder interests is a fragile one. Whilst the concentration of stakeholders[38] can facilitate decision making when their interests converge, this is often much more difficult when they diverge. Indeed, it is sometimes difficult to align the strategic priorities of the cooperative's management with those of the members. For example, the former may want to give priority to external growth to improve competitiveness, whilst the latter might consider any external growth as risky and so oppose it.
– Strong governance is necessary, because the employment of new funding sources requiring complex financing arrangements demands supplementary control and management capacities.[39]

The same study notes that all of these drawbacks linked to the cooperative business model are counterbalanced by advantages. For example:

– Cooperatives benefit from lower capital costs since they often fund most of their activities by the contributions of their members. The members are required to contribute financially to the cooperative when they join. This contribution by each of the members makes it possible to make cooperative governance democratic.[40] Further, the members do not expect to obtain a return on this investment; they receive limited payments based on the capital they contribute when they join.

[38] The members are not only owners but also customers, suppliers and even, sometimes, employees.
[39] This point will be developed in the next section.
[40] "One Man One Vote".

Cooperatives also fund themselves by loans, on which the interest payments are tax deductible.

– The principles on which cooperatives are managed facilitate access to finance from funders seeking projects that will be profitable in the long-term. Indeed, funders who are averse to risk often pay great attention to long-term projects, since the benefits are less volatile and reduce the amount of risk taken in different projects. Cooperative managers are expected to take decisions to maintain the productive capital and maintain the firm's activity for future generations rather than take into account market pressures.
– The principle of inter-cooperative cooperation can also be a significant lever to obtain funding. The mutual guarantees undertaken by vertically linked cooperatives can reduce funding needs for commercial operations.

Cooperatives capable of raising sufficient funds to ensure their growth and develop their competitiveness by increasing their operational efficiency can make the most of these opportunities.

Challenges and Opportunities of the Bazancourt-Pomacle Biorefinery Cooperative Business Model

In structural terms, the firms present on the Bazancourt-Pomacle site have important needs (c.f. supra Fig. 2.13).

The firms are characterised by intensive capital requirements. Their capital expenditure is high because of the need to purchase and maintain costly, customised equipment. The number of innovative industrial-scale projects that emerge is not high, but their implementation, and the various stages required to increase progressively in scale require significant investment (Fig. 2.15).

The cooperatives and the firms present on the Bazancourt-Pomacle site have limited financial means because of the reduction in public financial support and also because of the volatility of raw material prices.

Their working capital requirement is also high, due to the seasonality of their activity directly related to the sugar beet and wheat harvests and short supplier payment times.

The Bazancourt-Pomacle Biorefinery has many new challenges to face, with firms globally tending to increase in size through mergers and acquisitions,[41] the development of the value chain upstream and downstream of processing, including R&D (c.f. Fig. 2.16) and the need for increased internationalisation to access new markets.

The example of the creation of CRISTANOL is interesting, because it illustrates both the structural requirements of actors on the site (significant capital expenditure, limited funding sources) and the new challenges encountered (need to unite the actors in a union of cooperatives, diversification and development of the value chain upstream of processing and the possibility of exporting production all over

[41] For example, the acquisition of the sugar group Vermandoise by Cristal Union in 2011.

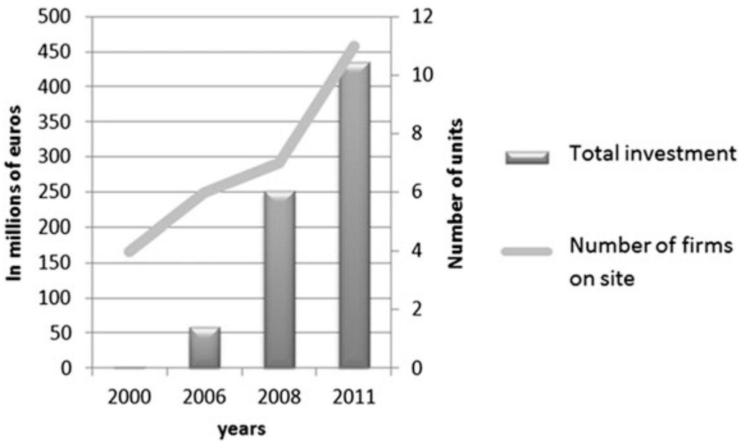


Fig. 2.15 Increase in total investment needs on the Bazancourt-Pomacle site between 2000 and 2011

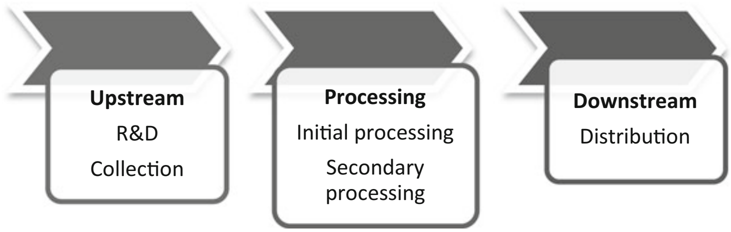


Fig. 2.16 Summary of the value chain upstream and downstream of processing

Europe). Created in 2006, CRISTANOL is today one of Europe's leading bioethanol producers. The firm is a subsidiary of CRISTAL UNION and BLETANOL, and required an initial investment of 272 million euros for a production capacity of 280,000 tonnes of ethanol.

The initial investment to launch the firm was funded as shown in Fig. 2.17.

Although equity and quasi-equity[42] make up 29 % of the initial investment, long-term debt alone, typically bank loans, makes up 71 % of the investment required to set up CRISTANOL.

In France, the CREDIT AGRICOLE DU NORD-EST (CANE)[43] has clearly positioned itself as the agro-industry's bank, and has partly enabled the major projects on the Bazancourt-Pomacle site to be brought to fruition.

[42] Current account.

[43] Summary of information collected during interviews with Bazancourt-Pomacle biorefinery actors.

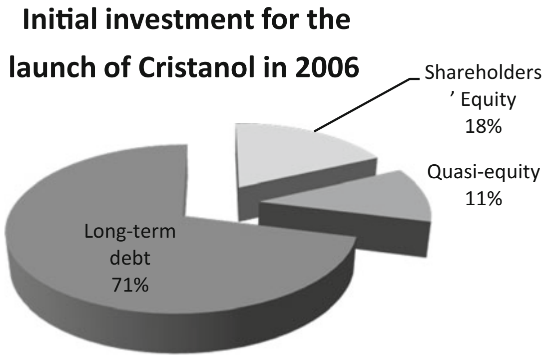


Fig. 2.17 Initial investment for the creation of CRISTANOL in 2006

Resulting from the merger of the Reims, Aisne, Champagne and Ardennes regional banks, the CANE had enough shareholder equity to fund the Bazancourt-Pomacle Biorefinery agro-industrial projects. Indeed, the cooperatives were growing in size, merging and/or buying up other companies, and their funding requirements to support this growth were high. The origins of the CANE make it above all "the bank for agriculture, wine-growing and agro-industry", which is why the bank agreed to take on the justified, bearable risk that was required to support the investment at Bazancourt-Pomacle. It was aware of the risk and was committed to local and agricultural development. Other banks would undoubtedly have reacted differently.

Today, while the 2008 financial crisis and the events that it led to, in particular the debt crisis in the Eurozone, continue to shake the world's markets, banks, even those that are closest to their customers, have become reluctant to take even moderate risk. The investment required has driven cooperatives as a whole, and the actors of the Bazancourt-Pomacle Biorefinery in particular, to turn towards other funding sources, including complex financial packages. We will examine this trend in the next section.

2.3 The Strategies and Solutions that Have made the Biorefinery What It Is Today

In the face of these endogenous and exogenous changes, the Bazancourt-Pomacle site chose to develop via the value chain upstream and downstream of processing. Internal funding capacity was insufficient to ensure this growth and bank loans were increasingly difficult to obtain, so the firms decided to turn to complex financial packages.

2.3.1 Financial Packages

The cooperatives at the Bazancourt-Pomacle site were thus led to modify their structure and to exist in a less "pure" state. These are made up of cooperatives or unions of cooperatives with groups of non-cooperative subsidiaries. These

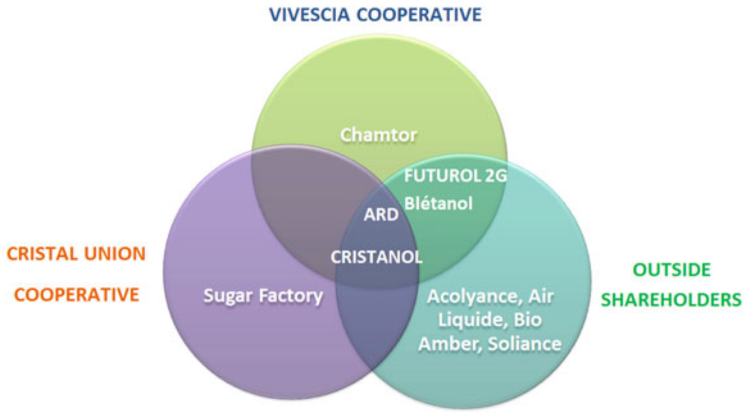


Fig. 2.18 Changing structure of the cooperatives and joint subsidiaries

subsidiaries are often jointly owned with other cooperatives or with non-cooperative industrial or banking firms[44] (c.f. Fig. 2.18).

According to Mauget (2013), all of these economic changes can disturb the relationship between the cooperative and its members. One of the major challenges for cooperatives is without doubt that of developing their members' "market" culture. They need to understand better the socio-economic environment in which their cooperative operates and take a more active part in the changes cooperative groups are undergoing. Cooperatives need then to inform and train not only their members but also their industrial and financial partners, to make sure each stakeholder understands the mind-set of the others.

Eleven firms are present on the site of the biorefinery. However, the platform is much broader in scope if we take into consideration all the indirect stakeholders and subsidiaries (Cf. Fig. 2.19).

The risk represented by this type of financial arrangement in terms of loss of power for the members, the original cooperatives and the holding groups (c.f. Box 2.4) does not outweigh the advantages of such arrangements. This is particularly true if the rules for payment of the farmers, the ratio between dividends and retained profit of profit retained, and the rules for changes in majority shareholdings are settled beforehand.

[44] Thus, two different logics find themselves combined: cooperative and capitalist.

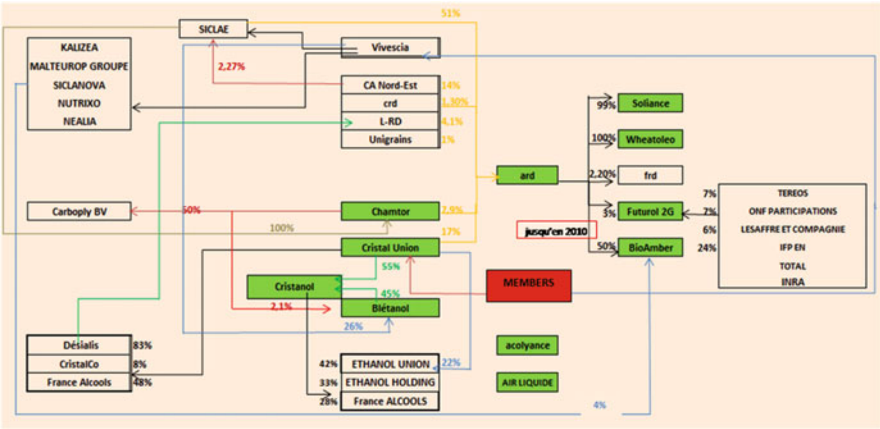


Fig. 2.19 Financial structure of the Bazancourt-Pomacle site in 2012

Box 2.6 Presentation of Siclaé, VIVESCIA Holding Group and Player in the Bazancourt-Pomacle Biorefinery

SICLAE[45] is an agro-food industry group that specialises in transforming plant material into food and non-food fibres. SICLAE is a partnership limited by shares, controlled by its founders from the farming sector.

SICLAE is present in promising markets at the crossroads between agriculture and industry, such as malting, milling and bakery, starch and glucose production, maize processing, animal feed and environmental plant chemistry. Its core activity is processing cereal production (wheat, barley, maize, oats), oilseed (rape, sunflower) high-protein crops (peas, horse beans), with the aim of developing regional agriculture and attaining critical mass.

Key Figures

- World Leader in malt
- Leading French milling company and major European player in baking, cakes and pastries
- Number Two in Europe for maize processing
- 6546 employees
- Active in 25 countries
- Turnover of 2.45 billion euros

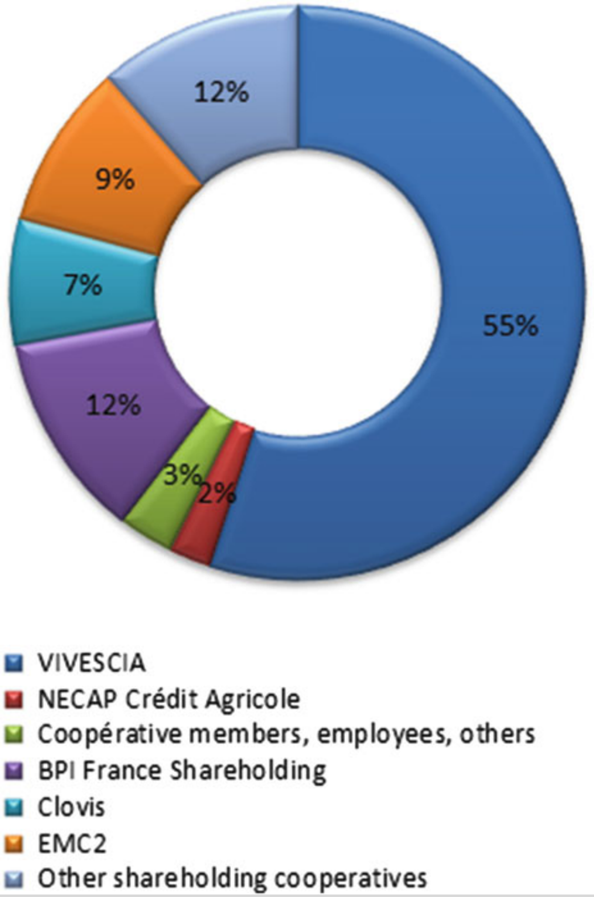
Shareholders of SICLAE[46]:

(continued)

[45] Source: http://www.siclae.com/

[46] Source: http://www.siclae.com/siclae-en-bref/actionnaires-filieres/index.html

Box 2.6 (continued)



With such a complex ownership structure, quality management is vital. Today, agricultural cooperatives have to call on skilled managers who are capable of leading the strategic development of such structures. Cooperatives are prepared to attract leading managers from other sectors to decide and implement growth and development strategies, as long as these managers adhere to and recognise the specific values and characteristics of the cooperative model.

For the Bazancourt-Pomacle Biorefinery, these financial arrangements are the price it has to pay if developing the value chain upstream of processing is to be financially possible.

2.3.2 Developing the Value Chain Upstream of Processing

The firms present on the site did not wait to have their backs to the wall to tackle the problems linked to changes in their regulatory and competitive environment. Well before the exogenous changes occurred, they implemented strategies to diversify their activity or internalise more processes.

The firms making up the biorefinery had and have the possibility of moving in different strategic directions to develop the cooperatives' activities all along the value chain: concentration, strengthening different sectors, upstream integration, downstream integration and internationalisation.

Whilst the actors on the site have to decide on their strategic priorities, it is even more important to foresee the investment choices and strategic decisions that will be necessary to develop their activity. From an early stage, the founders of what was to become the Bazancourt-Pomacle Biorefinery were determined to diversify so as to develop non-food applications for agro-resources. This would give farmers new outlets and make them less dependent on public policy.[47]

The foresight and anticipation of the leaders of the site explains how Bazancourt-Pomacle has evolved over time. Today, the biorefinery covers the whole of the agro-food industry value chain (c.f. Fig. 2.20).

The different segments of the value chain have been integrated both by firms specialising in one part of the chain, and by cooperatives involved in several segments. While historically agricultural cooperatives such as CRISTAL UNION have been positioned at the centre of the chain, they have invested upstream in order to innovate and downstream to get closer to the consumer.

Developing upstream of processing has allowed them to guarantee their raw material supplies and to invest more in R&D (c.f. Fig. 2.21).

These different strategies have enabled the platform to develop and progressively become an integrated biorefinery. There are benefits in this throughout the value chain, and also for each of the firms present (c.f. Table 2.3).

The above example is interesting, because we can see the increasing volumes of raw materials and production between 2006, when CRISTANOL was beginning its activity, and 2011, when this activity was fully developed.

An increase in inputs of 18 % enables production of fermentation substrates for the production of biofuel to be increased by 173 %. Meanwhile technical starch production increased by 30 %. There was little or no impact on the production of food and animal feed.

The ecosystem provided by the biorefinery thus stimulates the production of the firms present on the site. The steady rise in turnover since 2000 (c.f. Fig. 2.22) for the whole of the platform is the result not only of the arrival of new companies on

[47] As an example, the construction of Cristanol foresaw the end of CAP quotas and gave farmers a new outlet for their sugar beet when prices fell.

Similarly, the development of SOLIANCE was linked to low prices for agricultural crops; it was necessary to find a more profitable outlet for local farmers' produce.

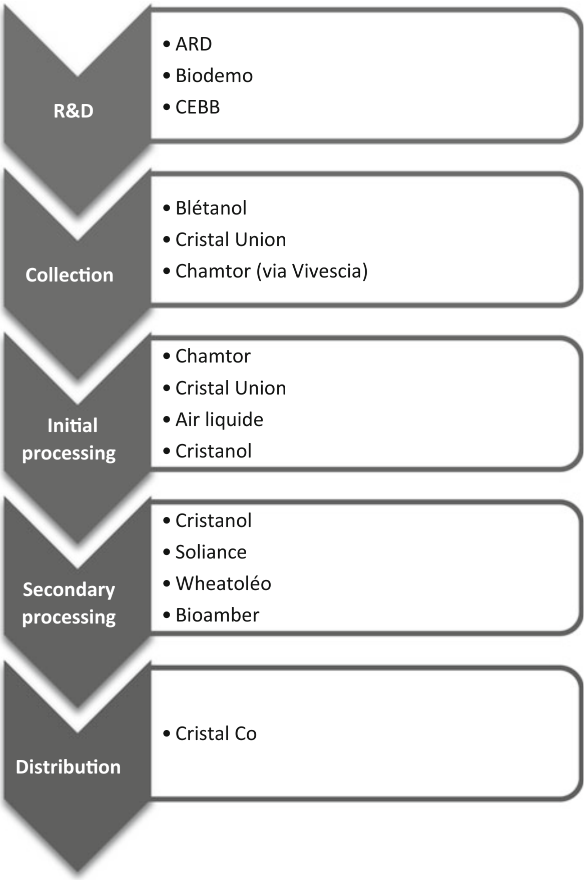


Fig. 2.20 Increased diversification of the companies on the Bazancourt-Pomacle site in the agro-food industry value chain

the site but also of increased production by the firms already present in relation with the activity of the new arrivals.

All of the strategic decisions taken since the creation of the Bazancourt sugar factory in 1953 and until the development of the biorefinery have resulted in a steady growth in activity on the site.

This observation leads us to ask the following two questions:

– Is activity at the Bazancourt-Pomacle Biorefinery optimal, or could productivity be improved even more?
– The importance of the Bazancourt-Pomacle Biorefinery is no longer in doubt, but what of its competitiveness?

We will attempt to answer these questions in the next section.

Fig. 2.21 Development strategy upstream of processing

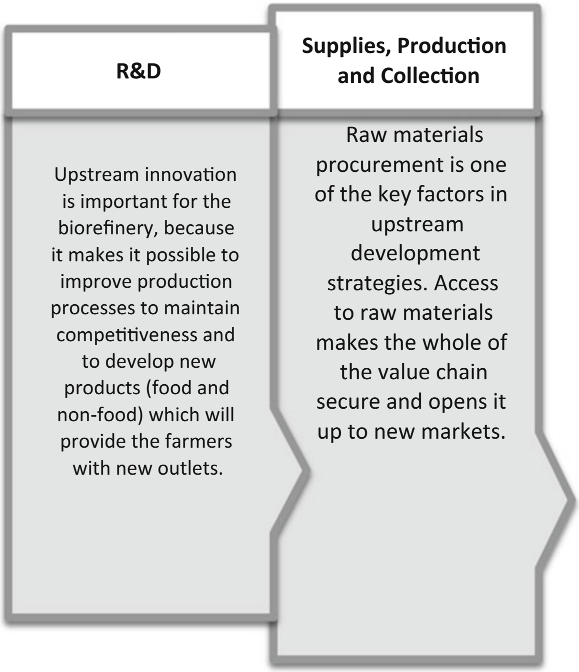


Table 2.3 Benefits of the biorefinery for the company CHAMTOR between 2006 and 2011 (period of development of CRISTANOL)

	Volume 2006	Volume 2011
Inputs		
Wheat	340 Kt	400 Kt
Outputs		
Food	192 Kt	190 Kt
Animal feed	126 Kt	122 Kt
Biofuel[a]	94 Khl	257 Khl
Ingredients/molecules for downstream industry (technical starch)	27 Kt	35 Kt

[a]Production and sale to the CRISTANOL distillery of a fermentation substrate (liquid hydrolysed wheat) equivalent to the production of 94 Khl of bioethanol in 2006 and 257 Khl of bioethanol in 2011

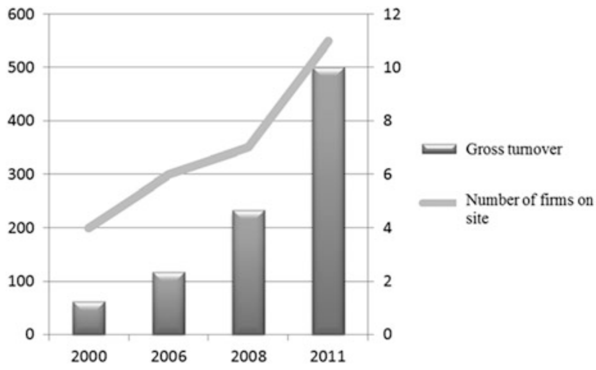


Fig. 2.22 Turnover on the Bazancourt-Pomacle site, 2000–2011 (This graph does not include data for the sugar cooperative, because Cristal Union publishes sales figure for the whole of the group but not for each of its companies)

3 The Bazancourt-Pomacle Biorefinery: An On-Going Success Story?

During this section, we will investigate whether the Bazancourt-Pomacle Biorefinery has enough strong points to continue its growth. To do so we will carry out a SWOT analysis (strengths/weaknesses/opportunities/threats) and will illustrate our analysis with an application that will demonstrate the extent of the threats that hang over the biorefinery.

We will also discuss whether all of the companies present on the site are at an optimal level of technological maturity, or whether there is still untapped potential for development within these firms.

3.1 Technological Readiness Levels: TRL

TRL are scale measuring the degree of maturity reached by a technology. The scale was developed by NASA to manage the technological risk presented by its programmes. Initially it was made up of seven levels, which was increased to nine in 1995.

Since then the TRL scale (c.f. Box 2.5) has been adopted in numerous fields.

Box 2.7 The Nine Levels of Technological Maturity

TRL	Definition
1	Basic principles observed and reported
2	Technology concept and/or application formulated
3	Analytical and experimental critical function and/or characteristic proof of concept
4	Component and/or breadboard validation in laboratory environment
5	Component and/or breadboard validation in relevant environment
6	System/subsystem model or prototype demonstration in a relevant environment

(continued)

Box 2.7 (continued)

TRL	Definition
7	System prototype demonstration in an operational environment
8	Actual system completed and qualified through test and demonstration
9	Actual system proven through successful mission operations

When applied to the Bazancourt-Pomacle site, this typology results in the following analysis (Fig. 2.23).

This diagram highlights all the development potential existing at the biorefinery. It also shows the chances of success for each of these projects.

Of course, beyond the level of technological readiness, other criteria need to be taken into account to ensure the development of the projects, particularly:

– The relative prices of oil and plant raw materials, which enable us to calculate the breakeven point for a bio-based product, on which the development of the sector depends.
– The level of public authority subsidies, which encourage investment in new equipment and make it worthwhile.
– The level of inducement from society, corresponding to consumer demand.

It is in the interest of the biorefinery, as at the present time, to have technologies at different levels of maturity in order to provide the potential for further innovation at the site and thus to maintain competitiveness.

3.2 What Are the Strengths, Weaknesses, Opportunities and Threats for the Bazancourt-Pomacle Biorefinery?

The SWOT[48] analysis is used to examine corporate strategy and to discover what strategic options are feasible in an area of strategic activity. The model was developed in the 1960s by four professors at the Harvard Business School: Learned, Christensen, Andrews and Guth.

This analytical tool combines the study of the strengths and weaknesses of an organisation, a territory or a sector, with that of the opportunities and threats provided by its environment, in order to contribute to the definition of a development strategy.

[48] Strengths – Weaknesses – Opportunities – Threats

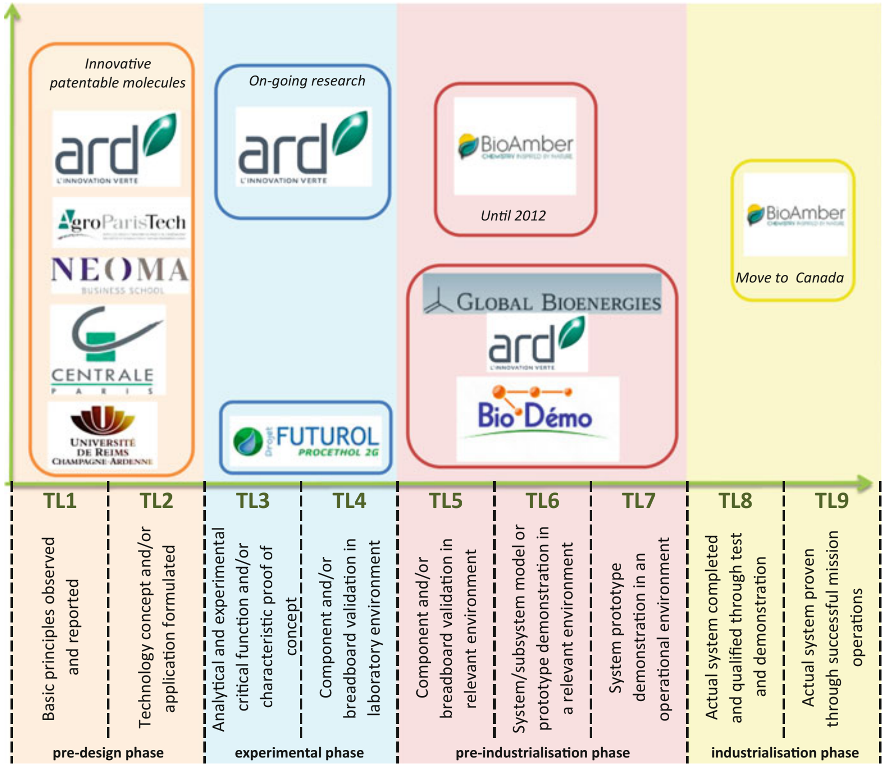


Fig. 2.23 Application of TRL to the Bazancourt-Pomacle site (With regard to the joint project between Global Bioenergies and Biodemo, see Chap. 4)

The aim of the analysis is to take account of both internal and external factors when defining strategy, by maximising the potential of the strengths and opportunities and by minimising the effects of the weaknesses and threats.

It is interesting to read this analysis carried out in 2011 for the Bazancourt-Pomacle Biorefinery (c.f. Box 2.6).

Box 2.8 SWOT Analysis of the Biorefinery[49] in 2011

Strengths	Weaknesses
A recognised site • world-famous site: organised visits, conferences on the topic of agro-resources • A site that attracts higher education institutions *Recognised innovation capacity* • ARD, Europe's leading agro-resource technology transfer centre • Successful, value-creating projects such as SOLIANCE, BIODEMO, BIOAMBER, FUTUROL • Well-established industrial symbiosis *Extremely accessible location* • A34 motorway exit • Improved rail access via Bazancourt station with direct connections to the high-speed train line at Reims	*High levels of conflicting interests on the site* • pollution: noise, odour, atmospheric, visual • Insufficient road development on the site: footpaths, clear road and other signs. . . • Problems caused by HGV traffic, despite a rail connection to CRISTANOL, the sugar factory and AIR LIQUIDE • Insufficient road furniture • Problems with gas and electricity supplies *Reputation still to be developed* • Scientific status needs to be more visible *Insufficient hotel and catering facilities* • Accommodation, hotels, restaurants (work in progress) *Leadership problems* • no real leader/coordinator for decision making
Opportunities	**Threats**
Significant assets in a fast-growing, diversifying world bioethanol market • Fast-growing world market: + 67 % between 2006 and 2009 (in volume), currently dominated by the USA (45 % of production), and Brazil (31 %) • French positioning needs strengthening: production in France represents 30 % of European production (growth of 117 % between 2006 and 2009) • CRISTANOL: leading French company • diversification of raw materials: projects for producing production of bioethanol from lignocellulosic biomass	*Risk that actors on the site may leave* • Increased competition between regions to attract innovative firms • Regions offering more attractive working conditions and environment? *Overall facilities might not correspond to the site's ambition to be a world-renowned centre* • Poor quality facilities • Insufficient attention paid to all those concerned with the site • insufficiently coherent overall communication by the site *Difficulty of attracting SMEs and start-up firms* • A big challenge for the agro-industrial site in years to come *Uncertainty of public policy* • Aim of achieving at least 10 % renewable fuel by 2020[50] then 6 % limit on first generation biofuel[51]

[49] From Algoé Consultants, Diagnostic Presentation Diagnostic of the Reims Champagne Nord agro-industrial complex, September 2011. Study carried out at the request of the Burgundy Plain Community of Communes and that of the Suippe Valley.

[50] DIRECTIVE 2009/28/CE.

[51] Vote in the European parliament on 11/09/2013.

This analysis demonstrates that the Bazancourt-Pomacle Biorefinery has at its disposal sufficient skills and know how to become a central player nationally, in Europe and globally in a context where markets for bio-based products are booming. However, the platform still has recurring problems concerning the attractiveness of the site (environment, fiscal and regulatory situation) to innovative firms. The recent example of BIOAMBER illustrates this perfectly.

3.3 BIOAMBER: A Locally Unrecognised Success Story

As early as 2002, ARD was declared by experts to have exceptional competence in the field of biotechnologies. The Scientific Council of the time recommended it to investigate succinic acid, a four-carbon molecule[52] that ferments anaerobically.[53]

Together with its American partner DNP Green Technology, ARD set up a joint venture in this area in 2008 (c.f. Fig. 2.24). BIOAMBER SAS, the result of this R&D partnership between the two shareholders, is the first company in the world to have developed commercially the technology to produce plant-sourced succinic acid. This technology, licenced with the American Department of Energy, is based on an *E. coli* bacterial strain and significantly reduces production costs. It opens up new markets that today are inaccessible for fossil-based succinic acid.[54]

In the context of its agreement with DNP, ARD industrialised its laboratory process and invested 21 million euros in an industrial demonstration unit,

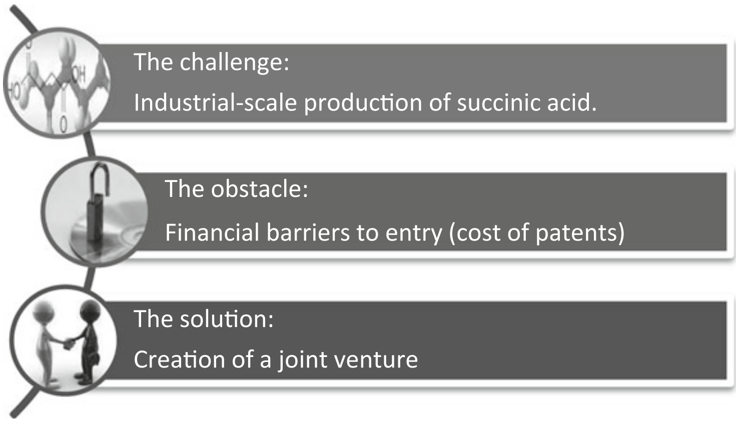


Fig. 2.24 BIOAMBER: challenge, obstacle and solution

[52] Four-carbon chemistry is extremely important.

[53] As succinic acid provides four carbon atoms and glucose six, in theory with one glucose molecule and two CO_2, we can produce two succinic acid molecules. This never works in practice, but the yield remains high. Carbon can be metabolised into succinic acid.

[54] http://www.a-r-d.fr/ARD-filiales-et-partenaires-BIOAMBER-46.html

BIODEMO[55] with a capacity of 2000 tonnes per year. With this unit, BIOAMBER successfully tested its technology and finalised the process book with a view to the sale of licences.

This type of production was the first of its kind in the world. It could revolutionise the markets for bio-based products. It has already provoked a wave of enthusiasm, enabling large funding sums to be raised (c.f. Box 2.7).

Box 2.9 BIOAMBER Funding[56]

For example, in the autumn of 2009, DNP Green Technology was granted $12 million of funding by a large investment fund managed by Sofinnova Partners, an important European risk capital company. Associates of this firm include Mitsui & Co. Venture Partners, the risk-capital branch of the Japanese trading company Mitsui & Co, and Samsung Ventures, the risk-capital branch of Samsung, one of the largest industrial groups in Asia. Other investors include the Cliffton group, a Canadian property group with interests in clean technology.

In the autumn of 2010, DNP Green Technology bought from ARD the whole of its joint venture BIOAMBER. At the same time it changed its name to BIOAMBER Inc. In the process, Siclae became a shareholder of BIOAMBER.

BIOAMBER completed two further rounds of funding in 2011 and 2012, for a total sum of $75 million, from two new shareholders, Naxos Capital Partners and LANXESS Corporation.

In May 2013, BIOAMBER was listed on the New York Stock Exchange, with the symbol BIOA. The firm raised $80 million and issued warrants giving investors the right to buy an additional sum of $44 million in ordinary stocks.

Currently, BIOAMBER is still integrated with the Bazancourt-Pomacle Biorefinery, which supplies the succinic acid factory with glucose, carbon dioxide, steam, ammonia and process water.

However, BIOAMBER has entered into a partnership with Mitsui & Co. to build a world production plant in Sarnia, Ontario. The two firms intend to build two other plants, one in Thailand and the other in the USA or Brazil.

The Sarnia plant, in Ontario will be the first to result from the joint venture signed between BIOAMBER and Mitsui & Co. It will be located in a bio-industrial site belonging to Lanxess, which is itself part of a vast petrochemical centre with infrastructure giving access to public services and a number of raw materials (steam, electricity, hydrogen, process water and carbon dioxide) and finished product distribution services. The plant's initial capacity will be around 17,000 tonnes of bio-based succinic acid. When it reaches full capacity, total production should be around 34,000 tonnes of succinic acid.

[55] BIODEMO was built with financial assistance from the Marne Department Council, the Champagne-Ardenne Region and the ERDF.

[56] Source: http://www.bio-amber.com/

This departure takes nothing away from the results achieved by ARD. Its aim, to develop commercially viable technology to produce bio-based succinic acid, has been achieved. It does represent a loss for the local area: reputation, employment, prospects etc. However, the environment in Ontario is much more attractive and favourable to the development of BIOAMBER Inc. (funding conditions, operating costs etc.)

This disappointment needs to be qualified however by the fact that the industrial symbioses offered by the Bazancourt biorefinery's ecosystem are a major asset in its competitive advantage, which counterbalances such threats.

The synergies developed as the industrial site grew initially focussed on what are known as "good sense" synergies, such as joint management of waste, sharing water and steam, industrial maintenance etc. This cooperation was essentially between two actors: CRISTAL UNION and CHAMTOR.[57]

Since the beginning of the 2000s, this dynamic has accelerated and intensified thanks to ARD working on the innovative use of agricultural products, the products and by-products of firms on the site, and on processes unique to the biorefinery. ARD thus created a favourable context for more mutualisation, optimisation and synergy. At the same time, the creation of CRISTANOL, led to the development not only of traditional exchanges (water and steam) but also of product exchange, since CRISTANOL processes products from the sugar factory and CHAMTOR and the CO_2 produced by the Air Liquide liquefaction unit.

Conclusion

In view of what we have described, we can assert that the Bazancourt-Pomacle Biorefinery is an excellent subject for a study insofar as it is a concrete illustration of what is often still considered just as a concept: the integrated biorefinery.

The site is unique in that it is an "ecosystem," in which exchange and interaction have boosted the production of the firms present on the platform. The unity of the site is based on research, which provides fertile ground for mutualisation and synergy.

Whilst it is often suggested that the common good, good sense and a spirit of cooperation were behind the development of the site and its uniqueness, this study has shed light on other factors that came into play. The Bazancourt-Pomacle Biorefinery is also the result of the cooperatives adapting to changes in their competitive, industrial and regulatory environment: WTO regulations, CAP and unstable raw material prices. It is also the consequence of the fact that the actors involved with the site were able to learn from their mistakes; the opportunities offered by the cooperative model; and the quality of the bank partnership that they enjoyed until the 2008 financial crisis.

The Bazancourt-Pomacle Biorefinery is a good lesson in adaptability, reactivity and anticipation.

Managerially and organisationally, this study provides several lessons.

The firms on the site were able to reduce their dependence on subsidies by early diversification to develop non-food outlets for agro-resources, but the fact remains

[57] It should be noted that water is also exchanged between the sugar factory and Cristanol.

that their internal funding capacity was limited and bank loans became more difficult to obtain. They were forced to look for new sources of finance to develop the new activities desired by the cooperative members, while attempting to maintain stable cooperative governance structures.

To integrate activities upstream and downstream of processing, firms on the site developed complex financial arrangements, which included participation by capitalist firms. Whilst this method made it possible to extend their activities, it made the cooperative logic less clear for their members. The members are the base of the whole cooperative system. They are at once owners, clients and suppliers. The managers must therefore be careful to maintain their trust. One of their major challenges is undoubtedly to develop the farmers' "market culture" through training and communication, since in the future they will have to reason more as a private company to anticipate the progress of their global competitors and market trends.

The Bazancourt-Pomacle Biorefinery has significant potential for growth. Markets for bio-based products are booming, which provides excellent opportunities for development. However, the region is less attractive than a number of international competitors due to the European regulatory situation and French tax laws.

A high degree of synergy has been developed on the site (steam, products, waste, R&D), which we will describe in more detail in Chap. 3.

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