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Towards a Data-driven Circular Economy: Stakeholder Interviews

Inka Orko (ed.)

VTT TECHNOLOGY 400

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Preface

The lean and efficient use of raw materials, energy and products is a key principle in the circular economy. However, our activities and industrial operations can only be designed as circular in a holistic way if we share information across the value chain and between the stakeholders.

In the Circular Design Network project (2020–2022), we have focused on understanding the opportunities and pathways to data-enabled circular operations, and on creating a network in data for circular design.

This report analyses the findings and summarises the results of the first step in the project: the stakeholder interviews (CircDNet WP 1). The interviews were carried out as a shared effort by all the project partners (VTT Technical Research Centre of Finland, Geological Survey of Finland GTK, Natural Resources Institute Finland LUKE, Finnish Environment Institute SYKE and Aalto University) mainly during the year 2021.

We'd like to thank the Academy of Finland (337713, 337714, 337715, 337716, 337717) for funding the work, the many researchers contributing to the interviews and this report, and the interviewees and their organisations for their valuable insights.

Espoo, 11.2.2022

Inka Orko
VTT Technical Research Centre of Finland
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Contents

Abstract

The lean and efficient use of raw materials, energy and products is a key principle in the circular economy. However, our activities and industrial operations can only be designed as circular in a holistic way if we share information across the value chain and between the stakeholders.

In the Circular Design Network project (2020–2022), funded by the Academy of Finland, we have focused on understanding the opportunities and pathways to data-enabled circular operations, and on creating a network in data for circular design. This report analyses the findings and summarises the results of the first step in the project: the stakeholder interviews (CircDNet WP 1). The interviews were carried out as a shared effort by all project partners (VTT Technical Research Centre of Finland, Geological Survey of Finland GTK, Natural Resources Institute Finland LUKE, Finnish Environment Institute SYKE and Aalto University) mainly during 2021.

The stakeholder interviews consisted of 81 company, R&D and regional support organisation interviews mainly in the value chains of batteries, textiles and food-carbon cycles, with a few interviews in the pulp and paper and chemical industries. We interviewed the stakeholders on their roles in the value chain, their data-related challenges and needs in circular practices, the role and data use in their current operations, the data tools, collaboration and activities around data, and the opportunities they saw in data for a circular economy. The stakeholders were categorised per value chain and also according to their position in the value chain: raw material suppliers, product manufacturers/solution providers, technology providers, (end) users, recycling and recycling service providers, waste management, and/or others (regional, R&D and data platform providers). To study the findings per value chain and per their position in the value chain, we encoded the responses into a specific analysis frame and studied them by the value chain and by their position in the value chain.

The role of circular economy thinking, ie. whether the business model is fully based on circularity vs. circular practices are emerging or in the margin, varies greatly between the interviewed organisations depending on their business model and sector of industry, and theier position in the value chain (B-to-B, B-to-C). Also, the role of data varies between stakeholders.

In general, all interviewed organisations collect and use data for operations and customer management as a standard practice; but at the same time, most would like to better utilise data, also for circularity. Large manufacturing organisations have the means to invest in developing new data-based opportunities, and some have taken steps forward and are developing data platforms internally or with an external partner. On the other hand, smaller innovative and data-oriented organisations have the opportunity to design and implement new data-based approaches in an agile way.

Data platform providers can play an important role in enabling data sharing and internal use. Overall, almost all of the interviewees had an interest in specifically expanding customer data collection and utilisation and to create new business models based on that. Traceability of materials through the value chain is a key driver and opportunity for data management. In particular, the stakeholders saw a growing need for localised and transparent LCA and sustainability data.

Open data or data sharing at the general level was also regarded as interesting. However, the concrete data opportunities are still for the most part hazy, and few stakeholders are willing to share their own data unless there is a valid business reason and the means to control the use of the data. We deduct that in order to create a living data ecosystem, an initiator and driver, with a vision of a data-based (business) operation, is needed. Also, smaller data pilots may create a controlled and agile way to proceed.

We noted that the boundaries of the different roles in the value chain are blurring in a circular economy. New circular business models seek the value in combining, for example, circular products manufacturing to waste management, or end-of-life recycling service to retail or manufacturing. Connecting data to operations requires cross-disciplinary competences. In a circular economy, the roles are expanding and combining in innovative ways, which may shake up the traditional practices and collaboration in the value chains. New combinations of competencies may be needed. The changes may also cause some need for readjustments at the regulatory and public policies levels, such as end-of-waste processes or GDPR practices.

1. Introduction

A circular economy is an emerging economic system based on business models supporting the recycling and recovery of materials in production and consumption processes (Korhonen et al., 2018; Ghaffar et al., 2020). The circular economy is based on three key principles: designing out waste and pollution, prolonging the life cycles of products and materials, and regenerating natural systems (Ellen MacArthur Foundation, 2020).

Circular economy, and especially the recycling models, has been studied for several decades (Ginga et al., 2020). However, climate change and loss of biodiversity are proceeding at an exponential rate and call for rapid responses in a broader scope. The economy needs solutions that are circular by design and have the potential to speed up transition from our current linear model of operation towards a circular model.

Data has emerged in public discussion as a key enabler for the circular economy. Still, only a few studies have explored the role of data in the circular economy (c.f. Berg and Wilts, 2019; Konietzko et al., 2019; Luoma et al., 2021). The Circular Design Network project (2020–2022), funded by the Academy of Finland, focuses on understanding the opportunities and pathways to data-enabled circular operations, and on creating a network in data for circular design. The project partners comprise state-of-the-art organisations researching and developing a circular economy in Finland: VTT Technical Research Centre of Finland, Geological Survey of Finland (GTK), Natural Resources Institute Finland (LUKE), Finnish Environment Institute (SYKE) and Aalto University.

This report documents the findings from the first work package (WP1), “Stakeholder and Needs Assessment”. The study was carried out as a stakeholder interview campaign. The work focused on identifying relevant stakeholders, their major data uses and needs, and data gaps at the system level in three various value chains: textiles, batteries and food system carbon cycles. We also looked for future circular opportunities based on data and the role of digital platform ecosystems in a data-driven circular economy (see also Orko and Lavikka, 2021).The results of the interviews will be presented by the value chain and as a summary of all findings.

Table 1. Stakeholder roles in a circular value chain as applied in the study.

Stakeholder roles in a circular value chain
Raw material supplier
Product manufacturer/solution provider
Logistics service provider
Retailer/distributor
User/customer
Recycling and services
Waste management
Technology provider
Other: NGOs, regional development companies etc.

2. Research approach

As the first step in the networking project, we connected with circular economy stakeholders in the field to understand their data use and perspectives. We designed an interview program for the potential data and circular economy stakeholders to understand the role of data in today's operations, and to scan and eventually develop the opportunities for the future. The interview questions are presented in Appendix A: Research questions. We used snowball sampling to identify potential interviewees.

In spring 2021, we conducted 81 interviews within three specific domains: the battery value chain (industrial applications/B-to-B), the textile value chain (B-to-B-to-C) and the carbon cycles in the food system (B-to-B). We also interviewed three companies in the pulp and paper and chemistry sectors. The said domains were selected to support the European Green Deal focus areas (Circular Economy Action Plan, EU 2020). These value chains have also been identified as key areas in the Finnish Circular Economy Program (Uusi suunta: Ehdotus kiertotalouden strategiseksi ohjelmaksi, YM 2021) and consequently, for the project partners. In addition, we carried out interviews of governmental organisations, such as ministries and the Finnish Innovation Fund Sitra. These interviews were carried out according to a modified interview frame and analysis method and will be reported separately.

We created a structured frame for the interviews to ensure coherent study material. We interviewed the stakeholders on their roles in the value chain, their data-related challenges and needs in circular practices, the role and data use in their current operations, data tools, data collaboration, and the opportunities they saw in circular data. We also organised the responses according to industrial sectors and position in the value chain. The emphasis was on data use connected to material cycles, and only one end user was interviewed (the textile value chain). We also interviewed digital platform owner organisations and regional facilitators about the role of digital platform ecosystems in a data-driven circular economy.

Most interviewees in the battery value chain represented stakeholders – companies and NGOs – operating in Finland; many are subsidiaries of multinational companies or organisations operating globally. The interviewees represented mostly managers or directors in the business operations, manufacturing, corporate sustainability function, or R&D functions; one IT manager was also interviewed.

The interviews were transcribed verbatim. An interview analysis framework was designed to help the encoding and analysis of the responses. In most cases, the researcher conducting the interview was also responsible for its coding. After initial coding, each value chain interview team developed an understanding of their relevance per value chain. The encoded responses were also analysed through all the study material per stakeholder role in the value chain by a separate team.

3. Textile value chains

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3.1 Interviews

Altogether 27 organisations were interviewed in the textiles value chain. The interviewed organisations represent different stakeholder roles in the value chain of the textile and clothing sector. One organisation was a research institute in the role of a work wear user, one was the sector's employer association Finnish Textile and Fashion, and the remaining 25 organisations were companies that operate in varied roles in the value chain. Thirteen of the interviewed companies are especially active in product manufacturing and retail sector. Apart from one, all the companies interviewed were from Finland. Among them, there are also a few companies interested in developing digital platforms for the needs of the textile and clothing industry.

In most of the interviews, one representative from an organisation was interviewed. Often, the interviewees were persons responsible for sustainability and corporate responsibility functions in the organisation.

Figure 1 presents the organisations interviewed in the textile and clothing value chain. It provides an overview of the companies' roles in the traditional value chain. It should be noted that many stakeholders have multiple roles in the value chain. The interviewed employers' association aims to promote circular economy in the textile business in various parts of the value chain.

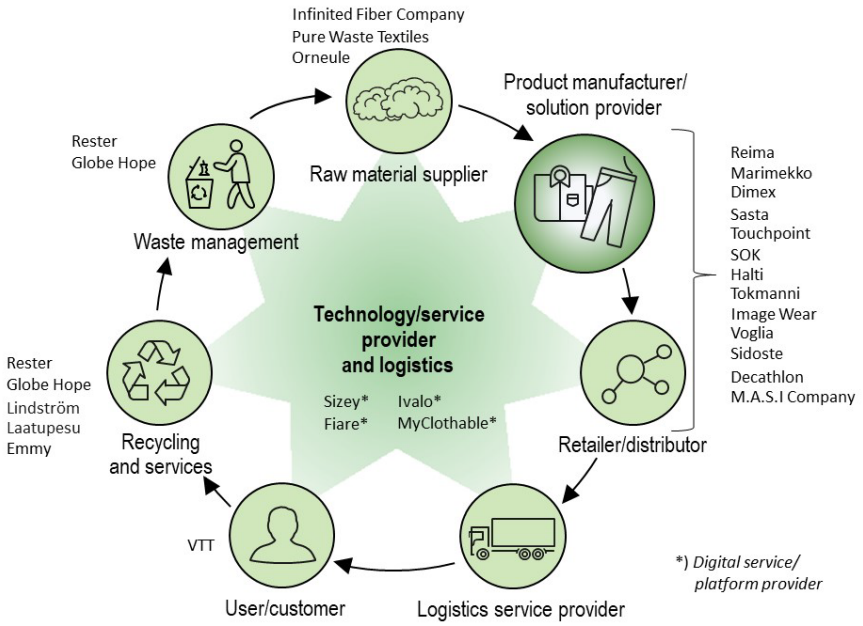

Figure 1. Organisations interviewed in the textile and clothing value chain.

3.2 Data uses and motivations

Different drivers motivate companies to adopt circular economy principles. The interviewed companies identified numerous trends and drivers that are affecting their business. A key phenomenon for business is the changing customer behaviour requiring more sustainable and ethical products, while the recommerce is growing. In B-to-B, sustainability values and product lifecycle management perspectives in the procurement processes drive the textile industry to improve their processes and consider their material selections. There are also regulations – for example, concerning chemicals used in different phases of garment or textile production – that affect the choices during the manufacturing process; for example, certain types of colour dyes are forbidden in the EU, but not in Asia. Sustainability and the circular economy are, in general, considered good principles to apply and make the world a better place. Some of the interviewed companies have brought these values to the company strategy.

Today, data are essential in everyday business, but they also have a special role in the circular and sustainable economy. Most of the interviewed companies use enterprise resource planning (ERP) solutions to support production and operations. Sales actions are supported by customer management (CRM) solutions. Some of the companies also use separate product information management (PIM) systems. Commonly used e-commerce platforms provide information about customer behaviour. In addition, based on the interviews, spread sheets, such as MS Excel, are a

common tool to process data, substituting heavy information management systems and filling in the gaps in data management.

As data are considered important, most of the interviewed companies had development of different data-based production systems ongoing. The development activities are, for example, related to deepening system integrations and data analytics as well as customer behaviour understanding. Activities for automating LCA calculations and product traceability were under development by some companies. Many interviewees stated that data regarding circular economy exists in the current systems but would need development of new system interfaces to be utilisable.

The interviews highlighted that, in the textile and clothing industry, a crucial data source is product and material data from suppliers. This data include, for example, certificates of transparency and material origins, and material and product information. Customer behaviour data are collected from the companies' own systems, utilising often e-commerce platforms. Companies providing garment loaning or renting services can create and analyse data through their platforms. They can, for example, provide data of garment life cycle and garment usage concerning either an individual garment or larger trends of garment use. Material- and product-related data are provided to the customers with the product, and overall environmental sustainability data of the company is often available on the company's website.

Generally, data from the suppliers are collected manually, but there is some progress towards higher automation in data collection. The data itself come in many different formats. The data generated by the companies themselves to support their own operations are often managed with regular business and management data tools, and the level of automation is quite high.

Some of the interviewees saw that data from the use phase of the garment could also benefit the design process. Data from the use phase would increase, for example, the understanding regarding the durability of the garment and how the garments are used. Overall, if data related to the use phase of a garment were available, it could be used in designing new garments. Moreover, there are also data links between the recyclers of textile materials and the product designers, where recyclers can give important inputs on improving recyclability in the product design phase.

The interviews showed that it is not completely clear what type of data are needed and by whom to support a circular economy in the textiles value chains. Understanding the potential business case is not easy for many of the interviewed companies, especially the manufacturers and retailers. In general, there was a willingness to share data to benefit the circular economy if the business case is clear and sharing the data does not risk the operative actions. Companies do not always own the data, and that may complicate data sharing.

The interviews further revealed that data sharing is expected to have more potential benefits than drawbacks or threats. Currently, for example, many manufacturers and retailers are already creating business in the circular economy by widely utilising recycled materials in their products. The understanding of data business opportunities, as well as what type of data are needed to promote the circular economy needs more clarification.

The metrics for circular resource efficiency and environmental sustainability as well as product traceability were under development by some companies. Among the interviewees, there is interest to understand the circular economy data opportunities better.

3.3 Data gaps

The interviews showed that several data needs and gaps are experienced by varied types of stakeholders. To gain transparency and traceability of textile products is one of the major challenges from the data perspective. A lack of reliable data from the different actors in the textile products value chain is a challenge. There is a clear need for specific and precise product data, such as the measures, materials, origin, etc. Also, a view to the lifecycle of a textile product is missing. A database with material information would be needed to provide up-to-date information on new materials, the ways to prolong product lifespans, as well as the possibility to compare the materials from the sustainability perspective.

The consumers and customers need data to validate their choices from the sustainability perspective. Aggregation of a second-hand product offering into one service or user interface for the consumers would enhance the reuse of textile products. The brands, on the other hand, need data on the demand of varied products, qualitative data to improve the customer or user understanding, e.g., on their purchase decision-making processes and motivations, and insight into customer behaviour in global marketplaces (e.g. Amazon). The brands, the retailers and other consumer service providers would also benefit from the feedback from the customers and data from the use phase along the life of the product, for example to understand the repairability of products. These data are currently only marginally collected and utilised.

Many of the companies also see sustainability as a way to differentiate from the competition, and some leading brands are even developing sustainability into a standard practice. This calls for the development of an objective sustainability metrics and more specific and reliable certificates. The consumers and other purchase decision makers need reliable information on the sustainability of a brand or a product, which can be compared with information from other providers. Similarily, the brands need reliable data in order to compare their sustainability performance with the competitors in the market. Such data could also be used to find the best practices from the environmental perspective. Often, the average data are not sufficient, and product-specific metrics, e.g., the carbon footprint should be used to include the actual and specific value chain impacts. This data are often not available, and the environmental footprint does not reflect the brand or product-specific impacts or improvements.

The textile products' end-of-life data should contain information on the volume of textile products recycled into new materials and information on the actual destiny of recycled textile products, including information on final location and recycling into

new material. Information on different possibilities for recycling at the item level should be made available.

Data access is one of the challenges in the textile industry along the value chain. The current systems and services do not provide reports supporting sustainability (e.g., number of garments returned). For the customers and users, the system should have an interface (e.g., based on QR codes) to query the material and product data. There is also the need for a centralised information database including all publicly available information on the textiles circular economy. The access should be open to the data required for estimation of the environmental impact of products, and the access to research data should be made easier for all stakeholders.

3.4 New data-driven opportunities

Overall, data were seen as a key factor for the circular economy in the clothing and garments sector. Many data-related opportunities emerged from the interviews by varied types of stakeholders in the value chain. Data-based solutions were foreseen to enhance the companies' own operations and to better understand the consumer interface and B2B customers. The interviews highlighted the opportunities of digital services based on data, as well as the possibilities of data supporting decision making and as a promoter of transparency and traceability. The data were seen as the tool to make the impact of a decision visible and to allow companies to focus their efforts into the most impactful measures.

The data were further seen as enabling the development of advanced digital fitting rooms for web stores in the future. In the reuse business, in particular, data can enable a more efficient assessment of the condition of the products when products are prepared for sale. In addition, it was suggested that data could be used to determine the utilisation rate, location and user of the garment. This information could be used to enhance reuse and utilisation of products. In addition, richer data can boost the sales for brands that currently operate in new product sales but want to broaden their scope to include second-hand business.

In the interviews, data were seen to play a key role in the implementation of more accurate and product-specific LCA assessments and sustainability indicators over the value chain; in the future, data could enable companies to reliably demonstrate their carbon neutrality. Regarding the end of the product life cycle and waste management, the interviews reflected the interest in services that facilitate the reuse of waste material. One opportunity is the utilisation of the company's own waste material in the production.

One of the key themes in the interviews was the potential of data from and at the consumer interface. In the future, data will make it possible to better meet the customer needs and, on the other hand, guide consumer behaviour towards environmentally sustainable choices. Concretely, we need to understand and decide how and what information should be provided to the consumers to influence consumer behaviour. We should further develop supporting policies to enhance sustainable consumption patterns.

The interviewees also referred to Finland's pioneering position in digitalisation and the strenghts related to corporate responsibility implementation. This was seen as enabling Finland to lead the way in new solutions, which would provide Finnish companies with a good starting point to succeed internationally as providers of new, data-driven circular economy solutions.

Many interviewees saw the need to employ data to steer the actors in the textile value chain more efficiently towards sustainability. Naturally, this will require extra effort. Practical actions are needed to turn the new, data-based possibilities in the textile and clothing sector into practical solutions.

3.5 Other observations

In the interviews, some additional topics were brought up.

The product manufacturers and retailers are very aware of the importance of the circular economy and sustainability in their business. Specifically, those who operate with consumer products desire more information regarding circular economy stakeholders and partners and the options to recycle their products.

An interesting question emerges: who should educate and influence the consumers? It is well understood that the consumer purchase decisions have a big effect on what type of products are on the market. Consumers need to be offered clear information and education on how they can contribute to sustainability with their choices. Even the interviewed companies feel that there are too many labels and certificates available, and the large variety confuses the customers. In addition, many customers are not truly aware of the impacts of their purchase decisions. Currently, only the sustainability-oriented minority of the customers is truly aware of the impacts of their purchase decisions.

4. Battery value chains

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4.1 Interviews

Twenty-six interviews were conducted to map the circularity drivers, current data uses, data needs and future data-related possibilities of battery value chain actors. The interviewed actors included private companies, organisations, educational organisations, and governmental institutes (Figure 2).

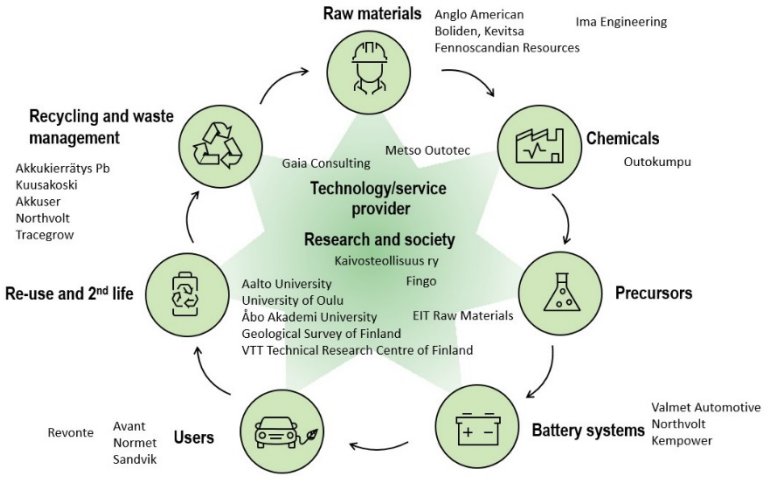

Figure 2. Organisations interviewed in the battery value chain.

4.2 Data uses and motivations

The interviewees reported that the drivers for circularity come from legislation and regulation but also arise from direct requests and claims from the customers. These drivers together set the company sustainability targets. There is a general trend towards digitalisation and data collection. However, there are marked differences in how data are collected along the value chain.

Most data are collected in the core business areas of the companies. Companies and research organisations working with the production, use and recycling of bat-

teries collect data about production processes, materials and battery characteristics. These data are often collected systematically and continuously. Data are generated during the manufacturing process itself, and there are aspirations to collect customer usage data as well if possible.

Customer data can provide useful information of the use phase, e.g., about the charging cycles of the battery. This data can be utilised, for example, to instruct customers on optimal charging patterns to maximise battery life-time. Product and production data are gathered to ensure product quality and to enable traceability, and for evaluation of production efficiency and safety. In the battery use phase, the machine operating data are important for diagnosing a machine fault condition, instructing the customer on the optimal use of the machine, warranty monitoring and for product development. Detailed information about side streams, e.g., mine tailings, gangue and waste rock, are less readily available and are collected only upon demand.

Despite a general trend towards digitalisation and data sharing, there are organisational and technical barriers for sharing data. Data closely related to the core business of a company (e.g., technical specifications of a battery) are shared only on demand and under an NDA. Although universities and research organisations support open science, data produced in cooperation with private companies cannot be published under open access. Data formats are manyfold and vary between the different fields of activities. Therefore, it is difficult to get an overview along the entire value chain of a battery. These obstacles have to be overcome through cross-sectoral research and cooperation.

In addition, several interviewees mentioned an increasing demand to get a view to the origin of the materials. This requires technologies to trace the materials from the mine to the battery and the re-cycles.

4.3 Data gaps

Transparency, traceability and openness were considered important aspects for data. It would be important to know and be able to communicate where and how the battery materials are produced and whether the production is executed in an ethical manner. An increase in the regenerating material cycles was mentioned as a necessity.

In order to optimise material handling and the selection of processing technologies for each material stream, the stakeholders named preliminary data availability (e.g., exploration data, LCA data) as a necessity, because this data can be useful already when a facility is being designed. The data needs in operations and at the stress points during production were also acknowledged as important. Such data would help maximise machinery lifespan as well as reuse and recycling potential. Being able to react to the changes in production processes would be possible with real-time data, which would also contribute to the technology and process development. However, it is seen that all actors need to provide their share of data in order

to complement the big picture and enable true optimisation of solutions. Thus, standards and formal auditing processes may be needed.

Data from ore exploration have been digitally reported only since the beginning of the 2000s, and the reports have been required in a spread sheet format for only a few years. Before the 2000s, there were no guidelines or requirements for the formats of the reports. Therefore, accessing older ore exploration reports may be challenging. Particular actors, such as GTK, are working on storing these reports in a digital database, but this is time consuming. A key requirement for a successful, open and informative database for the stakeholders is to provide easy and functional access and accurate and relevant data.

Even if R&D or exploration does not lead to new concepts or opening of a mine, it is crucial to make sure the collected data are not discarded or lost. At the moment, there is no dedicated place for, e.g., unexploited exploration data and thus, it is unclear where this data will be collected. Providing a uniform location for the data would ensure that the data can be accessed at a later time, benefitting the long-term development of holistic circular concepts.

Data availability and data practices vary in different countries and may restrict mineral business development, especially in countries that don't allow data export. Also, data are difficult to access in some countries due to political reasons.

These acknowledged gaps could be partly managed with simulation tools, efficient reporting, uniform data formats as well as standards. Training and sharing the know-how is essential. A tool is useless without a competent user. Comprehensive data on batteries and their use need aggregation and upgrading, e.g., into a battery passport.

4.4 New data-driven opportunities

Suggested measures and opportunities included exploitation of artificial intelligence, digitalisation, remote practices, key performance indicators, shared data portal for domestic know-how and interdisciplinary practices. The risk of losing the competitive edge via data sharing was acknowledged. The ability to properly collect data was seen as a restrictive factor and could be developed with existing technologies.

Several concrete ideas were suggested: setting up a database for the exploitation of unused materials, initiating a study of battery use data for the development of smaller and more durable batteries, and aggregating data sources with properties of new and recycled raw materials, in order to optimise their ratios in manufacturing, as well as to support collaboration with research organisations to expand the reusable and recyclable materials base. Indicators for the reuse potential and assessing the content of harmful substances in particular material streams were also suggested. According to the interviews, better design of electronics might help support circularity as well.

Data development and data-based solutions were seen to benefit the future generations. The current methods may not be able to solve the problems, but today's R&D is beneficial for the scientists to come. There is a need to establish baselines

for the efficiency of recycling processes, e.g., how much material can be extracted out of a certain amount of batteries, how much energy is required in the process and how cost effective the recycling processes are. Well-documented studies from potential mining sites and data flow from currently active mines contribute to the excavation method development, enabling the production of even better and more efficient mining practices. There is a clear need for development and implementation of the battery passport to support the transparency and traceability of battery life-cycle information. A digital battery passport has been suggested as a tool that would allow different stakeholders to have access to product and materials data to improve circularity and to prove sustainability of the whole value chain. For mineral producers, a battery passport provides a tool to communicate, e.g., the mineral origin and environmental impacts of the processes. For battery recycling and reuse companies, the information of battery chemistries and battery state of health is beneficial in order to plan more efficient reuse and recycling operations.

4.5 Other observations

The interviews suggest that the current legislation regulating waste is not optimal for a circular economy. Laws and regulations are in need of an update so that the industry can keep up with the ongoing direction. Several actors recognise this need and are willing to make changes in their operations, but legislation can be an obstacle for actions. The definition for, e.g., mining waste (including all waste produced at a mine site) is strictly regulated, which is perceived as a bottleneck for its recycling possibilities (Mining waste directive 2006/21/EC). According to the interviews, certain waste streams could be recycled or reused; but at the moment, this is not allowed. Legislative relieves would enable the reuse of non-hazardous materials now defined as waste. Side streams form the majority of the material produced at mines, and depending on the ore, they could be exploited further, e.g., as construction materials, fillers or in ceramics production. Additional processing of side streams would be beneficial, as they also contain secondary minerals and metal residues. Utilisation of these products would create viable businesses, which would also reduce the amount of mine waste and the need for waste management at the mine sites. Another part of regulation also in need of system development is permit procedure, which takes a long time at the moment. This makes it difficult to estimate the timelines necessary for efficient practices for new opportunities.

The current regulatory framework for batteries covers only the end-of-life stage of batteries through the EU Batteries Directive (European Commission, DIRECTIVE 2006/66/EC). Currently, there are no legal provisions in the EU that cover other aspects of the production and use phases of batteries. The European Commission has proposed a new proposal for a Batteries Regulation on 10 December 2020, which aims to modernise the EU's legislative framework for batteries. This proposal builds upon the 2006 Battery Directive and will replace it. The submitted proposal is an integral part of the European Green Deal and the first initiative of the European

Commission on the Circular Economy Action Plan. The proposal addresses the social, economic and ecological aspects in connection with batteries, but also provides for a regulation of access to the EU internal market. Regulation aims to ensure that batteries placed in the EU market are sustainable and safe throughout their entire life cycle.

In general, the actors from the battery-related interviews supported the idea of a data-sharing network. However, the benefits for data sharing for each value chain actor needs to be clear. A majority would be willing to share most of their data, and felt they would benefit from receiving data from other actors, even though some interviewed companies would require a non-disclosure agreement (NDA) before sharing data with others. Currently, raw data are collected locally and data should be processed before they can be shared. Several actors named legislation and waste-related regulations as a factor that is complicating the process development. Other complicating issues mentioned were logistics, lack of reliable data without respective demand for data, lack of data analysis tools, or lack of information about, e.g., battery specifications. Generally, it is not clear to actors as to what the key CE supporting performance indicators to be calculated from the data are. Future data-related opportunities are seen in new business models and earnings logic.

The importance of education on data management was mentioned. Data are everywhere, and we need data, which emphasises the need for know-how on how to handle data.

5. Food system carbon cycle

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[2] VTT Technical Research Centre of Finland

5.1 Interviews

Cutting down greenhouse gas emissions into the atmosphere is one of the main challenges for the EU to reach climate neutrality by 2050 (European Green Deal). The current Finnish government programme (Hallitusohjelma) also pursues a carbon-neutral society by 2035. The food sector generates significant volumes of side streams and releases carbon and nitrogen into the air and water systems. In line with the targets on carbon neutrality, the current national food research and innovation strategy (Food Research Strategy 2021–35) focuses on increasing resource efficiency and reaching zero waste in the Finnish food system by 2035. To reach the targets, new operational models for enhancing an ecological transition to a sustainable and circular food system are required. A prerequisite for this transition is sufficient and accurate data, efficient tools to collect, manage and use the data, and organisations' willingness to share data with others.

Representatives of 15 food system stakeholder organisations were interviewed to obtain information about the role of data in the organisation, data sources and types, ways to gather data, data applications, management and needs, as well as willingness and needs for data sharing and future opportunities that data may offer. Based on the analyses of the interviews, practical data needs and data gaps were recognised. The interviewed companies and their core business are shown in Table 2.

Table 2. Interviewed organisations in the food-carbon cycle and their core business.

Organisation	Core business
Biolan	Growth media for greenhouses and gardens
Soilfood	Recycled fertilizers and soil amendments
Yara	Mineral and recycled fertilizers
Oy Karl Fazer Ab	Manufacture of milled grain and bakery products
Paulig	Import and manufacture of tea and coffee
Altia	Distilling, rectifying and blending of alcoholic beverages
Raisio	Edible fat and cereal products
Valio	Operation of dairies and cheese
Atria	Meat products
Finsect	Insects for feed
Honkajoki	Animal feed production

Organisation	Core business
Envor	Waste refining
St1	Wholesale of liquid and gaseous fuels
Gasum	Wholesale of liquid and gaseous fuels
Doranova	Technology solution provider

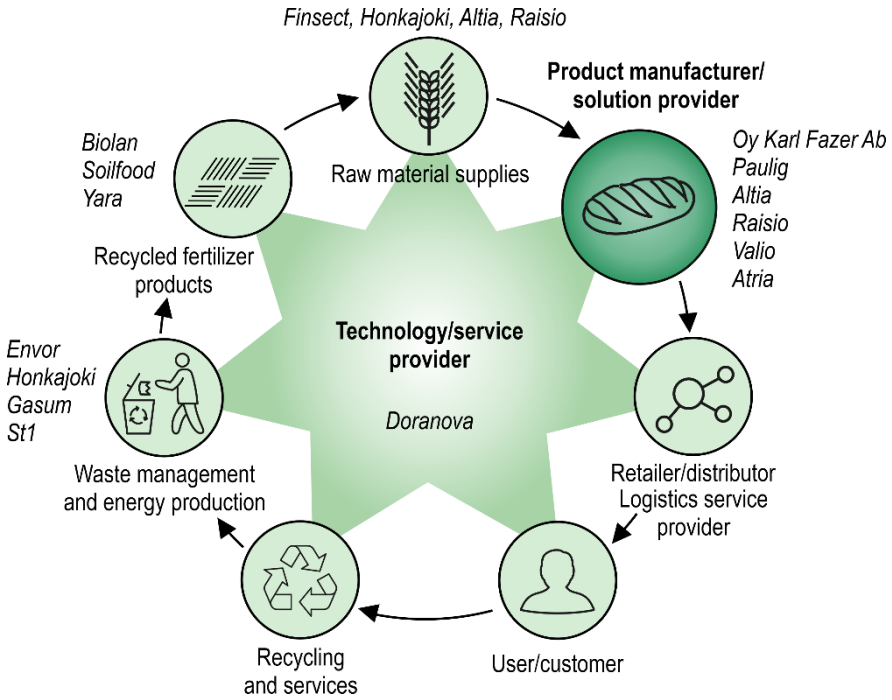

Figure 3. Organisations interviewed in the food-carbon cycles value chain.

5.2 Data uses and motivations

In the food chain, the types of data collected typically include primary data from monitoring the production and data collected from a company's own processes. The companies also collect secondary data, like indicators for sustainability, that are derived from the primary data.

The primary data include raw-material-related data, product quality data, volumes, types and composition of waste, energy and water consumption in processing, water balances and wastewater generation. In particular, the environmental data include waste amounts, energy consumed, water inlet and outlet, chemical oxygen demand of wastewater, etc. The raw material, process and product data are

needed for quality assurance and to ensure compliance with the conditions of the environmental permits.

The companies also collect data for assessing the product carbon footprint and for LCA to benchmark their facility performance to the competitors. For these assessments, secondary data (pre-determined coefficients) are commonly used due to insufficient primary data. The lack of harmonisation of the data and the methods makes comparisons difficult.

The types of data vary depending on different types of processes and technology. The units measured may also vary, which lowers the usability of the data. Data collection is mostly automatised, although manual collection and storage in spreadsheet-type applications is still a common practice. Automated and real-time visualisation of the data was considered an important tool to follow one's own processes, whereas the carbon footprint along the entire value chain is regarded to be important for improving the sustainability and responsibility of the enterprise functions.

The data needed for promoting a circular economy are diverse and need to be combined from different sources. The system-level data view may be missing; e.g., waste amounts are measured but not integrated into the CO_2 emissions, making its use limited from the sustainable circular economy perspective.

Data management tools and systems vary significantly, and companies invest in data management tools with variable intensity. Data are gathered and managed with a range of tools, starting with conservative spread sheet files to fully automated systems or combinations of the two. There can be several systems even within one organisation. To save resources (expertise and cost), the companies seem to prefer adding new data tools on top of existing ones rather than investing in a completely new system. Most often, this kind of layered architecture leads to complications in data use, because the separate systems have not been developed to communicate with each other.

Overall, the companies use data mainly in production management and development of operations within the company, for example to benchmark and develop production facilities, and for loss and quality control. Setting quality criteria to subcontractors is based on requirements derived from production-related data. Raw-material-related data cover authenticity (raw material origin), availability, chemical composition and quality. Data are collected also for fulfilling the demands set by the authorities (e.g. environmental permits) and for complying with sector-specific regulations, such as the directives on the use of animal by-products, fertilizer products and on waste management. The voluntary product data the companies collect focus on assessing the carbon footprint and to control food waste formation, but also comparisons between production lines in different plants. Data are also required in the food value chain for traceability of the products.

The main material flows in the production processes are commonly monitored by automatised systems. By analysing this data, the development hotspots are identified and production and product information is verified.

Data sharing was regarded with varied interests. Some interviewees were not willing to share their data at all, while others regarded data sharing as a potential route for enhancing sustainability. Sharing data, however, raises concerns of risking

confidentiality and business advantage. Today, the amounts of side streams are already reported to the authorities and available for research purposes, but this data are not openly shared to a broader stakeholder group. Several interviewees felt positive about data sharing with potential partner companies in cooperation for a joint goal. Data sharing is a prerequisite for integrating businesses, e.g., to valorise side streams. One interviewee mentioned that the companies have much more data that could be openly shared than what is considered as business-related, confidential data.

5.3 Data gaps

Data, their collection, management, and use, have an important role in production control, management and development towards improved efficiency. This has already manifested in several cases as reduction of production loss. Data are also used for investor and consumer communication, obligatory reporting to authorities, sustainability reporting and developing the enterprise's own operations towards minimised environmental and climate impacts. Sufficiently efficient and fluent data utilisation necessitates expertise development in data mining, integration, use, storage, harmonisation and standardisation. These needs, however, vary significantly among companies. Some of the interviewees did not identify any data related needs, while others saw data sharing as a focal need, i.e., a possibility to get access data for benchmarking company operations to other actors operating in the field.

Many companies see that data are insufficiently shared, even when it is not business critical. Sharing is found to be difficult along the value chain operators and with companies outside the value chain. The present non-collaborative business culture hinders companies to find potential partners to add value to the chain and to, e.g., valorise side streams. The ownership of data are not always clear.

There is a need to get up-to-date and reliable data about primary and secondary raw materials (availability, quality, composition, location) to enable supply and demand to meet. Nevertheless, monitoring side stream generation is too often insufficient and incoherent. This is a clear hindrance for advancing the waste reduction targets of the circular economy. The reasons for this are the lack of resources, non-existent business case in-house, and the lack of partners to utilise the generated side streams.

Assessing the carbon footprint is often experienced as expensive and with inaccurate outcomes due to the lack of localised data; often, the assessments must be based on secondary data (coefficients) that have not been determined for the products produced in Finland but are rather fitted to the Central European operational environment. There is a need to get accurate coefficients to assess the carbon footprint of products and production premises.

In the future, data needs should be determined together with all stakeholders operating in the value chain. This would facilitate data integration and harmonisation

as well as developing an enterprise's own data systems. A practical example is retailers that increasingly require data from the manufacturers' environmental assessment for the products they sell.

5.4 New data-driven opportunities

The interviewees raised virtual biomass marketplaces and platforms as a circular opportunity in one of the interviews. This can be a viable opportunity in Finland where the biomass streams are small and geographically scattered. In addition, companies that produce secondary materials in small volumes and on an irregular basis can benefit from a common marketplace, because the business opportunity for small-volume material is not necessarily seen within the company. The platforms could provide real-time and accurate data on the available raw materials (primary or secondary), thus helping operators find novel raw material opportunities and business partnerships.

Data sharing with other food companies and side stream refineries would enable a company to benchmark its own position in the markets. It would also facilitate integration of secondary material streams, together with collaborating companies leading to new business opportunities, such as using certain secondary streams in carbon sequestration to soil. While carbon sequestration to soil was seen as a promising new business opportunity among several interviewed stakeholders, it also creates a new demand for traceability, i.e., how to certify that the carbon binding to a certain field parcel is sold only once. Yet another use for data could be data-based policy measures, which would improve the cost efficiency in reaching GHG emission reduction targets, such as replacing fixed investment support for biogas plants, with production support based on the realised emission reduction.

5.5 Other observations

To reduce emissions and effluents, and to identify potential reduction measures in the agro-food system, data mining and analysis of losses and side streams should be developed, followed by developing further partnerships for secondary streams' valorisation. Some data are collected, but their use is still limited. Data could be used to measure energy consumption of process machinery to forecast maintenance need or device damage. Data-based methods could also be developed to measure the climate impacts of a production process and then linking this information to consumer products to provide information on environmental sustainability. Yet another topic is to use data to improve logistics and supply chain efficiency.

The food industry regards circular economy broadly as a sustainable operation model that focuses on resource efficiency and valorisation of side streams and residues, reducing water and energy consumption, efficient utilisation of raw materials and minimising loss and waste. Important drivers to companies' strategic choices to move towards a carbon-neutral circular economy are also consumer attitudes, economic feasibility, investors' choices and regulation.

Today's food industry generates, utilises and provides data. In the longer perspective, the gathered data are seen as a means to predict such future scenarios that support circular economic and sustainability development. All in all, the development of data mining, management and use could support a more swift and controlled transition.

6. Digital platform ecosystems

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6.1 Interviews

Digital platforms can connect geographically dispersed and diverse businesses into circular business models (European Commission, 2015; Berg and Wilts, 2019; Benachio et al., 2020; Chidepatil et al., 2020; Lacy et al., 2020). Interdependent and complementary actors can create value around technological platforms to attract customers (Gawer, 2014; Jacobides et al., 2018). In addition, the platforms enable resource sharing and excess capacity leveraging, thus reducing the negative environmental impacts of using raw materials or buying new products (Konietzko et al., 2019).

Three types of digital platforms can be recognised: transaction, innovation and hybrid platforms. *Transaction platforms*, such as Airbnb, are multi-sided markets that facilitate exchanges and transactions across demand and supply (McIntyre and Srinivasan, 2017). *Innovation platforms*, such as Google Android, are technological architectures that enable users and other stakeholders to create complementary products and services. Finally, *hybrid platforms* (e.g., Amazon, Facebook) combine features from the transactions and innovation platforms. Successful platforms tend to evolve into hybrid platforms over time (Gawer, 2021).

We identified three examples of emerging digital platform ecosystems supporting the creation of a circular economy in Finland. They showcase different approaches towards building circular data-driven business. The first example is a transaction platform ecosystem, where data are shared between the selected companies. In contrast, the second example is an innovation platform ecosystem that allows the creation of complementary services based on data sharing between several companies. Although still young and developing, these two platforms are already in operational use, but the third example ecosystem is still being developed. This third ecosystem aims to become a hybrid digital platform ecosystem supporting transactions and innovation creation between platform stakeholders.

We interviewed managers and technical developers representing owners or initiators of these three platform ecosystems. Next, we shortly introduce them and discuss data-driven opportunities foreseen by these platform owners. Lavikka et al. (2021) provide a more detailed description of the initiation and design of these platforms.

6.2 Findings on transaction platforms, innovation platforms and hybrid platforms

Circular Economy Platform CEP[1] resembles a **transaction platform,** allowing efficient knowledge sharing and operations management between selected companies. The platform allows a data-driven approach to reuse industrial side streams – such as fibre sludge and wood chips – of several large pulp and paper firms in the manufacturing industry. The platform, jointly developed by Evianet Solutions, CLIC Innovation and Conrec, aims to provide a data-driven service that refines customers' data on sidestreams into knowledge that can be used to manage industrial operations. The platform applies data to close the firms' material cycles towards the non-landfill factories, reveal best practices and make risk analyses in time. The customer companies in the platform have agreed to share data from their Enterprise Resource Planning (ERP) systems for the benefit of all organisations.

The need for this platform has been obvious since several industrial side streams are not efficiently reused because the potential buyers do not know about the availability of side streams, their location and reuse potential. Also, the fluctuating availability and inconsistent quality of side streams raised concerns. Currently, the interpretation of waste status varies, and for this reason, companies would need a harmonised way to report by-products at their factories. Conrec has also created its own Circular Economy Index (CEix), to assist organizations in improving their circularity performance.

The platform owner has identified some trends and drivers for data-driven circularity, such as increased open data, public limited companies' mandatory annual sustainability reporting, and the possible negative and positive impact of sustainability actions on the share value. Also, the role of data in business is growing as use cases for data are discovered. But, all use cases necessitate trusted data.

The platform's current data sources include industrial companies' ERP systems, the government's open reporting platform (YLVA), open data related to environmental permits from Pirkanmaan ELY-keskus, companies' annual reports and non-financial disclosure data. The most interesting data for the companies are material quantities, their location and production rhythm, and various quality documents. Data are retrieved to the platform manually from YLVA but automatically from customers' ERP systems.

Platform of Trust[2] operates partly as an **innovation platform** and already offers data harmonisation from different data sources, enabling their utilisation for various services, such as measuring CO_2 emissions or following energy consumption. Any organisation is welcome to start sharing their data through the platform, which provides a data network with specialist services concerning identity, consent and log data management, and service management. The data sharing takes place using Application Programming Interfaces (APIs).

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[1] Conrec's circular economy services, available https://conrec.fi/wp/services/, accessed 20.9.2021.

[2] Platform of Trust data-driven use cases, available: https://platformoftrust.net/en/cases/, accessed 16.9.2021.

The platform has experimented with several data-driven use cases where data from several sources – such as data from a building (IFC) model, measurements from external systems – are retrieved, harmonised and integrated[3]. One of the latest use cases in the circular economy domain is piloting a "climate-economy situation room" based on CO_2 emissions. In the pilot, data was collected manually using Excel. The platform necessitates reliable data on CO_2 emissions, as the platform itself cannot guarantee data reliability. Another circular economy use case concerns the reuse of construction materials, which is an ongoing collaborative pilot between the platform owners and Motiva Services.

Motiva Services is facilitating the development of a **hybrid platform**. The national target is to create an ecosystem around the platform to circulate construction materials and to matchmake relevant stakeholders and business interests. This initiative is still in the requirements elicitation phase, and the technological platform will be later developed when the customer needs are identified. The aim is first to identify the necessary ecosystem actors for co-creating the needed services, and later on, create the needed technical platform, thus aiming towards a hybrid platform ecosystem.

Currently, construction waste materials are not efficiently reused. Demolition waste material is mainly incinerated for energy use or landfilled. Some materials – uncontaminated soil, blast stone and concrete – are only partially recycled as potential customers do not know their existence, location, application potential or price.

The platform ecosystem aims to provide visibility to the existing materials supply and demand and to matchmake the potential suppliers with buyers to enable a circular economy. Thus, the platform ecosystem will combine the demand and supply of cycles, unify and enrich a database needed for material cycles, integrate services to support cycles, and connect digital platforms and marketplaces across industry boundaries. During the ecosystem early development phases, data are collected using spread sheets. In the future, data sources for the platform will be various public required-by-law administration registers and companies' ERP data.

6.3 New data-driven opportunities

Conrec envisions that e.g. power plants could share their ash data to get "critical ash masses" that can be more easily circulated. An automated way of reporting public "waste production quantities" for the annual report provides another data-driven opportunity.

Motiva Services foresees that data on material flows need to be shared between actors to create new circular value networks. More than six billion euros in annual public works contracts and government's ambitious carbon neutrality targets make public administration an important driver of the circular economy. In addition to data related to buildings, material properties, logistics and processing, information on

[3] Sitra (2021) "Data boosts the recirculation of materials in the circular economy marketplace", available: https://www.sitra.fi/en/cases/data-boosts-the-recirculation-of-materials-in-the-circular-economy-marketplace/, accessed 16.9.2021.

available repair services must be shared to optimise the cycles' profitably. Digital platform ecosystems could help build regional material cycles. Digital solutions are scalable, thus providing platform owners and their users opportunities for export business. An understanding of companies' current maturity level is needed to help companies develop data-driven service businesses.

Platform of Trust has learned that, currently, the carbon footprint is calculated differently in organisations, which reduces the reliability of measurements. Thus, a common way to calculate and collect carbon dioxide data are needed to display carbon footprint similarly. In addition, reducing CO_2 emissions at city and country levels based on real-time data necessitates data interoperability, reliability and harmonisation, which provides a data-driven business opportunity to platform operators, such as Platform of Trust.

7. Summary of findings and conclusions

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The stakeholder interviews consisted of 81 company, R&D and regional support organisations, which were categorised into raw material suppliers, product manufacturers/solution providers, technology providers, users, recycling and recycling service providers, waste management and/or others (regional, R&D and data platform providers). The categorisation was made in relation to the organisations' position and role in the selected three value chains, mainly batteries, textiles and food-carbon cycles, and a few in the pulp and paper industry. This chapter will report the cross-cutting summary of the findings through these roles.

In addition to the stakeholders above, seven governmental or NGO stakeholders, such as ministries and Sitra, were interviewed. These perspectives are reported separately in the Circular Design Network project Work Package 2 report, as the interviews were carried out with a modified interview structure.

The traditional **raw material suppliers** (or primary producers) are often investment-heavy operators and facilities, and their core function is to extract and process the virgin materials into commodities. The production margins may be narrow, and data on, e.g., current price of energy or logistics is essential in running the operations efficiently. Digitalisation has usually been adopted early on in large facilities with the throughput in the million-tonne range and plays an important role. Process data may be plentiful, and it is used mostly for production management and internal development purposes. Environmental regulation drives much of the external data use and reporting, and all the stakeholders reported a routine for collecting and reporting the necessary data to the authority as required. Increasingly, the suppliers also see demand from their customers to provide data of origin and use of resources in their products. These data are typically collected and managed internally. Raw material and production side streams are a factor in increasing production efficiency but are also seen as a resource with revenue potential; future data needs were reported by many stakeholders in internal and external side streams quality and locations. Some of the raw material suppliers were interested in employing new data-enabled business models, especially based on side streams, but overall, the opportunities of data for circularity at the company level were unclear. Data sharing was seen as somewhat complicated to carry out, as it may be business critical.

Product manufacturers and/or solution providers are traditionally responsible for solution design and manufacturing and managing their supply chain to optimally serve these processes. Also, managing the customer interface is important. The manufacturers' or solution providers' current uses of data reflect this mission: according to the majority of the interviewees, data are extensively utilised for production management and optimisation, resource management and internal development purposes. Some companies experience increasing demand from their customers or are bound by regulation to collect and provide data on raw material origin

and properties and are processing this data into sustainability information and customer communications. A handful of the companies have moved forward and incorporated data as a key functional element in their customer solution (e.g., Sandvik). Further, as a next-generation business model, a handful of these companies are collecting data from the customer and using this data to anticipate the future customer needs and to differentiate from the competition (e.g., Kempower) or as an element of additional value creation for the customer and/or the manufacturer (Soilfood). The future data needs for circularity were seen in sharing product development data across the value chain, connecting customer use data to design and manufacturing, developing transparent carbon footprint tools, integrating and standardising data, automatising data collection and improving product data management. Still, quite a few stakeholders did not have a clear view or concrete steps planned to harness data for circularity at the company level.

The **recycling and recycling service providers** have circular business models at the core of the operation, by definition. The interviewed stakeholders included secondary material collectors and refining operators, textile maintenance operations, sharing or data platforms and leasing, technology providers, and manufacturers with advanced maintenance services. The data uses vary between different value chains: when handling materials containing potentially harmful substances, such as batteries, safety and regulatory data are important. Processing the recyclates requires data on incoming materials, which many interviewees see as a current blind spot: the incoming materials may vary, and there is not enough information available on the incoming lots. The origin and composition of the material are generally seen as very important in product and material recycling and in waste and side stream utilisation. In consumer products, as-a-service business models are emerging. Such operators have included intelligent tags or chips in their products to collect and use the information in product maintenance and provide data for customer service management. The recycling and service providers see needs in making original materials and manufacturers' product data more extensively available, as well as data on available side streams. Data-based opportunities were seen in logistics optimisation, connecting environmental benefits data to product features and communications, connecting customers to data, and business based on sharing platforms. The interviewed recycling and service companies share some of their data confidentially in R&D projects, but data-sharing outwards is considered difficult due to confidentiality issues.

In **retail**, customer demands and benefits drive the data use directly. The current trend in retail is building capacities to provide material traceability and environmental impacts information for the customers. Also, most companies collect customer feedback systematically and use it in managing the supply chain efficiently and for developing the company functions. Certificates and standards play a role in customer communications. The reported data needs include sustainability-performance benchmarking data, connecting customer use data to products or services, filling in the gaps on data for new materials, data management systems integration, and better access to transparent and localised LCA data. New data-based opportunities are expected in as-a-service business models or other service concepts based on

user data, and in connecting user data to product design. Digital commerce and retail services, such as digital fitting rooms and procurement tools, were seen as a future opportunity. The more prominent players are also exploring the opportunities in new technologies, such as the blockchain. One interviewee saw data as a means to bring together the value chain and different operators. Also, some of the retail companies already had a data strategy in place. Overall, retail sees data as a powerful trend for the future – “data is money”.

In **waste management**, regulatory requirements guide the basic data collection and reporting practices. The publicly owned operators (regional waste management companies, etc.) collect data from their operations and partners and report this data. Some have opened certain data to the general public (e.g., HSY Open data). For the public operators, the EU and regional waste reduction targets give the basic KPI framework for the data reporting and encourage the development of new pay-as-you-throw and other business models. Also, in waste management, processing and logistics are managed based on data, as with any industrial operations. In some cases, GDPR restricts data sharing and utilisation. Development work is needed to standardise collection and reporting practices and data-based circular economy indicators.

Many interviewees across the value chains were interested in the latest R&D, but they found it laborious to follow the different projects and channels for available data and results.

Independent of the position in the value chain, data management is mostly based on traditional ERP and Excel tools. Some companies are exploring opportunities to develop their own tools or apply emerging circular data platforms, blockchain solutions or cloud services, but these technologies are not the general practice. Excluding process or customer management data, much of the sustainability data are still collected manually, and many interviewees brought forward the need to develop automated value chain data management tools. Some tools are in the pilot phase and entering the market to support environmental products traceability (e.g., Circulor and ReSource for minerals traceability to batteries).

A fully functional data ecosystem is enabled by **data platform and service providers**, as well as **regional facilitators**. The data platform providers develop and offer specific approaches to support circularity, e.g., ERP connected side streams management tools (Conrec), harmonised carbon-footprint data management across company functions (Platform of Trust), digital service models supported by tailored software (Vincit) or secondary materials digital market place (Materiaalitori by Motiva). CLIC Innovation developed a Circular Economy Platform to extensively combine many of these features, but has since decided to focus on selected functionalities with partners, aiming to transfer the development to a commercial operator. Many platform providers anticipate multi-platform ecosystems for circular data. The regional development organisations, usually owned by municipalities, can have an important role in initiating regional circular economy activities, e.g., industrial side streams utilisation and matchmaking (Digipolis and Verte) and refining data into relevant information (Paimion Kehitys). These organisations can also facilitate data sharing.

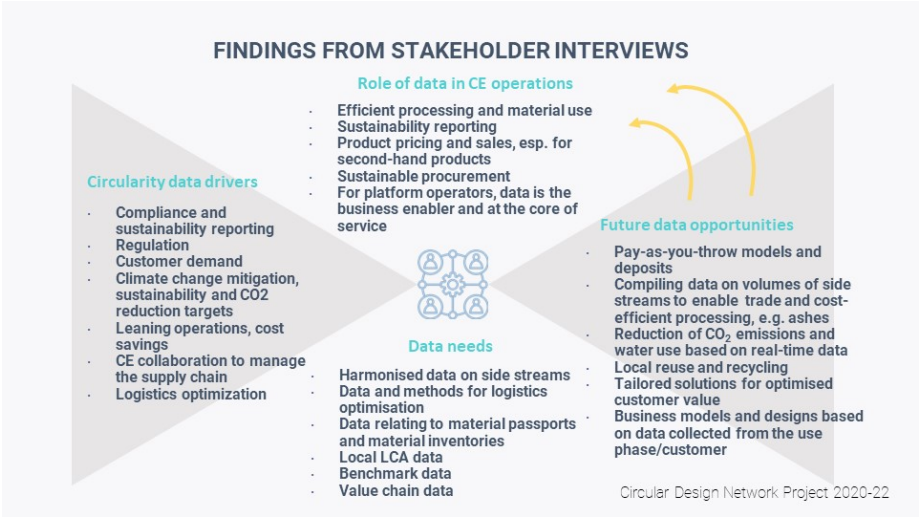

Figure 4. Summary of findings.

Overall, almost all of the interviewees saw opportunities in expanding customer data utilisation and in open data. The practical data opportunities are still hazy, though, and fewer stakeholders are willing to share their own data, unless there is a valid business reason and the means to control the use of the data. Also, the value and potential uses of internal data are not clear. Therefore, we deduct that to create a living data ecosystem, an initiator and driver with a vision of a data-based (business) operation is needed.

We noted that the boundaries of the different roles in the value chain are blurring in the circular economy. New circular business models seek value in combining circular products manufacturing to waste management, or end-of-life recycling service to retail or manufacturing. With a circular economy, the roles are expanding and combining in innovative ways, which may shake up the traditional practices in the value chains. This may also cause some need for readjustments at the regulatory and public policies levels, such as end-of-waste processes or GDPR practices.

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Other organisations (data platforms, regional organisations and governmental organisations): Inka Orko, Rita Lavikka, Jaana Sorvari and Annukka Berg

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Appendix A: Research questions

The market of the circular economy and the potential of new activities:

- How is the circular economy reflected in its own activities and industry?
- What are the trends, needs and opportunities in the circular economy?
- What practical needs/challenges need to be addressed now and in the longer term?
- How does regulation affect the new opportunities for the circular economy?

Data sources, data and tools:

- What data sources and data (business) activities are used for internal/external value creation?
- Is the data part of a customer solution or external activity?
- Is the data open? Who owns the data?
- What kind of data processing tools are used?
- How is the data utilised? How reliable is the data?
- What is the role of data in digitisation, and how is digitisation reflected in action?

Data needs and utilisation:

- What data are needed to realise the circular economy opportunities of the industry/operator?
- What data are missing?
- How should the data be processed?
- Which actors are needed to produce or process the data?
- Are new technologies, tools or practices needed to leverage data extensively?
- Is there a need for cooperation or agreements and with whom?
- How could the data appear in future business, e.g., in new business models?
- Does the operator have the capacity to utilise the data?
- Are there any administrative or legal obstacles to the use of the data?
- How could data support the management of the circular economy? Could your own data be opened up for use in the circular economy; what, under what conditions?

Appendix B: Interviewed organisations

Textile value chains

Rester Oy
Lindström Oy
Reima Oy
PureWaste Oy (Pure Waste Textiles Oy)
Image Wear Oy
Touchpoint Oy
MyClothable Oy
Orneule Oy
Sidoste Oy
Emmy Oy (Emmy Clothing Coompany Oy)
Marimekko Oyj
Ivalo Oy (Pearl & Starr Enterprises Oy)
Halti Oy
Sizey Oy
Voglia Oy
SOK (Suomen Osuuskauppojen Keskuskunta)
VTT Oy
Fiare Oy
Dimex Oy
M.A.S.I Company Oy
Decathlon Ltd
Tokmanni Oy
Sasta Oy
Vincit Oyj
Globe Hope Oy
Laatupesu/Tekstiilihuoltoliitto ry
STJM Ry (Suomen Tekstiili & Muoti ry)

Battery value chains

Boliden Kevitsa Mining Oyj
Anglo American (Sakatti) Oy /AA Sakatti Mining Oy Ab
Fennoscandian Resources Oy Ab (Beowulf)
Ima Engineering Ltd Oy
Outokumpu Oyj
Metso Outotec Oyj
Valmet Automotive Oy
Northvolt Ab
Kempower Oyj
Normet Oy
Revonte Oy
Avant Tecno Oy
AkkuSer Oy
Kuusakoski Oy
Akkukierrätys Pb Oy
Tracegrow Oy
Gaia Consulting Oy
Åbo Akademi
Aalto University
University of Oulu
VTT Technical Research Centre of Finland Ltd
Geological Survey of Finland
EIT Raw Materials
Kaivosteollisuus ry
Fingo Oy
Sandvik AB

Note: The list of interviewed organisations continues on the following page.

Carbon cycles in food systems

Valio Oy
Soilfood Oy
Biolan Oy
St1 Oy
Yara Suomi Oy
Atria Oyj
Raisio Oyj
Envor Group Oy
Gasum Oy
Karl Fazer Oy Ab
HKScan Oyj
Viking Malt Oy
Honkajoki Oy
Doranova Oy
Altia Oyj
Finsect Oy
Forssan Yrityskehitys Oy
Paulig Oy

Digital platform ecosystems

Conrec Oy
Motiva Services Oy
Platform of Trust Oy
Taival Advisory Oy
Kemin Digipolis Oy
Sitra & CLIC / CEP initiative

Governance (reported in WP 1 report/ CircDNet project)

Ympäristöministeriö
TEM
Motiva
LVM
VM
Teknologiateollisuus
EIT RM
VTT
Sitra

Other organisations

Kemira Oyj
Stora Enso Oyj
UPM-Kymmene Oyj
Andritz Oy

Series title and number

VTT Technology 400

Title	**Towards a Data-driven Circular Economy: Stakeholder Interviews**
Author(s)	Inka Orko (ed.)
Abstract	The lean and efficient use of raw materials, energy and products is a key principle in the circular economy. As a hypothesis, our activities and industrial operations can only be designed as circular in a holistic way if we share information across the value chain and between the stakeholders. In the Circular Design Network project (2020–2022), funded by the Academy of Finland, we have focused on understanding the opportunities and pathways to data-enabled circular operations, and on creating a network in data for circular design. This report analyses the findings and summarises the results of the stakeholder interviews (WP 1) mainly during 2020. The stakeholder interviews consisted of 81 company, R&D and regional support organisation interviews mainly in the value chains of batteries, textiles and food-carbon cycles, with a few interviews in the pulp and paper and chemical industries. We interviewed the stakeholders on their roles in the value chain, their data-related challenges and needs in circular practices, the role and data use in their current operations, the data tools, collaboration and activities around data, and the opportunities they saw in data for a circular economy. The findings were analysed per value chain and according to their position in the value chain: raw material suppliers, product manufacturers/solution providers, end users, etc. The role of the circular economy principles, as well as use of data, varies greatly depending on the business model and sector of industry. In general, all the interviewed organisations collect and use data for operations and customer management as a standard practice; but at the same time, most would like to better utilise data, also for circularity. Large manufacturing organisations have the means to invest in developing new data-based opportunities, and some have taken steps forward and are developing data platforms internally or with an external partner. On the other hand, some smaller innovative and data-oriented organisations design and implement new data-based approaches in an agile way. Data platform providers can play an important role in enabling organised data sharing and internal use. Overall, almost all of the interviewees had an interest in specifically expanding customer data collection and utilisation and to create new business models based on that. Traceability of materials through the value chain is a key driver and opportunity for data management. In particular, the stakeholders saw a growing need for localised and transparent LCA and sustainability data. Open data or data sharing at the general level was also regarded as interesting. However, the concrete data opportunities are still for the most part hazy, and few stakeholders are willing to share their own data unless there is a valid business reason and the means to control the use of the data. We deduct that in order to create a living data ecosystem, an initiator and driver, with a vision of a data-based (business) operation, is needed. We noted that the boundaries of the different roles in the value chain are blurred in a circular economy. New circular business models seek the value in combining, for example, circular products manufacturing to waste management, or end-of-life recycling service to retail or manufacturing. Connecting data to operations requires cross-disciplinary competences. In a circular economy, the roles are expanding and combining in innovative ways, which may shake up the traditional practices and collaboration in the value chains. New combinations of competencies may be needed. The changes may also cause some need for readjustments at the regulatory and public policies levels, such as end-of-waste processes or GDPR practices.
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