Innovation biographies

Deliverable 2.7

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[This is a revised version based on the feedback from the midterm review report]

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1. Introduction to innovation biographies

Innovation biographies reconstruct the narrative of an innovation process from its conception to implementation by analyzing territorial knowledge dynamics across time, space and individuals (Butzin & Widmaier, 2016). The ultimate purpose is to be able to uncover how knowledge is moved through time and space, capturing the importance of critical events, contextual settings and collaborations for innovation processes. As a research tool, innovation biographies analyze these processes and dynamics from a micro-level perspective, and in doing so, they capture the *"social relations, contextual settings, and the cross-sectoral and multi-local reach of knowledge developed and applied in innovation processes"* (Butzin & Widmaier, 2016, p. 220). This approach has been applied in studying multiple types of innovations (see also Terstriep et al., 2015).

Thus, the innovation biographies provide in-depth analysis of both agency by actors central to the innovation, and the role played by contextual dimensions. Consequently, the analysis in the current deliverable feeds into a number of subsequent deliverables in the REINVENT project, including *D2.8 Climate innovations and new pathways for decarbonisation* (synthesis of WP2 work), *D3.3 Summary of decarbonisation case studies* (two case studies focus on innovations analyzed in the current deliverable), *D3.7 Assessment of the Broader Impacts of Decarbonisation* (innovation biographies are part of the foundation for developing the typology), and *D6.1 Decarbonisation at scale* (innovation biographies contribute to understanding challenges for upscaling innovations).

Data collection for the development of an innovation biography involves a multi-step process. First, a qualitative historic event analysis is conducted in order to construct a narrative of the innovation process. Then, an in-depth semi-structured interview with (a) key initiator(s) of the innovation is performed,[1] in which the development of the innovation is explored according to the interviewee's perspective, in order to complement the narrative. As Butzin & Widmaier (2016, p. 225) note, this interview is the backbone of the innovation biography, as it is the *"essential instrument in operationalizing the open and explorative approach of innovation biographies"*. From here, the social network of the innovation is explored through subsequent desktop research and/or additional interviews. This additional research is based around an "egocentric network analysis" in which one node (ego) – in this case the innovation being analyzed – is assessed and described via its relationship to other organizations and people. Finally, all obtained information regarding the innovation is combined and analyzed comprehensively. This allows for the creation of a robust innovation biography with special attention paid to the spatial and temporal dimensions of the innovation's development. These dimensions can then be visualized, as inspired by Butzin & Widmaier (2016) (figure 1.1).

[1] In the case of Green Protein Alliance (see below), the innovation biography builds on two in-depth interviews with persons central to the innovation, as well as four interviews with stakeholders.

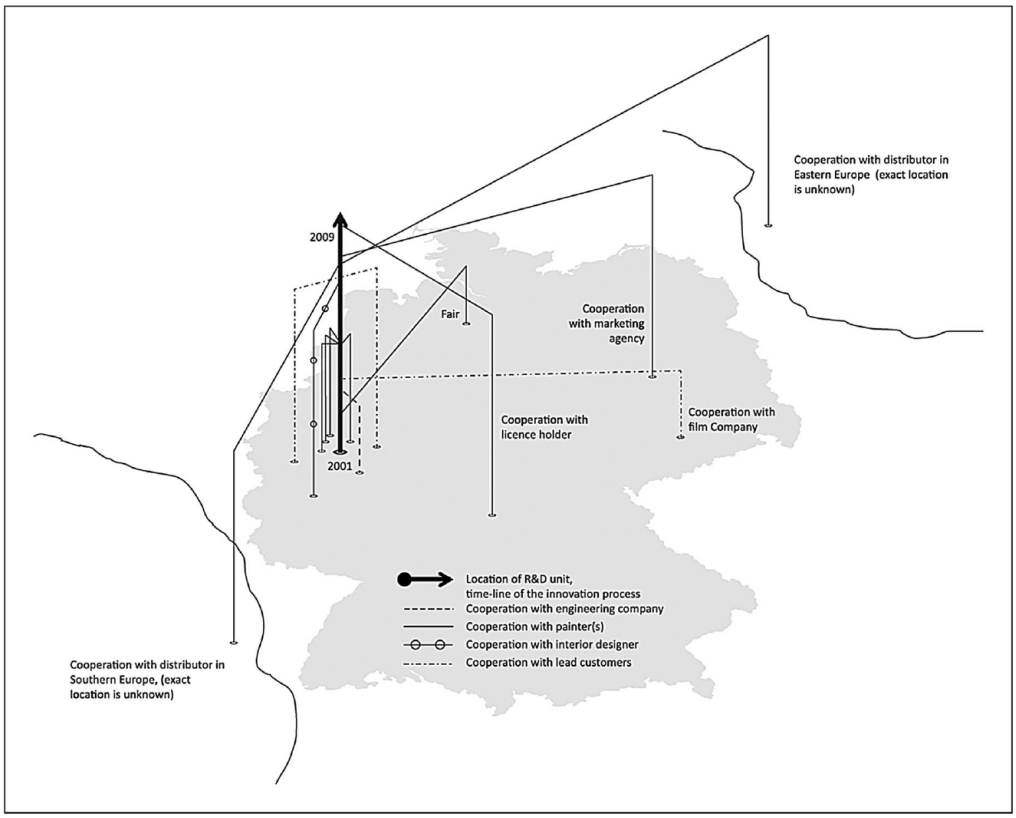

Fig. 1.1 Time–space path of territorial knowledge dynamics in innovation biography.

Source: Butzin & Widmaier (2016, p. 226).

For task 2.3, the partners of REINVENT have created five innovation biographies of selected decarbonization innovations distributed across three of the four sectors and different parts of the value-chain. The innovations analyzed through innovation biographies include: Oatly (meat and dairy; production); Green Protein Alliance (meat and dairy; consumption); Ojah (meat and dairy; production); cardyon (plastics; production); and LignoBoost (paper; production). The purpose of undertaking this task in WP2 is to offer an in-depth understanding of how key decarbonisation innovations developed and came to fruition, which will provide an important input to the detailed analysis in WP3.

Monica Keaney authored the innovation biographies on Oatly, cardyon and LignoBoost. Maria Tziva and Simona Negro authored the innovation biographies on Green Protein Alliance and Ojah.

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2. Oatly innovation biography

Context & Framework Conditions

In 2007, the Food and Agriculture Organization of the United Nations (FAO) found that the global dairy industry is responsible for 4% of GHG emissions worldwide (FAO, 2010). As demand continues to rise, particularly in developing countries and China, this number is expected to increase. These high numbers are fueled, in large part, by the resource-intensive global livestock industry, to which the dairy industry is closely linked. In response to increasing awareness of overconsumption of meat and dairy products in many industrialized countries, a number of companies and initiatives have sprouted in recent years in an effort to change the way people eat in order to improve health and lower carbon emissions. They are doing this by, essentially, removing the middle step in nutrient consumption: the animal. Rather than creating vast agricultural infrastructure on which cows must feed, enterprises are producing milk and dairy substitutes directly from plants, instead.

One such enterprise is Oatly. A Swedish oat drink company based in Malmö, Sweden, Oatly produces a number of vegan, oat-based substitutes to standard dairy products, like milk (including chocolate and other flavored milk) yogurt, coffee drinks, cream cheese, and cooking cream. The company has a long history, beginning at Lund University in 1994. While still small, it has since grown substantially, thanks in large part to successful collaborations and partnerships both in Sweden and around the world.

Since Oatly's founding in 1994, several key events have contributed to its growth and development (table 2.1). These events, internal to the company, have coincided with increased awareness of the adverse environmental impacts of meat and dairy production and a growing cultural acceptance of meat and dairy alternatives.

Year	Event
1994	First oat drink patent is created
2001	Oatly brand is launched
2006	Oatly owned factory in Landskrona is opened
2012	Toni Petersson hired as CEO
2013	Relaunch of the Oatly brand
2014	Swedish Dairy Association (LRF Mjölk) files lawsuit against Oatly for disparaging cow's milk as unhealthy
2016	Joint venture investment secured from Verlinvest and China Resources

Table 2.1. Summary of selected events

Development

When Oatly first began in 1994 as a research project at Lund University it did not expect to become a challenger to major established dairy producers. The small team was most interested in creating ideas that they might be able to sell to these large existing dairy producers in the region, such as Skånemejerier and Arla, by focusing on a niche plant-based market. According to sustainability manager, Carina Tollmar, to major dairy producers, this

idea was considered acceptable only in the most extreme of cases – mainly for consumers who were allergic to cow's milk. Thus, not viewing Oatly's innovation as a threat, but rather a niche market possibility, Skånemejerier opened their doors to them, housing Oatly's production activities from the late 1990s until 2006. During this time, Oatly also utilized Skånemejerier's sales team, allowing them access to supermarket shelves and food service outlets that they would likely never have otherwise been able to secure.

This early development highlights two of the most crucial collaborations upon which Oatly's long term success is based: Lund University, where the initial science behind the oat drink process was developed, and Skånemejerier. In addition to these, collaborations with ingredient suppliers, packaging partners, investors, and others have been crucial to the company's growth and development. During these early years the company was characterized by a small, entrepreneurial team and maintained a dynamic and flexible approach to their product development.

The first big shift happened in 2006, when Oatly moved into their own production facility in Landskrona, Sweden, about 45 km north of Malmö. Oatly had begun to grow too large for Skanemejerier to handle, already producing 7 million liters of oat drink in their first year at the Landskrona facility. As Tollmar noted, *"If we were going to stay there we would have had to invest together, but that was not a good solution for any of us"*. A joint investment was not an ideal solution for Oatly because they ideally wanted full control over their production processes.

The downside of this new-found freedom and independence was a loss of creativity, flexibility and entrepreneurial spirit which had characterized the early stages of development. As Tollmar remarks, the mindset within the company at this point was that they were *"going to prove that we are a real company and not just some start-up"*. But this meant aligning their company mentality to what they thought a *"real company"* should look like: conservative and risk-averse. This resulted in a rigid development process, where Oatly began *"analyzing everything, counting and counting"*. Even noting that this is a reflection of their Swedish identity, Tollmar describes that, in this phase, the company wanted to be 110% certain of any and all claims before making public proclamations, often at the expense of their communications abilities and brand image. One of the main areas where the company held back was its marketing efforts. It steered clear of challenging the narrative of the powerful and established dairy industry, trying instead to promote its own products without saying anything negative about cow's milk products. This proved challenging when trying to explain why consumers ought to change their behavior.

The second major shift for Oatly happened in 2012 when it hired a new CEO, Toni Petersson. Though an experienced leader, Petersson was a novice to the food industry, so bringing him on board to lead the growing company was a drastic and surprising change for many. Tollmar underscores this quite radical decision: *"I didn't think we had such a brave board, so I'm still astonished. I can't really understand how they dared."* Soon after Petersson's hiring, major changes started happening at Oatly, and in 2013 the company underwent an overhauling *"change process"*. The obvious outward signs of this reinvention were the complete transformation of the company's brand, image and marketing efforts, as depicted in figures 2.1 and 2.2. But these were reflective of deeper, more fundamental organizational changes going on behind the scenes.

Fig. 2.1. Left: Oatly's packaging from before the 2013 change process. Right: A tweet from Oatly in 2017 directly comparing their product to cow's milk in terms of CO_2 emissions

After years of feeling unable to share their true values, which fundamentally challenge the dairy industry, Oatly's new image decided to tackle the challenge head on and do just that. It has now become synonymous with punchy, edgy marketing, with slogans such as, "Wow, No cow!" and "No milk, no soy, no badness".

Fig. 2.2. Recent Oatly advertisements

Many in the company had been waiting for this type of enthusiastic and forward-thinking marketing and communications effort. But numerous others were also worried about the backlash from the powerful dairy industry and from potential consumers being challenged for the first time about their behavior. This has to do with the formal and informal ways in which cow's milk has become institutionalized in Sweden, Scandinavia, and many other parts of the world. As Tollmar describes, the dairy industry in Sweden has long acted as an authoritative body, and this authority and confidence has allowed them to maintain a prominent position as an authoritative voice on food matters. The cultural attitude toward cow's milk was also tough to challenge. It has been an unquestioned truth for many Swedes that milk is good for you, and people generally do not like to be told that something they have been doing for years – and something that they think is good and healthy for them – has negative, environmentally

damaging consequences. The company was therefore nervous about challenging not only a major force in the food industry, but also established and engrained cultural narratives around milk.

Despite the nerves and misgivings of some, Oatly went forward with its revamped marketing and communications campaign, taking on the dairy industry and challenging the norms and behaviors of consumers. The result was a highly publicized law-suit in 2014. LRF Mjölk, the Swedish dairy lobby, claimed that Oatly was disparaging milk and took the small company to court over their claims. Though Oatly lost, the lawsuit backfired on LRF Mjölk, only boosting Oatly's sales and billing them as the creative, environmentally-conscious alternative to the powerful milk lobby.

Implementation

Partnerships have been crucial to implementing Oatly's vision and furthering the company's development, with both national and international collaborations offering opportunities for growth and expansion. While Oatly moved into their own production facility in 2006, they maintained a retail sales partnership with Skånemejerier until 2009 and a food service partnership with them until 2012. This, crucially, was because Skånemejerier did not sell any of its dairy products outside the region of Skåne, meaning they were in no direct competition with Oatly for those market shares – making them more open to the venture.

While Skånemejerier and Läntmannen had invested in Oatly during its tenure at Skånemejerier's facilities, around the time they moved to independent production in Landskrona, these two investors left and new ones, including Carnegie and Industrifonden, came on board. These Swedish investors proved very fruitful for the company during these earlier stages of development, and played crucial roles in developing the product and creating the opportunity for independent production. However, they would not be sufficient to sustain Oatly's continued and desired future growth, which includes expanding to markets outside Europe – most notably the United States and China.

At the same time as the internal organizational change process was happening and the lawsuit unfolding, Oatly was still expanding rapidly, developing new products, establishing new collaborators, and planning moves into new markets. Its production facility in Landskrona, though large, was not enough to accommodate all of the company's new production and packaging needs. Therefore, a number of processes were outsourced in the region. The oat-base itself – the foundation of all Oatly products – is produced in other locations in southern Sweden. Oatly's oats come from other regions in Sweden, outside of Skåne, including Vara and Mälardalen. Regarding packaging, Oatly similarly relies on partnerships in other European countries, with packaging facilities in Schwein, Germany and Ennstal, Austria. This is because Oatly's product range – and thus packaging range – has developed faster than its Landskrona plant can manage.

Oatly's future plans involve moving beyond the European market and into the United States and China. They will begin in the United States, where the cultural and market conditions are more comparable to Europe than they are in China. Here, their production and packaging will take place in New Jersey, and their oats will be purchased from Canada, as domestic oat production in the United States is quite limited. The spatial and temporal dynamics of Oatly's development are depicted in figure 2.3.

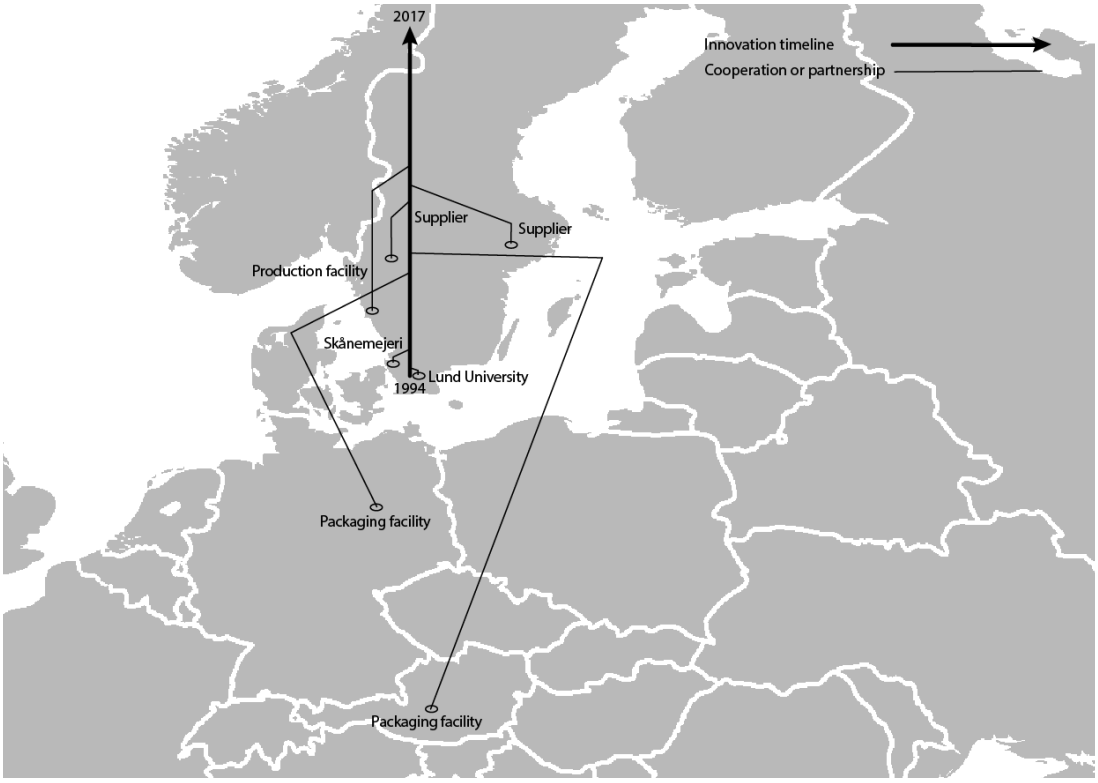

Fig. 2.3. Time-space path of innovation biography, adapted from Butzin & Widmaier (2016)

Impact

The potential impact of switching to plant-based dairy alternatives is vast and affects numerous different sectors and environmental areas, including greenhouse gas emissions, water and land use, biodiversity, air and water pollution, and many more. Dairy operations, for example, consume much greater amounts of water than oat fields, as they need to grow feed, water cows, and manage manure, according to WWF. Likewise, livestock farming is a main contributor to soil erosion worldwide, as the transformation of forests into pasture land or production space for feed crops, overgrazing, and soil impaction can cause serious topsoil loss (WWF, 2018).

As a consumer-facing product, Oatly must not only be concerned with the technical and environmental components of the production process, but also with consumer behavior and market uptake. Unlike some process innovations, where success can be dependent on accessing a small handful of customers, a food product like Oatly must access a broad consumer base in order to be successful and make an impact within the larger dairy industry market.

Currently, the global dairy alternative market is large and competitive, expected to be worth about $16.3 billion USD in 2018, up from $7.4 billion USD in 2010 (PR Newswire, 2017). In addition to other oat milk producers, Oatly also contends with soy, almond, coconut, cashew, and hemp milk dairy alternatives. In its burgeoning US market, Oatly is taking a different

approach than it had in Europe, and targeting coffee shops and cafes rather than only supermarkets. Between March 2017 and 2018, Oatly grew its presence from 10 to over 1,000 coffee shops across the US and expanding to a number of supermarket chains across the Northeast and Mid-Atlantic US.

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3. Green Protein Alliance innovation biography

Context & Framework Conditions

Meat and dairy consumption has risen sharply in recent decades. Although, more recently, willingness to reduce meat consumption has emerged among European consumers, the overall consumption of animal products is still expected to increase (EC, 2017). The wider diffusion of a range of plant-based protein products, could contribute to an accelerated dietary shift and disrupt meat and dairy consumption. The Netherlands is one of the largest producers and markets for plant-based protein products in Europe. However, the market for plant-based protein products remains significantly smaller than the meat and dairy markets. The growth of plant-based protein consumption faces many challenges and particularly low consumer acceptance.

The GPA is an initiative of the plant-based protein products association Het Planeet, the Netherlands Enterprise Agency (RVO) and the private consultancy company New Foresight. It is a multi-stakeholder partnership, which consists of firms from the complete supply chain of plant-protein products, the ministry of economics and knowledge partners such as the Dutch Nutrition Center and environmental NGOs. It aims to change the protein consumption balance in the Netherlands to 50:50 protein in 2025 (plant:animal) by providing a space for sector organization activities such as setting sector-wide product standards, stimulating product development partnerships and new product market introductions, and implementing consumer awareness campaigns and education initiatives.

Between the period 2008-2015, several developments contributed to the later establishment of the GPA. Table 3.1 illustrates key selected events. Increased awareness of the adverse environmental impacts of meat and dairy production led to increased public pressure and political attention. As a response, the need for a “protein transition” entered public discourses. Several NGOs introduced programs that supported plant-based protein consumption. Influential reports from international and national scientific organizations recognized plant-based diets as healthier. During the same period, significant financial resources were directed to plant-based protein innovation. Entrepreneurial experimentation with plant-based protein products, both from start-ups and established firms had been increasing. In 2009, the meat substitutes company Ojah was founded and four years later, in 2012, the founders of Ojah organized the first plant-based protein producers association in the Netherlands, the Planeet.

Year	Event
2008	Minister of Agriculture, Gerda Verburg, calls for attention on protein transition
2008	RVO implements program "Eitwitdialoog"
2009	Ojah is founded
2010	The Vegetarian Butcher is founded
2010	Ministry of Agriculture allocates 1.7 million euro in R&D for plant-based protein products
2010	Ministry of Agriculture integrates with Ministry of Economic Affairs
2011	Health Council of the Netherlands publishes "Guidelines for a healthy diet, the ecological perspective"
2011	NGO Natuur & Milieu launches campaign for plant-based protein products
2012	Het Planeet is founded
2013	RVO launches Doorzaamdoor
2014	Scientific council of the Netherlands publishes "Towards a Food Policy"
2015	Exploration phase for the development of the Green Protein Alliance begins
2016	Dutch Nutrition Center refines dietary guidelines and includes plant-based protein products
2016	The Green Protein Alliance is founded
2017	The Green Protein Alliance publishes the "Green Growth Plan"
2017	Dutch National Food Summit
2017	The Green Protein Alliance officially becomes an association
2017	Unilever in Green Protein Alliance
2017	Voluntary agreement on International Corporate Social Responsibility (ICSR)
2017	Food Valley Summit: Green Proteins
2017	The Protein Cluster is founded

Table 3.1. Summary of selected events

Within the RVO, a few initiatives related to the protein transition had been taken up. The program "Eitwitdialoog", provided space for stakeholders from the Dutch food system, such as retailers, meat firms and NGOs to discuss the possibilities for the acceleration of plant-based protein production and consumption. The scope of the protein transition was broad and included e.g. the development of sustainable protein sources for animal feed. In 2010, the Ministry of Agriculture was integrated with the Ministry of Economic Affairs into a new ministry named Ministry of Economic Affairs, Agriculture and Innovation. The change of minister ultimately led to less political support for the protein transition and progress stagnated. In 2013, the program Duurzaamdoor was founded. Duurzaamdoor aimed to accelerate the development towards a green economy, in several areas, including food. The protein transition re-emerged in the agenda and was chosen as one of the key topics.

Development

One of the co-founders of Ojah and Planeet, Jeroen Willemsen, was the initiator of the Green Protein Alliance. In 2015, Jeroen Willemsen had left Ojah to become an independent consultant. Due to his involvement in Het Planeet, he had developed a strong network in the plant-based protein sector and had become familiar with the challenges firms faced, in terms of demand and their limited reach at influencing consumption patterns. He approached RVO, on behalf of het Planeet, in order to discuss the possibility of a collaboration. At the same time, RVO's efforts, in the framework of Duurzaamdoor, to involve businesses from the food sector in the discussions for the protein transition were not successful. Therefore, they agreed to set up an experts' meeting and explore ideas on how to give a new impulse to the protein transition.

Lucas Simons, the CEO of the consulting company New Foresight was invited to the meeting and New Foresight and Guus ter Haar, a consultant in the company, were chosen to co-ordinate an exploration phase on the stage of the protein transition. The guiding principles behind New Foresight's work were heuristic models for market transformation, the company had developed (Simons, 2014). The models argue that forces of demand, supply and environment determine the character of a sector and its ability to adapt to challenges, and stipulate a set of interventions for the transformation of markets. The models were used by New Foresight, Planeet members and industry experts, to identify barriers that inhibit the transition to plant-based protein consumption and how they could be overcome.

The exploration phase led to a set of suggested activities that would strengthen consumer demand for plant-based products, improve the supply of products and build an enabling environment for the sector. These activities included first developing a shared message for a healthier and sustainable food system, awareness and educational campaigns on the health and sustainability benefits of plant-based products, broadening and improving the supply of products through innovation and coordinating the various initiatives of the sector through a partnership, the GPA.

Different stakeholders from the food system of the Netherlands would have a role in these activities. The government, the Nutrition Center and the environmental NGOs had a role in enabling the sharing of credible information and education relevant to plant-based protein consumption. Producing firms had a role in co-operating on the supply side and product innovation as well as on communicating the shared message for health and sustainability. The role of business to consumer firms, such as retailers, was providing consumers more opportunities for plant-based protein consumption. Particularly the active participation of business, across the supply chain was deemed very important.

"they are the ones that really can change, …, you can do whatever you like and you can, you know, fight for the sense of urgency with the people, but in the end to sell it to the people you need at least a lot of business to consumer companies also, and producers, in the willing, so you need the front-runners." (Interview 2)

"And so then the conclusion was, so if that's what we are going to do, then the missing link is that we had all these meetings for the last 10 years and at none of them, have we even invited retailers, we've never invited food service companies, we've never invited, well we've invited a couple of producers but never the link between the supply chain and the market, right, which is the retailers." (Interview 1)

These insights resonated with Planeet and the RVO, who considered the absence of firms, from the complete supply chain, in their earlier efforts, one of the reasons progress on the protein transition had stagnated. Thus, in 2016, together with New Foresight, they started setting up the alliance.

Implementation

The GPA was financed through the Dutch government and the participating firms. The firms which would participate in the GPA had to contribute a specific membership fee. Three different membership categories were established, representing different firm sizes.

Ensuring firms' participation in the GPA was a challenging and iterative process. Because firms were initially reluctant to invest, the first step was getting them to sign a letter of interest. This letter was used to convince other firms to show interest as well. In July 2016, when enough symbolic support had been developed, 15 firms, including incumbents such as the retailer Albert Heijn and start-ups, invested and officially became members. The evolution of the GPA is illustrated spatially in figure 3.1.

Fig. 3.1 Time-space path of innovation biography, adapted from Butzin & Widmaier (2016)

An important factor in ensuring the participation of firms was the value proposition of the GPA. Investing in the GPA could be a corporate social responsibility action or an opportunity to mitigate long-term risks in the supply chain. Cooperation with the other members would mean cost sharing for a common goal. Cooperation with the government of the Netherlands, the Nutrition Centre and environmental agencies could be a way to legitimize their efforts. The contribution of New Foresight's approach was appealing to the different members by tailoring the value proposition to their specific needs.

"Working together with the government and government agencies or semi-governmental agencies such as the Dutch center for nutrition, gives them a lot of credibility, because the

nutrition center would never work with just one company but they will work together with a number of companies that work together with the government" (Interview 1)

The goal of 50:50 (plant:animal) protein consumption by 2025 was strategically chosen and contributed to the participation of firms as well as of the governmental and independent organizations in two ways. First, it was aligned with the established goals and campaigns of many of the members. Participating in the GPA was an opportunity for members to act upon their established goals. Additionally, the 50:50 target does not directly communicate the message "eat less meat", which was perceived as politically controversial both by the firms and the government. Therefore, it was more easily adopted.

"We asked him, what his purpose and goals were with the GPA. And when he told us that's it was 50:50 until 2025, that fits perfectly." (Interview 3)

"We almost immediately decided to participate. Membership of the GPA was very much in line with our strategic priorities and our mission." (Interview 5)

In February 2017, the GPA organized a public event to introduce the alliance and present its strategic plan, the Green Growth Plan, in which New Foresight's models for sector transformation were the underlying principles of the plan. The overarching vision of a healthier and more sustainable food system was recognized as guiding the activities of the members in the alliance. Accordingly, the plan committed the GPA to set specific standards for plant-based products to comply with the dietary guidelines of the Nutrition center. All members of the GPA committed to efforts that aimed to make plant-based products the "easy" choice for consumers. For example, producers of plant-based protein products committed to scale-up 20 new products, and business to consumer firms pledged to introduce more plant-based product and meals to the market. Knowledge partners undertook the task of providing consumers with credible information relevant to plant-based products.

Moreover, the Green Growth Plan introduced two initiatives for the long-term development of the plant-based protein sector. The first one was a subsidy scheme for the development of innovative plant-based protein products with a budget of EUR 1.8 million. The second one was the partnership between two producers of plant-based protein products and a university of applied sciences. They developed an educational program through which students could be trained in activities relevant to the complete supply chain of plant-based products.

The development of the GPA and the Green Growth Plan received significant political support from the, at the time, Secretary of State, Martijn Van Dam. He supported the ministry's participation in the GPA and enabled the subsidy for plant-based protein innovation. He was also present at the presentation of the Green Growth Plan and endorsed the alliance's efforts.

Impact

The GPA has contributed to the development of a more enabling environment for plant-based protein consumption through the commitments the members made in the Green Growth Plan. It triggered knowledge sharing between firms, new product development partnerships, the introduction of new products and plant-based protein meals, mobilization of public resources for innovation and establishment of an educational program for plant-based protein innovation. Additionally, it managed to attract new members such as Unilever, one of the

biggest agri-food firms globally and therefore the potential impact of GPA projects is growing.

The extend that the GPA has been embedded in the different members and partners varies, depending on the organization's scope. For instance, HAK, a bean producer firm, has been involved in at least one partnership, the educational program and has a representative in the board of the GPA. However, the fact that all the members and partners officially committed to the goal of changing the protein consumption balance in the Netherlands to 50:50 (animal:plant protein) in 2025 for a healthy and sustainable food system is an important step in legitimizing the consumption of plant-based protein products.

Moreover, the GPA constitutes an important step in establishing novel cognitive associations for plant-based products. It connects producers of different products such as meat and dairy substitutes, mushrooms and beans, and structures the sector of plant-based protein products. In this way, it attempts to reframe the relationship between product categories and their service. By defining the shared vision of a healthy and sustainable food system, the GPA further attempts to link the new sector of plant-based protein products with the health and environmental impact of meat and dairy consumption and introduce it as a sustainability pathway. The support and membership of the government of the Netherlands and independent knowledge partners contributes in legitimize this message.

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4. Ojah innovation biography

Context & Framework Conditions

Meat and dairy production contributes significantly to climate change. It is estimated that it accounts for about 14.5% of global GHG emissions (FAO, 2013). Meeting the EU 2050 emission reduction targets will require the deep decarbonization of the agri-food sector. Reducing consumption of livestock products in European countries could be part of the solution towards deep decarbonization. The diffusion of innovations, such as a wider range of plant-based meat substitutes, could contribute to an accelerated dietary shift and disrupt meat and dairy consumption.

The majority of plant-based meat substitutes are produced by cooking extrusion technology. The basis of the technology is a screw system within a barrel. In the barrel, raw materials are compressed and heated to high temperatures at high pressures before being extruded (Phillips & Williams, 2011). The resulting product is further processed for the development of finished meat substitutes.

Cooking extrusion is a category, which includes different processes. Products developed at a low moisture content level (low-moisture extrusion process) have existed in Europe since the 1960's (Aiking et al., 2006). The majority of these products are extruded defatted soy flour or flakes and soy concentrates, commonly referred to as Textured Vegetable Protein (TVP) (Asgar et al., 2010). In low-moisture extrusion, the protein product expands and requires a hydration process before it is transformed into a meat substitute. Products developed at a high moisture content level (high-moisture extrusion process) are relatively new. Due to the higher moisture content during the process, the product is dense and does not require hydration (Cheftel et al., 1992). It is characterized by well-defined fiber formations that closely resemble meat structure and have enhanced taste sensation (Lin et al., 2000; Yao et al., 2006). Therefore, higher moisture extrusion products can better satisfy consumer expectations.

The founders of the company Ojah, Frank Giezen, Jeroen Willemsen and Wouter Jansen developed a high moisture extrusion process for turning vegetable protein composition into meat-like structures. The product "Beeter" or "Plenti" is produced, with a similar moisture level and bite to meat, and can be further processed into a variety of end products comparable to chicken, beef, pork or fish. Between the years 2005-2017, several events contributed to the development of Ojah. Table 4.1 illustrates key selected events.

Year	Event
2005	TOP BV is founded
2006	Development of high-moisture extrusion process is initiated
2008	Upscaling-test
2009	Ojah is founded
2010	The Vegetarian Butcher is founded
2012	Ojah in first place of SME Innovation top 100
2012	Het Planeet is founded
2013	Ojah among the winners of the Oranje Handelsmissiepakket award
2016	The Green Protein Alliance is founded
2017	Ojah acquired by Korys

Table 4.1 Summary of selected events

Development

The founders of Ojah met while working at Wageningen Research (WR) and shared many years of experience in the agri-food sector. In 2005, Frank Giezen had left WR and co-founded the company TOP BV, a service provider for the development of food products and technologies. The high-moisture extrusion process of Ojah was developed in 2006, within TOP BV. The process did not arise from the intention to develop a meat substitute, but rather from curiosity (Sprout, 2011). The three founders applied techniques from the polymer industry to plant based proteins, and this resulted in the development of long muscle-like fibers of protein (Sprout, 2011). The product's quality and taste was perceived as unique and therefore, the three founders decided to move forward in setting up the firm Ojah.

TOP BV provided the incubation ground for Ojah to further develop the high-moisture extrusion process. The access to expertise and facilities allowed the innovators to steadily continue their work in-house. Substantial effort was put in early on. First, obtaining patents and intellectual property rights was carefully tended to, to ensure that the technology was secured. During that time, an upscaling test was implemented to assess whether the extrusion process could successfully upscale to industrial production. The result of the upscaling test was positive and Ojah was founded in 2009. Figure 4.1 illustrates the time-space path of the innovation process.

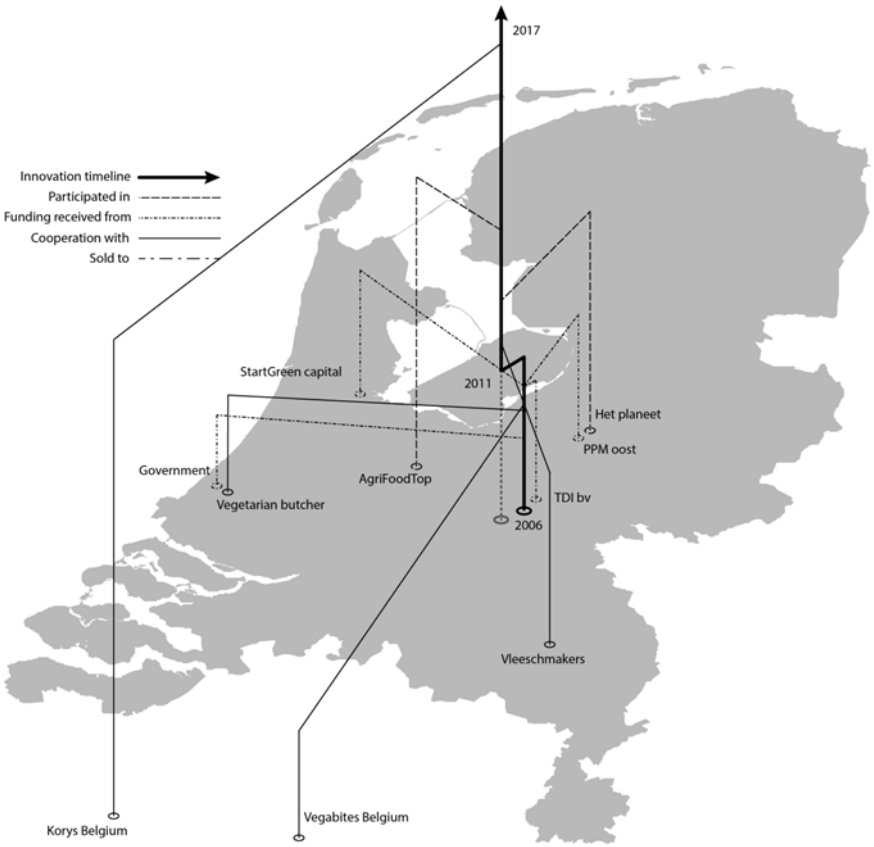

Fig. 4.1. Time-space path of innovation biography, adapted from Butzin & Widmaier (2016)

Implementation

The early production of Beeter was taking place in a hired facility, by the three founders. The upscaling of their production proved one of the most challenging phases of the innovation process, as there were many bottlenecks, including ensuring food safety, consistent output and stable quality. The upscaling test that had been conducted earlier, contributed to overcoming these challenges. However, in order to further develop, Ojah needed to establish its own production facility. The first production facility was funded through a regional investment agency and venture capital funds. Particularly, the investments were realized by PPM Oost, a regional investment agency that promotes the economy of the provinces of Gelderland and Overijssel, in the east of the Netherlands, and the venture capitals TDI-BV and StartGreen capital. A total of 1,5 million euro was raised and the production plant of the company was built in Ochten, with a production capacity of 800 tons.

Partnering with a launching customer, The Vegetarian Butcher, proved to be pivotal in the development of Ojah. During that time, The Vegetarian Butcher had an innovative marketing idea for a meat substitute products store in The Hague. The base for the meat substitute products was Beeter, supplied by Ojah. The Vegetarian Butcher was launched in October 2010, on the 'National Animals' Day' and obtained significant publicity. In the following 7 years, The Vegetarian Butcher firm grew from one store in The Hague to one of the most popular meat substitute products firms in the Netherlands. Since Beeter is not a consumer-facing product, the partnership with The Vegetarian Butcher was very useful in developing the market for Ojah.

During the following years, Ojah attracted more customers in the Netherlands and abroad. For instance, Ojah supplied the Belgian firm Vegabites and the Dutch firm Vleeschmakers. Additionally, Ojah did not only expand in terms of sheer volume of output, but also in terms of product range. Up to 2013, 27 Beeter products were available in the Netherlands, 6 in Belgium and 5 in Germany, under the name Plenti (Evmi, 2013).

In 2012, Jeroen Willemsen, one of Ojah's founders, organized Het Planeet, the first industry association for producers of meat substitutes in the Netherlands. The idea behind Het Planeet was cooperating to achieve an increase in the market share for plant-based meat substitutes. Ojah, sought to work together with other firms in order to increase their knowledge and their network on the demand side of meat substitute products. Several firms became members in Het Planeet and since then several knowledge and product development partnerships have been forged.

Additionally, in 2016, Het Planeet became one of the founding members of Green Protein Alliance (GPA). The GPA is a multi-stakeholder partnership, which consists of firms from the complete supply chain of plant-based meat substitutes, the ministry of economics and knowledge partners such as the Dutch Nutrition Center and environmental NGOs. It aims to change the protein consumption balance in the Netherlands to 50:50 protein in 2025 (plant:animal). The GPA provided the opportunity for firms to reach out to the wider agri-food sector and implement collaborative activities for the development of the market.

The innovation of the high-moisture extrusion process of Ojah has received significant recognition. In 2012, Ojah made it to the first place of SME Innovation top 100 in the Netherlands. In 2013, Ojah was among the winners of the Oranje Handelsmissiepakket award, which offers firms access to an international network and the ability to participate in official trade missions from the Dutch government. As a result, Ojah expanded internationally. In 2014, Beeter was nominated for Invention of the Century by popular science magazine Quest.

Ojah matured to be an established industrial actor. In 2016, Ojah established a second production line in Ochten. By 2017 Ojah's products were available in 22 countries throughout the whole world. In 2017 the firm was sold to Korys, a Belgian investment company. Overall, expectations for the growth of the firm are positive. The managing director, Frank Giezen, expects a possible quintupling of 2016's 4 million turnover for the next five years, and the establishment of 5 additional production lines by 2020 (Bron, 2017; Moolenaar, 2017).

Impact

At the time of the introduction of Ojah, the majority of meat substitute products in the Dutch market were based on TVP. The market share of meat substitutes remained very small for decades, mainly due to the structure and taste of products that could not satisfy consumer expectations. Ojah managed to up-scale a high-moisture extrusion process and develop a plant-based meat substitute of higher quality in terms of structure and taste. In the following years, several firms used Beeter for product development. Therefore, the establishment of Ojah contributed to widen the variety of meat substitutes in the Dutch market and higher acceptance of products by consumers.

The high-moisture extrusion process of Ojah offers additional benefits, including a broader range of plant-based ingredients that can be used as raw materials and the development of products that fulfil attributes, such as "gluten free". It allows the development of products that

satisfy key long-term consumer trends, such as ‘local origin of raw materials’ and “health conscious diets”. Therefore, it contributes in the long-term robustness of the sector of meat substitutes.

Finally, the founders of Ojah contributed significantly in the promotion of the sector of meat substitutes in the Netherlands. By setting up the first industry association, Het Planeet, they enabled knowledge diffusion and co-operation among firms, a crucial process in emerging sectors. Additionally, by participating in the development of the GPA they contributed in expanding the market for plant-based protein products.

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5. Cardyon innovation biography

Context & Framework Conditions

The negative environmental consequences of plastic use are well known and constantly developing. While plastic pollution in oceans and waterways has garnered particular attention of late and remains a formidable and immediate challenge, the entire life cycle of plastics must be managed more sustainably in order to respond to growing environmental concerns. For example, oil is the primary chemical feedstock for plastic production in Europe and Asia, and currently between 4% and 8% of global oil production goes to making plastics, with business as usual scenarios expecting this figure to rise to about 20% by 2050 (Center for International Environmental Law, 2018). Yet, there is growing public concern for the environmental and economic consequences of oil consumption, and an increasing interest in reducing oil, coal, and gas consumption and finding viable alternatives.

Covestro has spent the past 10 years exploring these alternatives in an effort to use more sustainable feedstock for plastic production. This has led to the creation of one of its flagship products, cardyon. Cardyon is a raw material for the production of high quality and flexible polyurethane foams, made using up to 20% CO_2 instead of fully crude oil. The product was created through a two-stage research program that included a number of departments from Bayer (from where Covestro was created), headquartered in Leverkusen, Germany, as well as RWTH Aachen University and energy providers. A summary of selected events in the development of cardyon can be seen in Table 5.1.

Year	Event
2004	Bayer MaterialScience becomes an independent subgroup of Bayer
2008	Dream Reactions project launched
2010	Dream Production project launched
2014	Covestro established as a legal independent company, formerly Bayer MaterialScience
2016	Covestro opens the production facility which creates cardyon in Dormagen, Germany

Table 5.1. Summary of selected events

Development

The development of cardyon started in 2008 with the publicly financed project, “Dream Reactions”. Funded by the German Federal Ministry for Education and Research (BMBF), the goal of this project was to develop an improved catalyst for mobilizing CO_2 and to better understand its principle mode of action (Bayer Technology, 2010). The main collaborators on the project were Bayer MaterialScience, Bayer Technology Services, and the CAT Catalytic Center of the RWTH Aachen University. It is Bayer MaterialScience that would ultimately, in 2015, branch off from Bayer to become the independent company, Covestro.

Because the carbon and oxygen atoms of CO_2 are tightly bound, it is difficult to move them from an inert to an active state, allowing it to function as a raw material. This is why a catalyst

is required to provide the activation energy needed to allow this process. However, not just any catalyst can do this, as it must be efficient enough to warrant the energy used in processing it. Thus, the ability for this research program to develop a useful catalyst for this process was a major milestone in the development of cardyon and Bayer's plans of creating more sustainable chemical feedstock for plastics.

With a promising catalyst developed, the project team began its second phase in 2010, dubbed "Dream Production". This research project moved from laboratory experiments to technical scale production at a pilot plant in Leverkusen, Germany. A new partner also joined Bayer Material Science, Bayer Technology Services and the CAT Catalytic Center: RWE Power, one of the largest electricity producers in Germany (Bayer Technology, 2010). The utility provided the CO_2 from its lignite-fired power plant in Niederaussem, Germany. This addition secured the main ingredient of CO_2 needed to run the technical process. In total, Germany's BMBF invested over 45 million euros in this project over its three years. The spatial and temporal dynamics of cardyon's development are depicted in figure 5.1.

Since 2016, Covestro has maintained full control over the production of its now patented CO_2 catalyst, cardyon. It is produced at the company's Dormagen plant, which has an annual capacity of 5,000 metric tons. The CO_2 processed is a waste product from a neighboring chemical facility.

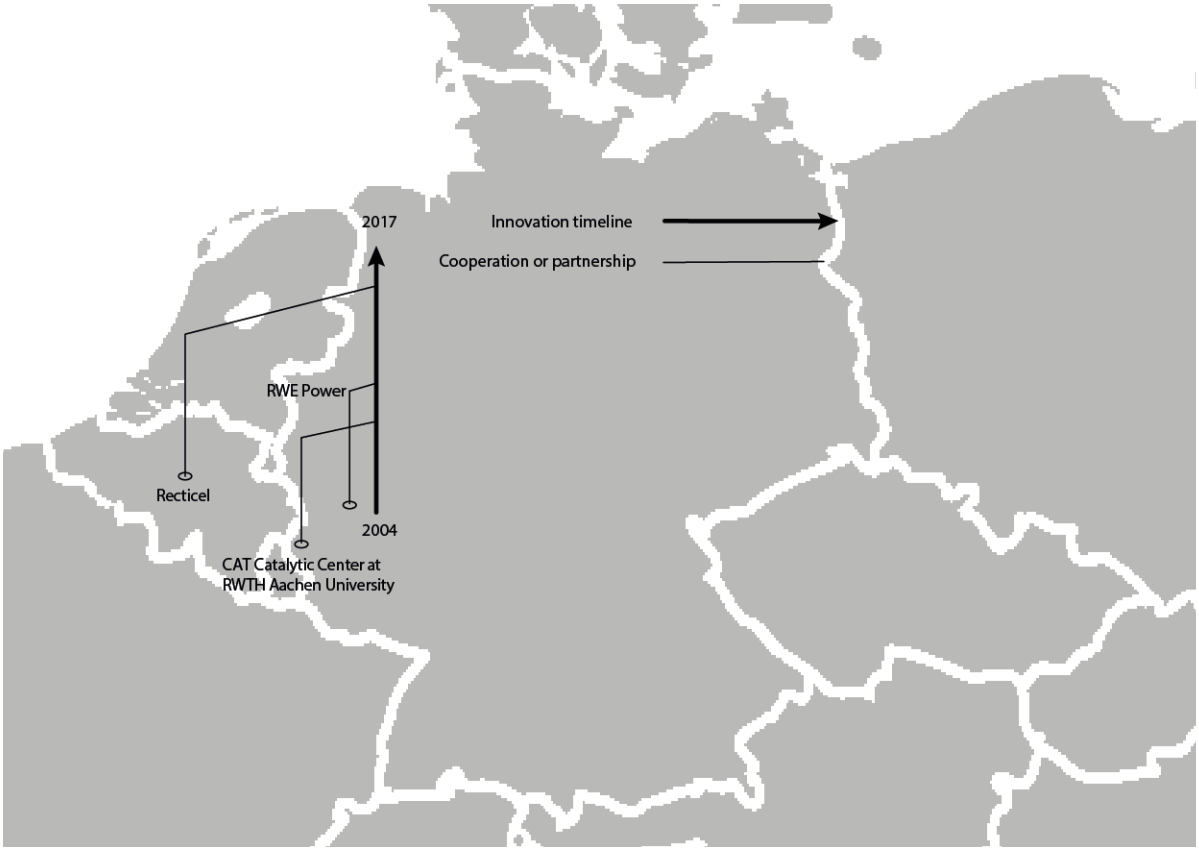

Fig. 5.1. Time-space path of innovation biography, adapted from Butzin & Widmaier (2016)

Implementation

The first commercialized product that utilizes cardyon is the KAPUA® foam mattress from Recticel, which hit the market in 2016 (figure 5.2). According to the company, these mattresses are made of polyurethane foam, which is typically created by combining di-isocyanates and polyols, made from crude oil (Recticel, undated). By using cardyon, though, about 20% of the crude oil use is eliminated and replaced with CO_2 feedstock instead. According to Recticel, two versions of the KAPUA mattress are currently available, the KAPUA®M130 for mattress cores and KAPUA®S90 for mattress top layers.

Recticel is clearly proud of its association with this climate-friendly innovation, taking the time to explain on its website just how the process works, describing how the discovery of a usable catalyst by Covestro was the key development in turning CO_2 into productive input material. The company also contextualizes the development by framing the innovation within the context of rising CO_2 levels, ice core records in the Artic, and the 2015 Paris agreement.

Fig. 5.2. Recticel's KAPUA mattress showcases that it is made with a climate-friendly innovation (Recticel, undated).

According to Covestro, the company plans to extend its applicability beyond flexible polyurethane foam based on CO_2 in the near future. They are working to apply the cardyon technology to other types of plastics, and aim to develop a range of CO_2-based polyurethane materials. This includes, for example, plans to apply the cardyon technology to thermoset elastomers. These are a class of copolymers or a physical mix of polymers (usually a plastic and a rubber) made of materials with both thermoplastic and elastomeric properties. These could be, for example, gaskets or seals.

Impact

The impact of cardyon is twofold: first, it will work as a type of carbon sequestration, preventing waste CO_2 from being emitted into the atmosphere. Second, the utilization of an otherwise wasted CO_2 resource in the production of plastic products prevents the need for as much crude oil use as would otherwise be necessary.

Cardyon is one product in a larger trend of creating value from waste products. Many of these innovations stem from utilizing plastic waste, with high-profile examples including a venture between Adidas and ocean advocacy organization, Parlay for the Oceans. Their retail line includes men's and women's running shoes, football cleats, apparel, and swimwear which is partially made from plastic waste found on beaches and coastal communities (Adidas, undated). What sets Covestro and cardyon apart is that it is utilizing a less tangible, yet equally abundant, waste resource of CO_2. Moreover, the key turning point in cardyon's development has been the technological breakthrough of finding the catalyst that allows the process to operate efficiently.

As this innovation is fairly new and only commercialized in the form of one product, currently, the extent to which it will impact or transform the plastics industry remains to be seen. Additionally, it is important to remember that that 80% of the feedstock for cardyon products must still come from crude oil. This highlights the complex nature of the debate around plastics and plastic use. Ultimately, technical innovations that seek to reduce the environmental impact of plastic production must also be combined with social and governance innovations that aim to change behavior and reduce the use of plastic.

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6. LignoBoost innovation biography

Context & Framework Conditions

Currently (2016), global paper and cardboard production is around 411 million tonnes (Statista, 2018). Despite an increase in electronic and digital communications, the industry continues to grow, with production expected to reach 490 million tonnes by 2020 (Bajpai, 2014). Much of this growth actually goes hand in hand with the rise in digitization, as packaging and shipping material use continues to grow alongside online shopping. The pulp and paper industry is also very resource intensive; it ranks as the fourth largest industrial energy user, according to the International Energy Agency (IEA), consuming approximately 6% of the world's industrial energy and producing around 2% of worldwide industrial CO_2 emissions. Much of this energy is used during heating processes and electricity needed during the production process (Shabbir and Mirzaeian, 2017).

In order to address these issues and reduce the environmental impact of pulp and paper production, a number of enterprises are working to develop solutions that will reduce energy use and improve efficiency. One such innovation is LignoBoost, developed by a team of partners headed by RISE, a collaboration of research institutes in Sweden. LignoBoost is an innovative process by which black lignin is extracted from the paper production process and cleaned, allowing it to function again either as a fuel or in other capacities. An organic polymer, lignin is one of the most common materials in wood, in addition to cellulose and hemi cellulose. It has a heating value similar to carbon, making it a useful fuel alternative when treated properly (Valmet, 2015). LignoBoost works by treating the black liquor from the kraft pulping process with carbon dioxide and acid. This allows the lignin to be precipitated, washed and dried. The key element in this innovation is the washing process, as other innovations have figured out how to remove black lignin, but none have been able to return it to such a clean state. The extraction and cleansing of lignin from black liquor allows the solid dried powder to be used in-house as a replacement for oil or gas fuel for the lime kiln, or sold as a fuel or raw material in the production of other products, like carbon fiber. The LignoBoost process thus makes it possible to expand the capacity of a pulp mill at a lower cost and with less fossil fuel energy.

Since the development of LignoBoost began in 1996, several key events have contributed to its growth and shaped its implementation (table 6.1).

Year	Event
1996	Lignin development begins with the KAM research program
2000	The concept behind LignoBoost is discovered
2003	FRAM "Future resource-adapted pulp mill" research program launched to further develop this knowledge and design a functional plant
2006	Bäckhammar demonstration plant opened and technical patent created
2006	FRAM 2 research project launched
2008	Valmet acquires LignoBoost technology from RISE
2009	LignoFuel research program starts
2013	LignoBoost-equipped plant owned by Domtar opens in Plymouth, North Carolina, USA
2015	LignoBoost-equipped plant owned by Stora Enso opens at Sunila mill in Kotka, Finland

Table 6.1. Summary of selected events

Development

The LignoBoost process first began in 1996 with the creation of a research program called KAM (Circular Pulp Mill), headed by a number of partners including the state-owned network of Swedish research institutes, RISE (then known as Innventia), and the Finnish technology supplier, Valmet. Other collaborators in the program included Chalmers University, pulp and paper companies Stora Enso and Sodra Cell, and Fortum, the Swedish energy producer. This research program had a number of goals mostly concerning how technological breakthroughs can help the paper production process, and one of these hoped-for breakthroughs was the extraction of black lignin. In 2000, this breakthrough was realized, and the team was successful in figuring out how to extract black lignin from the production process and wash it, allowing a cleaner by-product.

With the innovation developed, the next step for Innventia was to optimize the lignin extraction and cleaning process with the goal of creating a functional plant to carry out the work. To do this, they started another research program, called "Future resource-adapted pulp mill", or FRAM, more specifically focused on this task. During this time, from around 2000 to 2006, a number of trials and lab tests were undertaken, either in labs at Chalmers University in Gothenburg, Sweden or at a paper plant in Bäckhammar, Sweden then owned by Borregaard Lignotech, a Norwegian company.

FRAM morphed a new incarnation in 2006, FRAM 2, during which time Innventia got the opportunity to purchase the Bäckhammar plant, as Borregaard Lignotech had recently been bought out by another company and the plant would otherwise be abandoned. This was a crucial turning point for Innventia and the LignoBoost process, as the purchase of the plant offered them the chance to demonstrate the LignoBoost technology at a large scale, which is usually a major hurdle in commercializing a new technology and would otherwise likely not have been financially viable. While some redesigns were made to accommodate the LignoBoost patents, given that Bäckhammar was an old, existing plant, Innventia had to utilize much of the existing infrastructure. If they had had the opportunity to build their own plant from scratch, they would likely have created a different set up, however, the low-cost access to the existing infrastructure of this plant was invaluable in testing and commercializing LignoBoost. An important collaborator during the FRAM programs was the

filter supplier, Metso. As part of their investment in the LignoBoost process, the supplied filters free of charge – a crucial element in the LignoBoost technology.

In 2008, LignoBoost intellectual property rights were purchased by Valmet. They maintain a collaboration with Innventia, though, as Innventia still owns the Bäckhammar plant and has crucial tacit knowledge about the process, having been a part of it from the very beginning. In 2015 the LignoFuel research program began, which studied and tested new equipment and production processes at the Bäckhammar plant, exclusively.

Implementation

When Valmet sells the LignoBoost technology to pulp and paper producing companies, they are selling the entire plant at which the process takes place. This means that Valmet is responsible for the groundwork, buildings, steelwork, pumps, tanks, control systems, etc. at the plants it sells. As such, every plant is a major operation. Two pulp and paper plants are currently using LignoBoost's technology: one operated by Domtar in Plymouth, North Carolina, USA and one by Stora Enso in Kotka, Finland. Stora Enso's plant involved an investment of 32 million Euros (Stora Enso, 2014). The Domtar mill has an annual capacity of 466,000 ADMT of softwood kraft pulp. The LignoBoost technology allowed the mill to de-bottleneck its recovery boiler and sell the pulp. The process proved immediately beneficial to the mill, serving as a fuel for its own use and a funding source (Valmet, undated). Domtar currently sells a registered product, BioChoice Lignin, which can be used for a number of applications, including adhesives, agricultural films and chemicals, carbon products, coatings, fuels and fuel additives, natural binders, plastics, and resins (Domtar, 2018). Stora Enso's Sunila mill has a slightly smaller production, at 370,000 ADMT and has also created a new revenue stream for the company through the sale of high quality lignin (Valmet, undated).

While Valmet has goals of selling more plants in the future, a current obstacle facing their sales is that many potential customers are unsure what exactly to do with the clean extracted lignin. This uncertainty makes investment calculations difficult and the result is a reluctance to purchase. Still, interest in LignoBoost is growing, and the paper industry as a whole has been a driving force in its development and popularity. According to Henrik Wallmo, research and development manager for pulp mill processes at Valmet, four main factors have contributed to the current implementation of LignoBoost: (1) the pulp and paper industry's commitment over the past 10 years to making the production process of pulp and paper less energy intensive by focusing on energy efficiency and energy surplus, thereby incentivizing the development of CO_2 emissions saving technologies; (2) the industry's interest in turning those energy savings and energy surplus into the production of products other than solely pulp and paper and expanding their reach into, for instance, fuel creation through lignin extraction and cleansing; (3) the Bäckhammar demonstration plant and its ability to showcase the technology's potential at a commercial scale. These three driving factors illustrate how events both within and internal to the innovation process combine with much larger industry and cultural shifts to create the conditions under which an innovation like LignoBoost can thrive; (4) critical financial investment from the Swedish Energy Agency.

Despite these driving forces, the implementation of the LignoBoost technology has not been without its obstacles. Two issues and events have been particularly noteworthy for Henrik Wallmo. Ironically, despite the Swedish Energy Agency's crucial role in driving the process forward through its investment, it also played a part in slowing the innovation down. This is

because in 2010, the Agency made a call for companies to apply for government funding if they were going to undertake a major environmentally beneficial project. Södra Cell, one of the world's largest pulp suppliers based in Sweden, applied for this funding in order to build a plant equipped with LignoBoost – what would have been the first of its kind – and was selected to be a recipient. However, according to Wallmo, concerns of competition and fairness were raised, and so the Swedish government asked the European Union to review their selection process to ensure that the results were fair and that no companies had received preferential treatment. Unfortunately, this stalled the development process and Södra Cell ended up not investing in LignoBoost's technology due to the long waiting time.

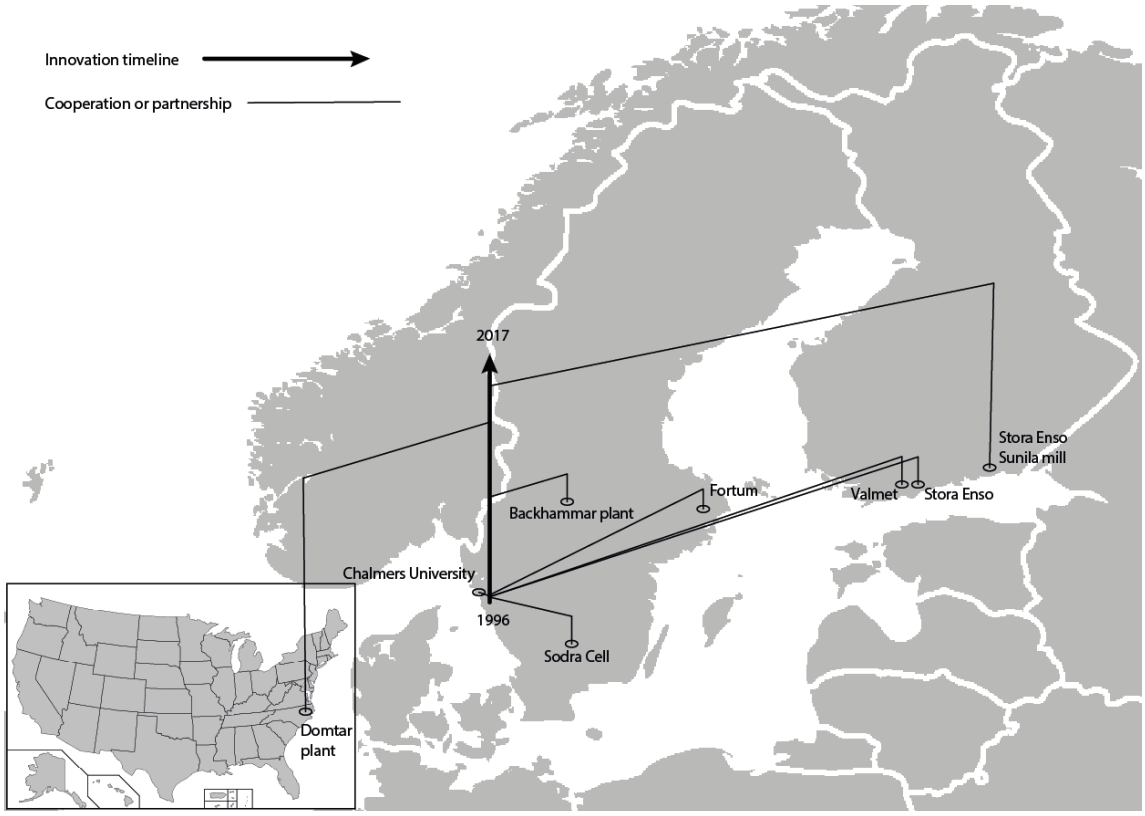

Fig. 6.1. Time-space path of innovation biography, adapted from Butzin & Widmaier (2016)

Impact

LignoBoost is expected to have an impact across a number of fields and applications. One of the key features of LignoBoost is that it's clean extraction of lignin allows companies to replace traditional fuel with lignin. This allows them to save on energy costs and reduce carbon emissions. At the Stora Enso Sunila plant in Finland, for example, lignin, extracted through the LignoBoost process, has replaced 70% of the natural gas used to fire lime kilns. This has resulted in a reduction of CO_2 emissions by 27,000 tonnes per year, according to the company (Stora Enso, 2016). According to Valmet, the potential savings of using lignin in lime kilns are as much as 50 liters of fuel oil per ton of pulp (Valmet, 2016).

Another application is to sell lignin as a fuel to other companies as an additional revenue source. Third, and most exciting, yet also least proven, is the potential for lignin to be sold as a chemical precursor that could play a key role in the production of other materials. Lignin is anticipated to offer an alternative to phenols used in plywood, paper lamination and insulation material; glues for wood paneling; and polyols used in foams. All of these materials are common in the construction, petrochemical, and automotive industries (Stora Enso, 2014; undated). Stora Enso is already selling Lineo™, its kraft lignin made via the LignoBoost process, to replace phenol. The product was recently awarded "Bio-Based Product of the Year" at the Bio-Based World News Innovation Awards, 2018.

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