LignoBoost

An innovation biography

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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.

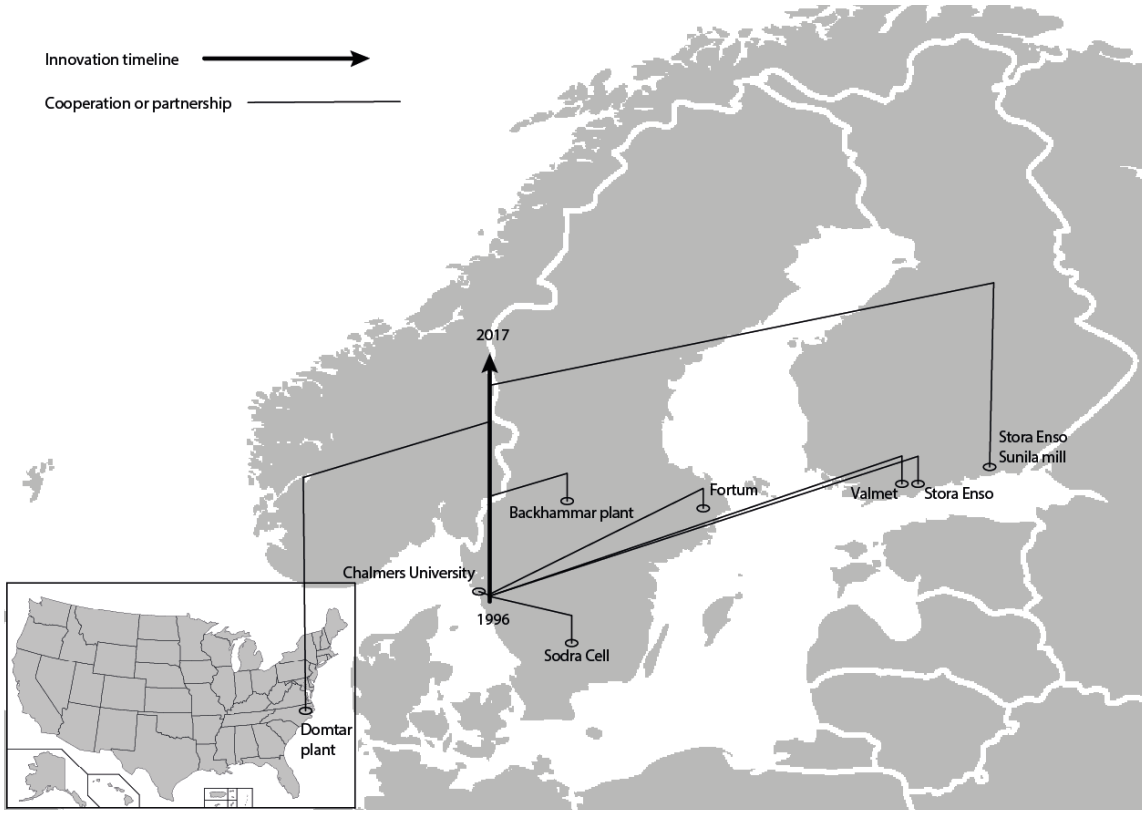

Fig. 6.1. Time-space path of innovation biography, adapted from Butzin & Widmaier (2016)

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.

References

Bajpai, P. (2014). Introduction. In Bajpai, P. Recycling and Deinking of Recovered Paper. London: Elsevier.

Butzin, A., & Widmaier, B. (2016). Exploring Territorial Knowledge Dynamics through Innovation Biographies. Regional Studies, 50(2), 220-232.

Domtar. (2018). BioChoice Lignin. <https://www.domtar.com/en/what-we-make/biomaterials/biochoice-lignin> Accessed 18 July 2018.

Shabbir, I. and Mirzaeian, M. (2017). Carbon emissions reduction potentials in pulp and paper mills by applying cogeneration technologies. Energy Procedia, 112, 142-149.

Statista. (2018). Production volume of paper and cardboard worldwide 2006 to 2016 (in million metric tons). <https://www.statista.com/statistics/270314/production-of-paper-and-cardboard-in-selected-countries/> Accessed 27 September 2018.

Stora Enso. (2014). New kind of gold from Nordic forests. <http://www.storaenso.com/newsandmedia/new-kind-of-gold-from-nordic-forests> Accessed 18 July 2018.

Stora Enso. (2016). Lignin of tomorrow. <http://www.storaenso.com/newsandmedia/lignin-of-tomorrow> Accessed 18 July 2018.

Stora Enso. (undated). Lignin solutions. <http://biomaterials.storaenso.com/ProductsServices-Site/Pages/Lignin.aspx> Accessed 18 July 2018.

Valmet. (2015). Valmet-supplied LignoBoost plant now handed over to Stora Enso's Sunila mill in Finland. <https://www.valmet.com/media/news/press-releases/2015/valmet-supplied-lignoboost-plant-now-handed-over-to-stora-ensos-sunila-mill-in-finland/> Accessed 18 July 2018.

Valmet. (2016). Valmet in circular economy. <http://www.baltic.org/wp-content/uploads/2016/04/Valmet-Circular-Economy-Presentation_public.pdf> Accessed 18 July 2018.

Valmet. (undated). First LignoBoost plants producing large volumes of kraft lignin to the market place. <https://www.valmet.com/media/articles/up-and-running/new-technology/PEERS1stLignoBoostPlants/> Accessed 18 July 2018.

For Europe to achieve its long-term climate objectives, carbon-intensive industries have to reduce their emissions.

REINVENT focuses on plastics, steel, paper and meat & dairy – industrial sectors that are key to our daily lives, but where low-carbon transitions are still relatively unexplored.

To gain a broader understanding of the possibilities of transition, entire value chains of the industries are studied. This includes non-technical factors such as supply chains, financing, trade, and social and economic impacts. Together with forward-looking industry leaders and policy-makers, we explore potentials and capabilities for making transitions in these resource-intensive industries.

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