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Towards Circular Business Models Experiences in Eight Danish Companies

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1. Foreword

This report was prepared as part of the Closing Material Loops research project led by the Department of Development and Planning, Aalborg University. The goal of the project was to examine the relevance of circular business models to the participating companies as well as gain practical experience with the circular business model innovation process.

The first report yielded by the research project, 'Best Practice Examples of Circular Business Models', presented the basic principles of circular economy and international best practice examples of circular business models; it can be found via the homepage of the Environmental Protection Agency: <http://www2.mst.dk/Udgiv/publications/2016/06/978-87-93435-86-5.pdf>

This report concerns the practical development of initiatives based on circular economy in eight Danish companies. The report outlines how each of the participating companies attempted to advance towards circular economy during 2014 and 2015 and the outcomes in each case. The case descriptions have been approved by each of the companies.

The purpose of the report is to disseminate knowledge generated from the companies' collaborations with academics in the field of sustainable business development and circular economy in particular, in the hope that this will improve understanding of how to work towards circular economy from a company perspective.

The author would like to thank Aalborg University and the MUDP program of the Ministry of Environment and Food of Denmark for funding this project.

This study would not have been possible without the interest and engagement of the participating firms, and the author wishes to thank Gabriel, KnowledgeCotton Apparel, Schilder and Brown, Danfoss, Grundfos, AVV, Kuvatek, and Siemens Wind Power for their contributions to the project.

The author would also like to thank Martin Lehmann and Rikke Dorothea Huulgaard, Aalborg University for their comments on an earlier version of the manuscript; and Signe Kromann-Rasmussen, Ministry of Environment and Food, for fruitful co-operation throughout the Closing Material Loops project.

Eva Guldmann
Aalborg, September 2017

2. Summary and conclusion

The concept of circular economy has been proposed as a model for sustainable business operations that generate both environmental and economic benefits for companies and society at large, but little has been known about how companies can examine the relevance of the concept to their specific business or how they can develop viable circular business models. The purpose of the Closing Material Loops project was to address this lack of knowledge about the practical application of the circular economy concept. The Closing Material Loops project was carried out during 2014 and 2015 as collaboration between researchers from Aalborg University and eight Danish companies.

2.1 Background

During the Closing Material Loops project the participating companies began examining whether the concept of circular economy was interesting in their particular business context. This report presents the results from these explorative investigations. It outlines how the investigation process unfolded and what the results were. The target audience of the report is practitioners in the field of sustainable business development and circular economy such as business developers, sustainability consultants, and business consultants in addition to researchers.

For an introduction to the field of circular economy, circular business model innovation, and concrete examples of circular business models in operation please see the first report from the project 'Best Practice Examples of Circular Business Models'. The report can be found - like the present report - at the Danish Environmental Protection Agency's homepage (<http://www2.mst.dk/Udgiv/publications/2016/06/978-87-93435-86-5.pdf>).

A brief overview of circular economy initiatives carried out in some of the companies participating in the Closing Material Loops project is presented in Danish in the pamphlet 'Ressourceeffektivitet og cirkulær økonomi: Nordjyske eksempler', which was prepared in collaboration with Netværk for Bæredygtig Erhvervsudvikling NordDanmark ([http://vbn.aau.dk/en/publications/ressourceeffektivitet-og-cirkulaer-oekonomi\(daaf6e37-d0f9-456c-99b8-02bc986332be\).html](http://vbn.aau.dk/en/publications/ressourceeffektivitet-og-cirkulaer-oekonomi(daaf6e37-d0f9-456c-99b8-02bc986332be).html)). Similar cases can be found at the homepage of Netværk for Bæredygtig Erhvervsudvikling NordDanmark (www.nben.dk/cases).

2.2 Circular business models and technological innovation

Circular economy is in our understanding a sustainability concept in which companies move beyond optimization of resource efficiency in a linear value chain towards actively closing resource loops and creating circular value chains. Maintenance, repair, upgrades, reuse, refurbishment, remanufacturing and recycling are examples of potential means, which companies can integrate into their business models to keep products, components and materials in use at their highest utility for as long as possible. The process of identifying opportunities to narrow, slow and close resource loops is referred to as circular business model innovation.

Efforts related to clean technology and environmental technology have historically focused on technological innovations. This type of technology solutions does not necessarily affect the business models (i.e. the fundamental way in which a company operates). In this project, an overall mapping of circular business potentials was carried out together with key employees in the participating companies, and the ideas that emerged spanned from implementing product take-back schemes, over product design changes to improve performance, to establishing product-service systems.

Based on the discussions and the mapping of potentials for circular business models some key realizations can be highlighted:

- Designing products to ease repair (modularization, spare parts, etc.) and maintenance as well as prolonging the product lifespan were initiatives considered in most of the companies
- Product development for reparability, durability, reuse and refurbishment demands new business models (e.g. service contracts and product-service systems) to fully realize the business potentials
- Product take-back is a core element in circular business models, which requires that product disassembly is possible as well as the establishment of reverse logistics and to some extent of socio-economic work places
- Digitization in the form of collecting data on the product use is a means to improve predictive maintenance, product development, and product take-back system efficiency
- Circular business model innovation is stimulated via collaboration between value chain partners and between companies and customers (e.g. demonstration projects within business to business relations was high-lighted as a way forward)
- The traditional environmental focus on cleaner production and resource efficiency in manufacturing in current practices can be strengthened further.

The strength of mapping the overall circular economy potentials in each enterprise was the overview and visualization of the different options that also created engagement and commitment among the participants. In several cases selected circular business model ideas were substantially developed, however it still proved challenging for the companies to move on to implementation. Some incremental changes could be done rather easily, but most circular business model opportunities were more radical and demanded either technological innovations or new business models or even combinations of the two.

Take-back of textiles for example requires technological innovations before such a scheme can be fully circular, which was highlighted by all three textile and clothing companies. Fabrics are made of different fibers and often each fabric contains mixed fibers. Thus, it is necessary to develop technologies that can sort the different fiber types and recycle them into fibers again with minimal loss of quality. Alternatively, the individual company can develop a business model that focus on service contracts and/or on leasing, so it becomes feasible to take its products back (since the material composition and quality is known to the company).

Whether technological innovations or new business models need to come first depends fully on the company, the type of products, the value of materials, its customer segment (B2B or B2C), etc. In several cases, technological innovations and circular business models are intertwined and understanding and developing these connections - as opposed to overestimating the need for technology development - can realize the full potential of the circular economy.

Connections between digitization of products and the circular economy were highlighted especially by the large companies (Grundfos and Danfoss). Thus, monitoring product performance could improve feedback to product development on what parts to upgrade in future product revisions, improve predictive maintenance and servitization, etc. To some extent, digitization was also considered a means to product-take back, tagging of products, providing product passports and in this sense an enabler of product, component, and material recovery and reuse.

Circular business model innovation commands substantial time and effort from the company. Not least since a large number of internal stakeholders need to be involved in the process towards redefining the business model. The small companies in the project generally proved

more agile in this respect than the large companies, but all the companies engaged in a change process towards this end (see section 2.4).

Examinations into circular business models will often lead to a demand for new technological solutions to support the new business models. The present report nevertheless describes the innovation and change processes that lead to the formulation of the new circular business models and thus precedes a specification of what technologies are needed.

2.3 A flexible, collaborative process

The eight companies that participated in the project were Schilder and Brown, Kuvatek, KnowledgeCotton Apparel, AVV, Gabriel, Siemens Wind Power, Grundfos and Danfoss. These companies represented different industries, such as the clothing and textile industry and the industrial products and durable goods industry. They also varied in size, from micro to large.

The process of introducing circular economy and beginning to investigate circular business models was different in each case. Hence the number of employees involved, the time spent on the project, the scheduling and tempo of project work and the support given by the researchers at Aalborg University was different in each case. The starting point in each case was based on the specific company context, the company's wishes and its motivation. As a consequence of the differences in the processes, the outcomes were also different for each of the participating companies.

Researchers from Aalborg University facilitated the circular economy explorations by explaining a few key principles and providing useful tools. The researchers supported the innovation process by providing assistance that was supplementary to the companies' own efforts, in a setup where ultimately it was the companies that decided on the direction of the process and the steps they wanted to take.

The facilitation was based first and foremost on a close and inquiring dialogue between researchers and company representatives during meetings, brainstorming sessions and workshops involving both small and large groups. Presentations of the principles of circular economy also played a key role in kick-starting the innovation process along with best practice examples of circular business models already in operation.

2.4 Process characteristics

Although there were differences between the companies with respect to the examination process and its outcomes some typical steps were identified (see FIGURE 4). The companies did not necessarily go through all the steps or in the order given. Raising awareness and generating interest was a necessary first step in all the companies, but ensuring internal alignment, including management commitment, was not required in the small companies where the owner-manager(s) were often directly involved in project activities. The large companies, on the other hand, had to work to achieve internal buy-in and in consequence several of them spent less time on circular business model idea generation than the smaller companies. This meant that not all the companies got to the stage of examining business model ideas, developing a business case, or experimenting with a particular circular business model, but some did.

The smaller companies seemed more open to new ideas and to collaborating with external partners, whereas the larger companies appeared to be less open to experimentation, in part because cost-optimization was a concern to most of them following the financial crisis. This difference is probably one of the reasons why the small- and medium-sized companies tended to be quicker to adopt the circular economy paradigm and initiate activities to develop circular business models.

All companies worked actively to find ways of combining the new circular economy paradigm with their present strategies, so on-going activities and business plans influenced which aspects of the circular economy concept and ideas were most relevant to each company. The smaller companies were more adept at combining the new ideas with current activities and strategies due to their openness to the new concept and to external collaboration.

The employees directly involved in the project in the larger companies were not part of the top tier of management, whereas in the small companies the owner-managers were typically involved and often held strong personal beliefs about the importance of sustainable business operations. The dissimilarities in the organizational level at which the Closing Material Loops project was anchored and in management commitment to sustainability is also likely to have influenced the pace of the circular economy innovation process.

2.5 Outcome

The aim of the Closing Material Loops project was to generate insights into how to apply the circular economy concept to companies. We found that taking a flexible approach to the innovation process helped to generate interest in circular economy and motivate companies to move forward with the circular economy agenda. The flexibility of our approach allowed the companies to continue the work either in the context of the Closing Material Loops project, via industrial PhDs or via other partnerships.

A circular economy system diagram describing and visualizing the main resource loops of the circular economy (FIGURE 1) was a key tool in the collaboration process and proved helpful as a catalyst for circular economy discussions and clarification at all phases of the examination process and across the diverse group of companies. Throughout the innovation process the companies adhered to four fundamental principles of value creation in a circular economy, namely the powers of the inner circle, of cascaded use, of circling longer and of pure circles. Best practice examples were used for reference and inspiration in discussions. A business model framework adapted to the circular economy context (FIGURE 3) was helpful when companies were at the stage of making the circular business models more specific.

Despite the different company contexts and the variations in the business model innovation process all the companies saw circular economy as relevant to them, and during the project most companies appeared to become more engaged with the idea of circular business models. A development that took place in parallel with an increased interest in circular economy in society at large. Some companies made substantial progress towards circular business models, whereas in others the effort went mostly into building organizational support for investigation of the potential of circular business models. Although there were differences in how the innovation process unfolded, all the companies developed a better understanding of circular business models and how they could be relevant.

More than 100 initial ideas for circular business models were generated and eight of these were investigated more closely during the Closing Material Loops project. The companies examined additional circular business model ideas in collaboration with other external partners, and a number of student projects dealing with broader sustainability issues raised by the Closing Material Loops project were also carried out. A list of the student projects can be found in the Annex.

The detailed practical knowledge that was generated regarding the circular economy innovation process is presented in the eight company case studies in chapters 4-11 and the aggregate results can be found in this chapter and chapters 3 and 12.

3. Company collaboration processes

3.1 Aim of the project collaboration

At the beginning of 2014 researchers from Aalborg University invited a group of companies to learn about circular economy and to begin to investigate what the concept might have to offer each individual company. Each company chose whether to meet the researchers a few times to get an overall understanding of the circular economy concept and its relevance to them or to commence internal discussions on the subject, generate ideas for new circular business models and evaluate their viability in collaboration with the researchers. Some of the companies chose to invest relatively few hours in the collaboration, but the majority engaged in more substantive examination of the potential of circular economy.

3.2 Overview of case companies

The eight participating companies were Schilder and Brown, Kuvatek, KnowledgeCotton Apparel, AVV, Gabriel, Siemens Wind Power, Grundfos and Danfoss. These companies varied in size and represented different industries, as summarized in TABLE 1.

TABLE 1. Overview of company cases.

Case	Industry	No. of employees	Customer segment	Project anchoring
Schilder and Brown	Textile goods	2	Business	Owner manager
Kuvatek	Beverage coolers	4	Business	Owner manager
KnowledgeCotton Apparel	Apparel	13	Consumer	Owner manager
AVV	Waste management	102	Business and consumer	Parts of management
Gabriel	Textiles	238	Business	Corporate function
Siemens Windpower	Wind turbines	14.500	Business	Corporate function
Grundfos	Pumping solutions	18.000	Business	Corporate function
Danfoss	Mechatronic goods	24.000	Business	Corporate function

The companies also had different starting points in terms of previous experience with sustainability and circular business models and in terms of the potential to get key organizational stakeholders to support a circular economy agenda. The company contexts and the unfolding of the investigation process in each case are elaborated in the detailed company descriptions in chapters 4-11.

3.3 Circular business models

The business and environmental potentials inherent in the circular economy are exploited by companies via the implementation of circular business models, and so circular business model opportunities were key to the dialogues in the case companies. The basic principles of circular economy and of circular business models are explained in the previous project report, 'Best Practice Examples of Circular Business Models' (Guldmann 2016), along with frameworks for categorizing the business models and a number of practical examples of circular business models that are currently in operation, hence only a brief summary is presented here.

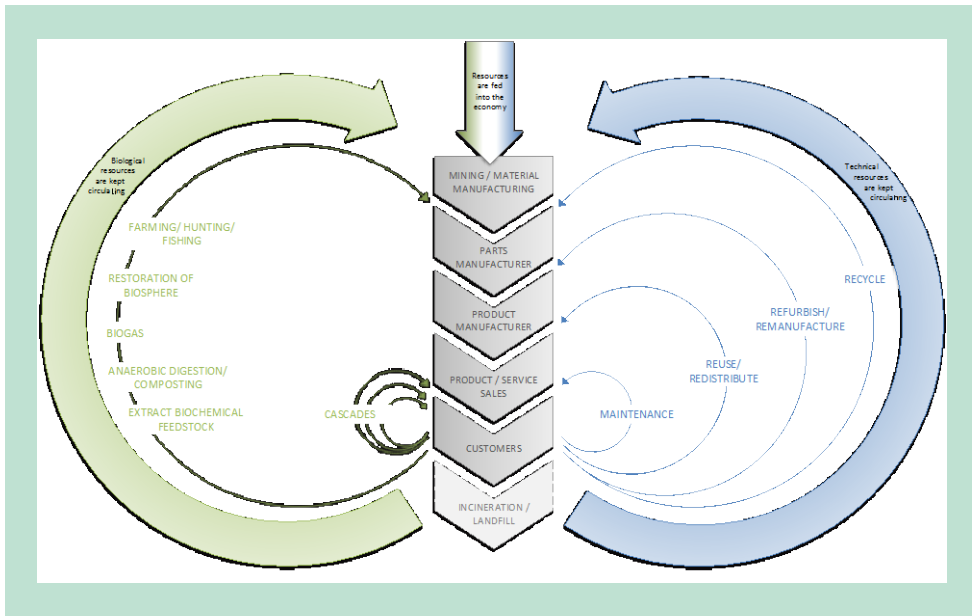


FIGURE 1. Circular economy system diagram. Adapted from Ellen MacArthur Foundation (2013b).

A business model is a blueprint of how an organization creates, delivers, and captures value (Osterwalder & Pigneur, 2010). A linear business model can be described as comprising a number of building blocks. In Osterwalder and Pigneur's (2010) terminology, the building blocks are 'customer segments', 'value propositions', 'channels', 'customer relationships', 'revenue streams', 'key resources', 'key activities', 'key partnerships' and 'cost structure', and they can be organized in a business model canvas as depicted in FIGURE 2.

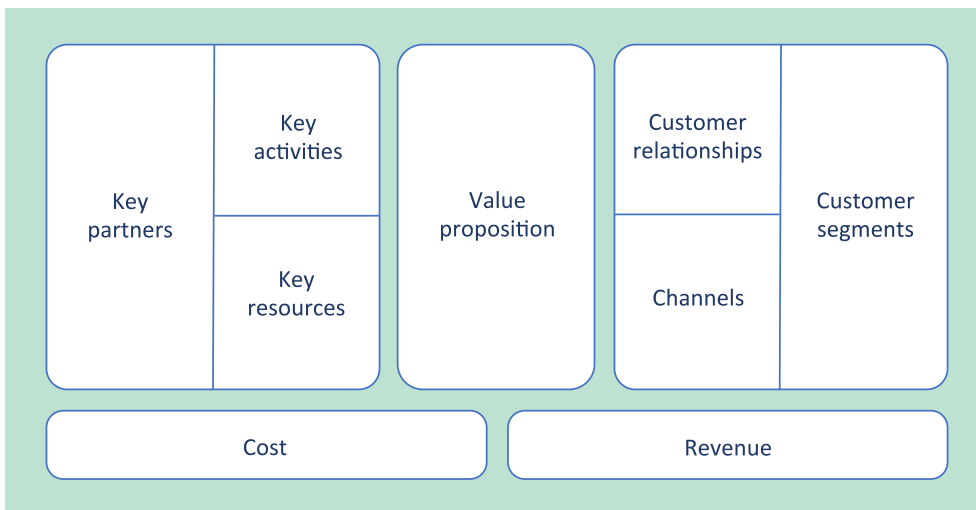


FIGURE 2. Business model canvas (Osterwalder and Pigneur 2010).

In a circular business model the company aims to keep products, components and materials in circulation in one or more of the resource loops illustrated in FIGURE 1. The objective is to keep technical resources at their highest utility for as long as possible through maintenance, reuse, redistribution, refurbishment, remanufacturing and/or recycling. Similarly, the use of biological resources is improved by cascading use, for instance through extraction of biochemical feedstock from biological waste or composting of waste.

There are four principles of value creation, also referred to as four value bases, that a circular business model can exploit. The first principle is that circulation of goods in the inner circles of FIGURE 1 has the potential to generate more value than circulation in the outer circles. The second is that products and materials should be applied to the most demanding tasks first, and move on to less demanding tasks as their quality deteriorates. The third principle is that products, components and materials should circulate for as long as possible at their maximum utility. Finally the fourth principle of value creation is that input materials should be kept free of any contaminants that would hinder recycling (Ellen MacArthur Foundation 2013b).

A circular business model aims to slow down and close resource loops (Bocken et al. 2016) by building on the value bases. An element termed 'Slow and close resource loops' was added to Osterwalder and Pigneur's (2010) business model canvas to reflect this feature of circular business models, which distinguishes them from their linear counterparts. The 'Slow and close resource loops' building block represents activities directed at slowing or closing one or more of the resource loops illustrated in FIGURE 1, e.g. the technical maintenance loop and the technical recycling loop. A building block termed 'Sustainable Inputs', which highlights the importance of using renewable or recyclable materials in the manufacturing of goods as well as renewable energy throughout the value chain, was also included, as this is also something to strive for in the circular economy (Ellen MacArthur Foundation 2013b). The resulting circular business model canvas is depicted in FIGURE 3.

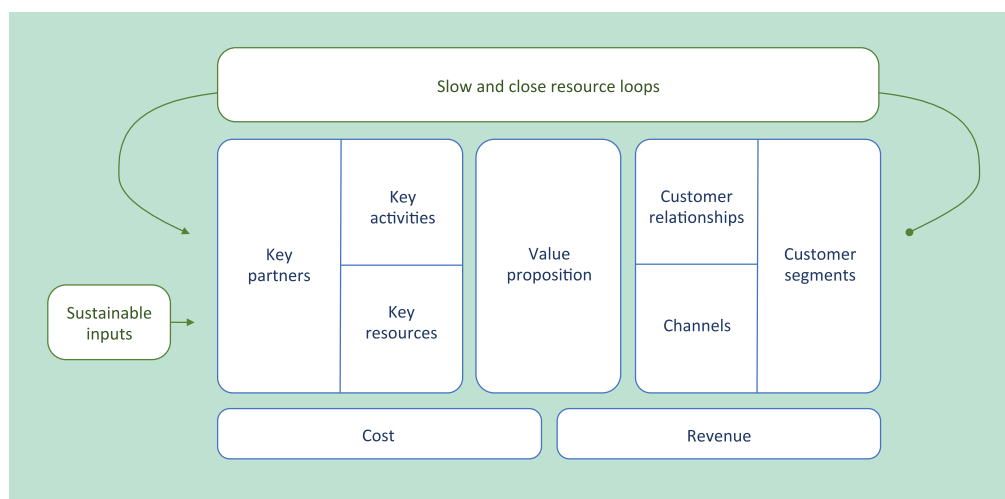


FIGURE 3. Circular business model canvas. Developed from Osterwalder and Pigneur (2010), Bocken et al. (2016) and Ellen MacArthur Foundation (2013b).

Ultimately decisions must be made about all the elements or building blocks of a circular business model if the design is to be completed, but the Closing Material Loops project started by introducing the companies to the principles of circular economy and then initiating discussions about their relevance to the company. The aim was to assist the companies in identifying opportunities inherent in the circular economy and stimulate experimentation and internal and external stakeholder dialogue and learning about circular business models. Whether a fully described circular business model came out of these activities or not was not important.

3.4 Process Steps

The context of each individual company was the point of departure for the collaborations between the researchers and company contacts. The collaboration was based on the principle of providing assistance that would supplement the company's own efforts. This consisted of an ongoing dialogue and facilitation of discussions between the researchers, company contacts and other employees that were involved in meetings, workshops, interviews etc. during the Closing Material Loops project.

The researchers' intention was to support the company contacts in their work as internal change agents in the best way possible, through dialogue, sharing insights, asking questions, and making suggestions about who to involve and how. The final decision about whether and how to pursue the project rested with the company contacts, hence the way in which the circular economy investigation process unfolded was different in each of the eight companies. The investigations did share some common features, as described in the following, and all involved one or more of the steps outlined in FIGURE 4, although not necessarily in the order outlined in the illustration.

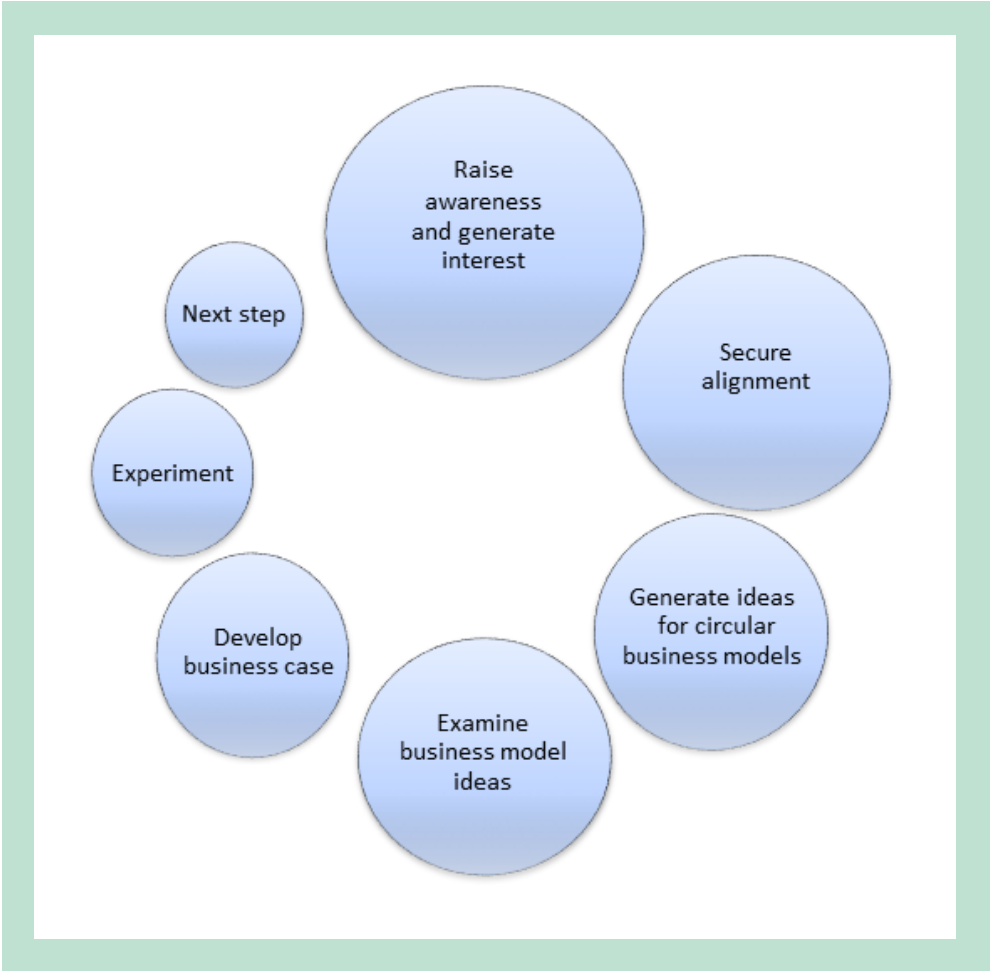


FIGURE 4. Typical process steps.

In all the companies the first step was to raise awareness of, and generate interest in circular economy. This process began when the researchers first contacted the companies to explain the Closing Material Loops project and invite them to participate and it continued throughout the project, in collaboration with the company contacts, to ensure that all relevant internal and external actors knew what circular economy is and how it might benefit the company.

In the large companies in particular, for example Grundfos and Danfoss, raising awareness and creating interest in circular economy went hand in hand with efforts to secure internal agreement about how to take the circular economy agenda forward in the company. In some cases these first two steps took up most of the time of the project team, which consisted of company contacts and the researchers.

In some small companies the researchers collaborated directly with the owner-manager(s), who committed to considering the potential of circular business models without further ado.

Moreover, several companies had previous experience with sustainability work that used circular economy principles or circular business models, albeit not always explicitly recognized as such. These experiences provided the foundations for rapid progress on deliberations about circular economy.

For some of the larger companies it was vital to get organizational buy-in before moving ahead with the circular economy innovation process, but other companies felt comfortable analyzing the most interesting circular business models in parallel with working to get support from key stakeholders. In Gabriel, for instance, two business models were examined in parallel with discussions about how to involve the broader organization in the circular economy discussions. This difference in approach was one of the reasons why some companies began closer examination of selected business models during the project, whilst others did not get that far.

Most of the companies generated a number of ideas for circular business models. Ideas could relate to any of the resource loops and value bases outlined in section 3.3. All ideas were considered valid regardless of whether they were simple and straightforward to implement or complex and represented significant changes to the existing business model.

Some of the companies, e.g. KnowledgeCotton Apparel and Schilder and Brown, selected a few circular business models, also referred to as 'pilot project ideas', for further inquiry. The aim of these more in-depth inquiries was to answer key questions about that particular business model: Whom would the service or product serve? What would the value proposition be? What internal and external partners would need to get involved and were they interested in doing so? What would it take to make it work from a technical point of view? What would it cost? Who would the competitors be? etc.

The objective was gradually to clarify uncertainties and develop the pilot project idea further, in order eventually to map out a promising business model configuration or decide that the idea was not feasible. Important elements of these inquiries were clarification of the attitude of key internal and external stakeholders and getting further input into examination of key challenges and opportunities. We combined this stakeholder-focused approach to the explorations of the business models with the application of tools such as market analyses, customer interviews, trend analyses etc., in order to get an overview of the setting in which the new business model would operate.

A number of factors determine the kind of business model that is most relevant to a company, including product type, supply chain setup, contact with end-customers, price point, mass-production or small-scale production. In the Closing Material Loops project the researchers supported the companies in the examination of the business models that the companies considered most relevant. Relevance was not rated based on an explicit mapping of factors such as those described above, or on the researchers' perception of what would be most profitable, but rather on what ideas resonated with the company staff involved in the project. During the process the researchers asked questions, suggested alternative solutions and occasionally challenged the companies, but it was ultimately the companies that decided how to proceed.

This approach was chosen in acknowledgement of the importance of the participants' motivation for examining the business model ideas more carefully and the importance of a fit between the initiatives and existing strategic agendas, resources available at the time, the power of the company contacts, personal relations etc.

Many of the companies got as far as examining some of the elements of the proposed circular business models, but only a few got as far as defining a detailed business model that would provide the basis for subsequent development of a business case. KnowledgeCotton Apparel was one of the companies that developed a circular business model and an accompanying

business case, whilst Kuvatek outlined a circular business model and moved straight into experimenting with it in the market, because the key elements of the business model were familiar to the owner-manager and could be implemented at minimal risk and cost.

3.5 Tools applied in the process

Only a few tools and frameworks were prepared in advance; these encompassed the fairly general models described above:

- Circular economy system diagram
- Four principles of value creation
- Best practice examples of circular business models
- Circular business model canvas

The circular economy diagram illustrated in FIGURE 1 was applied both in the initial creating awareness and interest phase and in later phases of the project collaboration, such as generation and discussion of various ideas for circular business models.

In some cases the initial list of rough ideas for circular business models was based on a dialogue between the researchers and company representatives and in other cases on a brainstorming session that took place as part of a broader workshop. In both cases it proved helpful to use an illustration like FIGURE 1 to guide the discussions and illustrate the kind of resource loops that would be involved in a particular new circular business model. We termed the resulting graphic an 'idea map' and examples can be found throughout the report (see e.g. FIGURE 6).

The idea maps comprised preliminary ideas for circular business models and specific improvement activities. Complexities and hindrances were typically not considered at this point in the innovation process as ideas were kept at a conceptual level. Company contacts and researchers subsequently worked together to develop a few of the most interesting ideas and to clarify the practical implications of the models under consideration, and at this point the practical challenges were considered.

The four bases for value creation in a circular economy, described in section 3.3, were seen as fundamental to the creation of circular business models and so the companies were introduced to these and both the companies and researchers returned to them throughout the exploration processes.

Best practice examples and the distinct ways in which they link to the resource loops depicted in FIGURE 1 were also employed to initiate the dialogue between company and researchers and as a supporting tool throughout the innovation process. The companies were often inspired to consider how they might do something similar to the best practice case companies. See 'Best Practice Examples of Circular Business Models' (Guldmann 2016), for examples of the kind of best practice cases that were used.

The building blocks of a circular business model - listed above and depicted in FIGURE 3 - were used for general guidance in the process of developing business models and to illustrate elements that would need to be considered at some point. The points that it seemed important to examine at an early stage varied, depending on, for example, the specific business model under consideration, the concrete company context, the likely market environment and the concerns of key stakeholders.

In conjunction the four tools (circular economy system diagram, four principles of value creation, best practice examples of circular business models, and circular business model canvas) formed a core toolbox for investigation of the circular economy that was deployed flexibly. The

value bases illustrated what fundamental principles circular business models are built on, the circular economy system diagram illustrated the resource loops to which these principles could be applied, the circular business model canvas demonstrated the building blocks that should be considered individually and in combination, and the best practice examples provided inspiration for the configuration of all of the above-mentioned elements.

These four tools were specifically relevant to circular business model innovation, but a number of other more general innovation tools were also used: customer interviews, competitor analyses, trend analyses and examinations of available technologies. The tools used are described as part of the individual case descriptions presented in the following chapters.

3.6 Scope of the report

This report is a description of initiatives taken during 2014 and 2015 as part of the Closing Material Loops project and their outcomes. The report outlines activities in other parts of the companies that were outside the direct scope of the Closing Material Loops project where they were found to be relevant to the Closing Material Loops project. Likewise, the report occasionally mentions ventures currently underway in the companies that were not initiated as part of this project.

The intention of the report is not to map every circular economy-related activity of the participating companies during 2014 and 2015 (or the following years); it is instead to focus on the activities that took place in the context of the Closing Material Loops project. It is possible, therefore, that circular economy activities took place outside the scope of the project in the participating companies, particularly the large companies, that are not described here.

The collaboration with Aalborg University resulted in examinations into sustainable business development in some of the companies; these examinations included a number of student project collaborations both during and after the Closing Material Loops project. In other companies the cooperation with Aalborg University ended when the Closing Material Loops project was complete. An overview of student projects prompted by the Closing Material Loops project can be found in the Annex. Several companies continued to look into the potential of circular economy independently or in new projects with external partners, but these activities are not described in this report.

The case descriptions that follow in the next eight chapters describe the processes undertaken by each individual company in depth. Discussion of the results can be found in chapter 12; the conclusion and summary are presented in chapter 2.

Textile and Clothing Companies

4. Gabriel

4.1 The company in brief

Gabriel is a textile company that develops, produces and sells furniture fabrics, components, upholstered surfaces and related services and products. Turnover was 334.8 million DKK in 2014/15 and the company had an average of 238 employees during that year (Gabriel Holding 2015b).

Gabriel was founded in 1851 under the name Kjærs Mølle and at that time was located on the outskirts of Aalborg. From the outset Gabriel managed the entire manufacturing process, from the receipt of the wool to the manufacturing of finished cloths, including spinning, dyeing and printing. In the early years wool was sourced from Denmark, but as early as the 1900s Gabriel began importing wool from New Zealand and Australia, as they still do today. In 2008 the last component of production - washing and dyeing of woolen fabrics - was outsourced to Lithuania. The headquarters of Gabriel Holding remains in Aalborg (Kærgaard 2001; Sørensen 2008) along with the Danish operating company, Gabriel A/S, and a few global functions. The operating companies - Gabriel A/S, Gabriel North America Inc., and Gabriel Asia Pacific - all have a development department, quality department, environmental management department etc. and operate within the three business areas Fabrics, FurnMaster and SampleMaster, see FIGURE 5.

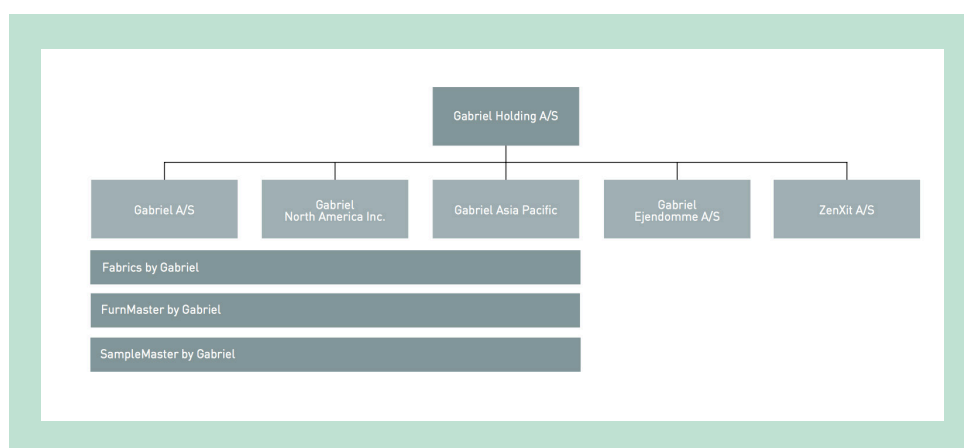


FIGURE 5. Organizational chart (Gabriel Holding 2015b, p.7).

Gabriel's main business area is Fabrics, this business involves customers buying fabrics from Gabriel but fitting them to furniture themselves. The customers are typically large furniture manufacturing companies, such as Steelcase, Herman Miller, and Kinnarps. It is becoming more and more common, however, for customers to ask Gabriel to do subassembly in the form of upholstering (i.e. mounting textile and padding to the furniture) furniture parts and then send the upholstered parts for final assembly at the customers' factories. FurnMaster handles this kind of business. The upholstering process is highly skilled, and within the European market Gabriel offers these services via its subsidiary upholstery companies in Poland and Lithuania. Gabriel is also a co-owner of UAB Scandye, a textile-dyeing company based in Lithuania (Gabriel Holding 2015b).

Quality, Environment and Production Master (QEP-Master) is a support function oriented towards products, services and processes for the European market and thus supports the three business areas Fabrics, FurnMaster and SampleMaster. This department was the primary

company contact during the Closing Material Loops collaboration. QEP-Master has competences in quality and environmental management, product labeling, health and safety, and manufacturing processes and is part of Gabriel A/S (Gabriel Holding 2012, p.10).

4.2 Sustainability at Gabriel

Gabriel takes pride in placing corporate social responsibility (CSR) efforts at the heart of its business operations and finds that CSR is a strategic driver in line with e.g. product development or sales (Gabriel Holding 2012, p.16). Environmental strategies are part of the company's CSR efforts (Gabriel Holding 2015c) and the company has been committed to sustainability since it was founded in 1851 (Gabriel Holding 2015a). The sustainability focus has placed Gabriel in a front-runner position, first in relation to Environmental Management and later in relation to eco labeling, cf. the outline below.

TABLE 2. Important environmental achievements, adapted from Gabriel Holding (n.d.).

1989	Gabriel was the first Danish textile manufacturer to offer fabrics dyed without the use of heavy metals.
1991	ISO 9001 quality management system was introduced.
1994	The impregnation of fabric with toxic chemicals to treat clothes moth was phased out.
1996	Introduction of an environmental management system in the form of EMAS/ISO 14001.
2003	Gabriel manufactured the first product to carry the EU Eco-label.
2006	The Oeko-Tex label was introduced for the fabric Comfort.
2010	Cradle to Cradle certification of the fabric Gaja C2C.
2016	56% of Gabriel's fabrics carried the EU Eco-label.
2016	95% of Gabriel's fabrics carried the Oeko-Tex label.
2016	12% of Gabriel's fabrics held Cradle to Cradle certification

The high environmental performance of Gabriel's products has helped sales. This is in part because of the compelling sales proposition of environmentally friendly products and in part because Gabriel's prices are competitive, which in turn is partly due to minimization of waste in the manufacturing processes (J. Thiesen 2014, personal communication, 19 June).

Recently, however, Gabriel's competitive advantage in this respect has diminished, as competitors have attained comparable levels of CSR. Against this backdrop Gabriel feels it is vital to find new ways to move ahead of the game again. QEP-Master considered circular economy a potential opportunity to do that, which was a factor in Gabriel's decision to join the Closing Material Loops project and collaborate with Aalborg University in 2014 (J. Thiesen 2014, personal communication, 19 June).

4.3 Circular economy experiences

Gabriel has worked with the Cradle-to-Cradle philosophy on several occasions. In 2010 the company became the first in Denmark to be awarded a Cradle-to-Cradle (C2C) label for a woolen fabric. Careful consideration of how the woolen fabric is manufactured means it can be composed at the end of its useful life thus closing a biological loop. Gabriel also offers C2C-certified polyester fabrics made from reused PET, which can be sourced from discarded water bottles. These fabrics can potentially be reused for new polyester yarns and fabrics once they are discarded hence closing a technical loop.

Cradle-to-Cradle is one of the schools of thought behind the circular economy concept (Ellen MacArthur Foundation 2013b) and so it was easy for Gabriel to relate to the concept of circular economy. Gabriel's work on C2C certification meant that QEP-Master was familiar with considering the entire product life cycle, to ensure that a product was manufactured in an envi-

ronmentally sensible way and could be integrated into new resource loops at disposal. The pursuit of C2C certification had also forced Gabriel to place more emphasis on socially responsible behavior, use of renewable energy, and minimization of water usage during the manufacturing process (Netværk for Bæredygtig Erhvervsudvikling NordDanmark 2015, pp. 16-17).

Thus when the collaboration with Aalborg University on the Closing Material Loops project started in 2014, Gabriel already had experience of designing products that *could be* circulated in closed material recycling loops or returned safely to the biosphere, and had successfully sold these fabrics to international customers like Steelcase and Herman Miller. It was nevertheless new to Gabriel to *ensure* that fabrics and other furniture components *were* circulated in technical or biological loops through new business model designs.

4.4 Project collaboration

The core project team that worked on the Closing Material Loops project consisted of one or two researchers from Aalborg University and a project manager from QEP-Master. At the start of the collaboration the project manager gave a presentation covering the history of the company, current ways of working with customers, customer profiles, interesting research going on in Gabriel and the current focus of the management team and of QEP-Master to help the researchers get a feel for the company and its values and gain some insight into the furniture business. The project manager also shared annual reports and CSR reports with the researchers. The researchers presented key elements of circular economy and best practice examples on circular business models from related industries.

It was important to Gabriel to involve customers as much as possible in their examination of the circular economy opportunities, and the Closing Material Loops project deliberately sought out customer input at an early stage. This approach to the research work was in line with the prevailing view in Gabriel, which was that the company's growth potential is closely linked to collaboration with a select group of key customers and that these customers should, therefore, be involved in Gabriel's innovation activities (Gabriel Holding 2012, p. 38).

With this customer focus in mind, it was decided to start the project with a broad and open-minded discussion within the project team about what circular economy ideas might be most relevant to Gabriel. An idea map was developed to illustrate the ideas generated in early meetings and show what resource loops they would target. The map worked as an overview that assisted further discussions and decision-making; it is presented in FIGURE 6.

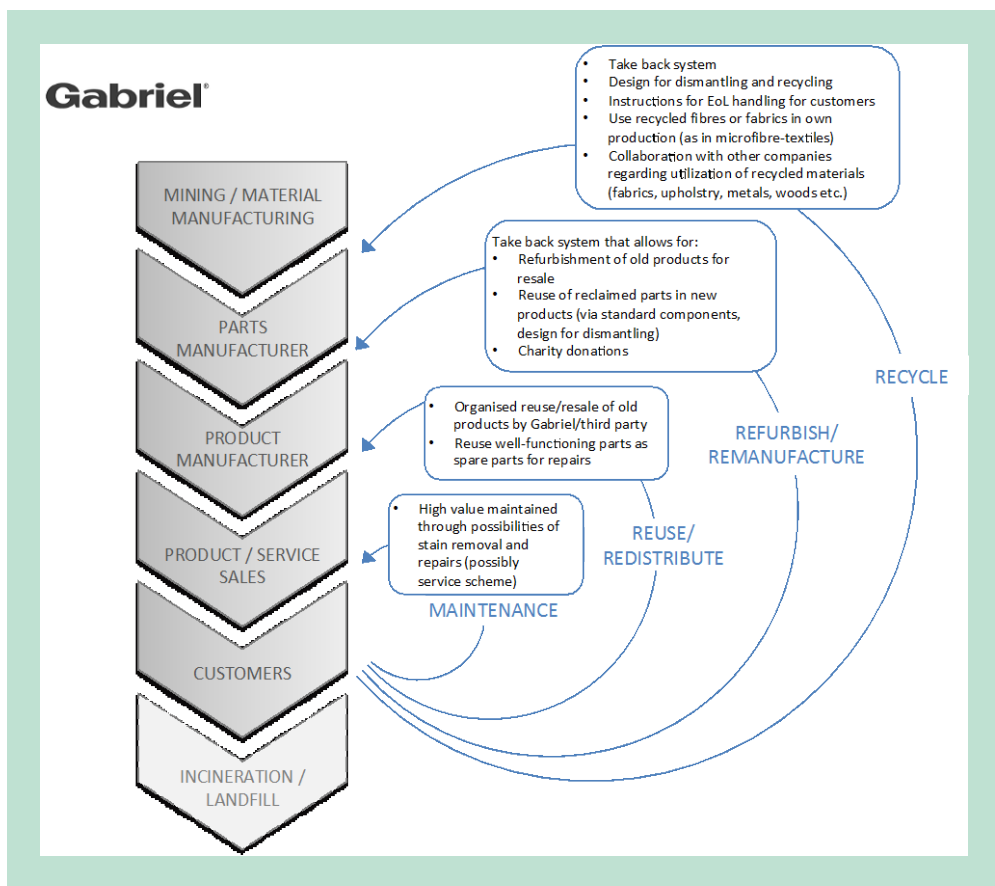


FIGURE 6. Idea map for Gabriel.

After further discussion Gabriel decided to look into two areas of particular interest. The first project idea was an examination of the market impact of recent French legislation on furniture take-back and the business opportunities it might offer for Gabriel. The second project idea was oriented towards an investigation of the circular economy potential in the FurnMaster business area in Gabriel.

4.4.1 Circular business models for office furniture

Investigation into the first project idea, relating to the new legislation in France, began with a search for information on the new regulations governing take-back in the furniture industry in France. We discovered that France had indeed implemented Extended Producer Responsibility (EPR) for, amongst other items, couches, tables, seats, kitchen cabinets, mattresses, bathroom furniture and office desks (des Abbayes 2014). The furniture EPR scheme required manufacturers and retailers to register with the scheme and manufacturers were obliged to add recycling fees to the price of their products from 2013. The recycling fee would be progressively increased until 2020, when the whole of France would be covered by the scheme (des Abbayes 2014).

Manufacturers and importers of furniture were required to join a collective scheme operated by Éco-Mobilier, a nonprofit organization owned by 12 retailers and 12 manufacturers or to set up their own systems to "(...) provide for the collection, sorting, recovery and treatment of waste furniture (...)" (des Abbayes 2014, p.6). The scheme was put in place to decrease the quantity of waste furniture sent to landfill, increase recycling and facilitate more ecological design of furniture (des Abbayes 2014). The legislation set targets for the collection, recycling and valorization of the furniture: by 2015 45% of furniture was to be recycled and a total of 80% should be recycled or used for energy recovery (EY 2016).

To gain insight into what this scheme meant for Gabriel's customers in the French market the project conducted interviews with a sustainability manager at a high-end furniture manufacturer with facilities in France and with Gabriel's Key Account Manager (KAM) in Southern Europe, who covered the French market. Surprisingly, the manager, who had intimate knowledge of the French market, felt the new EPR legislation had not induced any significant changes in design, manufacturing, sales or reuse of furniture. The KAM had not noted any difference in the market either.

The project manager from QEP-Master and the researcher therefore decided to look more generally into the conditions for circular business models in the European market for office furniture, based on new interviews with the sustainability manager, the KAM in Southern Europe, as well as with Gabriel's KAM for the UK market. With regards to circular business models, the interviews indicated that:

- Circular business models in the form of refurbishment, resale, and recycling were already in place in the European furniture market. However, these services constituted only a niche market with lots of small companies such as Amaryllis and Senator competing.
- Refurbishment or recycling of used furniture seemed to be offered on a case-by-case basis by the furniture manufacturers. Typically it was offered to large customers in order to keep competitors out.
- Furniture manufacturers typically outsourced refurbishment, recycling and reselling tasks to specialist companies or referred customers to these specialist companies directly.
- There were some differences between the circular business models that were most typical in different European markets, e.g. leasing was common in the UK, but not in France.

The interviewees also pointed to a number of technical barriers to circular business models:

- The widespread practice of attaching fabrics and foam with glue and staples was found to be a technical barrier to refurbishment. The risk of fabrics being contaminated in the manufacturing or use phases and difficulty ensuring the quality of secondhand fabrics were mentioned as issues in textile recycling. Difficulties associated with handling second-hand goods in processes that are separate from the ordinary flow of goods in companies were also emphasized.
- A specific dismantling process has to be developed for each furniture design as each piece of furniture is designed to be manufactured and assembled in a specific way.
- Refurbishment and recycling was more expensive than simply disposing of the furniture, which may why advantage was not being taken of opportunities to disassemble or refurbish eco-designed furniture, or to bring C2C certified fabrics into new resource loops at the end of their lives.

Finally, some challenges relating to typical behavior and complicated value chains were identified:

- The custom of disposing of old or broken office furniture without considering opportunities for reuse, repair, refurbishment and recycling of the furniture, perhaps due to a lack of knowledge.
- Complex supply chain setups that involved many different stakeholders from all over the globe and a similar complexity on the customer side, with vast number of customers in different markets across the globe.
- Implementation of circular business models would require that all the parties involved developed new ways of thinking about value chains and about how to create profitable business.

Despite these issues, the KAMs believed that offering circular business models might give Gabriel a competitive advantage. One example mentioned was the refurbishment of office chairs. They noted that such refurbishment should be possible, because Gabriel's FurnMaster has upholstery capabilities and fabrics and foam are known to age more quickly than the other

parts of furniture. It was expected that wheels and metal parts would be easy to change, if necessary. According to one of the KAMs, the textile and foam constituted only a small part of the total cost of a chair, implying that the value of an office chair could be retained with just a small material investment (and an associated labor cost). It was anticipated that refurbished furniture would be attractive to a specific customer segment, provided the price was lower and the warranty the same as for new furniture.

4.4.2 Next step for the office furniture idea

As outlined in the previous section, the interviews offered insights into potential obstacles to building closed loop systems in the office furniture market, but also revealed that there was already a niche market for circular business models. In fact, a number of small companies were reselling, refurbishing and recycling used office furniture. Even large furniture manufacturers occasionally offered to take care of refurbishment or recycling of office furniture for their customers or referred them to companies that offered such services.

These findings pointed to some potential opportunities, although no clear implementation path was established during the interviews. Given the complexity of value chains in the office furniture business and the need for all parties in the value chain to collaborate in order to make circular business models a reality, the QEP project manager believed the next step should be to involve a few customers in a more in-depth dialogue about whether they would be interested in developing circular business models in collaboration with Gabriel and vice versa, and if so, what form the models should take. The dialogue could be initiated at the regular, 'Academy' customer meetings Gabriel held with its largest customers.

Because businesses that were already operating schemes for reuse, refurbishment and recycling of office furniture were a potential source of inspiration for the building blocks of any new circular business model it was judged that it would be interesting to gain more insights into existing business models, in preparation for meetings with customers. Contacting some of the companies offering office furniture repair, refurbishment, resale and recycling services to which end-customers would typically be referred by furniture manufacturers would allow the project team to examine in more detail how manufacturers handle large refurbishment and recycling orders, get an overview of the companies with which manufacturers are working and determine whether offering easy textile renewal or having closed loop credentials would add to the manufacturers' selling proposition in this connection. Such discussions could have focused on the C2C certified polyester fabrics Repetto, Elevation and the Go collection, and on the wool fabric C2C which already had strong environmental credentials and could be recycled or returned safely to the biosphere.

Unfortunately the plan to discuss circular business models at customer meetings was not carried through, for various reasons. Gabriel's design department, DesignMaster, needed to be involved in the circular economy discussions, both prior to and in connection with the customer meetings, because DesignMaster would be responsible for the design of high-quality fabrics based on, e.g. recycled textile fibers, and held key knowledge about what Gabriel could and could not do in this regard. During the Closing Material Loops project the department was, however, reorganizing and hiring new employees and needed time to resettle before it could engage in discussion about circular economy with QEP-Master, the researchers and the customers. By the time it was possible to initiate dialogue with DesignMaster, the design department was uncertain if customers would be interested in circular business models and was therefore reluctant to start examining the possibilities.

The project manager from QEP-Master and her manager also wanted to inform and involve as large a portion of the employees as possible in the general debate about Gabriel's position on circular economy. QEP-Master considered inviting all employees to a voluntary, after-hours workshop that would kick off the debate. QEP-Master needed management support for the

cross-organizational debate on circular economy and potential related initiatives that it envisaged. Unfortunately, Gabriel was engaged in establishing operations in the US during the Closing Material Loops project collaboration, a significant task, taking up a considerable amount of the management team's attention and time. This meant that it was not an ideal time to start a cross-organizational debate and so QEP-Master did not go through with the idea of a voluntary workshop for all employees.

Finally, the efforts to advance the project on circular business models for office furniture were affected by changes in the Closing Material Loops core project team, as the primary company contact from QEP-Master went on maternity leave.

4.4.3 Circular business models in project sales

The second project idea was examined in parallel with the first. This idea centered on investigations of the potential for circular economy in the FurnMaster business area. The FurnMaster business unit is responsible for sales that entails upholstery work, such as sales to concert halls, conference centers, movie theatres and the similar. Orders are typically large and concern for instance a sizeable number of new seats or refurbishment of old seats in a concert hall or train carriages.

Gabriel's main business, Fabrics, supplies fabrics to furniture companies, which upholster and assemble furniture and sell it to e.g. interior decorators, who then sell it on to end-customers. Thus Gabriel is not in contact with the end-users in this business area, whereas in the FurnMaster business area Gabriel often perform a task for an end-customer and has direct contact with the customer. Gabriel and the researchers wanted to take advantage of the opportunity this presented to talk to FurnMaster customers about their attitudes and aspirations regarding circular business models.

The investigation began with a meeting between the QEP-Master project manager, the researcher and a FurnMaster project manager. The purpose of the meeting was to gain insight into the particular line of business and ask the project manager to evaluate the potential for circular business model in this business area. We were also interested in examining the general attitude to this kind of business model innovation within Gabriel and gauging likely client interest in such innovation.

Our meeting revealed that although Gabriel occasionally sold goods and services directly to end-customers in connection with e.g. furnishing or refurbishing of music halls, congress centers, movie theatres etc. this was often not the case. Often Gabriel was a subcontractor or had bid on a pre-determined tender rather than collaborating with the customer to develop a solution. In these cases Gabriel had little influence over the design of the finished product. Orders in the segment were usually large and sometimes required very complex upholstery work.

The FurnMaster project manager was skeptical about introducing circular business models in the project sales market. First of all, product liability issues meant that Project Sales preferred that products were the responsibility of the customers. Second, refurbishment work was done in Gabriel's facilities in Lithuania, so handling and transportation costs would have to be added to the service price. The time required for transportation to and from Lithuania might also pose a challenge, since the customer would have to close down a room for quite a while for the refurbishment.

On the other hand, the project manager knew of examples where fabrics were designed to be clicked on and off or fastened with Velcro for easy maintenance or replacement. She was also familiar with furniture manufacturers that had dedicated service teams that repaired defective products.

The Project Sales project manager believed there would be little customer interest in circular business models, but it was agreed that the researcher would contact a recent project sales client to arrange an interview to investigate further.

The researcher contacted the technical manager of a long-term client of Gabriel's. This client had recently ordered and installed new chairs with Gabriel fabric throughout the organization's facilities as part of a major refurbishment. The client was a self-governing institution that received yearly funds from Aalborg municipality and was not required to generate profits. Thus it was the municipality that had financed the refurbishment program. This meant that leasing and other take-back schemes were less relevant to the client as it would be the municipality, rather than the client that would stand to benefit economically from such schemes.

In terms of maintenance, the client had an employee who was responsible for setting up chairs and other furniture for events held at the facility. This employee was responsible for monitoring the state of the furniture and notifying the facility manager when cleaning or repairs were needed. The manager would then contact craftspeople and dry-cleaners who could carry out these tasks. In other words, there was already an arrangement for maintenance of the chairs, although it was not necessarily the most convenient, as it required the employee who set up the chairs to discuss maintenance issues regularly with the technical manager, who would then have to contact craftspeople and dry-cleaners, negotiate terms for their services and arrange for their visits to the facilities.

Interestingly, the technical manager we interviewed had arranged for donation of the old furniture by publicly announcing that the old chairs were available for pick-up. The manager had willingly taken on the extra work of handling the contact with all those interested in the chairs. These included both small local organizations such as a bridge club and larger establishments such as an out-of-town children's theater. The process had taken the client some time and generated no income for Gabriel's client, but it demonstrated that both the client and the organizations that expressed interest in the old chairs felt they still had some value.

4.4.4 Next step for the project sales idea

To sum up, the interviews indicated there might be potential in the project sales market, although a number of challenges had also been identified. More client interviews were needed to reach firm conclusions as well as a closer assessment of the timelines that would be associated with refurbishment services based in Lithuania.

What we had discovered at this point was that several elements of the setup of individual customers, i.e. their financial structure, daily operations and need for refurbishment services or new furniture, were relevant to determining which business models would be appropriate to each.

Initiating a dialogue with the supporting municipality, would be an interesting next step in clarifying the potential for circular business model that focus on take-back or leasing of furniture, since the financial benefits that could come out of such a model for the client would eventually be to the municipality's advantage. Private organizations in this segment might also find leasing and take-back schemes relevant as it could minimize tied-up capital and ease the process of disposing of the furniture.

More interviews are also needed to draw conclusions about the potential of business models in which Gabriel would offer to care for, clean and repair fabrics and upholstery for its project sales customers. Most project sales clients have a lot of furniture with Gabriel's fabrics in one place, and they are likely to be interested in having the furniture look good, so that their customers feel comfortable and well cared for.

Would it, for instance, be worthwhile for Gabriel to offer cleaning services thus providing an alternative to local cleaning companies and taking advantage of the company's knowledge about caring for and cleaning fabrics? It is possible that partnerships could be formed in which Gabriel shares its know-how about cleaning and caring for fabrics with designated cleaning companies; this would allow Gabriel to sell cleaning services to project sales clients in a convenient, no-frills way, but contract out the delivery of the service.

Such a service might be offered on a one-off basis or on a contract basis, whereby Gabriel (or a designated local cleaning company that has a partnership with Gabriel) makes regular visits to the customer to monitor on the furniture and carry out necessary care and cleaning - the arrangement would be similar to a regular window cleaning service.

The interview with the technical manager revealed that, in the example discussed above, old chairs of which the customer was disposing still had value. The actions of both Gabriel's customer and the interested organizations demonstrated this. This suggests that there might be a business potential associated with handling such processes for customers. The service offered would be similar to those offered by companies such as the aforementioned Amaryllis (cf. section 4.4.1).

Gabriel would be uniquely qualified to refurbish the chairs in connection with such a disposal process and thus to take advantage of the enhanced market value of the chairs, as upholstery and fabrics are often the most damaged parts of old chairs. Maybe Gabriel could upgrade and resell used furniture that it recovers from customers who are purchasing new furniture and would like to dispose of the old furniture easily?

As already noted, further interviews with both private and public customers are necessary to determine whether circular business models would in fact be attractive to customers in the project sales segment. A study into the timelines and economy associated with refurbishment services based in Lithuania is also needed.

In a similar vein, the FurnMaster project manager suggested that DesignMaster should be involved in any next steps and that a dialogue with key customers should be initiated, in accordance with the follow up steps described for the project idea involving office furniture (cf. section 4.4.2).

4.5 Findings

Today small companies seem to fill the gaps left by the major companies when it comes to caring for furniture fabrics and refurbishing, reselling and recycling furniture. This goes for both Gabriel's core business of fabric and upholstery sales and the project sales market. The fragmented nature of these markets means that furniture customers, whether private companies, public institutions or large venues, usually have to deal with multiple companies to arrange for furniture care and realize its full market value at the time of disposal. This is resource-intensive for customers and there would seem to be business potential in offering a convenient service that entails caring for the furniture, i.e. cleaning and repair, as well as taking the furniture off the customer's hands when the customer decides to dispose of it, in order to refurbish and resell it.

Working with the other actors in the market to create seamless and convenient end-to-end furniture services might have business potential for Gabriel and could provide a competitive advantage based on demonstrating greater environmental responsibility, offering advanced customer services and developing hard-to-copy partnerships up and down the value chain. Furthermore, making caring, refurbishing, reselling or recycling more convenient and attractive to end-customers in the different segments would mean that more customers would be likely

to take an interest in such services, which would benefit the environment and enhance Gabriel's profitability.

At Gabriel further organization-wide discussions involving top management are needed to clarify whether the company wants to investigate circular business models in more depth. The work carried out so far points to both opportunities and challenges in the markets studied. Should Gabriel decide to explore these in more detail a natural next step would be the development of concrete business cases in cooperation with manufacturing customers and project sales customers.

5. KnowledgeCotton Apparel

5.1 The company in brief

KnowledgeCotton Apparel is a menswear fashion company with headquarters in Herning. The company dates back to 1969, when Jørgen Mørup founded J. Mørup Stof, a high-end fabric mill. From 1992 J. Mørup Stof produced only organic cotton fabrics, which were sold to fashion houses around Europe. J. Mørup Stof was shut down in 2008 and succeeded by the current menswear company, KnowledgeCotton Apparel. The company employs around 13 people and has agents in 5 countries and a turnover of around DKK 45 million (Mørup 2014).

5.2 Sustainability at KnowledgeCotton Apparel

As a result of its history KnowledgeCotton Apparel has a considerable knowledge about sustainable fabrics. Its collections are primarily based on organic cotton, although the range also contains jackets made from recycled PET and woolen garments. The company remains in close contact with suppliers and collaborates with them to ensure that its environmental standards are met (Mørup 2014). Its clothes are sold in more than 450 shops across eight countries and are also available via online shops.

The driving forces behind the creation of the new company were the prospect of communicating with and influencing end-users and the opportunity to show that organic clothing can be fashionable (Mørup 2014). Hence the company's marketing is centered on the concept of 'gain knowledge', which involves:

- Training of shop staff through an 'Academy program'
- Campaigns targeted at end-users
- Providing end-users with information via hangtags, brochures, the company homepage, social media etc. (Mørup 2014)

The marketing poster in FIGURE 7 is a recent example of KnowledgeCotton Apparel's user-engagement communications featuring the recurring slogan "Gain Knowledge - Take Action - Earn Respect".



FIGURE 7. Cotton brain campaign poster (KnowledgeCotton Apparel 2015b).

5.3 Circular economy experience

From the beginning of the Closing Material Loops collaboration it was clear that KnowledgeCotton Apparel had already discussed many ideas involving closed-loop elements. Some, such as a jeans recycling program, had even undergone real-life testing. Both these older ideas and new ideas that emerged during the discussion between the researchers and the management group at the first meeting were mapped in an idea map similar to that in FIGURE 8.

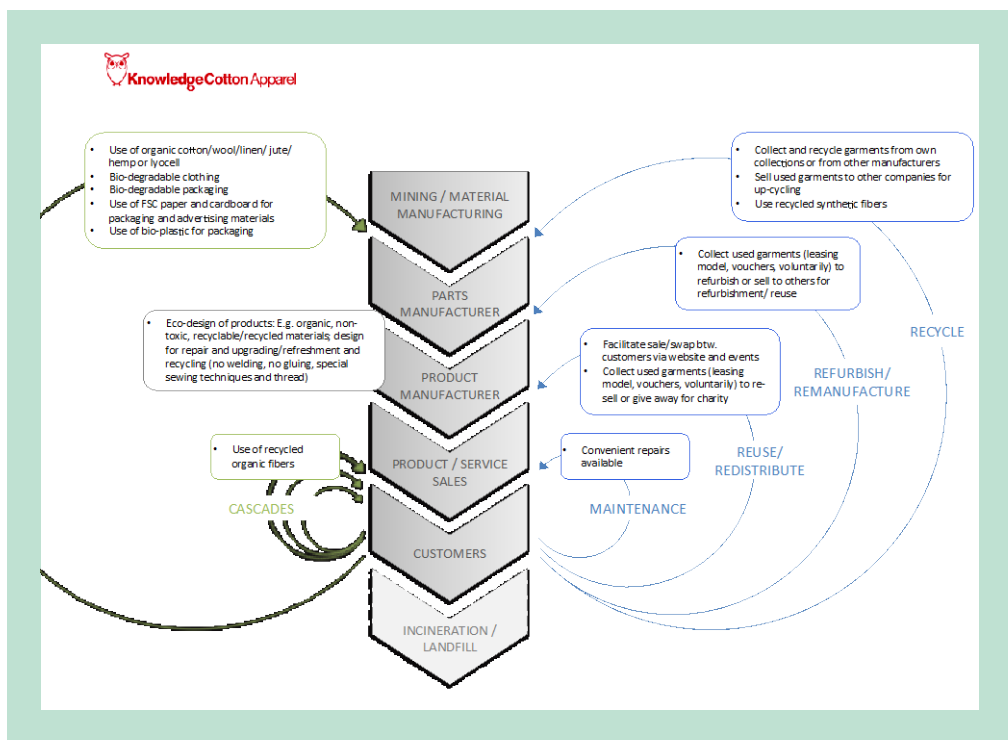


FIGURE 8. Selection of ideas from initial idea map at KnowledgeCotton Apparel.

It was clear from the initial meetings that it was crucial that any initiatives taken in the context of the Closing Material Loops project provided value to KnowledgeCotton Apparel's customers, so the researchers suggested preparing an overview of key consumer trends that were relevant to the ideas discussed and to KnowledgeCotton Apparel's brand values. The purpose of this exercise was to identify the ideas that seemed most relevant from a consumer trend perspective. Sustainability, fashion and lifestyle were central factors in the analysis of consumer trends. The trends were compiled from an array of resources (Trendwatching 2014; JWT Intelligence 2014; Springwise 2014; Trend Hunter 2014; More Inspiration 2014; Trends@alltop 2014; Notcouture 2014; coolbusinessideas.com 2014; dr.dk 2014; COWI 2012) and presented in two boards shown in FIGURE 9 and FIGURE 10.

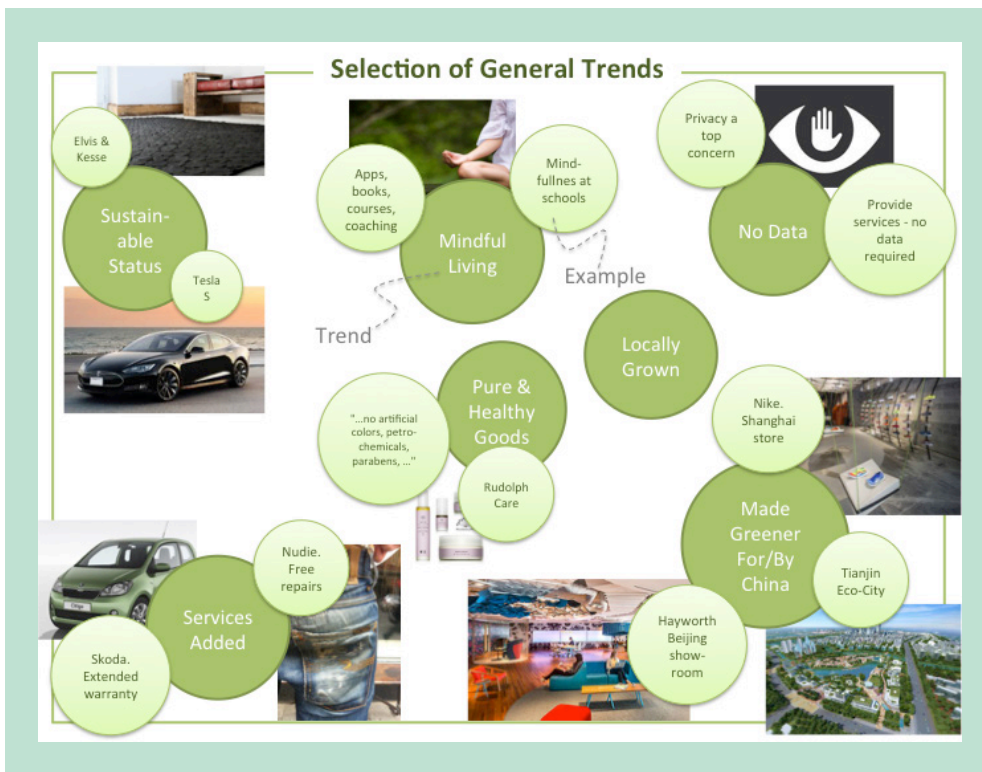


FIGURE 9. Trend board illustrating general trends.



FIGURE 10. Trend board with fashion and lifestyle trends.

The trend boards were used to examine which of the trends were most relevant to KnowledgeCotton Apparel and its customers. The boards also presented examples of sustainable and circular business model and initiated deliberations about which of the circular business model concepts in the idea map in FIGURE 8 had the potential to capitalize on strong consumer trends whilst fitting with KnowledgeCotton Apparel's values and priorities.

5.4 Project collaboration

Two ideas of particular interest emerged from the dialogue:

- An organic cotton oil skin care product
- Development of a new store concept

These ideas were investigated in more detail to clarify their potential. The analyses included market analysis in each case, development of a spreadsheet tool to simulate different cost and sales scenarios, interviews with sales representatives to clarify the customer segments and, finally, various consultations with trusted contacts from KnowledgeCotton Apparel's professional network to test ideas and assumptions. As KnowledgeCotton Apparel was participating in the regional circular economy development project Rethink Business, the consultants COWI took part in the innovation activities for a while and provided some of the analyses.

The customer segments and preferences that emerged from the analyses of the German and Swedish markets were visualized using AC Nielsen's 'Minerva Model'. This information, along with data from the market analyses and other information, was reviewed and discussed at a seminar attended by KnowledgeCotton Apparel's management group, the COWI consultant and one of the researchers from Aalborg University. Based on the analyses and the ensuing debate KnowledgeCotton Apparel decided that the idea of developing a brand store concept based on closed-loop principles was the most interesting to the company. Not least since the store would provide a new platform for the company to engage directly with the end-users.

At the subsequent meetings the new store concept was developed further through internal discussions between the managers, KnowledgeCotton Apparel's professional network, the consultant and the researcher. External funds were applied for so that the company would have sufficient finances to experiment with the format of the closed-loop offerings, which would be integrated into the store concept and tested in a full-scale shop. Having external funding would allow KnowledgeCotton Apparel to focus less on financial return from the new shop in the first year or two and instead focus on experiments and learning in relation to customer engagement in closed-loop activities.

The process of preparing a grant application for a 'Long Life Lab' (LL Lab) forced clarification of the closed-loop store idea and ensured that financial, environmental, and consumer-engagement effects were estimated.

5.4.1 Long Life Lab

The proposed LL Lab encompassed all four technical resource loops shown in FIGURE 1, as well as additional ideas for increasing the environmental benefits and the impact on consumer mindsets in accordance with KnowledgeCotton Apparel's brand value 'Gain Knowledge' (KnowledgeCotton Apparel 2015a). The company planned to maintain its standards with respect to sustainable sourcing of organic cotton, wool, and recycled PET, as well as non-toxic dyeing and processing. To advance the idea of recycling KnowledgeCotton Apparel would furthermore add garments from recycled fibers to their collections.

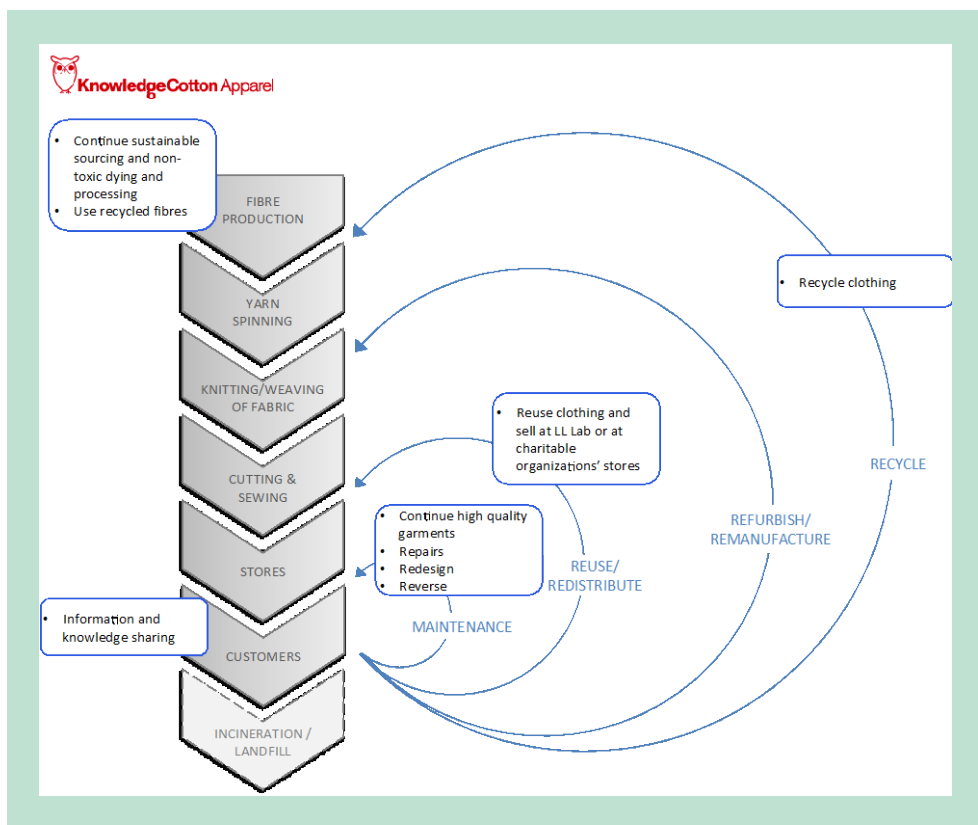


FIGURE 11. Long Life Lab elements.

The company proposed to use the LL Lab to increase its communication with customers, because it was envisaged that the LL Lab would include a number of interactive experiences explaining the journey of a T-shirt from the farmer to the customer, visualizing differences between organic and conventional cotton farming etc. The LL Lab would have changing exhibitions and interactive stories that would communicate knowledge in an interesting and relaxed way, thus taking the Gain Knowledge brand value to the next level.

KnowledgeCotton Apparel proposed to uphold focus on the maintenance loop by continuing to design and manufacture long-lasting apparel in quality materials and with enduring fashion appeal. In addition, the LL Lab would contain a small dressmaker's workroom that could carry out small repairs. Customers would be able to get professional assistance with repairs or borrow sewing machines to mend clothes of any brand. Surplus piece goods and yarns, as well as buttons, zippers, labels, patches etc. would be available for repairs.

The next step in prolonging the life of a garment might be to modify or repurpose it, for example turning chinos into shorts, adding a pocket to a t-shirt, using patches, adding a new print etc. Piece goods, zippers, patches etc. would be available in the shop for free. To increase interest in redesign KnowledgeCotton Apparel intended to host events with guest student (re-)designers e.g. from the Royal Danish Academy of Fine Arts. The option of modification at the Lab would again apply to any brand of clothes.

The company also proposed to add clothes with reversibility to their collections thus saving resources by offering the functionality of two pieces of clothing in just one piece. One reversible garment would provide two different looks depending on which side is on the outside. Garments could be turned inside out to create a new look. It was anticipated that this feature would prolong garment life or increase wearing frequency.

Once a garment is no longer of value to its first owner for whatever reason reuse opportunities become relevant. At the LL Lab customers would be able to exchange old clothes of any brand for a voucher for purchases in the Lab. Garments of good quality in a style appropriate to the LL Lab would be resold there.

Apparel that was not salable at the Lab would be handed over to charitable organizations or to private companies dealing with textile recycling, preferably for reuse as clothes, but alternatively for reuse as rags, upholstery filling or similar, or as fibers (KnowledgeCotton Apparel 2015a).

5.4.2 The benefits

The researcher, the consultant, and KnowledgeCotton Apparel collaborated to estimate the effects of establishing such a LL Lab in central Copenhagen.

It was estimated that an LL Lab would repair 2,000 garments/year, redesign 2,240 garments/year and reuse 420 garments/year. The effect of these activities would be an annual reduction in environmental footprint of around:

- 16,000 kg CO₂e
- 2,200,000 L water
- 750 kg waste
- 1400 kg pesticides

It was calculated that the full-scale solutions outlined above would only be viable if KnowledgeCotton Apparel obtained external financial support for the roll out. As the application to Grøn Omstillingsfond was declined, KnowledgeCotton Apparel is evaluating the feasibility of proceeding with a smaller scale LL Lab on its own or in collaboration with sustainable womenswear, childrenswear and/or shoe companies.

5.5 Findings

The tangible result of our collaboration with KnowledgeCotton Apparel was a well-described, new fashion shop concept, offering a new way of selling, repairing, redesigning, reselling and reusing clothes. KnowledgeCotton Apparel found this concept so appealing that it is considering taking the idea further.

The collaboration also yielded intangible results, in the form of new knowledge from the development of the LL Lab concept. The steps in the innovation process, such as developing the concept, describing it, initiating dialogues within KnowledgeCotton Apparel and between KnowledgeCotton Apparel and new partners as well as contacts in the company's professional network, and clarifying and quantifying the environmental, occupational and financial effects, resulted in substantial knowledge building.

Overall, circular economy proved interesting to KnowledgeCotton Apparel, as the concept provided a good foundation for the company to pursue its objective of enhancing sustainability activities and staying ahead of competitors. Consequently, KnowledgeCotton Apparel decided to continue investigating the potential of circular business models. Their new research examines the potential of supplementing the sales of clothes with a repair service and involves environmental engineering students from Aalborg University.

In addition to the investigations into the LL Lab, KnowledgeCotton Apparel worked with an environmental engineering student to improve communication with suppliers from China. The student visited some of the Chinese suppliers and worked with the local agent to examine how the communication platform could be strengthened. Subsequently the supplier manual was

updated to integrate the findings from the study with the Chinese suppliers as well as to comply with the current regulations.

Although these kinds of supply chain efforts relate to less prominent parts of the circular economy principles, supplier communication and regulatory compliance are key elements in a sustainable sourcing strategy and as such they need to be managed alongside the development of new circular business models.

6. Schilder and Brown

6.1 The company in brief

Schilder and Brown is a small textile company founded in 2008 (Schilder and Brown 2014). The company delivers customer-specific textile solutions to, for instance, customers in the retail and health care sectors. Products include hospital wear, bonnets, apparel, towels, bed linen, toys etc. (Schilder and Brown n.d.)

Schilder and Brown collaborates with its customers to develop textile products and provides assistance with choice of materials, product design and procurement, as well as ensuring that production is environmentally friendly (Schilder and Brown n.d.).

6.2 Sustainability at Schilder and Brown

Schilder and Brown is built on three sustainability pillars in that it aims to provide products and processes that are eco-friendly, people-friendly and tree-friendly (Schilder and Brown n.d.).

In particular, the company offers raw materials that are grown without depleting the ecosystem and on processing and manufacturing facilities where employees are treated fairly. The products are thus produced in accordance with international standards and customers can choose GOTS, ISO, Demeter and Fairtrade certification. Customers can also choose any combination of conventional, sustainable, recycled or organic fabrics (Schilder and Brown n.d.).

6.3 Circular economy experience

When the collaboration with Schilder and Brown commenced in 2014 the company was collaborating with Vraa Dampvaskeri and Lifestyle & Design Cluster on an innovation project sponsored by Grøn Omstillingsfond. The project was concerned with how to: "(...) develop and commercialize a new sustainable material and production concept for the laundry sector" (Schilder and Brown 2014).

One of the project's key objectives was to demonstrate that organic cotton is a viable alternative to conventional cotton for workwear in terms of both fiber characteristics and price, and that the ecological footprint of workwear could be improved by replacing conventional cotton with organic cotton. The collaboration between Schilder and Brown and Aalborg University focused on how to close the material loop by recycling the fabrics when they were no longer suitable for workwear.

6.4 Project collaboration

The initial intention was to close the recycling loop by reusing fibers from used workwear in the manufacture of fabrics for new workwear. However, it proved necessary to add synthetic fibers to the virgin fabrics that were developed for the workwear to ensure good performance and sufficient durability. This meant that it would not be possible to recycle the garments at their end-of-life. Technology exists for recycling pure textiles, whether cotton or synthetic, but not mixed fiber textiles.

Pure polyester textiles or textiles with at least 80% polyester can be recycled into new thread. This technology is being applied by, amongst others, workwear and fashion company Dutch Awearness and outdoor clothing company Patagonia. Patagonia uses recycled soda bottles, manufacturing waste and worn-out garments of various origins to make new polyester yarn (Patagonia n.d.).

Pure cotton can also be recycled although virgin fibers must be added to the new thread to compensate for the shortening of fibers in the recycling process.

Technologies involving mechanical or chemical separation of mixed fibers or chemical recycling of cotton into viscose are currently in development and may alleviate some of these problems (Watson et al. 2014). Currently, however, the recycling of mixed-fiber workwear via traditional large-scale recycling facilities would mean downcycling into rags, furniture cushioning, items for the automobile industry and the like.

The project discussed opportunities to transform the workwear into small series of other clothing items or household linen by hand as an alternative to such downcycling, but Schilder and Brown felt that small series reworking was too much of a niche market and therefore unattractive to the company.

Instead, efforts focused on alternative ways of recycling workwear and it was decided to examine a new kind of recycling technology developed by Advance Nonwoven, a Danish start-up.

A meeting with Advance Nonwoven was arranged and they explained that they had been developing an air-laid/carding technology since 2006. The process turned natural fibers, waste or recycled material into various nonwoven products (S. Gamborg 2014, personal communication, 20 August; Advance Nonwoven 2015a) such as:

- Insulation for buildings and machines
- Growth media's for cultivated plants
- Oil absorption mats and rolls
- Absorptions cloths for consumer products
- Boards for building construction
- Composites for automobile and furniture
- Furniture upholstery
- Packaging
- Filtration
- Mattresses

(Advance Nonwoven 2015b)

Advance Nonwoven found it beneficial that the company would have access to the process equipment as needed and for whatever application desired (see the above list). This would make it possible for Schilder and Brown to process batches of old textiles as needed without them being mixed with other companies' textiles. Schilder and Brown felt this would allow them to tell a stronger, more convincing story around the resulting recycled products compared with recycling products at large-scale facilities.

The meeting at Advance Nonwoven gave rise to new ideas. The possibility of turning old textiles into a growth media for cultivated plants or into a mat that would help retain moisture in desert areas was judged particularly interesting. The inspiration for making a moisture retention mat was ongoing efforts by one of Schilder and Brown's suppliers, the Egyptian farming company Sekem, to turn desert land into fertile soil.

Founded in 1977, Sekem specializes in organic farming of crops including vegetables and cotton. By 2015, some 35 years after it was founded Sekem had reclaimed about 684 ha of land (Sekem 2015a) and provided jobs for local people, healthcare for employees and schooling for employees' children (Sekem 2015b). A moisture retention mat could be produced from worn-out textiles, possibly textiles produced from cotton grown at Sekem, or manufactured from parts of the cotton plant that would not otherwise be used.

The various ideas that were discussed in relation to the used work wear are summed up in FIGURE 12 in relation to the four technical resource loops.

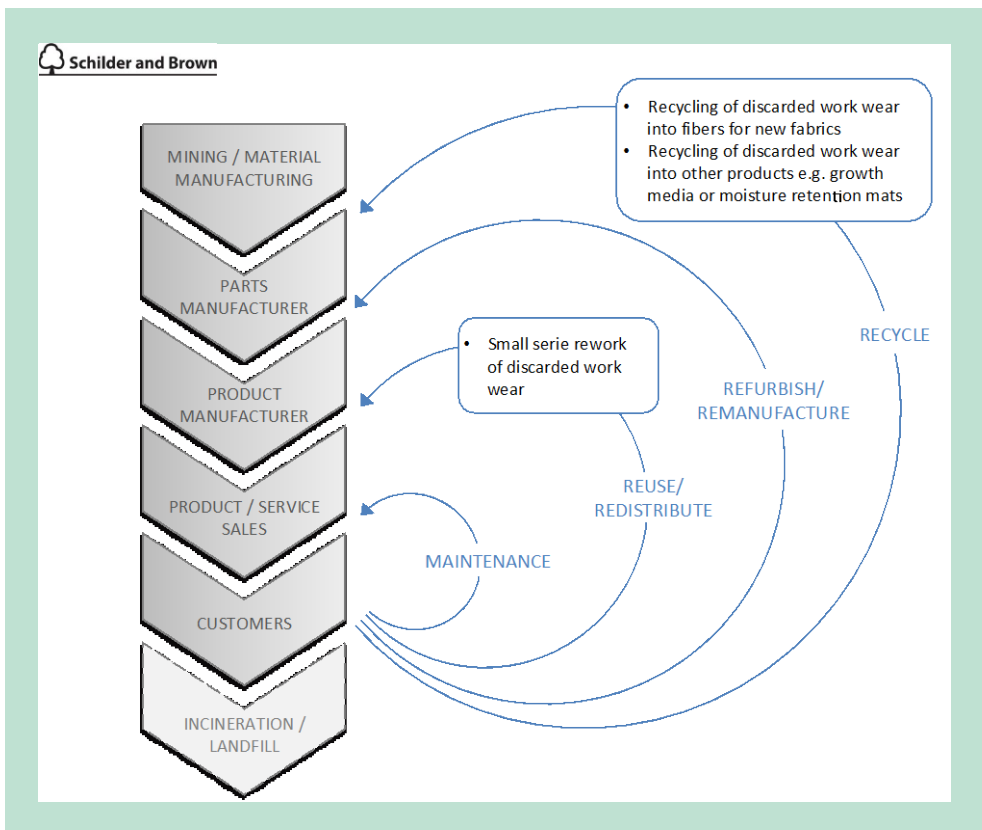


FIGURE 12. Ideas discussed at Schilder and Brown.

6.5 Findings

Schilder and Brown developed a fabric that could be used for workwear by combining organic cotton and polyester fibers, but unfortunately the project with Vraa Dampvaskeri and Lifestyle and Design Cluster was never commercialized. Consequently the idea of reusing old workwear to make moisture mats was not carried through either.

Schilder and Brown continues to work with organic cotton, although it has moved into selling organic cotton yarns and threads rather than finished textile goods. The company also remains interested in textile recycling technologies and in the future it is keen to sell recycled cotton fibers produced at a textile mill that is currently under development at Advance Nonwoven.

Industrial Products and Durable Goods Companies

7. Danfoss

7.1 The company in brief

Danfoss is a large industrial company operating in four business segments (i.e. divisions) namely power solutions, cooling, drives and heating, as shown in the organizational chart below. It was founded by Mads Clausen in Nordborg, Denmark in 1933 and since then it has grown to sell its products in more than 100 countries worldwide.

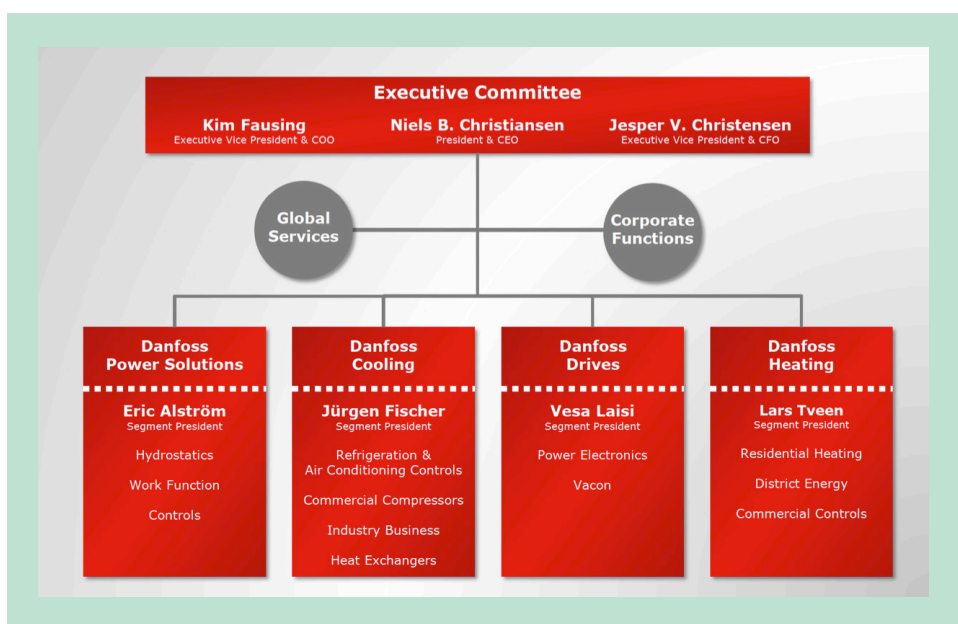


FIGURE 13. Danfoss organizational chart (Danfoss Group 2015, p.21).

The company employs some 25,300 people in Danfoss factories situated in 19 different countries (Danfoss Group 2015). Engineering innovation has been a key driver of Danfoss' growth and today the company holds 1200 patent families (Danfoss Group 2015).

7.2 Sustainability at Danfoss

There are three departments in Danfoss that are responsible for development and monitoring of sustainability efforts at corporate level. Public Affairs & Sustainability handles the overall political perspective and operational aspects are managed primarily by Group Regulatory and Group Ethics & Compliance. Public Affairs & Sustainability was the primary company contact during the Closing Material Loops project.

Danfoss is a signatory of the UN Global Compact Initiative. This means that the annual sustainability report serves as the Communication on Progress report. Danfoss made this commitment more than 10 years ago and continues to support the initiative, which has 10 guiding principles, outlined in TABLE 3.

TABLE 3. Ten principles of the UN Global Compact Initiative (United Nations n.d.).

Human Rights

1. Businesses should support and respect the protection of internationally proclaimed human rights; and
2. make sure that they are not complicit in human rights abuses.

Labor

3. Businesses should uphold the freedom of association and the effective recognition of the right to collective bargaining;
4. the elimination of all forms of forced and compulsory labor;
5. the effective abolition of child labor; and
6. the elimination of discrimination in respect of employment and occupation.

Environment

7. Businesses should support a precautionary approach to environmental challenges;
8. undertake initiatives to promote greater environmental responsibility; and
9. encourage the development and diffusion of environmentally friendly technologies.

Anti-Corruption

10. Businesses should work against corruption in all its forms, including extortion and bribery.

It is evident from these ten guiding principles that sustainability is viewed as more than environmental considerations in the Global Compact Initiative and hence also at Danfoss. This broader understanding of sustainability is reflected in Danfoss' sustainability reports, which cover topics such as diversity, anti-corruption and community engagement.

The focal areas of Danfoss' 2014-17 sustainability program were decided using a materiality assessment to select between more than 100 topics of potential relevance to sustainability in Danfoss. The resulting key themes are illustrated in FIGURE 14. The horizontal axis displays the importance of the various themes to Danfoss, operationalised as impact on revenue, earnings, reputation and compliance and the vertical axis displays importance to Danfoss' stakeholders: the media/general public, customers, legislators, NGOs, employees/management and owners (Danfoss Group 2014c).

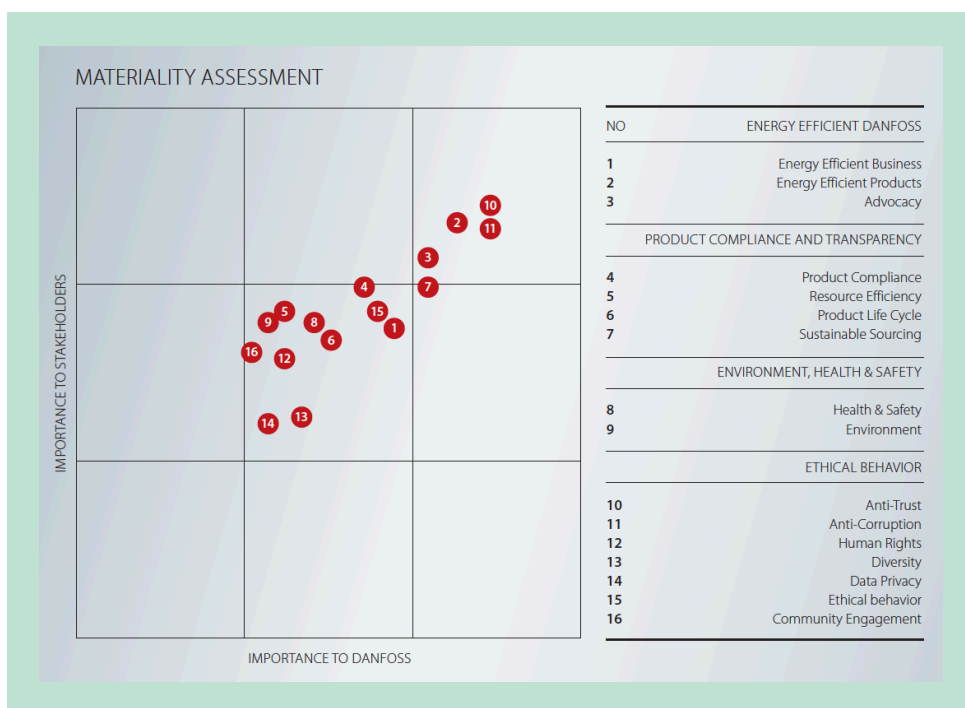


FIGURE 14. Danfoss materiality assessment (Danfoss Group 2014c, p.9).

The materiality assessment placed themes aligned with circular economy thinking, such as 'Resource Efficiency', 'Product Life Cycle' and 'Environment', in the middle of the chart, indicating their relevance to both Danfoss and its stakeholders. It follows that principles related to circular economy were considered important to Danfoss. Further, initial talks with Danfoss made it clear that the resource efficiency agenda of the Closing Material Loops project was in line with Danfoss' most recent strategy, 'Core & Clear', which was one of the main reasons the sustainability department was interested in enrolling Danfoss in the project.

Nevertheless the assessment rated other environmental themes as more important to Danfoss than the themes mentioned above, in particular 'Energy Efficient Products', 'Sustainable Sourcing', and 'Energy Efficient Business'. The energy efficiency of the products and the systems of which they are part is a key characteristic of most of the products in Danfoss' product portfolio and this is a feature that Danfoss is proud of (Danfoss Group 2015; Goldmann 2015) and uses as a unique selling proposition (From the Inside with Anders Agger - Danfoss 2016). Examples of the advantages of the energy efficiency of the company's products are presented in FIGURE 15.

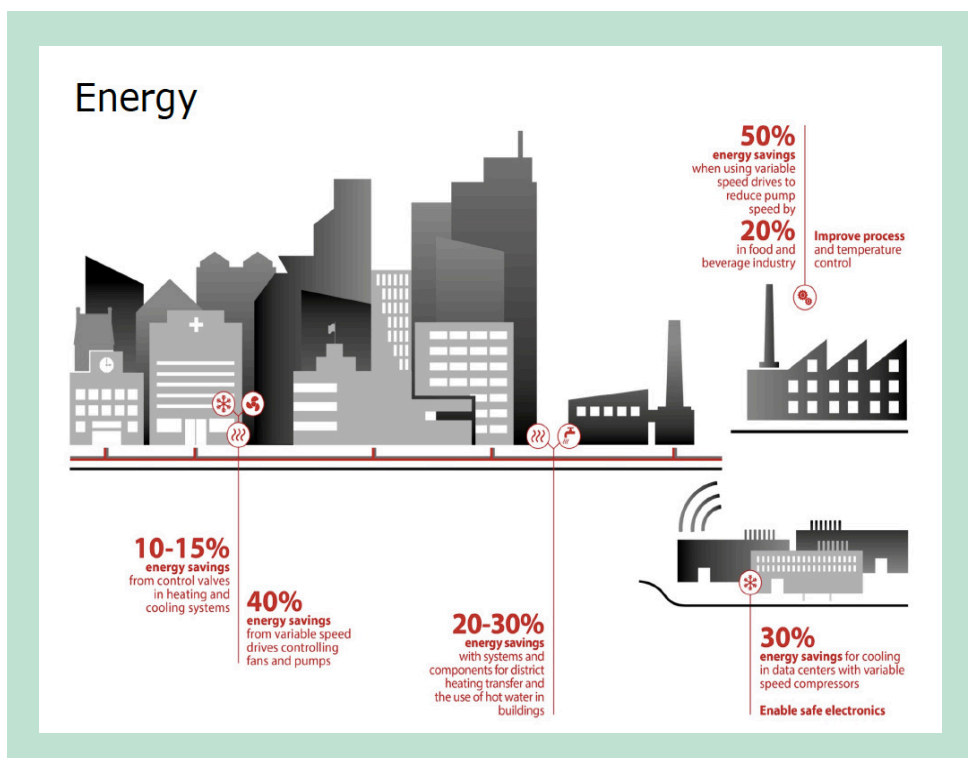


FIGURE 15. Efficiency opportunities available with Danfoss products (Danfoss Group 2015, p.4).

Based on the materiality assessment four key areas and associated topics were given special emphasis in Danfoss' sustainability program (Danfoss Group 2014c, p.8):

- Ethical behavior
 - Danfoss Ethics Handbook
 - New ethics e-lesson for all managers
 - Compliance programs for managers and key employees (anti-corruption, competition, data privacy and export controls)
- Product compliance and transparency
 - Customer and legislative requirements, e.g. RoHS, REACH, WEEE, and conflict minerals
 - Eco-design, material declarations
- Energy-efficient Danfoss
 - Danfoss' climate strategy and climate targets
 - Emissions reductions and energy savings in buildings, processes and transportation
- Environment, health and safety
 - Establishment of a global management system for environment, health and safety
 - Healthy and safe workplaces for productive employees
 - Reduction in the number of work-related accidents"

Energy efficiency, labeled 'Energy-efficient Danfoss', was one of the four key areas in the program whilst the other materiality assessment themes 'Resource Efficiency', 'Product Life Cycle', and 'Environment' were less prominent, presumably falling under the 'ECO-design, material declarations' as part of the 'Product compliance and transparency' topic.

It seems that energy efficiency is integral to product development at Danfoss, unlike some of the other elements of the strategy and this may explain why it was more difficult for the sustainability department to advance elements of the strategy that were not related to the energy efficiency agenda. These difficulties included advancing projects related to circular economy.

7.3 Circular economy experience

Although at least parts of Danfoss were aware of resource efficiency as a possible promoter of environmental sustainability, as indicated by the materiality assessment and the sustainability strategy outline, the company had little experience of working to optimize resource efficiency.

Resource efficiency was primarily promoted via a product development manual entitled 'Eco-Design Guidelines'. The recommendations were not mandatory, however, and interviews with employees revealed they were not implemented consistently across Danfoss (F. Nielsen 2016, personal communication, 23 October; K. Krabbe 2016, personal communication, 21 October; J. Holst 2016, personal communication, 23 October).

7.4 Project collaboration

The Public Affairs & Sustainability department suggested involving one of Danfoss' four business segments to ensure the explorations would be relevant to the given segment and results easy to implement there. Another reason for involving a specific segment and taking a pilot project approach was that Danfoss is a large company with diverse business areas facing different challenges and opportunities when it comes to resource efficiency and integrating circular economy thinking. This means that it was necessary to take a business segment-specific or product line-specific approach to the circular business model innovation process.

The Cooling and Heating segments were invited to participate in the development of a circular business model pilot project that was relevant to them but turned down the opportunity on the grounds that day-to-day operations already presented a heavy workload.

7.4.1 Eco-design guideline revision

Alternative ways of examining how circular economy models might present opportunities for Danfoss were discussed at this point and it was decided that the researchers would support an upcoming project on the revision of Danfoss' 'Eco-Design Guidelines'. The Guidelines covered incorporation of environmental considerations into the product development process and needed to be revised to ensure that they reflected the latest legislation and relevant design considerations.

The revision was carried out for Danfoss by the consultancy PE International (now Thinkstep) under the supervision of Public Affairs & Sustainability. During the process the researchers discussed the guidelines with Group Sustainability from a circular economy perspective and as a result circular economy principles were incorporated into the new 'Sustainable Design Guidelines' and the complementary 'Sustainable Design Checklist'.

The 'Sustainable Design Guidelines' thus summarizes key sustainability concepts that product development teams should consider at the outset of the design process, including efficiency, sufficiency, resilience, and circular economy (Danfoss Group 2014a). It is also recommended that teams should consider early on in the product development process whether new service oriented business models, take-back schemes and recycling of materials would be appropriate (Danfoss Group 2014b, p.2). At later stages teams are expected to consider whether the product could be designed so that it enables reuse, repair, disassembly and recycling (Danfoss Group 2014b).

The circular economy principles have been integrated into the Guidelines and Checklist as suggestions and points to consider rather than strict requirements, but this nevertheless repre-

sents a potentially important step in raising awareness of the relevance of taking account of circular principles when developing new products and new business models. Product development is a key area into which these principles should be embedded, since it is in the design phase that decisions are made that will promote or hinder the building of circular business models around a product.

The revised manual is now in the process of being approved by Danfoss' four segments before being integrated into the core product development toolbox used across Danfoss.

7.4.2 Cross-organizational workshop

From the beginning of the project collaboration, both the researchers and Public Affairs & Sustainability hoped to engage one of the four segments in the Closing Material Loops project.

One way of involving the operational part of Danfoss that was discussed was the possibility of holding a circular economy workshop to spur interest in circular economy, resource efficiency and eco-design and to identify areas of particular circular economy potential to the segments.

Initially it was difficult to interest the segments in such a workshop, but interest in circular economy increased within Danfoss during work on the new Sustainable Design Guidelines. Various events and activities may have prompted this change. For instance, Flemming Lynge Nielsen, Sustainability Director, is a member of the steering group for the UN Global Compact Nordic Network and circular economy was a core theme of the Network's biannual members' conference in May 2014. In December 2015 a memo on circular economy was prepared for Danfoss CEO Niels B. Christiansen as part of his preparation for attending the UN Climate Change Conference COP 21 in Paris. Similar notes were prepared for COO Kim Fausing in advance of his participation in the World Economic Forum's meeting in Davos in January 2016.

Interest also rose in the segments, which meant it was possible to organize a circular economy workshop in October 2015 with 14 participants from different segments who held various positions in the Research and Development, Product Management, Quality Assurance, Industry Affairs, Group Regulatory and Sustainability & Public Affairs departments.



FIGURE 16. Workshop participants reflecting on circular economy opportunities.

The workshop focused on circular economy and ways in which the notion could be relevant to Danfoss. It consisted of three main parts. In the first part participants were brought up to speed on the work that had been carried out for the revision of the Eco-Design Guideline and preparations for Environmental Product Declarations by Sustainability & Public Affairs. In the second part participants were introduced to and discussed the principles of circular economy and examples of circular business models in related industries. In the last part participants were asked to brainstorm ideas for circular economy innovation projects in Danfoss and place these on a poster-size idea map, these ideas were subsequently presented to the rest of the participants and discussed briefly by the group as a whole.



FIGURE 17. Suggestions for circular innovation projects are placed on idea map posters.

The workshop produced interesting ideas on how to take advantage of circular economy thinking in the different business segments and how to combine this kind of thinking with opportunities that had already been identified. For instance, modularity was found to be particularly relevant to one business area, Drives. Modularity was already a focus in Drives, an area in which they wanted to improve so that they would have the capacity to for last-minute specification and avoid unnecessary capital binding in warehousing and lost profit from obsolete products. These wishes fitted with the circular economy principle of promoting product modularity, although in from a circular economy perspective modularity is a means of prolonging product life e.g. via repairs and upgrades. Thus product modularity proved to be an area worth closer examination to determine the financial and environmental potential.

Offering service contracts was another idea that had previously been discussed at Danfoss for business reasons, and was revived at the workshop. Some workshop participants felt Danfoss was missing out on an opportunity to have continuous customer contact and make money from service contracts. These viewpoints resonated with ideas on digital monitoring of product performance to improve product and system performance and increase product lifespan. These are aspects of quality that customers are likely to appreciate and be willing to pay for, as in, for instance, the wind turbine industry (cf. chapter 10 on Siemens Wind Power). Danfoss would also benefit from learning about typical product weaknesses and could apply this knowledge to improve the durability and performance of future products.

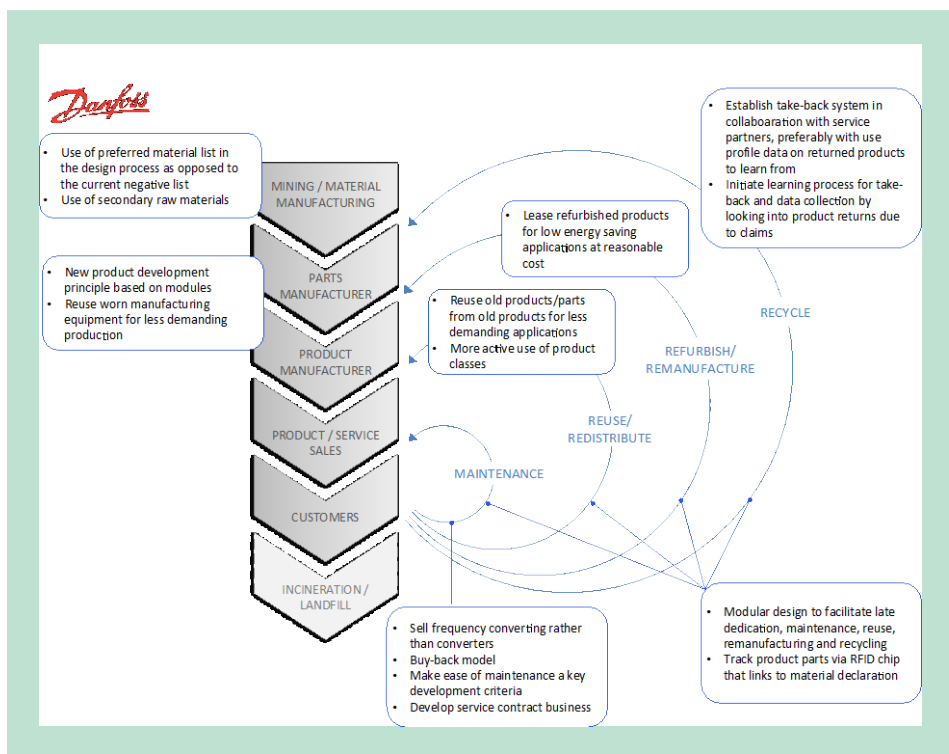


FIGURE 18. Selection of ideas from Danfoss workshop.

A lot more ideas were generated and discussed at the workshop, some of which are presented in the idea map in FIGURE 18. The workshop also highlighted possible challenges, however. One important point raised was the difficulty of communicating the potential of circular business models. Danfoss, like most companies, have standard business case templates with requirements on e.g. EBIT%. Workshop participants believed it would be difficult for circular business models to meet these requirements. Circular business models might deliver other advantages such as greater customer loyalty and stable revenue streams from service businesses and leasing schemes, but these elements are not integrated into the current business case template.

A related issue was that economy of scale is key to Danfoss' business and so workshop participants were concerned how circular business models would be received, because such business models would, in the beginning, be small-scale, niche operations. The participants felt a management decision to endorse small-scale circular pilot projects would be required.

The importance of having a better understanding of customers' use of Danfoss products was also highlighted; workshop participants found such understanding regrettably hard to attain and noted that better understanding would help Danfoss make customer-relevant circular product designs. A better understanding of customer needs was also highlighted in connection with deciding on the appropriate level of ambition in the preparation of future Full Material Declarations (FMDs) and Environmental Product Declarations (EPDs). Another customer-related concern was whether customers would want to collaborate closely with just one supplier in the way that many circular business models seem to presuppose. It was clear from this part of the discussion that closer customer contact would be useful in clarifying the potential of circular offerings at Danfoss and issues in developing them.

Legislation was another issue raised at the workshop, more specifically participants were uncertain about legislation on the transportation of used goods, the WEEE directive, and the handling of hazardous materials in older products. Some participants called for a more coherent framework of EU directives that would offer better support for systems thinking.

Overall the workshop prompted interesting discussions and pointed to both potential opportunities and concerns that warranted closer examination. The session also seemed to usher in a new openness in Danfoss to circular economy activities (K. Krabbe 2016, personal communication, 21 October), some of which are described below.

7.4.3 Other activities

In 2016 the Danish Design Counsel and a number of partners invited Danfoss to participate in an open circular economy event, a 'hackathon' that would focus on the redesign of a Danfoss product. Danfoss agreed to participate and the outcome was the development of new product packaging for one of Danfoss' frequency converters based on circular economy principles. Danfoss Drives is currently considering integrating the new packaging concept into an upcoming product development project for the frequency converter in question.

A collaboration with the University of Southern Denmark, called Experts-in-Teams, was also initiated in 2016. The objective was to have students from the Mechatronics program at the University of Southern Denmark look into the design of a frequency converter and see if they could redesign it using circular economy principles.

In 2016 Danfoss also joined a similar project organized by the Confederation of Danish Industry (DI) and a range of other trade organizations in the electrical and electronics sector (Danish Environmental Protection Agency n.d.). The aim of the project was to examine the potential for circular economy in the Danish electronics industry by developing a number of business cases. The project results are currently being reviewed by Danfoss and preliminary results suggest there are some interesting opportunities that will warrant further examination.

7.5 Findings

The internal workshop held in cooperation with Aalborg University and the other collaboration projects in which Danfoss has been involved have, in different ways, illustrated both the potential of the circular economy concept and risks and challenges to be aware of in connection with circular economy models and processes.

The workshop demonstrated that several of the circular economy ideas that could be developed at Danfoss went hand in hand with other core business optimization opportunities, for example in the cases of product modularity and the development of a service contract business. This may prove an important point of leverage for the development of circular activities at Danfoss.

In the two-year period during which researchers from Aalborg University followed Danfoss interest in circular economy appeared to spread from the Sustainability & Public Affairs and Group Regulatory departments to a wider range of stakeholders. The collaboration with Aalborg University played a role in this along with other external circular economy-related collaborations that have influenced the middle management layer in a number of departments at Danfoss.

Notably, the interest and attention of the top management team at Danfoss seem to have been influenced more by global events, such as COP21 and World Economic Forum meetings, where circular economy was on the agenda.

The result is that actors across Danfoss are now paying attention to the opportunities inherent in circular business activities, which may pave the way for the notion to be integrated into Danfoss' future sustainability strategies. Moreover, the updated Sustainable Design Guideline has the potential to guide future product development projects towards adoption of circular economy principles once it has been approved and accepted into the corporate product development toolbox.

8. Grundfos

8.1 The company in brief

Grundfos is a Danish pump manufacturer that operates in more than 56 countries and employs 18,000 people worldwide. The company's product portfolio covers pumping solutions for heating and air-conditioning in addition to centrifugal pumps for industry, water supply, sewage and dosing. Circulators are the most important products and Grundfos has approximately 50% of the world market in these pumps (Market Research Store 2016; Grundfos 2016a).

8.2 Sustainability at Grundfos

Sustainability is important to Grundfos and the company divides its efforts into six areas that span social, environmental and economic sustainability under the headings 'Sustainable Product Solutions', 'People Competences', 'Community', 'Responsible Business Conduct', 'Workplace' and 'Environmental Footprint', see FIGURE 19.



FIGURE 19. Foci of sustainability efforts at Grundfos (Hansen 2015).

The company's environmental improvement activities are most relevant to the Closing Material Loops project. Grundfos' approach to environmental sustainability has historically been focused on optimizing manufacturing processes, reducing material usage in products and minimizing its products' energy consumption.

With respect to optimization of manufacturing processes, Grundfos' production companies work to minimize the energy and carbon footprint, the water footprint, the waste footprint, and the chemical footprint (see FIGURE 20 for data on carbon emissions and energy consumption) (Grundfos 2016b). Grundfos aspires to reduce its water usage by 50% by 2025 relative to the 2008 level and to clean its waste water so that the quality of the discharged water is higher than the quality of the water that the factories receive. Grundfos has also pledged never to discharge more metric tons of carbon dioxide than the company did in 2008, regardless of increases in manufacturing volumes (Grundfos 2017).

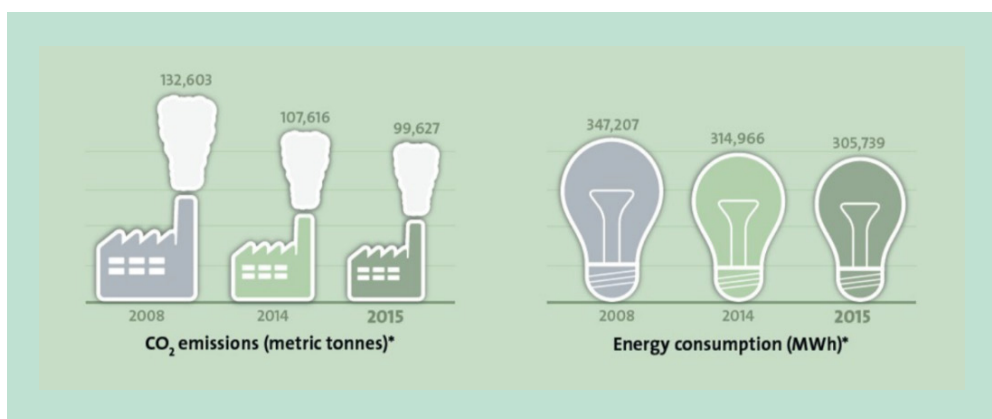


FIGURE 20. Example of resource efficiency efforts at Grundfos' manufacturing sites (Grundfos 2016b).

TABLE 4 presents an example of progress in reducing use of materials between one generation of circulators and the next. As the table illustrates, some material fractions were reduced significantly, for instance the usage of copper was reduced by more than one kilogram per pump.

TABLE 4. Advances in resource efficiency between two generations of circulators. Based on Nystrup (2006).

	Previous type (kg)	New type (kg)	Difference (kg)
Cast iron	1,40	0,79	-0,61
Tin	3,70	0,32	-3,38
Copper	1,20	0,10	-1,10
Permanent magnet	0	0,12	+0,12
Aluminium	0,95	0,22	-0,73
Plastic	0,21	0,20	-0,01

Although Grundfos continues to optimize manufacturing processes and material usage in its products, energy efficiency has now been the main focus in product development for some years (N. Thorup 2014, personal communication, 2 April; P. Jensen 2017, personal communication, 9 March). The energy efficiency of the pumps is a key parameter in the lifecycle cost of the products and in their lifetime environmental performance and it has historically been an order-winning feature of Grundfos' products. FIGURE 21 depicts Grundfos' progress in improving the energy efficiency of circulator pumps since 1999 to illustrate the immense development that has taken place in this field.

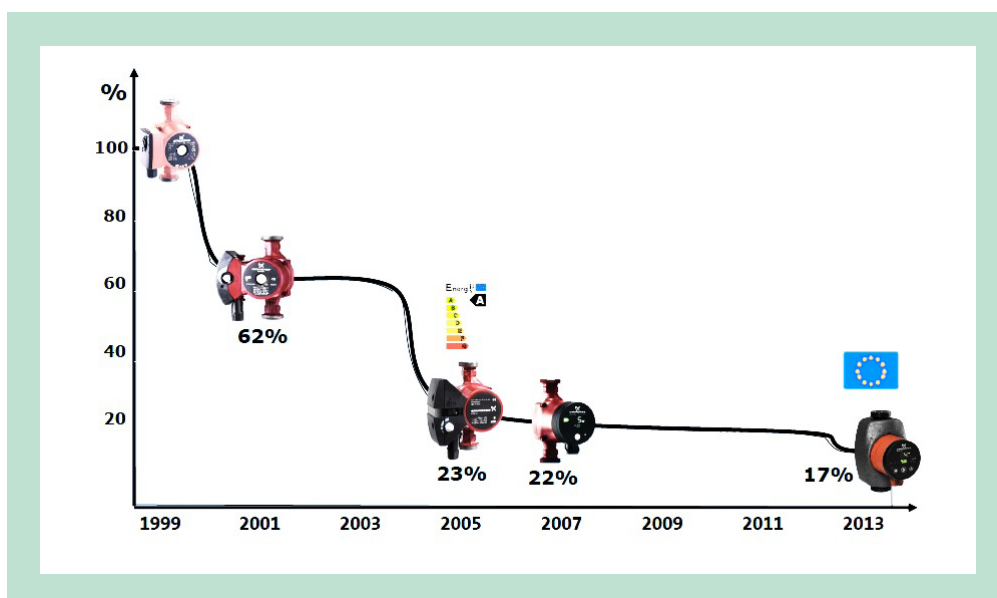


FIGURE 21. Reductions in the energy consumption of circulators since 1999. Adapted from Hansen (2015).

However, high energy efficiency has now shifted from being an order-winning feature to being an order-qualifying feature (P. Jensen 2017, personal communication, 9 March) and it is becoming increasingly difficult and expensive for Grundfos to make further improvements in the energy efficiency of the pumps, so it is likely that future product development will focus on new areas (Hansen 2015).

8.3 Circular economy experience

When the Closing Material Loops collaboration between Grundfos and Aalborg University began in 2014 Grundfos had already introduced circular economy-related activities. The take-back system for circulators in the Danish market and the Service and Solutions program were both examples of circular business models, although not explicitly labeled as such. The next sections outline these two business models.

A detailed description of the take-back scheme can be found in the first report from the Closing Material Loops project, 'Best Practice Examples of Circular Business Models' (Guldmann 2016), so only the main points of the scheme are presented below.

8.3.1 Take-back system

In 2012, in cooperation with wholesalers, Grundfos launched an experiment with a take-back system for circulators in the Danish market, motivated primarily by a desire to ensure jobs for employees at special terms as part of responsible business conduct (P. Jensen 2017, personal communication, 9 March).

Grundfos' sales model for circulators is based on distribution of the pumps to wholesalers, who sell the circulators on to installers. The return scheme utilizes the existing value chain for the return of used pumps as shown in FIGURE 22; installers are invited to return old circulators to the wholesalers for recycling when they are replacing circulators in plants and private homes.

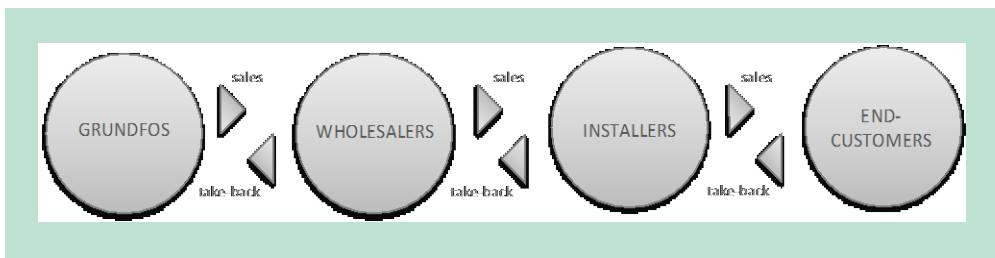


FIGURE 22. The sales and take-back flow in Grundfos.

Installers return defective or worn-out pumps to the wholesaler when they pick up new goods. The pumps are sent back to Grundfos in batches of at least 300 kg (K. Holleufer 2015, personal communication, 16 January; Grundfos 2014).

The return scheme demonstrates that return logistics can be established by developing stronger partnerships in the existing value chain, without the need to modify product design or the sales model directed at end-customers, who are not affected by the take-back system in this particular case.

8.3.2 Service & Solutions program

Grundfos Service & Solutions is another example of a business concept with circular economy qualities. The Service & Solutions program is a well-established, full-service proposition, targeted at industry customers needing waste water solutions; it offers customers advice on choice of pumping solution and assistance with installation, operations, maintenance and replacement (Grundfos n.d.; L. Mikkelsen 2016, personal communication, 17 June and 1 July).

The concept is around 10 years old, it is available from Grundfos enterprises around the world, and in Denmark alone some 650 contracts are in place (L. Mikkelsen 2016, personal communication, 17 June and 1 July). The Service & Solutions program is an example of a product-service system (PSS), in which service offerings supplement the products to enhance their value to the customer (see e.g. Tukker, 2015 for a discussion of the PSS concept). For example, it is important to select an appropriate pumping solution in order fully to exploit the energy efficiency of the pumps and so by complementing the physical pumps with advice on system optimization Grundfos improves overall customer value.

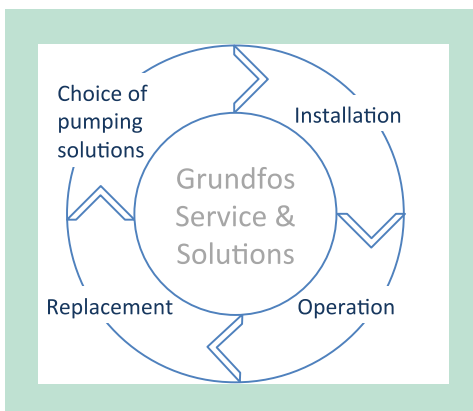


FIGURE 23. Illustration of service propositions. Adapted from Grundfos (n.d.).

This customer support, along with services such as installation assistance and maintenance, lowers the operating costs of the pumps and improves their reliability. This not only reduces downtime for the pumps and linked process facilities (Grundfos n.d.) but also increases the lifespan of the pumps, which benefits both customers and the environment, as demand for new pumps and raw materials for them is lower. Grundfos' economic resilience is ensured by

turnover generated from the service business as opposed to turnover from sales of replacement pumps.

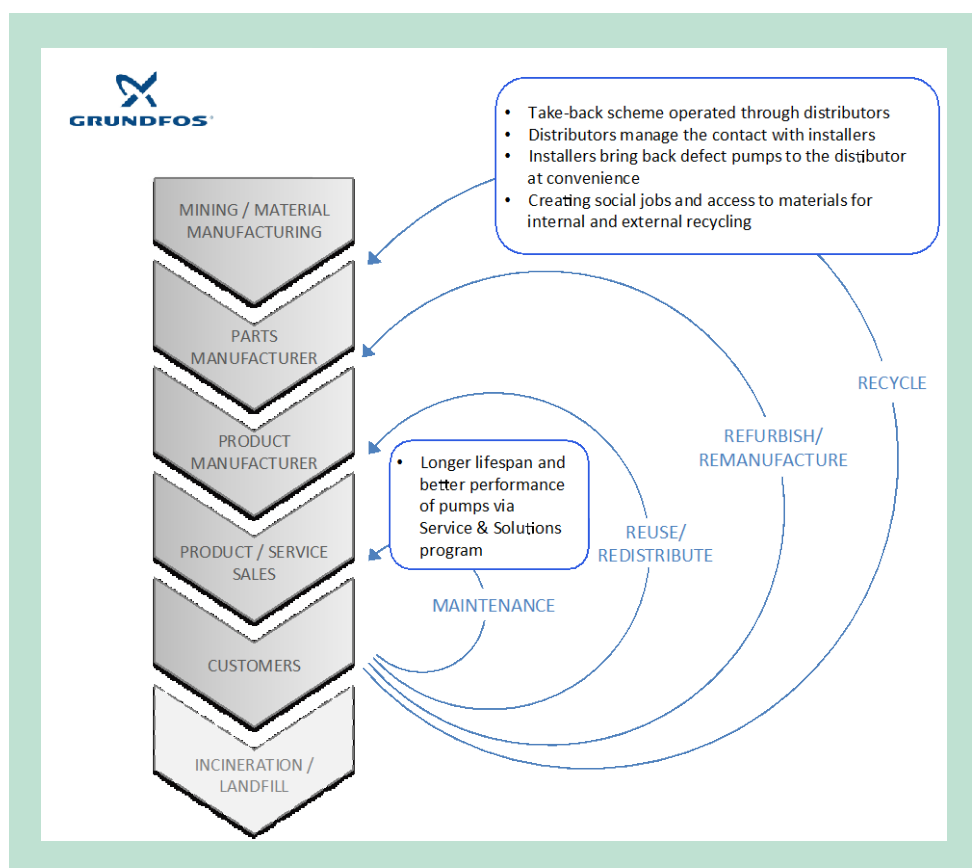


FIGURE 24. Grundfos' take-back scheme and Service & Solutions program.

Since the objective of Grundfos' services is to extend the life of its pumps, the business model is related to the innermost circle of FIGURE 24, which is concerned with extending the life of products through e.g. maintenance and repair activities. In Grundfos' case the business model is supplemented by other activities, including the advisory services described above, installation and assistance with operation and replacement.

8.4 Project collaboration

It is evident from the description of the take-back scheme and the Service & Solutions program that some business units in Grundfos were familiar with circular business models when the collaboration on the Closing Material Loops project started. The Closing Material Loops collaboration therefore considered building on the take-back scheme experiences (see list of project ideas below).

The existing circular activities were not, however, labeled as circular business models, and the stakeholders involved did not perceive the concrete business models as representing business opportunities to other divisions of Grundfos. It was judged worthwhile to determine whether other opportunities for circular activities could be identified, and a number of other ideas for circular economy pilots were discussed at the kick-off meeting.

The Closing Material Loops project was anchored in the Research and Technology (R&T) department, but stakeholders from other departments were invited to participate in the project, in order to ensure cross-organizational buy-in and collaboration on the project (cf. chapter 3).

This meant that the participants at the kick-off meeting for the Closing Material Loops project at Grundfos included an environment engineer from Group Sustainability and the head of Sustainable Product Solutions in the Development and Engineering (D&E) department as well as the head of Laboratory, Quality and Approvals in Business Development, head of R&T and the chief technical advisor in R&T, who was the primary contact during the collaboration.

A number of interesting ideas for further investigation during the Closing Material Loops project emerged during discussions at the kick-off meeting:

- Document experiences with the return scheme in the Danish market and investigate whether it could be expanded to include other markets or other product types.
- Integrate circular economy thinking into the upcoming Global Waste Strategy, perhaps through a workshop or meeting with another project participant, AVV (see Chapter 10 for a description of AVV). A joint event would allow Grundfos and AVV to share insights into how to eliminate waste and turn it into new resources.
- Exchange experiences with some of the other companies participating in the Closing Material Loops project to enhance knowledge sharing in relation to circular economy.
- Integrate circular economy principles into the product development process via modified Key Performance Indicators (KPIs) for product development projects. Grundfos was already working on integrating sustainability KPIs into development projects, so KPIs relating to closing resource loops and improving resource efficiency could perhaps be added to the set.
- Discuss and enhance a preliminary ideas map prepared by the researchers before the kick-off meeting to illustrate the range of opportunities. A selection of those preliminary ideas can be found in FIGURE 25.

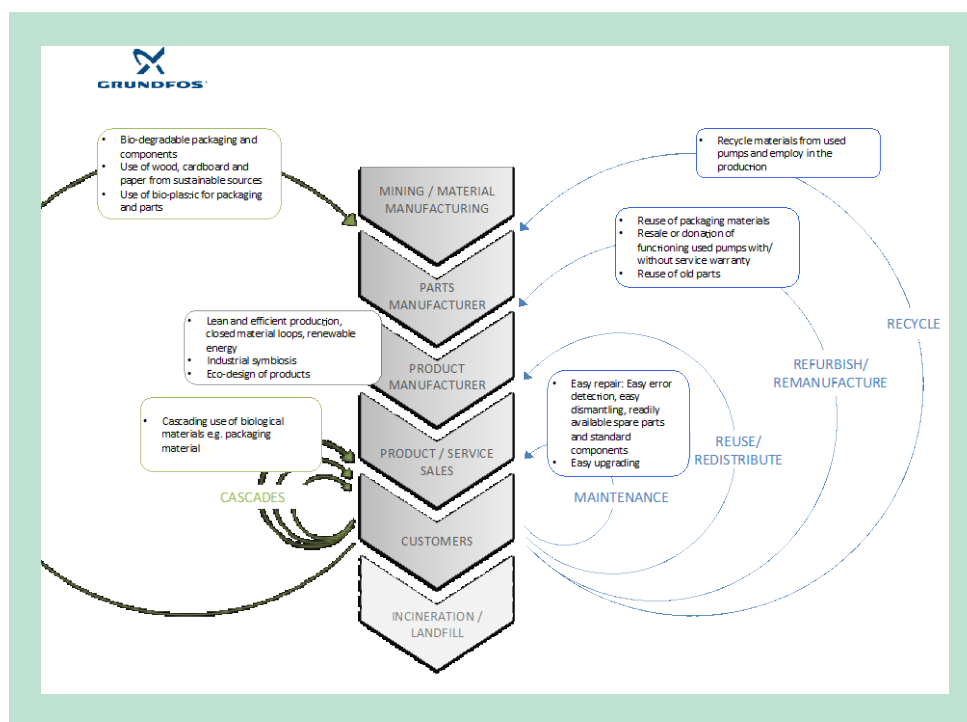


FIGURE 25. Selection of preliminary ideas for Grundfos.

Despite the attention given to the kick-off meeting by relevant departments across Grundfos, it proved difficult to establish the cross-organizational project team that the R&T department viewed as vital to the viability of the Closing Material Loops project. As an alternative R&T initiated meetings with employees working on sustainability across Grundfos, in order to promote greater cross-organizational collaboration on sustainability and to discuss the relevance of circular economy to Grundfos' sustainability work. The researchers participated in some of

these meetings to support discussion, but most were internal meetings intended to clarify the position of internal stakeholders on circular economy.

In a company of Grundfos' size with established product development processes and an established environmental strategy such discussions takes time and effort. Although resource efficiency and circular business models were already integrated in parts of the company, as described in sections 8.2 and 8.3, the initiatives taken in the context of the Closing Material Loops project to discuss the relevance of the circular economy and start a deeper cross-organizational dialogue on sustainability did not get the desired attention.

In view of the difficulty of establishing a cross-organizational project team and driving a circular economy agenda in the internal sustainability community, R&T adopted a new approach in fall 2014. This involved engaging key managers by inviting them for an inspirational tour around companies operating circular business models.

To support this venture the researchers prepared a description of four companies that would be interesting for the managers to visit, namely Philips, Renault, Caterpillar and Desso, and it was decided to set up a preparatory meeting with VPs from the Commercial Building Services and the Domestic Building Services division, from Group Quality & Sustainability and from R&T. The other participants were the Strategy & intelligence Director, a sustainability consultant involved in Grundfos' take-back scheme, the chief technical advisor from R&T who was the company contact for the Closing Material Loops project and the researchers from Aalborg University.

The purpose of the meeting was to present the concept of circular economy and its role in upcoming EU legislation. It was also intended that there should be a meeting to discuss what circular economy might mean to Grundfos and what approach it would be most appropriate for the company to take, but unfortunately, lay-offs and re-organization meant that it was cancelled. By this time, however, three VPs were interested in what circular economy might offer, and it was decided that the chief technical advisor would prepare a report examining the circular economy opportunities for R&T and for the commercial and domestic building services division in more detail. Before the report was prepared, however, initiatives driven by other departments in Grundfos became the focus of the company's circular economy activities.

In fact, during the spring of 2015 the Public Affairs department started to look into the circular economy package from the EU Commission and its relevance to Grundfos, independently from the activities of the Closing Material Loops project. Group Sustainability got involved in this exploratory process and the two departments successfully organized a cross-organizational workshop on circular economy with the aim of discussing what circular economy might mean to Grundfos.

Similar to the input from, The workshop featured presentations from companies such as Philips and Desso, which served a similar inspirational function to the visits to front-runner companies that were envisioned as part of the Closing Material Loops project. Four project ideas for further investigation were developed at the workshop:

- Extending the return scheme to other markets and product groups and using more of the returned materials in-house.
- Re-using more production waste in an expanded Return Department
- A lease-based business model for certain pumping solutions with high unit costs.
- A business model based on paying for new energy-efficient Grundfos pumps from the savings on electricity costs. This model could potentially involve taking back old pumps from other producers (P. Jensen 2017, personal communication, 9 March).

Subsequently CEO Mads Nipper and the Board of Directors got involved, and it was decided that a team of project managers would examine the four pilot project ideas further. Top management has tracked the progress of the pilot projects and thus clarification of the potential of circular economy is now a priority in Grundfos and a 'circular economy department' has been established to support the work (N. Thorup 2017, personal communication, 9 March; P. Jensen 2017, personal communication, 9 March).

As well as the pilot projects that emanated from the workshop Grundfos has also initiated a number of other activities relating to circular economy and resource efficiency. For instance, the R&T department now includes a life cycle assessment (LCA) expert and a recycling company prepares dismantling reports for key products. The preparation of dismantling reports represents a return to a former standard procedure for Grundfos; the reports are intended to provide information on how products are handled at the end of their life and get input on how to increase recyclability and prepare manuals for customers on how to deal with disposal (N. Thorup 2017, personal communication, 9 March).

8.5 Findings

During 2015 circular economy gained momentum at Grundfos thanks to the circular economy package from the EU Commission which prompted a workshop that was attended by managers from across the company.

The Closing Material Loops project did not yield the kind of progress that the R&T department and the researchers had hoped for. The activities undertaken as part of the project may nevertheless have fed into the discussions about circular economy that were later commenced in Grundfos, and may thus have helped to make the ground more fertile for circular economy ideas.

Grundfos' experience with the return scheme that was already in operation, recruitment of new top managers with an interest in resource efficiency, and the latent competence in resource efficiency within the product development department may well have contributed to the momentum as well.

Grundfos' circular economy efforts are continuing. Further development of the four circular economy pilot projects is being driven by the circular economy team and a number of stakeholders are involved.

9. Kuvatek

9.1 The company in brief

Kuvatek is a small company located in Sindal, in Northern Jutland. The company's main product is water coolers, but draught beer dispensers and special orders are also part of the product portfolio. Kuvatek's customers include schools, sports centers and private companies and it installs water coolers in place such as hallways, office areas and canteens.



FIGURE 26. Examples of Kuvatek coolers.

The company has a staff of four, including the owner, John Green. Sustainability has been a focus for John Green since he took over the company in 2007 (J. Green 2014, personal communication, 25 June).

9.2 Sustainability at Kuvatek

As far as the sustainability of the coolers is concerned, Kuvatek delivers high-quality coolers, with a long life span and minimal maintenance and service requirements. These features correspond with the qualities needed to ensure a long initial product life in the innermost technical loop, the maintenance loop. In addition the products are manufactured in recyclable materials and have a low environmental impact in the use phase. Kuvatek points out that Flexcool flow-coolers have the following advantages (Kuvatek 2012):

- Low energy consumption on stand-by. The only cool when water is drawn from the machine.
- Consistent with energy-saving programs, as the water is not stored in a tank.
- More efficient heat exchanger.
- The cooling agent is propane which has a much lower global warming potential than other cooling agents.
- Take up minimal space during transportation because of the compact design.
- Do not require servicing, which saves transportation.
- Easy to clean using just water and detergent.
- Main parts are fabricated in recyclable stainless steel and aluminum.

Kuvatek also ensures that all scrap material from the manufacturing process is sorted for recycling.

9.3 Circular economy experience

As well as its recycling activities, Kuvatek had circular economy experience in relation to repairs and refurbishment. The company was actively promoting repair rather than new purchases when it got in contact with customers that had a defective cooler. Kuvatek had also occasionally refurbished old machines for customers and was motivated by the potential environmental advantages as well as the opportunity to connect with old customers in need of a new cooler.

All this meant that the company was open to the possibility of making the taking back of products for refurbishment and recycling a more integral part of the business model, although it was uncertain about how to handle such the logistics, production planning and pricing implications and which customers to target.

9.4 Project collaboration

The starting point for the collaboration between Aalborg University and Kuvatek was Kuvatek's wish to offer a wider range of water coolers to customers, in combination with the company's openness to adopting circular business models. The company wanted to hold on to the strong sustainable profile of the products, but expand the product portfolio to include updated designs that would appeal to customers in a wider range of segments.

9.4.1 Industrial Design students

It was felt that expansion of the product range would be an interesting design challenge for a group of Industrial Design students at Aalborg University and would give them a chance to work on a real business assignment that involved considering the environmental consequences of different product design choices as well as determining which circular business model would best support the products. The student collaboration was intended to deliver creative product and business model suggestions that would inspire Kuvatek, whilst also contributing to the students' education.

Accordingly, in 2014 a group of 38 Industrial Design students were introduced to Kuvatek; John Green set out the company's products, its sustainability profile and current customer segments. Kuvatek stressed the importance of maintaining high energy efficiency and suggested that students focus on a new exterior for a well-functioning, energy-efficient cooler system. It was also stressed that Kuvatek preferred to use recyclable materials. These design criteria are related to the four technical resource loops in FIGURE 27.

The design students were not used to considering sustainability and had no experience with circular economy so a researcher from Aalborg University explained the principles of circular economy to them, drawing their attention to the importance of both product design and development of a business model that would ensure that products were reused, remanufactured or recycled. Students were encouraged to cover both product design and business models in their project work.

The students were also given a list of additional resources on circular economy to study at their convenience. In addition the researchers were available to answer questions relating to sustainability and circular economy throughout the duration of the students' project work.

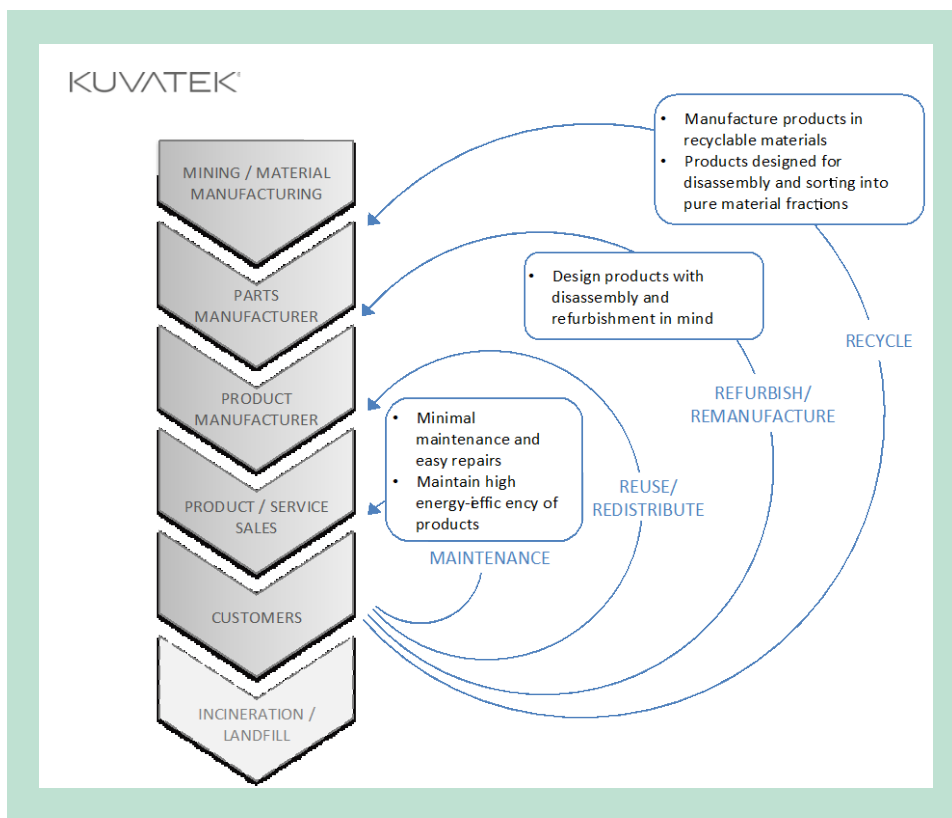


FIGURE 27. Design criteria for new Kuvatek products.

The students formed seven groups to develop new water cooler concepts for seven different customer segments including festival organizers, gas stations, private homes and offices. Representatives from Kuvatek and the circular economy researcher from Aalborg University were available throughout the semester for questions and critical debate. Moreover, students were given the opportunity to visit Kuvatek's suppliers in order to get a better understanding of what was possible on the manufacturing side.

The project work was presented and discussed at two midterm seminars and at a final project presentation day, attended by all students, Kuvatek representatives, the researcher and the students' supervisors.

9.4.2 Outcome of student projects

The collaboration resulted in seven new water cooler concepts, some of which were so interesting that Kuvatek decided to develop them further. FIGURE 28 gives a few examples of the designs.

The new designs developed by the Industrial Design students retained the existing coolers' high energy efficiency by retaining the existing cooling system, as suggested by Kuvatek. The students had also considered how to ensure sufficient airflow around the cooling unit and how to protect it from direct sunlight in designs for outdoor use, in order to avoid excessive energy consumption.

The suggested materials were predominantly recycled or recyclable, thus taking advantage of the recycling loop for materials (see FIGURE 1). The students had thought of how to ensure that the coolers would have a long life span, i.e. ensure that the product would stay in the inner resource loops of maintenance, reuse and refurbishment for a long time.

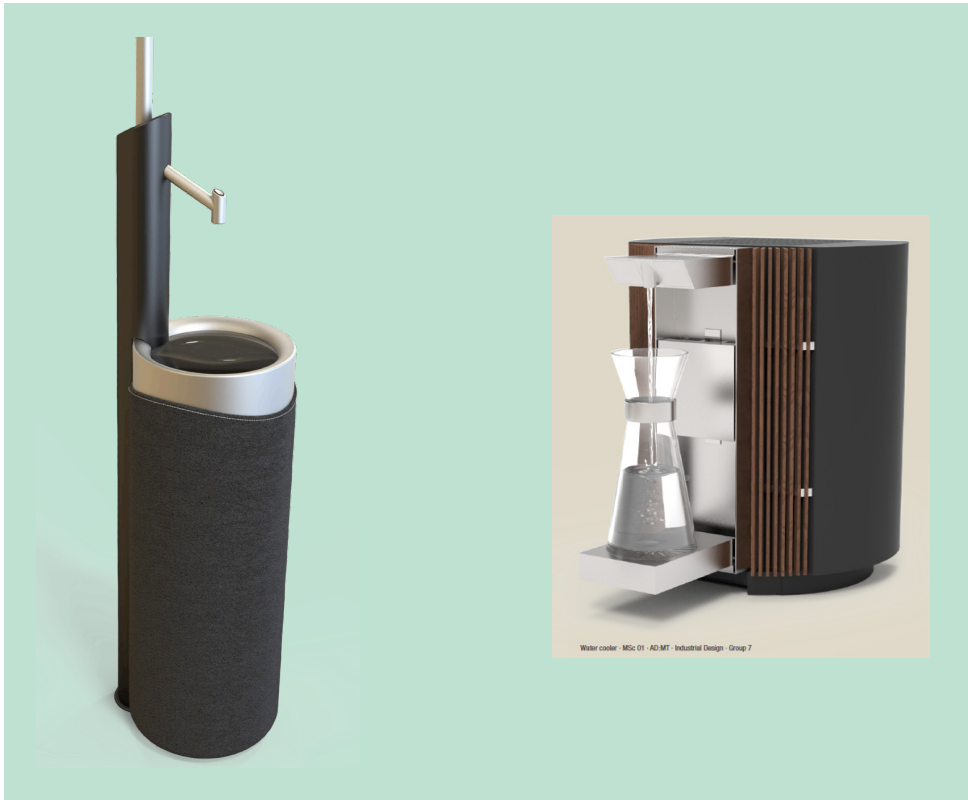


FIGURE 28. Examples of student designs for the office (Dam et al. 2014) and for private homes (Gogu et al. 2014) respectively.

In contrast, business model deliberations on, for instance, take-back systems, refurbishment opportunities, resale etc. were not widely represented in the students' output. This is probably because the focus of the Industrial Design master program is on how to develop solid technical, functional and aesthetic designs based on one-off sales in a linear business model; sale and return models for products are not yet a part of the curriculum.

Some students asked the researcher for extra material or information. The questions typically related to the relative sustainability of different materials. Questions about closing the maintenance, reuse, refurbishment or recycling loops through product and business model design were rare.

Nonetheless, despite their lack of previous experience with sustainable design, a few of the student groups picked up on the idea of circular business models, as FIGURE 29, which is taken from one of the student's reports shows.

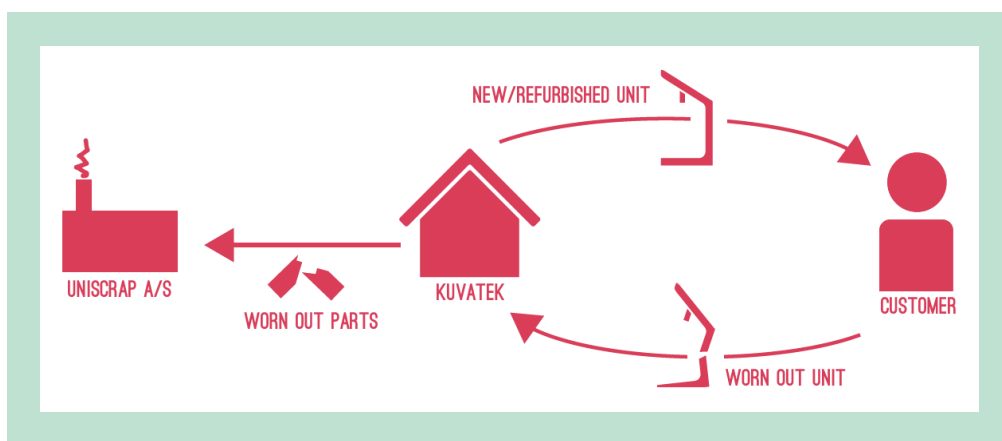


FIGURE 29. Return of worn out coolers for refurbishment and material recycling (Pedersen et al. 2014, p.53).

One group offered a simple, but potentially powerful way of having products returned to Kuvatek. A small sticker would be added to the water cooler stating something like: 'Kuvatek pays a small monetary reward for returned coolers. Please contact us on this address for further information'. The sticker would support a return flow of goods to Kuvatek, without the need for a leasing scheme or other demanding return scheme.

Although simple, this easy-to-implement suggestion could, in the long run, ensure a return flow of goods that would enable Kuvatek to explore a refurbishment business model or to reuse parts of the old machines.

The sticker communicates with customers in a non-intrusive way at the time of machine decommissioning, allowing customers to take advantage of the return benefit if they wish to do so. It thus provides an opportunity for Kuvatek to get in touch with customers at the time of machine decommissioning, when they are likely to need a new water cooler, and this might be valuable to the company regardless of whether it decides to operate a refurbishment or parts reuse business model. A further bonus is that the sticker signals Kuvatek's commitment to long-lasting products and to taking responsibility for its products throughout their entire lifecycle(s). Hence the marketing benefits of a Kuvatek reward sticker could be important.

9.4.3 Experimenting with refurbishment

Interestingly, Kuvatek experimented with a similar idea in parallel to the design cooperation process, inspired by the collaboration with the researchers at Aalborg University. Kuvatek decided to buy back some of its old water coolers, which it had come across in connection with the sale of new water coolers. The old coolers were refurbished and then resold to a price-sensitive customer at a reduced price and with a two-year warranty instead of the four-year warranty offered with new coolers.

Offering refurbished coolers was considered a way to attract new customers by Kuvatek, anticipating that once customers had experienced the quality and durability of the water coolers they would buy more expensive, brand new coolers in the future. It turned out that the customer who bought refurbished coolers from Kuvatek *did* go on to buy new coolers at a later date.

The reward sticker suggested by one of the student groups would be a simple and inexpensive way of supporting this kind of activity; the administrative burden for Kuvatek would be minimal and incurred only when an old cooler was available for take-back.

9.5 Findings

The collaboration between the design students and Kuvatek seemed to benefit both parties. Students had the opportunity to work on a real-life, sustainability-centered design challenge and Kuvatek was gained seven suggestions for new product concepts as well as having the chance to interact with the industrial design students and discuss different solutions with them throughout the semester.

During the collaboration process the students considered what a sustainable Kuvatek water cooler for each customer segment should look like and what circular business model could support product sustainability and profitability. The students discussed their suggestions with supervisors, Kuvatek and the researcher, and in the process new knowledge was generated for all the parties involved.

Today Kuvatek is familiar with the principles of circular economy and has begun to build experience and competences within the field. The students benefited from their involvement in an industrial collaboration revolving around the development of a sustainable product design and hopefully gained some insight into how sustainability considerations could be integrated into the design process and some understanding of what circular economy is.

New working relationships were formed during the collaboration and Kuvatek has subsequently employed some of the students involved in the project to work on different product development tasks within the company.

10. Siemens Wind Power

10.1 The company in brief

Siemens Wind Power manufactures wind turbines for both the onshore and offshore markets, and also services wind turbines. The company has approximately 14,500 employees and a turnover of around DKK 44 billion including the service division (Siemens Wind Power 2017).

10.2 Sustainability at Siemens Wind Power

Siemens Wind Power's environmental focus has historically revolved around providing ever more efficient wind turbines for onshore and offshore purposes. Recently, the company has also been engaged in internally oriented sustainability development projects. One of the projects looked at how to give more weight to environmental considerations in the design phase and resulted in a simplified ecodesign procedure that involves following checklists and setting environmental KPIs during the design process (J. Jensen 2015, personal communication, 28 May).

In consequence environmental KPIs are now specified for both the product development phase and the manufacturing of wind turbines. The setting of KPIs is supported by another Siemens Wind Power initiative, namely the carrying out of LCAs for all wind turbine platforms. The LCAs generate ample data on the current environmental performance of the turbines and thus provide a baseline for the creation of new KPIs (J. Jensen 2015, personal communication, 28 May).

10.3 Circular economy experience

The ecodesign and the LCA project were almost finished when the Closing Material Loops collaboration with Siemens Wind Power commenced in 2014.

Siemens Wind Power was engaged in service and maintenance of its turbines and was thus operating a business model corresponding to the innermost technical loop of FIGURE 1. These activities were not, however, explicitly recognized as part of a circular business model.

10.4 Project collaboration

In the months prior to the Closing Material Loops collaboration Siemens Wind Power had begun to take an interest in circular economy and had looked into the possibility of employing a PhD student to examine circular economy opportunities in the company.

Hence a natural starting point for the Closing Material Loops project was to clarify what circular economy might mean to Siemens Wind Power and what any future PhD student should be asked to examine. These topics were discussed at a number of meetings with representatives from the Environmental Health and Safety (EHS) department at Siemens Wind Power.

Some high-level ideas for how Siemens Wind Power could work with circular economy innovation emerged from these initial meetings, they are illustrated in FIGURE 30. These ideas were developed further in subsequent discussions between the EHS department, one of the researchers and the future PhD student. To summarize, it was decided that the PhD project would focus on determining which opportunities to slow down or close each of the four resource loops depicted in FIGURE 30 were most relevant to Siemens Wind Power and what could be gained environmentally and commercially from doing so.

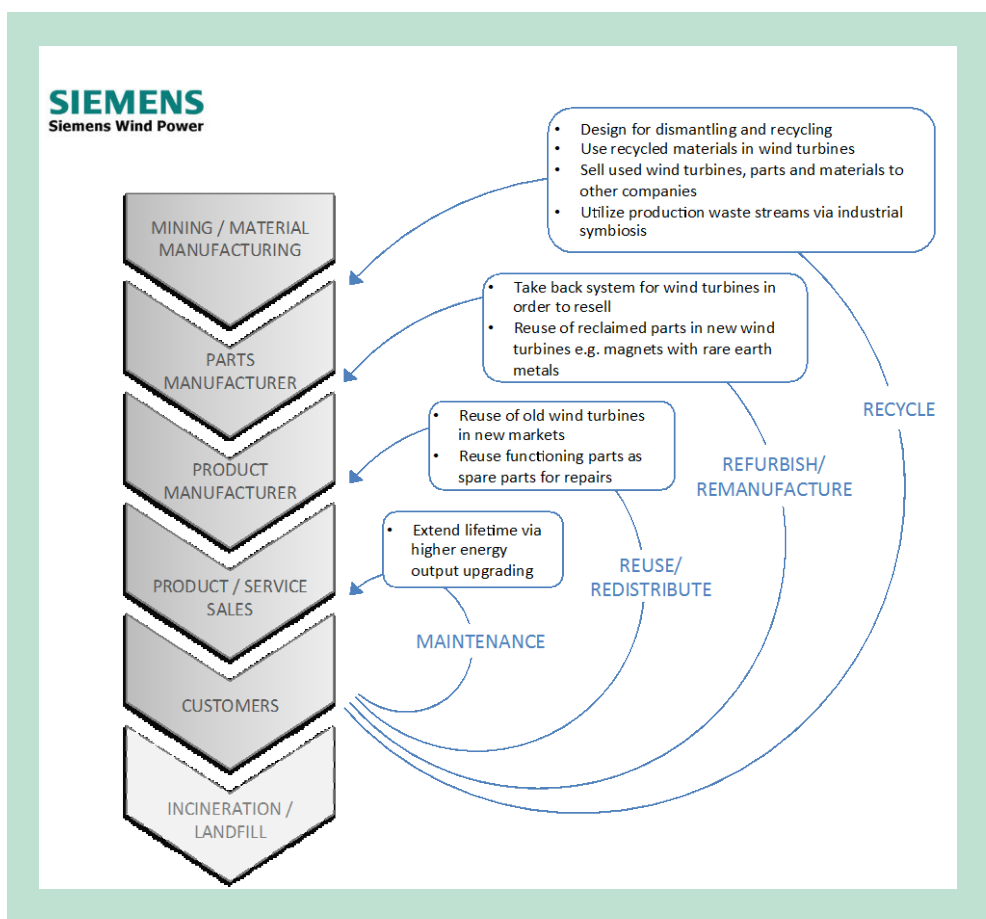


FIGURE 30. Preliminary idea map for Siemens Wind Power 2014.

10.4.1 GenVind innovation consortium

One of the approaches to closing resource loops that the PhD student later worked on concerned Siemens Wind Power's participation in the GenVind innovation consortium, which consisted of partners from 2 GTS institutes (i.e. technological service providers approved by the Minister of Higher Education and Science), 3 universities and 17 private companies, including other wind turbine manufacturers (J. Jensen 2015, personal communication, 28 May).

The GenVind consortium worked to identify and develop technically, environmentally and economically satisfying ways to handle end-of-life products and composite manufacturing waste. Specifically, the project aimed to establish symbiotic industrial processes, whereby waste materials from one manufacturer would be used in production processes at other manufacturers (J. Jensen 2015, personal communication, 28 May; GenVind 2014a).

The consortium's activities were inspired by the principles of circular economy and the various applications that were tested were grouped into categories corresponding to the resource loops presented in FIGURE 30: 1) reuse, 2) resize/reshape, 3) recycle, 4) recovery and 5) conversion. Viable possibilities were identified in all categories:

1. Reuse. The project established that wind turbine blades can be reused in their current form as a blade for another turbine or as a component of, e.g., playgrounds, bus shelters, city benches, interior furniture etc. (GenVind 2014b)
2. Resize/reshape. It was demonstrated that the blades could be turned into standardized or custom-made parts for buildings, furniture, skateboards, scooters etc. (GenVind 2014b).

3. **Recycle.** It was shown that recycled materials are efficient aggregates that can be used in secondary applications/products e.g. cement production, paint production etc. to improve their properties. The material can also be molded with a glue to make various products, noise screens being one example (GenVind 2014b).
4. **Recovery.** Waste-handling processes e.g. glycolysis, solvolysis or pyrolysis were shown to be efficient ways of extracting glass fiber and epoxy from the blades. The extracted epoxy can be used, e.g. as a fuel, and as the glass fibers retain 70-90% of the virgin fibers' strength they can be used in other structural applications e.g. insulation. Thus although the extracted materials cannot be reused in the manufacture of new turbine blades they can be used in other applications or products that require less tensile strength (Lillevang 2016; GenVind 2014b)
5. **Conversion.** Finally the project demonstrated how to improving the heat output from parts that are incinerated (because they cannot be used for any of the other purposes) (GenVind 2014b).

10.4.2 Rethink Resources innovation center

During the PhD project other circular economy opportunities were recognized in addition to those relating to the four resource loops and to energy recovery that were identified during the GenVind project. Siemens Wind Power participated in the Rethink Resource innovation center, collaborating with Technological Institute, the University of Southern Denmark, and GS1 to uncover potential in circular economy (Grüttner, Melchiorsen & Hamann n.d.; J. Jensen 2015, personal communication, 28 May). The results of this collaboration were:

- LCAs comparing the environmental effects of two competing generator designs, the direct drive and the geared generator designs. The results are currently used in the product development department at Siemens Wind Power.
- A mapping of opportunities and technologies for the recycling of magnetic components from direct drive generators at their life. This is an area in which Siemens Wind Power remains active.
- Conceptual groundwork for a tool that compiles product passports for wind turbines to improve recycling rates for components and materials when the turbines reach the end of their life (Grüttner, Melchiorsen & Hamann n.d.; J. Jensen 2015, personal communication, 28 May).

10.5 Findings

The work carried out in the PhD project on circular economy resulted, in combination with other activities in Siemens Wind Power, in new insights. For instance, Siemens Wind Power was able to confirm that large parts of the core business and ongoing environmental management efforts were consistent with circular economy principles. The existing service business, LCA-led efforts to reduce environmental impact, on site refurbishment activities such as upgrading of blades or software and the upcoming lifetime extension program all fit within the circular economy framework.

Other ways of working with circular economy principles were also developed and prospects were identified in relation to each of the resource loops in FIGURE 30. As an example, the reuse of blades for bus shelters and the recycling of magnetic components were examined. In some instances a business case that helped to clarify the environmental and economic effects of closing a resource loop was developed. These business cases showed that the economic benefits varied substantially and whether the company could tap into a standardized process, as in the case of magnet recycling, proved to be important. The business case for magnet recycling seems promising, whereas closing the loop for blades requires case by case evaluation, partly because there are as yet no standardized processes in place (J. Jensen 2015,

personal communication, 28 May). Other challenges associated with blade recycling are addressed in a discussion paper from WindEurope (2017).

The project gave Siemens Wind Power experience of solving challenges related to closing resource loops in collaboration with external partners in the GenVind and Rethink Resource projects. The various circular economy activities in which the company became involved meant that interest in circular economy spread from the EHS department to encompass large parts of the organization. Some of the project's investigations had a product development focus whereas others were aimed at remanufacturing (termed 'reuse' and 'resize/reshape' in the specific project).

The Closing Material Loops project helped to create awareness and interest in circular economy at Siemens Wind Power, and set in train the process of asking questions, generating support for the concept in the EHS department and developing the first ideas for circular business models. Subsequently other activities, specifically the hiring a PhD to examine circular economy opportunities for Siemens Wind Power and participation in external projects, meant that the company asked and investigated new questions in collaboration with its external partners. This process ultimately generated a number of concepts for closing resource loops. Over the same period organizational support for circular economy work increased.

Today circular economy is part of Siemens Wind Power's environmental strategy efforts to close resource loops continue. Siemens Wind Power is engaged in both internal and external projects aimed at extending the lifetime of products and components as well as closing the material loop at end-of-life.

Waste Management Company

11. AVV

11.1 The company in brief

Affaldsselskabet Vendsyssel Vest, or AVV, is a waste management company established in 1988. AVV operates an incineration facility in Hjørring and 18 recycling centers in the municipalities of Hjørring and Brønderslev, and has around 102 employees (AVV 2016). Around 600,000 people visit its recycling centers each year (H. Riisgaard 2015, personal communication, 26 August). AVV also sells second-hand goods via a bricks-and-mortar shop and an Internet shop (T. Nørgaard & H. Riisgaard 2015, personal communication, 16 March; AVV 2016).

11.2 Sustainability at AVV

AVV's mission is to be a leader in sustainable waste solutions and its operations are guided by the following key values:

- Consider the environment first
AVV works to promote waste prevention, direct reuse and recycling, with the target of transforming waste into new resources. The company keeps finding new ways of recycling so that it can remain one of the frontrunners in waste management and minimize waste depositing (AVV n.d.).
- Be proactive
AVV challenges itself and the industry through research, new thinking and the development of new methods and approaches. The company's aim is to have a solid economic foundation and an internal team that facilitates innovation and growth through diversity and mutual respect (AVV n.d.).
- Take responsibility
AVV is serious about its responsibility as part of the waste industry. The company wants to lead and help citizens and companies save natural resources and reduce their impact on the global climate. AVV also wish to be active in the local community and an inclusive employer (AVV n.d.).
- Show respect
Respect for the individual, the environment and coworkers is important to AVV and the company actively encourages employees get involved in and influence the company's future development (AVV n.d.).

One of the ways AVV works to promote new thinking is via research projects, which are also designed to involve citizens. Projects such as 'Tversted' and 'Nulskrald' were carried through recently. In these projects interested citizens of the municipality of Hjørring and Brønderslev were involved in co-development of new recycling routines (T. Nørgaard & H. Riisgaard 2015, personal communication, 16 March). Research is also done by two industrial PhD students with backgrounds in the humanities and engineering.

11.3 Circular economy experience

One of the research projects involved keen citizens sorting milk cartons from the waste stream for recycling by a Swedish recycling company identified by AVV. When the project came to an end AVV decided to continue to support the recycling of milk cartons, although there was no economic incentive to do so. This is an example of AVV's adherence to the value that the

environment comes first as economic interests were not allowed to scupper a scheme with environmental benefits (T. Nørgaard & H. Riisgaard 2015, personal communication, 16 March).

AVV has also tried to change perceptions of what counts as waste and what as resources by, for instance, working with designers to create art and furniture out of goods that are normally considered waste, see FIGURE 31. The solutions are meant as an inspiration, and have been shared with both professionals from the home furniture industry and the 300-400 private citizens who visit AVV and tour the facilities each year.



FIGURE 31. Chairs made out of old skateboards.

Offering free compost made from domestic garden refuse is a good example of circulating organic material and is a solution typically implemented by Danish recycling centers. With regards to closing technical loops, it is possible for citizens to donate functioning goods to a second-hand shop at the recycling center in Hjørring, shown in FIGURE 32, and many take the opportunity to do so.



FIGURE 32. Second-hand store at AVV.

AVV has observed that closing the reuse circle creates 1 local job for every 100 tons of goods that pass through the loop. For comparison, AVV's incineration facility creates 1 local job for every 5000 tons of goods processed. This is in line with the general perception that closing the inner circles has job creation potential than closing the outer circles (see e.g. Ellen MacArthur Foundation 2013a). Furthermore, although incineration does capture heat that is then transmitted to households in the municipality, the use value and the material value of the goods put into the system is destroyed. Only metals are currently mined from the incineration residue.

11.4 Project collaboration

Although recycling was clear a key part of AVV's operations the company did not have a circular economy perspective on its activities when the collaboration with Aalborg University commenced. AVV was interested in gaining such a perspective and in early 2015 a workshop involving the Head of Innovation and the Business Developer at AVV and one of the researchers from Aalborg University agreed to map how AVV's activities related to a circular economy framework.

The researcher prepared a draft map based on discussions at the workshop and information from AVV's 2014 Environmental Report (AVV 2014). This map was refined during subsequent dialogue between AVV and the researcher and resulted in the overview presented in FIGURE 33.

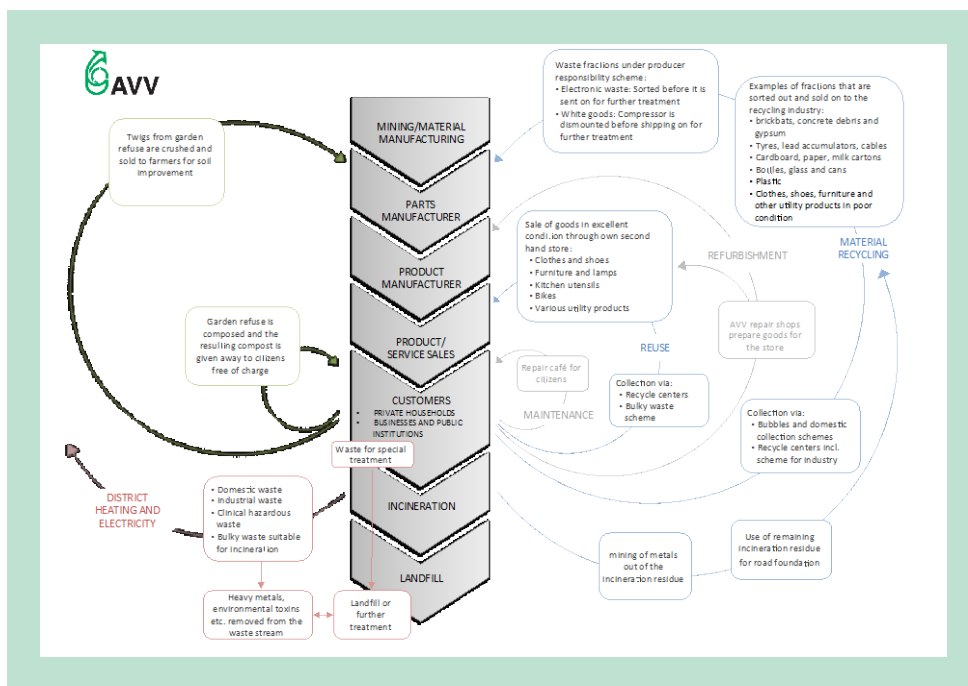


FIGURE 33. Circular economy mapping at AVV.

The blue lines in the diagram relate to technical products and materials and the green lines to biological cycles. The red lines indicate activities related to waste that requires special treatment and waste that is to be incinerated whilst the grey lines illustrate planned AVV initiatives.

11.5 Findings

The Closing Material Loops collaboration deepened understanding of the circular economy concept at AVV. One of the outputs of discussions between Aalborg University and AVV was an overview of how the company's current and future activities fit into the circular economy framework, which may help AVV to decide where to focus its efforts in the future.

The mapping of AVV's activities and the associated discussions highlighted some interesting points in relation to the circular economy framework. First, circulating goods is not always the best solution. If a product contains harmful toxins it is better to get it out of circulation and allow specialist companies to process it to avoid further damage to citizens and the environment.

Second, from AVV's perspective it is vital that waste prevention is part of the circular economy framework. Preventing generation of waste is the first priority in any strategy to minimize flow of materials and goods through the economy, alongside any efforts to keep goods and materials circulating in closed loops. Sometimes circular economy-based innovation overlooks the importance of waste prevention.

12. Discussion

The detailed case descriptions in the previous chapters illustrate the varied processes and outcomes resulting from collaborations that were part of the Closing Material Loops project. The project did, nevertheless, generate some more general findings, which are discussed below.

12.1 Different levels of agility

Some companies moved faster than others. Most of the small companies were quick to see the potential of circular economy and progressed to idea generation and initial business model examinations, whereas the large companies generally moved more slowly. It is likely that a number of factors contributed to this difference.

First, in the small companies the researchers collaborated directly with the owner-manager(s), so the project team included the company's leaders. This meant that organizational buy-in and management commitment was assured from the beginning, whereas in the large companies the project team was drawn from the environmental department, the R&D department or similar functions in the organizations and top management was less involved. This meant that in the large companies, the company contacts had to seek an internal decision on circular economy innovation before taking serious action. Moreover, the contacts had the extra challenge of belonging to departments that do not traditionally drive business model innovation activities.

Second, several of the small companies differentiated themselves on their sustainability profile and had owner-manager(s) who held strong personal beliefs regarding the importance of operating a sustainable company. The small companies were in close contact with their customers and they generally understood that they needed to stay ahead of large players in the market on issues such as sustainability in order to remain competitive. This may explain why the small companies seemed more receptive to the new sustainability ideas that circular economy represents.

Third, the small companies seemed to find it easier to experiment and were more open to new opportunities as this was in line with their usual modus operandi. They also tended to be more prepared for external collaboration - with their own network and with researchers and students from Aalborg University - as part of the examination process. In comparison the large companies seemed to have less flexibility to experiment and initiate external dialogue, as they tended to be more focused on cost optimization and continuous improvement of daily operations. This complicated the task of ensuring internal alignment and support for the Closing Material Loops project before moving too far.

12.2 The necessary match with existing agendas

During the project the companies tried to combine the new circular principles and business opportunities with existing aspirations and agendas. Accordingly, the principles of the circular economy seemed to generate particular interest when they aligned with an existing agenda. For example, Kuvatek wanted to develop new product designs and so circular economy principles were integrated into the new designs. At KnowledgeCotton Apparel circular principles were combined with the existing aspiration to establish a brand store. Danfoss already was already working on updating its Eco-Design Guideline and experiencing implementation difficulties, so combining the guideline project with the Closing Material Loops project was attractive as the two projects could support each other and jointly contribute to Danfoss' environmental performance. A final example is that Siemens Wind Power was already looking into

opportunities for responsible handling of end-of-life wind turbine blades when the company hired a PhD student to examine the opportunities of circular economy and so the company continued this work within a circular economy framework.

In this way ongoing activities and business plans influenced what circular economy concepts and ideas were most relevant to each company. Other factors also played a role, most notably market demand, but also the area where the greatest economic and environmental opportunities existed, the economic conditions in the company, organizational culture in the sense of space for new ideas and experimentation, organizational power structure and management's position on circular economy.

The mix of these elements in the large organizations often resulted in challenging working conditions for company contacts in the Closing Material Loops project, not least the need to clarify management's position on circular economy, which influenced the examination process. The importance of management support for any new business venture is well known, but since taking a circular economy perspective on how a business unit (or an entire company) operates constitutes a fundamental shift in *modus operandi*, management support is particularly important to investigations of circular economy and related innovation.

In companies like Gabriel, Grundfos and Danfoss the company contacts made efforts to involve management in the circular economy discussions to ensure organizational alignment on how to position the company in relation to the circular economy and approach potential opportunities inherent in circular business models. This was generally difficult, but the European Commission's plans on circular economy, ongoing debate in the business community e.g. at events like the World Economic Forum and UN Global Compact meetings, as well as debate amongst the general public seemed to be helpful in directing management's attention to circular economy and facilitating internal discussions.

12.3 Taking a flexible approach

As stated at the beginning of the report, the companies decided on the number of employees that were involved in the project collaboration, the tempo, the time spent on the project, and the direction of the investigations. This flexible approach seemed central in arousing interest in participating in the Closing Material Loops project and in sustaining the attention to circular economy investigations in the companies.

The fact that the companies continued to explore circular economy after the obligatory introductory meetings with the researchers whether, in the context of the Closing Material Loops project, in cooperation with other external partners, by hiring PhDs or in similar ways, goes to show that this approach can kick-start circular business model innovation in companies. The continued interest in circular economy signals that, regardless of size and industrial sector, the companies found the concept relevant.

The companies that explored more detailed circular business models did so in distinctive ways. They used various methods to explore the building blocks for different circular business models. One of the initiatives in Kuvatek, for instance, was to develop new product designs that were appropriate for a circular business model setup. In other words, Kuvatek's starting point was the 'value proposition', 'circling of goods', and 'sustainable inputs' (cf. the circular business model canvas in FIGURE 3) and it used a class of industrial design students to carry forward its exploration of circular economy. Gabriel, on the other hand, examined ways of offering a stronger 'value proposition' to their customers and building 'new relationships' with them via circular business models through dialogue and discussion with customers and relevant parts of the company. Siemens Wind Power explored various technical opportunities that might constitute 'key activities' in a new circular business model by collaborating with external partners in innovation consortia. Finally, KnowledgeCotton Apparel integrated circular econo-

my thinking with its aspiration to have KnowledgeCotton Apparel brand stores, clarifying what all of the business model building blocks in FIGURE 3 would look like for a circular brand store. The necessary inputs for this were generated by amongst other things, interviewing sales agents and seeking advice and support from external partners.

During the period we followed them most of the companies gradually engaged more and more with the idea of circular business models, apparently fuelled by a combination of the collaboration with the researchers from Aalborg University, other related projects and initiatives they were presented with, and the generally higher level of interest in circular economy throughout society. The result was that more than 100 ideas for circular business models were generated and eight of these were investigated more closely during the course of the Closing Material Loops project. Additional circular business model ideas were generated and examined by the companies in collaboration with other partners. Finally, a number of student projects examining broader sustainability issues prompted by the Closing Material Loops project were also carried out (see Annex for a list of these).

12.4 A suitable core toolbox

As outlined in section 3.5, the core toolbox for the company collaborations comprised a small number of models and principles. These were applied in different ways throughout the innovation process and were generally regarded as helpful in facilitating investigations.

The circular economy system diagram depicted in FIGURE 1 proved valuable in the initial phases of creating awareness and interest, where it was used to explain the basic principles of circular economy and the four bases of value creation. In later phases of the project collaboration the framework was transformed into ideas maps that captured ideas for circular business models in a way that enabled them to be organized and discussed. This simple visualization of the kind of resource loops that were involved in a particular idea for a new circular business model was found to be very useful for giving an overview of ideas and facilitating constructive discussion of them. The value bases supported discussions about which ideas had most potential from an environmental viewpoint. The four basic principles helped the project team to ask questions such as whether a certain idea would allow goods to circle longer, what subsequent usage of a second-hand product might be if pure material flows were ensured etc.

From the beginning of the project collaboration the companies were offered best practice examples of circular business models in operation in their own or related industries (such as those presented in 'Best Practice Examples of Circular Business Models', Guldmann 2016), and the companies referred to these and other cases they had encountered during project discussions. The best practice examples thus proved a valuable tool for starting company dialogue in the early phases of the collaboration and a source of inspiration throughout the innovation process. The examples seemed to prompt the companies to ask whether and how they might do something similar in their own business context.

The circular business model canvas was used most directly when a particular pilot project idea was examined in detail and during development of business cases (cf. the process at KnowledgeCotton Apparel). The circular business model canvas also helped the researchers to reflect on which circular business model building blocks had been examined during the innovation process and which should be introduced and explored next.

12.5 Future work

Experiences in this Closing Material Loops project suggest that it would be advisable to take a flexible approach to setting up collaborations and to the innovation process in future projects aimed at advancing the circular economy agenda in companies. It is important to build on existing company motivation.

The companies in the Closing Material Loops project focused on different circular business model building blocks as described above. Each of these building blocks was found to provide a valid basis for business model innovation. In all probability the companies will need to work out the exact design of all of the business model building blocks in order to yield robust and viable business models. Given the complications the companies encountered in attempting to integrate circular economy ideas into the companies' business models, we would recommend adopting a less ambitious approach at the beginning of the innovation process and looking at just a few of the building blocks to start with.

Experimenting with the development and implementation of a small-scale, low-risk, fairly simple pilot project also seems likely to be a good way for many companies to proceed. Such pilot project experiments would facilitate further organizational learning and competence building in the area of circular economy.

The Closing Material Loops project was a first-mover project that was intended to advance the circular economy agenda in the participating companies, at a time when the concept of circular economy was very young. The project was successful in prompting companies to explore circular economy explorations and was assisted in this by factors such as rising societal interest in circular economy and the presence of other similar initiatives. The future will show if innovation continues and eventually yields competitive advantage for the participating companies.

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Annex

The table below gives examples of student projects prompted by the Closing Material Loops project.

TABLE 5. Student projects.

Company	Title	Student(s)
Gabriel	ZenXit - the environmentally friendly alternative to flexible polyurethane foam	Juskan, M.P.
	Water management in a Lithuanian textile dye house	Gerdauskaite, D.
	Business Models for a Circular Economy - A case study of Gabriel Holding A/S	Li, M.A.R.
KnowledgeCotton Apparel	Sustainable Fashion Through Repair	Mathiesen, H.B., Blom, J.L., Ayala, M., Higgs, M., Andersen, S.L.
	Systems make it possible – People make it happen	Oldopp, M.
Danfoss	Eco-Design in Product Development Processes at Danfoss Drives - Practices and Requirements from the EU Directive	Clausen, A.
Grundfos	Implementation of an updated ISO 14001 environmental management system at Grundfos	Clausen, A.
Kuvatek	A Water Cooler for the Ambulant	Jelle, A., Nielsen, A.H., Knigge, A., Hansen, J.H., Jørgensen, T.
	Ponder	Dam, N., Lund, M., Nors, B., Verner, H.
	MO:ST - Kuvatek Bike Station	Norup, E., Søgaard, J., Knudsen, L.S., Pedersen, R.Ø.
	Wailua	Pedersen, N.N.H., Mindru, M., Palaima, M., Fischer, M.H.
	Sui	Østergaard, A., Nørgaard, M.H., Jensen, N.S., Nielsen, N., Vikingsdóttir, S.
	Neptune	Jakupovic, I., Møgelmoose, K., Henriksen, N.B., Sørensen, P.V., Jensen, T.M.
	FLEXdelux	Gogu, A., Hillingsøe, M.P., Poulsen, A., Jacobsen, M.S., Nogare, G.D.
Siemens Wind Power	Waste Management of End-of-Service Wind Turbines	Karavida, S., Nõmmik, R.
	Recovering critical materials in wind turbines	Jensen, J. P.

Towards Circular Business Models – Experiences in Eight Danish Companies

This report presents the early outcomes of circular business model innovation in a group of Danish companies. The aim of the collaborations between Aalborg University and the companies was to create new knowledge about how to move towards an integration of circular economy in industry.

The case descriptions in the report explain the ways in which the circular economy journeys unfolded in the participating companies and what the outcomes were. The journey and the outcome was different in each company. In some companies, most efforts were directed at building organizational support for a beginning integration of circular economy principles in the company. In other companies, circular business model ideas were advanced substantially. Nevertheless, in all participating companies a better understanding of circular business models and their relevance to the company was attained.

The study showed that a flexible approach to circular business model innovation, based on a few core tools, helped to generate interest in circular business models and motivated companies to move forward on their circular economy journey.

Exploration of the circular economy concept generated more than 100 initial ideas for circular business models, eight of which were investigated in more detail.



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