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Evaluating Circular Concepts and Activities Within the Manufacturing Industry

A study of proposing circular objectives and how to measure the progress by using indicators for the company SKF

Master's thesis in Industrial Ecology

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Gothenburg, Sweden 2023
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Master's thesis 2023

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Master's Thesis 2023
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Typeset in LaTeX
Gothenburg, Sweden 2023

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Abstract

Today's linear economy has put enormous pressure on the limited resources of our planet. The use of resources has been taken for granted for a long period of time, but it is now clear that there is a need for a transition in society. One possible solution to the transition is the concept of circular economy. Although the circular economy concept has existed in theory for quite some time companies still find it difficult to apply in practice. SKF is a company that relies on physical resources to continue operating the production of bearings. However, the company aims at increasing the awareness of circular economy by considering implementing circularity objectives.

This study aims to contribute to an evaluation of the current situation regarding circularity and develop proposals for new sustainability and environmental objectives focusing on circularity within the manufacturing industry. Furthermore, contributing to analysing the possibilities to measure circularity at a manufacturing company and thereby provide recommendations and insights on how to act to become a more circular business in the future.

To evaluate the current circularity a mapping of SKF's ongoing activities was performed. In the mapping process, the EU taxonomy regulation was used as a framework to categorize the activities. In addition to SKF activities, examples of good practices at other companies were found and categorized to the EU taxonomy. Improvement potentials were identified from the ongoing activities within SKF and the examples of good practices at other companies. The identified improvement potentials were used to develop the objectives. From the objectives, indicators were developed that aim at measuring the progress of the indicators.

The result of the study indicates that it is difficult to measure the overall circularity at manufacturing companies. For companies to increase their preparedness for measuring it would be important to extend the data collection. Furthermore, the results indicated that it is important to expand the use of the already existing circular activities within the company organisation. However, it is important to notice that the developed objectives and indicators are focused on specific areas, it is therefore uncertain how they will contribute to the overall circularity at SKF since the overall circularity has not been measured.

Keywords: Circular Economy, Indicators, Developing Objectives, Circularity, Circular Business Models, Measuring Circularity

Acknowledgements

First of all, we would like to thank our supervisor and examiner at Chalmers University of Technology, Ulrika Lundqvist. From the very start of this thesis she has been guiding us through this study by helping us with the structure of the report, input of which methods to use and always giving us valuable and constructive input. Despite her busy schedule she has always made time for us and been very dedicated to help us whenever we encountered problems.

We also want to thank our supervisors at SKF, Daniel Bosson, Annica Isebäck and Magnus Rosén for supporting us throughout this study. We want to thank them for believing in us and helping us moving forward by giving us the right tools when we encountered problems. Lastly, we would like to thank the whole sustainability and EHS team for welcoming us with open arms and for always making us feel included in the teams.

Malin Ahrenbeck & Frida Andreasson, Gothenburg, June 2023

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

CBN	Cubic Boron Nitride
$CSRD$	Corporate Sustainability Reporting Directive
EU	European Union
$EMEA$	Europe, Middle East and Africa
GHG	Greenhouse Gas
LAM	Latin America
LCV	Laser Cladding Venture
PET	Polyethylene terephthalate
$PFAS$	Poly and Perflouroalkyl Substance
$REACH$	Registration, Evaluation, Authorisation and Restriction of Chemicals
$ROHS$	Restriction of Hazardous Substances Directive
$R\&D$	Research and Development
SKF	Svenska Kullagerfabriken
VOC	Volatile Organic Compounds
$WBCSD$	World Business Council for Sustainable development

Glossary

Below is the glossary that have been used throughout this thesis explained in alphabetical order:

Bio-based - a material derived from biological orgin, excluding materials embedded in geological formation or fossilised.

CSRD - a new directive that requires companies to disclose information on what they see as the risks and opportunities arising from social and environmental issues, and on the impact of their activities on people and the environment.

Design for longevity - a strategy to design for an optimal use phase of the products, by for instance increase the durability, upgradability or repairability.

Disassemble - to take apart something.

Downcycling - when the recycled material gets a lower quality and functionality than the original product made from virgin material.

Durable - able to withstand wear, pressure or damage.

High-quality recycling - recycling that ensures that the distinct quality of the material is preserved.

Prolong - to makes something last a longer time.

REACH - an EU-regulation to strengthen human health and the environment against the potential risks that chemicals entail. The regulation includes registration of substances, evaluation, authorisation and restriction of chemicals.

Recycycle - convert waste to reuseable material.

Regenerate - to regrow or be renewed or restored, an example of this is trees.

Remanufacture - to refurbish a used product by renovating and reassembling its components.

Repair - restore a damaged component or product to a good condition.

Reuse - to use more than once.

ROHS - an EU-directive that aims at preventing the risk posed to human health and the environment related to the handling of electronic and electrical waste. This is done by restricting the use of certain hazardous substances in electronic and electrical equipment.

Secondary raw material - recycled material that can be used in a manufacturing process instead of primary raw material.

Upgrade - raise something to a higher standard, by for example installing new software into a used product.

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Introduction

Increased pressure on the earth's resources and the climate is a direct consequence of human activities. With a growing world population and with increased expected human welfare, challenges arise regarding the limited resources of our planet (Bjørnbet et al., 2021). It has also been shown that the link between economic growth and resource use is strong and in the next 40 years, the global consumption of materials such as metals, minerals, fossil fuels, and biomass is expected to double (European Commission, 2020b). In addition, it is known that in today's linear setting of society, large volumes of waste are generated where the forecast of global waste generation is expected to increase by 70% in the year 2050 (Bjørnbet et al., 2021; European Commission, 2020b). To overcome these challenges new ways of thinking have to be implemented in all levels of society.

The concept of sustainability and sustainable development has been a topic of interest ever since the release of the 1987 Brundtland report (Brundtland et al., 1987). One concept in the area of sustainability that has gained recognition is the circular economy. There is no commonly agreed definition of the circular economy concept, but one way of defining it is as an economy where resources that enter the system do not become waste or lose its value (Benton D., Hazell J., Hill J., 2014). A circular economy aims at recovering resources and keeping them in the loop as long as possible.

The area of circular economy has existed for quite some time in theory but has not to the same extent been implemented in the manufacturing industries. The Ellen MacArthur Foundation has done enormous work in educating and informing both academia and policymakers but also businesses in the field of circular economy (Ellen MacArthur Foundation, n.d.). But still, it is noticeable that the concept only recently gained traction in the industry. Industries have recently realized that in order to be competitive and to be prepared for the future, both in regards to competitiveness but also in regards to policy and regulation, it is important to consider the concept of circular economy.

Manufacturing companies play a major role in achieving improved living standards for future generations (Bjørnbet et al., 2021). However, since these companies and their operations often contribute to environmental problems it would be important to apply methods that reduce or eliminate these environmental problems. Svenska

Kullagerfabriken (SKF) is a company that is dependent on physical resources to operate its businesses. However, the company aims at increasing the awareness of circular economy by considering implementing circularity objectives. Therefore, it is of great importance to adopt a circular way of operating the company's businesses to be able to adapt to the limited resources of our planet and to limit their emissions of greenhouse gases (GHG).

1.1 Aim

The aim of this study is to contribute to an evaluation of the current situation regarding circularity and develop proposals for new sustainability and environmental objectives focusing on circularity within the manufacturing industry. Furthermore, contributing to analysing the possibilities to measure circularity at a manufacturing company and thereby provide recommendations and insights on how to act in order to become a more circular business in the future.

1.2 Limitations

The scope of this study is set to investigate the circular initiatives for operations within the company SKF. A limitation regarding circular initiatives is that SKF's buildings are excluded from the scope of the study. The geographical boundaries have been set globally as circularity is important for the whole SKF group.

Another limitation of this study is that the objectives only are developed from the identified improvement potentials and not from all possible perspectives. It was of interest to develop objectives that contribute the most to improving the circularity, and therefore objectives were developed from the identified improvement areas.

Due to the set time frame of the study, a limitation was made that the formulated indicators were not used for calculating the circularity. However, the indicators were analysed regarding the data availability and the applicability.

1.3 Research questions

In the project the following research questions are considered:

RQ1: What is the current situation at SKF regarding circularity?

RQ2: Which objectives should SKF have in order to become a more circular business?

RQ3: How can circularity be measured at SKF?

2

Background

SKF was founded in 1907 by Sven Wingquist (SKF, n.d.-b). Wingquist originally invented the double-row self-aligning ball bearing, which is still in use today over 100 years later. SKF is currently a company with over 40 000 employees and is operating in 129 countries (SKF, 2023). The company has 77 manufacturing sites and 29 remanufacturing centers distributed all around the world. The headquarter is located in Gothenburg, Sweden, in the same city where the company once was founded.

SKF's initial thought by inventing the double-row self-aligning ball bearing was to reduce the friction and cost of the operations and thereby save energy and time. Today, this idea is still very important and especially concerning SKF's goals regarding GHG emissions. By 2030, SKF has committed to reducing their absolute scope 1 and 2 GHG emissions by 95% and scope 3 by at least 31% compared to the year 2019. By 2050, SKF's full value chain will be net zero in terms of GHG emissions (SKF, n.d.-c). Scope 1 includes emissions in the company's own operations, for instance, the fuel consumption coming from vehicles that the company owns or controls (GHG Protocol, 2019). Scope 2 includes indirect emissions deriving from purchased electricity, steam, heat, and cold. The last scope is scope 3, which includes the remaining indirect emissions, deriving from purchased materials, product usage, waste management, business trips, etc., which the company does not own or have control over.

SKF has over the years largely increased its product portfolio to now contain numerous different types of bearings, seals, lubrication systems, maintenance products, condition monitoring devices, and grease. Below in Figure 2.1, there is an example of one out of many different bearings present in the SKF product portfolio, namely a double row angular contact ball bearing. The company has always made the primary money out of selling products but has for many years also been working with installing the products correctly, monitoring the condition of the bearings, and performing maintenance work. By offering these additional services SKF can increase their revenue and also get satisfied customers. In addition, SKF creates a more circular product life cycle by having these services to offer.

Figure 2.1: Double row angular contact ball bearings (SKF, n.d.-a).

2.1 Circular initiatives within SKF

SKF has several circular business activities that have been in place for many years. One of those examples is remanufacturing where SKF restores the bearings to be able to operate again. SKF has, for example, remanufactured more than 39000 bearings, weighing more than 400 tons, for a customer over the last 10 years. This has resulted in a carbon reduction of over 65 tonnes per year. Apart from this specific example, there are several sites all around the world working with remanufacturing. For instance in Sweden, there is a remanufacturing factory located in Gothenburg and one that currently is under construction in Kiruna as a result of the increased demand for circular activities.

Sustainability Design Aspects is another circular initiative that was formulated in 2018 by SKF and is a guideline on product material compliance and product & service sustainability performance. It aims to cover all life cycle phases by taking the right choices in the designing phase, as studies show that 80% of the environmental impacts are determined in the design phase of products (European Commission, n.d.-e). So, by making sustainable choices in the designing phase it can make huge differences throughout the life cycle. Furthermore, the Sustainability Design Aspects consist of two parts, one is material compliance and the other one being sustain-

ability performance. Material compliance is about what the product contains or potentially generates in the different stages of the life cycle. Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) and Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS) are examples of key legislations that are central when looking at material compliance. The sustainability performance part involves designing aspects such as reuse, recycling, minimised waste, material selection, and reduced energy use during the use phase.

The Sustainability Design Aspect guideline is structured like the following;

- Introduction with the purpose and governance
- Outlines the life cycle perspective, by describing why it is important, what it covers and what it means for SKF
- Connections between these guidelines and the SKF product development process
- Guidelines on material compliance
- Guidelines on sustainability performance.
- Appendix with explained key terms

This structure in the guidelines for Sustainability Design Aspects helps the designer to make more sustainable choices even though the knowledge within sustainability is limited. Under the material compliance the key legislations are listed with some basic information regarding these legislations that are applicable for SKF. Under the sustainability performance section different strategies to improve product and service sustainability performance are presented. Examples of these strategies are design for reduced amount of input material, design for optimized service life and design for recycling.

The Supplier Sustainability Standard is another extensive initiative within SKF that will be launched shortly. It has the ambition to cover SKF's requirements and expectations with respect to social responsibility and human rights, health and safety, and environmental protection. Like most other companies SKF is very dependent on its suppliers and subcontractors, and at the same time, it is important that these suppliers meet SKF's expectations and requirements. To more easily follow these requirements the Supplier Sustainability Standard was formed in order for the suppliers and subcontractors to know what is expected and required for SKF to be partnering with them.

The requirements within the Supplier Sustainability Standard is the minimum level which must be fulfilled by the business partner to continue do business with SKF. The expectations within the standard is where the business partner is strongly encourage to to develop effective approaches to meet the given objective.

The Supplier Sustainability Standard covers, among other things, the area environmental protection. Within this area there are different subareas which are the following; permits, environmental impact, material compliance and greenhouse gas reduction. One example within the subarea environmental impact is that SKF expects continual improvement to reduce negative environmental impact over time including soil change, water pollution, air pollution, harmful noise emission and excessive water consumption resulting from their operations.

3

Theory

In this chapter, the theory of the circular economy concept will be presented. The theory of directives and regulations that connects to circular economy will also be presented as well as the theory of circular economy indicators.

3.1 Circular economy definition

It is believed that the circular economy concept has gained popularity because of its ability to operationalise the concept of sustainable development among both practitioners and academia (Kirchherr et al., 2017). However, a reoccurring problem for concepts that gain popularity quickly is the absence of a commonly agreed definition. If there is no commonly agreed definition it may lead to a concept with various meanings and understandings which in the end might collapse. Therefore, in the following paragraphs definitions of circular economy will be discussed in order to determine the concept of circular economy that has been utilized in this study.

Circularity has been the fundamental principle of nature ever since the beginning of time. The balance of considering all three perspectives of environmental, economic, and social needs in society is something that is envisioned in sustainability but also in circular economy (Stahel., 2019). The purpose of a circular economy is to maintain values and manage stocks of assets, thus ensuring that resources do not lose their value and stay in the loop for as long as possible. In contrast to the linear model which can be described as a 'take-make-waste' system the circular economy is intended to be regenerative by design and to step by step decouple economic growth from the use of finite resources (Ellen MacArthur Foundation, 2017).

The circular economy concept presented by the Ellen MacArthur Foundation (2017) is based on three principles which are driven by design and are the following:

- Eliminate waste and pollution
- Circulate products and materials (at their highest value)
- Regenerate nature

The first principle provided by the Ellen MacArthur Foundation (2017) concerns

the prevention of waste and of pollution in the first place. A circular economy is intended to design systems so that negative impacts that may cause damage to natural systems and to human health are eliminated. The second principle is connected to the value preserving of the circular economy. Preserving the value is an important factor of the circular economy and could be done by sharing, maintaining, reusing, remanufacturing, and recycling of materials, components, and products (Ellen MacArthur Foundation, 2017). Circular systems benefit activities that are able to preserve value in the form of material, energy, and labor. The third principle concerns the use of regenerative systems. In a circular economy, it is important to use and preserve regenerative resources but also to improve them in order to assure further use of them. Another aspect of the third principle is to substitute non-renewable resources for renewable resources.

In order to implement the circular economy model in society new tools and concepts that describe and support the model are needed. Bocken et al. (2016) describes that there is a need for more coherent terminology so that businesses can transform into circular business models. When shifting from the traditional linear business model to a circular business model, the aim of the business shift from selling artifacts and thereby generating profits to generating profits from the flow of products and materials over time. Thus, the use of circular business models can enable economically feasible ways of reusing products and materials while utilizing renewable resources where possible (Bocken et al., 2016).

3.2 Directives & Regulations

When operating a business there are several regulations and laws to adapt to in order to get permission to continue operating. The regulations and laws are different from country to country, it is therefore important to be well informed to follow those regulations and laws which apply to each country or region. Besides from adapting to the current regulations, it is also crucial to foresee the upcoming regulations in order to be prepared for the future and in order to be competitive in the industry. As previously mentioned there are different regulations in different regions, but the primary focus here will be within the European Union as they have some of the world's highest environmental standards (European Union, n.d.).

3.2.1 European Green Deal

The goal that is presented by the European Commission in the European Green Deal is to make Europe the first climate-neutral continent in the world (European Commission, 2019b). To overcome the challenges of environmental degradation and climate change, the European Green Deal objectives will strive towards achieving a climate-neutral Europe. This will be achieved by ensuring; no net emissions of greenhouse gases by 2050, economic growth decoupled from resource use and no person and no place left behind.

The European Green Deal has adopted a set of proposals that are intended to make

all sectors of the EU's economy ready to meet the upcoming challenges (European Commission, 2019b). Also, a roadmap of actions has been presented in order to boost the efficient use of resources by moving to a clean, circular economy and stop climate change, revert biodiversity loss and cut pollution (European Commission, 2019a). This road map explains how to guarantee a just and inclusive transition and outlines which investments are needed and the tools available for this financing. With the European Green Deal, the path of actions for the months and years ahead is decided which will set the standards for all sectors of the EU but also influence other parts of the world.

The policy initiatives presented in the European Green Deal will affect manufacturing businesses since there will be new sustainability requirements which most certainly will lead to businesses making adjustments in the whole value chain. Manufacturing industries also have to consider the upcoming laws and regulations that will evolve from the presented objectives in order to be prepared for the future and in order to be competitive in the market. From the European Green Deal, several other frameworks and systems have emerged in order to support the development towards a climate-neutral continent. One of them is the EU taxonomy which is a part of the overall efforts to reach the objectives of the European Green Deal (European Commission, n.d.-a). The Waste Framework Directive is another part of the transition to a modern, resource-efficient, and competitive economy as the European Green Deal promotes (European Commission, n.d.-f). However, these frameworks and systems will be further explained in the following sections.

3.2.1.1 EU taxonomy

The EU taxonomy is a classification system for sustainable activities (European Commission, n.d.-a). It is implemented to be a part of the solution to the European green deal, where the EU taxonomy helps companies decide what to invest in, conducive to sustainable investments.

Currently, the EU taxonomy regulation sets mandatory requirements on disclosure. Companies that fall under the scope of the Corporate Sustainability Reporting Directive (CSRD) have to disclose in their annual reports to what extent the companies' activities are covered by the EU taxonomy and how these activities comply with the criteria set in the delegated acts (European Commission, n.d.-b). Companies covered by the CSRD are all large companies and all listed companies (except listed micro-enterprises) including small and medium-sized enterprises as defined by the European Commission (European Commission, 2023).

The Taxonomy regulation was published on 22^{nd} of June 2020 and entered into force on 12^{th} of July 2020. The taxonomy regulation establishes six environmental objectives which consist of:

1. Climate change mitigation

2. Climate change adaptation

3. The sustainable use and protection of water and marine resources
4. The transition to a circular economy
5. Pollution prevention and control
6. The protection and restoration of biodiversity and ecosystems

For each environmental objective, there are a number of examples of activities on how these objectives can be achieved. In addition to this, the European Commission had to come up with a list of environmentally sustainable activities by defining technical screening criteria through delegated acts (European Commission, n.d.-a). The technical screening criteria are performance criterias set by the EU. So far, technical screening criteria presented in delegated acts, have been set for economic activities that can make a substantial contribution to climate change mitigation and climate change adaptation, which are the two first environmental objectives in the EU taxonomy regulation (European Commission, n.d.-b). The first delegated act for the first two environmental objectives, climate change mitigation and adaptation, was published on 9^{th} of December 2021. The delegated acts for the remaining four environmental objectives were expected to be published in January 2023, but currently only drafts of the new delegated acts have been published and no finalised versions.

3.2.1.2 Waste framework directive

Waste is a growing problem all around the world and affects the environment as well as human health (European Commission, n.d.-h). One of the goals in The European Green Deal is the creation and implementation of a clean, circular economy, which is connected to the Waste Regulation that sets rules for waste management. In order to manage the waste, the European Union has come up with the waste framework directive to prevent and reduce the negative impacts and improve resource efficiency. The waste framework directive lays down four basic principles presented by European Commission (n.d.-g) which requires that the waste should be managed;

- without endangering human health and harming the environment
- without risk to water, air, soil, plants or animals
- without causing a nuisance through noise or odours
- without adversely affecting the countryside or places of special interest

This means that the waste should not harm the people nor the planet, by preventing contamination, nuisance and by not changing the environment.

The waste framework directive explains when waste stop to be waste and instead can be accounted for as a secondary raw material. The framework also describes how to differentiate between waste and by-products. In addition, the directive also

includes the "polluter pays principles" and the "extended producer responsibility". The polluter pays principle (PPP) is a principle where the polluters are required to carry the environmental and social cost of what they have caused (European Commission, n.d.-d). The extended producer responsibility (EPR) has a number of directives provided where a producer's responsibility, physical and/or financial, for a product is extended to the post-consumer stage of a products life-cycle (European Commission, n.d.-c). According to EPR, a producer is considered to be responsible for the final phase, the waste management. This is done to make the producer design their product in a way to simplify the waste management.

The foundation of EU waste management is the waste hierarchy shown in Figure 3.1 below, where the most preferred option is prevention, followed by preparing for re-use, recycling, energy recovery and lastly sending waste to landfill which should be the last option when handling waste. This waste hierarchy is established in the waste framework directive and explains the most preferred order of managing and disposing of waste.

Figure 3.1: The waste hierarchy (European Commission, n.d.-g).

The EU legislation on waste also have set targets in order to increase recycling of specific waste streams. Examples of waste streams where targets on recycling have been set are cars, electronic equipment, batteries, demolition, construction, municipal and packaging waste, but also to reduce the landfilling of bio-degradable waste.

3.3 Circular Economy Indicators

The concept of circular economy has been presented as one of the solutions to handle the upcoming environmental challenges. But in order to monitor this transition towards a circular society it becomes important to find suitable indicators that measure the progress (Huysman et al., 2017). It will be of interest for both companies and other organisations to be able to quantify their circular economy performance and this can be done by using indicators.

A possible way of monitoring this progress is to develop the indicators self by identifying what is suitable to measure. Another way of monitoring the progress towards circularity is to use pre-determined sets of indicators that is related to the topic of circular economy. With the development of circular economy as a concept, these kinds of pre-determined sets of indicators have increased. Organisations such as the Ellen Macarthur Foundation have developed the tools Circulytics and Material Circularity Indicator that measure the progress of the circular economy transition (Ellen Macarthur Foundation, 2015, 2022). World Business Council for Sustainable Development (WBCSD) has developed a framework for measuring the circularity at companies called Circular Transition Indicators which can provide an objective and quantitative framework that measures the circularity performance (WBCSD, 2022). In addition, the European Commission has developed a monitoring framework that includes new indicators in order to track the progress towards a circular economy in EU and the member states (Eurostat, 2023). The different pre-determined sets of indicators consist of different ways of quantifying the progress and all of them are connected to the concept of circular economy.

The other possible way of monitoring the progress as mentioned is to develop indicators separately. One possible methodology to use when developing indicators is the PICABUE framework. PICABUE is a methodology framework used for developing sustainability indicators (Mitchell et al., 1995). The name of the method PICABUE is related to the seven principal steps that derive from the letters of the name. The seven steps in the methodology are explained as the following (Mitchell et al., 1995);

(1) Stakeholders to reach a consensus on the Principles and definitions of sustainable development that are used and the objectives of the sustainability indicators programme:

(2) Identify and select Issues of concern;

(3) Construct/select indicators of issues of concern;

(4) Augment indicators developed in step (3) by sustainable development principles identified in step (1);

(5) Modify step (4) indicators to address - Boundary issues;

(6) Develop Uncertainty indicators from step (4) augmented indicators;

(7) Evaluate and review final sustainability indicators.

Although the method is focused on sustainability it would be of great relevance in the area of circular economy as well.

4

Method

This chapter aims to present the methodology used to answer the research questions. Firstly, the method of mapping SKF's circularity performance is explained which is followed by an explanation of the method for developing objectives. Lastly, is the method of how circularity can be measured at manufacturing companies explained.

4.1 Mapping of SKF's circularity performance

To be able to gain knowledge of the already ongoing work at SKF and thereby answer the first research question, a mapping of the current situation has been performed. It was important to map the current state of the work implemented regarding circularity at SKF and then gather information about other companies' circularity work to use as inspiration for SKF's future improvements. However, the first step in the process was to conduct a literature review to get an overview of the subject of circular economy and acquire the relevant background information to be able to answer the research questions. The analysis of mapping SKF's circularity performance encompassed qualitative methods such as using the EU taxonomy for mapping the ongoing work as well as conducting interviews with employees at SKF to gain a deeper understanding of the work already implemented at the company.

4.1.1 Literature review

A literature review was conducted as a first step in order to gain knowledge and understanding of the subject of circular economy and the many different definitions present in the field. Also, to be able to gain knowledge about the future of the circular economy, both current and upcoming regulations within the European Union were reviewed. The primary sources for conducting the literature and research review were Google Scholar, the official website of the European Union and Chalmers Library. The following keywords were used to find the desired literature: *circular economy, current regulation, upcoming regulation, waste hierarchy, remanufacturing, repair, re-use, EU taxonomy, circular economy indicators, European Green Deal* and *implementing circular economy.*

The ongoing initiatives and activities that SKF does or plan to do were found through reviewing internal documents at the company and through reviewing the

company´s annual report. Information regarding the activities and initiatives was also acquired through personal communication. Personal communication was used especially when the information that was found needed further explanation to get a greater understanding of the subject.

4.1.2 EU taxonomy matrix

The first step in the process of mapping the current state of SKF's circularity work was to use the EU taxonomy as a framework in the mapping process. As previously mentioned in section 3.2.1.1, the EU taxonomy consists of six environmental objectives where one of them is "The transition to a circular economy". Under this category called "The transition to a circular economy", there is a list with general examples of activities that describes how companies should work towards achieving these objectives. The activities that are presented under the objective "Transition to a circular economy" in the EU taxonomy are presented in Appendix A.

The EU taxonomy was chosen as a framework for mapping since the European Union have develop new regulations that will affect the companies' businesses (European Commission, n.d.-a). Thus, it was of interest for SKF to use the EU taxonomy as a framework because of the potential upcoming regulations. Also, since the European Union is known for having high environmental standards it was of interest to use the taxonomy regulation as a framework. However, when the study was conducted there were no delegated acts published regarding the fourth objective which is the "Transition to a circular economy" which relates to the topic of the report. But since the overall taxonomy regulation was available, which describes the examples of activities in regard to the transition to a circular economy, this was instead used as a framework in the mapping process.

So, in order to evaluate the work that SKF already has implemented or plans to implement in their business, a matrix was formulated that connects the ongoing activities or initiatives to each of the examples of activities that describe how companies should work towards achieving the objectives in the taxonomy. An overall outline of the EU taxonomy matrix that was used for mapping the ongoing initiatives and activities is shown in Table 4.1.

All of the examples of activities in the matrix did however not fit the scope of the study. Therefore it was decided that activity (g), concerning the construction and demolition of buildings, and activity (k), concerning litter, should be excluded from the mapping process and the matrix was limited to analyzing ten activities instead of the twelve activities that originally are presented in the objective in the EU taxonomy. All of the examples of activities from the EU taxonomy are presented in Appendix A.

After the EU taxonomy matrix had been formulated, a division between all the examples of activities was made in order to compile all the ten activities under a common category. This was also done because of the gathered information from the conducted interviews that revealed that other companies had divided their circular-

ity work in regards to a life cycle perspective. Therefore, it was decided that a division should be made which connects to the life cycle of the products. Consequently, four phases throughout the life cycle were decided on and were the following; Sustainable sourcing & circular design aspects, Resource optimized operation, Efficient & optimal use phase, and Circular end-of-life.

Sustainable sourcing & circular design aspects connect to the first phase of the four phases in the life cycle and include the sourcing of materials and the designing stage since these are actions that can be affected at an early stage and are therefore placed in the first phase. The Resource optimized operation is the second phase of the life cycle and it includes the manufacturing stage and other operations the company may perform. Because these actions cover the company's own operations it was categorized as the second phase of the life cycle.

The third phase, Efficient & optimal use phase, includes the use of the products and is connected to the use phase thus it is categorized as the third phase in the life cycle. Circular end-of-life, includes the end-of-life management and thereby also the waste formulated in production as that waste has reached its end-of-life. Therefore, this Circular end-of-life is categorized as the fourth phase in the life cycle. When the phases of the life cycle had been decided on the examples activities from the EU taxonomy were connected to each of the phases and the division is visible in Table 4.1. The division was made by analyzing the respective activities and thereby categorizing them under the life cycle phase that is connected to the activity. By making this division it will become more visible which activities connect to which part of the life cycle and thereby more straightforward where the company should put their efforts.

Table 4.1: EU taxonomy matrix that was used as a framework which also describes the division of activities from the EU taxonomy to each life cycle phase.

Life Cycle Phases	Examples of activities from EU taxonomy	Ongoing initiatives/ activities within SKF
Sustainable sourcing & circular design aspects	Activity (b) Activity (c) Activity (d)	
Resource optimized operations	Activity (a)	
Efficient & optimal use phase	Activity (e)	
Circular end-of-life	Activity (f) Activity (h) Activity (i) Activity (j)	

Activity (l) is not included in Table 4.1 since it enables circularity during all stages

of the life cycle and thus do not belong to any specific area of the life cycle. However, this activity is also taken into consideration when the evaluation of the activities is presented in the results.

4.1.3 Interviews

Interviews were conducted with employees at SKF to be able to gather information about the already ongoing work regarding circularity. The main focus of the interviews was to gain knowledge about the already implemented remanufacturing business and the servitization that SKF offers which includes services such as condition monitoring, lubrication services, and installation services.

The interviews were conducted in a semi-structured manner by using mainly open-ended questions. In a semi-structured interview, a set of questions is prepared in advance in order to set the topic that will be covered but the conversation is free to vary (Fylan, 2005). In that way, the interviewee is able to elaborate on the subject and explore other topics that may be relevant for the interview (Gill et al., 2008). This way of interviewing was chosen since it allows for discovery or elaboration of information that the interviewers may not have thought of but may be important for the exploration of the topic. In total, six semi-structured interviews were conducted with employees at SKF because of their knowledge of the remanufacturing services and the general servitization offers at SKF and a compilation of the interviewees is shown in Table 4.2.

Table 4.2: Compilation of interviews conducted internally at SKF and their respective topic, their role and from what region they belong to at SKF.

SKF Region	Interviewee role	Topic of interview
EMEA	Group business controller	Rotation Equipment Performance/ Mapping of SKF
EMEA	Partnership and Business Development Manager	Servitization at SKF/ Rotation as a service
LAM	Director of industrial business Development	Remanufacturing services/ Mapping of SKF
LAM	Portfolio management coordinator & Application engineering manager	Remanufacturing services/ Mapping of SKF
EMEA	Manager Bearing Recond Center and Workshop Kiruna	Circular Economy Center
LAM	Service center coordinator	Remanufacturing/ Mapping of SKF

The majority of the interviews were conducted via Microsoft Teams as that was the most suitable option in regard to the location of the interviewees. Although, some employees were located at the SKF office in Gothenburg, and thereby the interview was held in person instead of via Teams. The SKF region represents where the interviewees were based and those regions were the following, Europe, the Middle East and Africa (EMEA) and Latin America (LAM). The interviews were held in both English and Swedish depending on which language the interviewee preferred. All of the interviews were conducted with both authors of the study present which made it possible for one of the authors to take notes during the meeting while the other person could focus entirely on which questions to ask to the interviewee.

4.2 Developing objectives for improving circularity

In order to propose how SKF should become a more circular business and thereby answer the second research question, objectives were developed with the intent of improving the circularity of the company. By developing objectives, a company communicates its future intentions and ambitions (Sołoducho-Pelc, 2014). The objectives indicate a direction in which the company is aiming and by fulfilling these objectives the company will achieve the desired future state. Using objectives is of great importance since they decide the direction which in turn provides a basis for planning, prioritizing, and how to coordinate activities at the company (Sołoducho-Pelc, 2014). Consequently, by developing objectives for SKF, we indicate a direction of a desired future where SKF becomes a more circular business. The objectives thereby set the scope of the circularity work that will be implemented.

It was of interest to find examples of good practices at other companies regarding circularity to be able to propose improvement potentials and thereby formulate objectives, as presented in Figure 4.1. This was of interest to be able to compare SKF's ongoing circularity work against other companies. So, to each one of the examples activities from the EU taxonomy were examples of good practices found that connected to the topic of the activities. This column was useful to include in order to gather information that could be used as inspiration for future improvements.

Examples of good practices at other companies were found by reviewing companies' sustainability or annual reports or by searching for information regarding sustainability on the companies' web pages. Sustainability reports from various companies such as Sandvik, Volvo Cars, Volvo Group, ABB, Philips, Schaeffler, Tetra Pak, Patagonia, Essity, Schneider Electric, Valmet, and Adidas were reviewed to gain an understanding of other companies' work in the field of circularity. During the review of the sustainability reports, both companies in similar business areas as SKF were studied as well as companies with businesses different from SKF's to get a broader perspective of the circular economy approach at companies. This selection

of companies' sustainability reports was reviewed either because of their reputation of working towards becoming more circular or because they were recommended to us by our supervisors as being interesting to study further.

Improvement potentials were formulated to be able to develop the objectives. The improvement potentials were also connected to each one of the examples of activities from the EU taxonomy. Thus, at each example of activities presented in the EU taxonomy were a number of improvement potentials formulated. The improvement potentials were created by analysing the ongoing initiatives and activities at SKF together with the examples of activities from the EU taxonomy and the examples of good practices from other companies in order to identify where improvements were needed. So, by finding the gaps between what SKF already does regarding circularity and what the examples of activities say, together with what other companies do, it was possible to identify which areas SKF could improve.

The developing of objectives was an operationalisation of the formulated improvement potentials from the EU taxonomy matrix which laid the foundation for which areas the objectives were focused around, as can be seen in Figure 4.1. Because the objectives are an operationalisation of the improvement potentials the objectives will only cover the areas where SKF was in need of improvements. This is a limitation since the objectives theoretically could cover all areas not only areas where SKF possibly could make improvements in. The objectives are thus limited to only covering the areas of improvement that were identified in the EU taxonomy matrix.

Because the objectives were an operationalisation of the improvement potentials from the EU taxonomy matrix the objectives were also connected to the life cycle phases. To be able to cover the whole life cycle perspective at least two objectives per life cycle area were developed so that SKF has objectives implemented towards circularity in every phase of the life cycle.

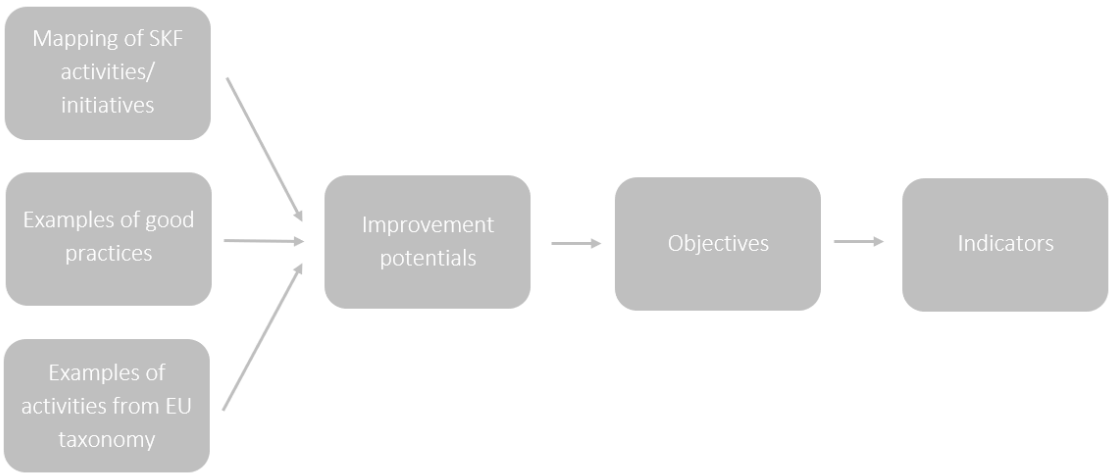

Figure 4.1: The operationalisation used for developing objectives and indicators.

When the first objectives had been developed the following step was to develop the indicators as can be seen in Figure 4.1. However, since this was an iterative process between formulating objectives and indicators they were re-evaluated along the process in order for the objectives to fit together with the indicators. The reason for connecting the objectives to an indicator was to be able to measure the progress of the circularity objectives, but the methodology for developing the indicators will be discussed in the following sections.

4.3 Measuring circularity

To be able to quantitatively analyze the circularity, and thereby answer the third research question, an analysis of the methodologies available for measuring circularity at manufacturing companies was performed. The analysis involved both quantitative and qualitative methods since both indicators were evaluated and interviews were conducted during the analysis of the quantification of circularity.

4.3.1 Interviews

During the study, interviews were held in order to gather information on how circularity can be quantified at manufacturing companies. The purpose of the interviews was partly to understand the current use of circular economy concepts but also how circularity can further be applied at company level. Interviews were therefore conducted with manufacturing companies that stated clearly that they work with circularity with the aim of gaining knowledge of how to quantify circularity at such companies. However, this selection of interviewed companies was also done since SKF had prior contact with these companies which enabled us to get in contact with the right people at the companies and thereby conduct the interviews. The interviews were also held to identify if there was a commonly agreed method already established for evaluating circularity at manufacturing companies.

The interviews were conducted in a semi-structured manner by mostly using open-ended questions that allowed the interviewee to elaborate on the subject. The questions were prepared separately for each interview in order to set the topic of the interview and to gather the desired information. In preparation for the interviews, the companies' annual or sustainability reports were reviewed to prepare relevant questions that related to the topic of the interviews. A compilation of the questions that were asked to the interviewees can be found in Appendix B. However, all interviews were structured and planned in order to suit the interviewed person and their area of knowledge, hence the questions could vary from person to person. In total, five semi-structured interviews were held with companies or departments because of their connection to the area of circular economy and the topic of measuring circularity at company level, and the chosen interviewees are presented in Table 4.3.

Table 4.3: Compilation of interviews conducted and their respective topic, company belonging and their role.

Company/Department	Interviewee Role	Topic of interview
Sandvik AB	Head Of Sustainability	Implementing circular economy at company level
Volvo Group	Global Environmental Leader Operations & Head of Environmental Sustainability	Implementing circular economy at company level
Chalmers Industriteknik	Group leader Circular Economy	Implementing circular economy at company level
Volvo Cars	Head Of Sustainability	Implementing circular economy at company level
ABB	R&D Sustainability Manager	Implementing circular economy at company level

All of the interviews were conducted via Microsoft Teams as that was the most suitable option in regard to the location of the interviewees. The interviews were held in both English and Swedish depending on which language the interviewee preferred. All of the interviews were conducted with both authors of the study present which made it possible for one of the authors to take notes during the meeting while the other person could focus entirely on which questions to ask the interviewee.

4.3.2 Ethics

In regards to the interviews that were conducted in the study a section with ethics is presented to inform about the procedures. All interviewees were informed about the purpose of the study when they were asked if they wanted to participate in the interview. By informing the interviewees of the purpose they become aware of what research they are contributing to and can thereby decide if they want to contribute to the study (Bell et al., 2022). The interviewees were also informed about how their interviews would be incorporated into the study and that their contributions would not be mentioned by name or be directly quoted. The interviewed person's company belonging and their role at the company have been presented but their names have been left out due to respect of integrity for the interviewees.

4.3.3 Evaluation of pre-determined indicators

Because of the complex nature of implementing circularity and sustainability concepts, it can be noticed that there is a need for quantifying the work to be able to compare the improvements that have been made (Sikdar et al., 2017). It is possible

to quantitatively express the use of variables when using indicators and thereby be able to compare the changes that have been made. Thus, by using indicators it is possible to measure the progress of the already developed objectives.

Circular economy indicators with pre-determined sets of indicators were firstly investigated in order to measure the circularity at manufacturing companies. By using keywords such as circular indicators, measuring circularity, and circularity tools at companies a range of pre-determined sets of indicators were found. The pre-determined sets of indicators that were found were assessed based on a set of requirements. These requirements were for example that the tool could be used by SKF themselves and not be dependent on a third-party company for performing the evaluation. Consequently, another requirement was that the methodology of applying the circular economy indicators should be easy to follow in order to ensure that the measuring of circularity could be correctly performed by the company. Another requirement was that the data that was required for performing the evaluation with the tool was available at SKF for the measuring of the circularity to take place in the near future.

When the majority of the available circular economy indicators had been assessed it was the pre-determined set of indicators available at World Business for Council Sustainable Development called Circular Transition Indicators that was best suited for applying in regard to the requirements (WBCSD, 2022). However, when the circular economy indicators were assessed further it was concluded that the data that was available at SKF was not detailed enough to be able to use the set of indicators correctly. As the initial intention was to calculate the circularity by using the pre-determined sets of indicators, it was important that the desired data from SKF was accessible which was not the case.

It was also noticed when the pre-determined sets of indicators were further evaluated that it mainly considered recycling which was not in line with the intended outcome of using the indicators. In addition, it was noticed through the conducted interviews with other companies regarding measuring circularity that almost none of the interviewed companies used these circular economy indicators with pre-determined sets of indicators. Therefore, a decision was made that the study would no longer investigate the possibilities of applying circular economy indicators with pre-determined sets but instead formulate independent indicators and then evaluate these indicators with regard to improving the circularity at a manufacturing company. Due to the added work of formulating indicators, it was not possible within the set time frame to perform calculations on the indicators.

4.3.4 Development of indicators

The method that was used for quantifying the circularity at a manufacturing company was to formulate indicators that are able to measure the progress. The indicators that were formulated were used since it was possible to perform quantifiable measurements that give an indication of the current circularity at companies. In comparison to the circular economy indicators with pre-determined sets, the self-

formulated indicators did not require an as extensive amount of data as the circular economy indicators that were assessed did. Therefore, indicators were developed separately instead of using pre-determined sets of indicators because it was easier to adapt the indicators to the data that was already available at the company. On the contrary, it would be relevant to develop indicators not only from what is possible to measure but also develop indicators from what is desired to be able to cover a broader perspective of circularity. No acknowledged method for developing indicators was used, but the PICABUE methodology was used as inspiration when constructing the authors' own methodology.

When developing the indicators separately it is possible for the company to decide for themselves what is suitable to measure instead of having a set of pre-determined indicators for measuring. In that way, it was possible to formulate the indicators so that the data that was available at the company suited the chosen indicator. Thus, by developing indicators, the company can immediately begin to evaluate the output from the indicators instead of having to gather new data which often is a very time-consuming process. The measurements from the indicators could then also be used to evaluate the company's performance in regard to circularity to monitor the development over a longer period of time.

The method that was used when formulating the indicators was to proceed from the objectives that were formulated from the improvement potentials in the EU taxonomy matrix. Thus, the method included operationalisation of the objectives and thereby developing indicators that were important for quantifying the objectives. Since this was an iterative process between formulating indicators and objectives the indicators were re-evaluated so that the indicators would measure the actual progress of the objectives. Additionally, the companies whose sustainability reports had been reviewed were in this phase used as inspiration and guidance for what indicators could be relevant for the topic, if the companies had used indicators in this area before.

During the development of indicators and objectives, continuous feedback was given by the supervisors at SKF who work within the area of sustainability and EHS. Their knowledge contributed to important insights into the development of objectives and indicators.

The next phase consisted of the actual construction of the indicators and with that deciding the units of measurement. During this phase, it was decided if the indicators should consist of an absolute value or if the indicators should consist of a relative value with or without dimensions. This was decided upon since it was discovered in the previous phase that in some cases the actual progress was more clearly shown by using absolute values instead of relative values.

The third phase consisted of the evaluation of the formulated indicators. The benefits and disadvantages of each of the developed indicators were assessed. The indicators were also evaluated based on their ability to cover a broader perspective or a narrower perspective of circularity, thus it was of interest to know to what

extent the indicator is able to quantify the circularity at a company. Another evaluation that was made was the applicability at the different organisation levels of the company, since some of the indicators only may be applicable at site level (e.g., manufacturing sites) while some might be applicable at group level which includes all organisation levels, meaning the whole company. The evaluation of the indicators was made because it was of interest to detect all the benefits and the drawbacks of using the indicator in order to find the indicators that were suitable for applying at the company. After this phase, a number of indicators were selected, based on the evaluation, that is believed to contribute the most to the work towards becoming a more circular company. The whole collection of indicators that were considered before the selection is presented in Appendix C.

5

Results

In this chapter, the result of the mapping of SKF's circularity will be presented. The result of the developed objectives and indicators will also be presented, explained, and motivated in this chapter.

5.1 Mapping of SKF's circularity

The result from the mapping of SKF's circularity performance will be presented in this section. The activities within the EU taxonomy are divided into the different phases of the life cycle (European Commission, 2020a). Within each activity, there are different initiatives within SKF connected to this activity, after that examples of good practices from other companies are presented and lastly the improvement potential within this activity. All of the initiatives and activities within SKF that are listed below have been sourced from SKF's internal network or annual reports.

5.1.1 Sustainable sourcing & circular design aspects

There are four different phases in the life cycle, where the first being sustainable sourcing and circular designing aspects. There are three different activities in the EU taxonomy that belongs to this phase in the life cycle, and these will be presented below.

5.1.1.1 Activity (b)

(b) increases the durability, reparability, upgradability or reusability of products, in particular in designing and manufacturing activities;

Circular initiatives within SKF

From activity (b) there are a number of different activities and initiatives within SKF which is connected to the activity. The first one is material coating for increased durability of rollers and rings with the example of black oxide as a material coating that protects the bearing against special operating conditions. Different kinds of material coatings are widely used within SKF to increase the lifetime of the product by being more durable. The material coating is decided upon in the designing phase and increases the durability of the products and therefore relates to activity (b).

The second initiative is called Sustainability Design Aspects, which is a guideline on product material compliance and product & service sustainability performance formulated by SKF. This relates to the activity presented above thus the guideline aims at taking different sustainable aspects into consideration such as durability, repairability, upgradability, and reusability. The Sustainability Design Aspects is currently not mandatory to use at SKF, only a guideline thus it is very uncertain to how large extent it is being used.

Magnetic bearings are a type of bearing designed to be more energy-efficient than regular bearings because of the low friction and is in addition more durable. It can be used in several different industrial applications, but in general, it is used for application where high speed and low friction is demanded.

Seals is an additional component that sometimes is used with the bearings to retain the grease in the bearing and to prevent contamination from the outer environment. It is chosen in the designing phase if seals should be included or not, depending on the application. There are several different kinds of seals available to fit in the different cases. Seals can contribute to increased durability as it ensures that the bearings contain grease and minimises the contamination from the outer environment which would otherwise contribute to the bearings being worn down. The downside with seals in some applications is higher friction, meaning more energy loss.

Lastly, an example of an activity that involves increased reusability is reusable trays for safe and sustainable shipments to a car manufacturer, where the trays have been changed from single-use to multiple-use by changing the material in the designing phase. This activity is only implemented for a few sites. Every activity mentioned above is compiled in Table 5.1 below.

Table 5.1: An overview of ongoing initiatives/activities within SKF with regards to activity (b).

Ongoing initiatives/activities within SKF
Material coating for increased durability of rollers and rings
Sustainability Design Aspects
Magnetic bearings
Seals
Reusable trays for safe and sustainable shipments to a car manufacturer

Examples of good practices at other companies

There are many examples of companies working with durability, repairability, upgradability, or reusability of products in the designing phase. One such company is

Schneider Electric that have been working with this since 2015, as a result of costumers growing demand for products with a lower carbon footprint. Their approach is called EcoDesignWay, that is a process in the designing phase to manage the environmental impact throughout the life cycle of the product (Schneider, 2023).

Volvo Cars is another example of a company working with this topic. Volvo Cars have set up a new team within design to investigate complex challenges, including applying circular economy principles in products (Volvo Car Group, 2023).

Improvement potentials within SKF

Improvement potential which involves activity (b) has been found by looking at what SKF is doing in combination with what other companies are doing. First of all, it is important to begin to think of sustainability already in the designing phase as it will affect the upcoming steps in the product development. As mentioned above, SKF has a guideline called Sustainability Design Aspects that helps the designer to make sustainable decisions. But currently, it is not mandatory to use this guideline, and the perception is that this guideline is not so widely used, so an improvement could be to set requirements to always use this tool when designing new products and implement a follow-up system to see if the requirements are being followed. When looking at other companies it has been noticed that companies that are at the forefront concerning circularity are often considering the designing phase as a way of improving the circularity, such as the company Schneider Electric.

5.1.1.2 Activity (c)

(c) increases the recyclability of products, including the recyclability of individual materials contained in those products, inter alia, by substitution or reduced use of products and materials that are not recyclable, in particular in designing and manufacturing activities;

Circular initiatives within SKF

There are three different activities that have been identified within SKF that relates to activity (c). The first one is; switched to one type of plastic instead of three different types. Before, SKF used three different types of plastics in a specific packaging material which now has been substituted to only using PET, which is a common plastic that is being recycled with a high-quality. By doing this the recyclability has increased from the packaging material being incinerated as waste to being recycled.

The second activity is Sustainability Design Aspects which is focusing on making the product more sustainable in the design phase, thereby having recyclability in mind when designing the new product. But this is as previously mentioned only a guideline, and not a requirement to follow.

The last activity, preparing for Digital Product Passport, is a tool for sharing product information across the entire value chain. This can enable better recycling of

the products as it is declared what kind of materials the product contains. This activity is not yet implemented into the business but is planned to be as EU will eventually require it to be mandatory to implement. The three different initiatives connected to activity (c) can be seen in Table 5.2 below.

Table 5.2: An overview of ongoing initiatives/activities within SKF with regards to activity (c).

Ongoing initiatives/activities within SKF
Switched to one type of plastic instead of three different types in packaging material
Sustainability Design Aspects
Preparing for Digital Product Passport

Examples of good practices at other companies

Other companies are working with increasing the recyclability of products by using different strategies. Volvo Group tries to substitute harmful materials, and when they need to use complex materials like plastic they use only one type of plastic to be able to recycle it in a good way and not use different kinds of plastic that are difficult to recycle together (personal communication, 9^{th} of March).

Adidas is working with this in a similar way, by having a range of footwear designed with recycling in mind. Its UltraBoost DNA Loop shoes are made from just one material – thermoplastic polyurethane (TPU). No glue is used in its manufacture, instead, it is assembled using high temperatures (Adidas, 2020). This enables high-quality recycling without downgrading.

Tetra Pak is a company working with increasing their recyclability by looking into the design phase. By developing a simplified material structure and making the paper-based content bigger they ensure that the recyclability will increase (Tetra Pak, n.d.-b).

Another example of a company working with increasing the recyclability in the design phase is ABB. ABB motion is redesigning their motors so they can be more easily disassembled in order to facilitate and thereby increase the recycling (ABB, 2023).

Lastly, a good example of a grocery store working with recycling is Aldi, which are working continuously to reduce, reuse, and recycle 100% of their plastic and packaging (Aldi, 2020). They have invented a pledge system with seven different pledges. These pledges are tackling problems such as problematic plastics, reducing plastic and reducing all packaging. The pledges also incorporate goals such as 100% of own label packaging to be reuseable, recyclable or compostable by 2022 and 50%

of plastic packaging to be made of recycled content by 2025.

Improvement potentials within SKF

An important improvement potential to increase the recyclability is to evaluate which materials that currently are being used in the production, which can be exchanged in order to make it more circular by enabling recycling with high-quality. This area has been identified as an important improvement potentials by looking at other companies and realizing that the Sustainability Design Aspects are important but do not consider already implemented products. It is therefore a priority to also evaluate materials in products that already are in use.

5.1.1.3 Activity (d)

(d) substantially reduces the content of hazardous substances and substitutes substances of very high concern in materials and products throughout their life cycle, in line with the objectives set out in Union law, including by replacing such substances with safer alternatives and ensuring traceability;

Circular initiatives within SKF

The first initiative within SKF concerning activity (d) is that SKF is investigating the possible presence of Poly and Perfluoroalkyl Substances (PFAS) in their product portfolio. SKF has recognized that certain jurisdictions in USA have established a new law concerning import and use of PFAS in different production processes. Other countries are following by undertaking similar initiatives. It is therefore important to investigate which of SKF's products contain PFAS to be able to eventually substitute them in order to favor the environment and if it is required by the law.

The second initiative is a target for 2025 to have eliminated Volatile Organic Compounds (VOC) from washing of bearings and bearings components. SKF has halved its use of VOC between 2007 to 2016. But then, increased their use again after a newly acquired business. Today SKF is mainly using the VOC in washing processes for bearings and bearings components and is therefore setting their target within this area.

As mentioned in activity (c), SKF is preparing for Digital Product Passport. This will enable easy identification of hazardous substances in products and by being aware of these substances they can be removed or substituted.

Another initiative is switching to biodegradable grease in those applications where it is suitable. Biodegradable grease has the ability to degrade naturally by biological organisms and therefore does not contaminate the environment as much as non-biodegradable grease thus it relates to activity (d). It is often used in applications where contamination of the environment is of concern and the biodegradable grease only accounts for less than 1% of the total grease that is used or sold within SKF. SKF has also recently teamed up with an institute called European Lubricant Grease Institute- Sustainability Technical Consortium, ELGI-STC, where SKF is being a

part of the user group. The aim of this is trying to increase the circularity of grease.

Hazardous substance policy, is another initiative concerning hazardous substances in SKF's product portfolio. In this policy, besides what is being forbidden by different environmental regulations they are proactively looking for substances that are on the register of intention and which today are only declarable (e.g., the EU-regulation REACH). Register of intention contains substances that have not been restricted by law but are on the radar of authorities to be considered for such actions in the future.

The last activity is Sustainability Design Aspects which have been mentioned both in activity (b) and (c). The Sustainability Design Aspects is connected with activity (d) as it takes hazardous substances in mind when designing the new product. The mentioned activities and initiative connected to activity (d) are listed in Table 5.3 below.

Table 5.3: An overview of ongoing initiatives/activities within SKF with regards to activity (d).

Ongoing initiatives/activities within SKF
Investigating the possible presence of PFAS in SKF product portfolio
Target for 2025 to have eliminated VOC from washing of bearings and bearing components
Preparing for Digital Product Passport
Biodegradable grease
Hazardous Substance policy
Sustainability Design Aspects

Examples of good practices at other companies

A good example of a company working with activity (d) is IKEA, which is working with phasing out hazardous substances and replacing them with safer alternatives (IKEA, n.d.). IKEA's chemical standards often go beyond chemical requirements and IKEA often phase out chemicals that are suspected of being harmful in beforehand of legislation.

Improvement potentials within SKF

There are already many ongoing initiatives within SKF concerning activity (d), but one possible improvement could be to evaluate expanding the use of biodegradable grease as it is a more environmentally friendly alternative. When looking at the whole world, almost none of all grease is recycled, but most are just burnt or used

in a dissipative manner by for example contamination in the environment. It has therefore been identified as a priority to improve this area as SKF is using large amounts of grease, which can make big improvements for the environment if it is changed to biodegradable. All of the initiatives listed above are also of great importance to improve but the perception is that SKF is already working considerably within these areas.

5.1.2 Resource optimized operations

In this subsection, the activity connected to the second phase of the life cycle is presented.

5.1.2.1 Activity (a)

(a) uses natural resources, including sustainably sourced bio-based and other raw materials, in production more efficiently, including by: (i) reducing the use of primary raw materials or increasing the use of by-products and secondary raw materials; or (ii) resource and energy efficiency measures;

Circular initiatives within SKF

There are a number of different ongoing initiatives within SKF that relates to activity (a). The first one is near-net shape that aims as minimizing the amount of material that needs to be removed when processing the material, which can be done by making adjustments in the production. This initiative is active on all manufacturing sites within SKF but some sites are working with it more than others. This initiative relates to activity (a) as it involves using natural resources more efficiently.

Cost of non-quality is an initiative that measures all costs associated with product and service failure, throughout and beyond the end-to-end process. To minimize the failure cost, money is invested in prevention activities. But if too much money is invested in prevention the total cost, becomes larger so it is important to balance the amount invested in prevention cost to balance the relationship. This activity is important for all manufacturing sites within SKF as it includes cost-saving operations.

Energy intensity effectivization is an initiative that concerns actions to save energy by for instance sealing leaky pipes. This effectivization is ongoing within all SKF's operations as it involves cost-savings at the same time.

An activity that relates to energy intensity effectivization is energy audits, which is an assessment of energy needs and efficiency of all buildings within SKF's ownership.

Seals are as mentioned in activity (b) used in bearings to retain the grease in the bearing and to prevent contamination from the outer environment. Seals can save large amounts of grease and are therefore related to activity (a).

The reuse of grinding wheels is an activity that is implemented at a few manufac-

turing sites within SKF. Before, the grinding wheels were not used to its fullest extent. But by reusing the grinding wheel for smaller applications they can be used again instead of being thrown away. This activity reduces the use of primary raw materials and the reuse can make cost-saving up to 70%.

Lastly, another similar initiative to the grinding wheels is re-usage of Cubic Boron Nitride (CBN) indexable inserts used in turning. This is a metal cutting tool that can be regrinded and used again which both saves money and reduces the use of the indirect material CBN indexable inserts. However, this initiative is currently only implemented on a small scale. There is a compiled list of the ongoing initiative within SKF concerning activity (a) in Table 5.4 below.

Table 5.4: An overview of ongoing initiatives/activities within SKF with regards to activity (a).

Ongoing initiatives/activities within SKF
Near-net shape
Cost of non-quality
Energy intensity effectivization
Energy audits
Seals
Reuse of grinding wheels
Reusage of CBN indexable inserts used in turning

Examples of good practices at other companies

There are numerous companies working in order to streamline its processes. An example of a company working with this is ABB which continually improves the energy efficiency of ABB sites by conducting energy audits, implementing energy management and monitoring systems, and making changes to buildings and production processes (ABB, n.d.).

Improvement potentials within SKF

There are some improvement potentials that have been identified within SKF in order to improve and strengthen the initiatives within activity (a). The first thing that can be done to strengthen the energy efficiency in production is to join the global corporate energy efficiency initiative EP100, which is bringing together over 120 ambitious businesses committed to measuring and reporting on efficiency improvements. To join a well-known initiative is a good way of showing its commitment to efficiency improvements and to hopefully exchange knowledge from other companies within the initiative.

The use of seals could be evaluated if it can be used in more applications as it saved large amounts of grease. But before deciding if seals should be used or not it is

important to check if it is suitable in the specific application and does not cause any disadvantages like higher friction. This improvement is relevant as seals can save large amounts of grease if used in the right applications and prevent contamination of the surrounding environment.

Other potential improvements are expanding the reuse of grinding wheels and CBN indexable inserts used in turning. To make considerable changes in terms of reducing the use of raw materials it becomes important to implement these kinds of activities on all manufacturing sites where they are using these tools.

5.1.3 Efficient & optimal use phase

In this subsection, the activity from the EU taxonomy which connects to the third phase in the life cycle will be presented.

5.1.3.1 Activity (e)

(e) prolongs the use of products, including through reuse, design for longevity, repurposing, disassembly, remanufacturing, upgrades and repair, and sharing products;

Circular initiatives within SKF

The first activity which SKF have been working with for many years is Circular economy centers, previously named remanufacturing centers. It aims at prolonging the use of bearings by remanufacturing. The remanufacturing business is located in many places, where SKF is operating, but the most successful Circular economy centers are located in Latin America. The business is currently consisting of 29 remanufacturing centers, but could expand even more in the future as it only accounts for a small share of the total revenue.

Condition monitoring is also an example of an activity that SKF works with, which means monitoring the bearings and making sure that everything is in order to be able to continue operating. For instance, fiber optic sensing, FOS, which can monitor the load, speed and temperature. By using condition monitoring, the product's lifetime can be extended by detecting errors that can be fixed before a failure, which in turn reduces the use of primary raw materials. Condition monitoring has been a part of SKF's business for a long time but it is only used if the customers want to have that included in their contracts with SKF.

Another activity is lubrication service which is a service where employees at SKF makes sure that the bearings have clean and enough lubrication to operate for as long as possible and not break down because of lacking service. This service has been offered by SKF for many years to the customers, but it is only the customers that sign a lubrication service contract that will have it included.

Rotation as a service is an initiative where the customer do not buy a product but instead pays for the service of having a bearing that rotates at all operating hours. For this initiative, it is important that the bearings should be able to operate without

any failures. This is a win-win situation where SKF can charge more for their quality and the customer can be carefree. As SKF gets paid when the bearings can operate it is important for SKF that their products last for as long as possible, which will prolong the use by for instance performing inspection services.

A relatively new initiative is RecondOil, a technology that cleans dirty used oil and the oil can be recirculated again and again. This is a good example of prolonging the use of a product. This initiative is however still only used in a few places, but the ambition is to expand the use of RecondOil.

In 2022, SKF acquired the company Laser Cladding Venture (LCV), to hopefully be able to increase the repairability even more by being able to add material to the damaged product instead of discarding it when it gets damaged in the use phase. This will enable repairing of products that today are being discarded, and thereby prolong the use of products. Currently, in the remanufacturing business, the products can not be repaired if there is too much material that has been abraded. Therefore, it would be of interest to increase the usage of laser cladding to be able to repair the products instead of having to discard them.

Sustainability Design Aspects, is as mentioned before a guideline on how to design the products in a sustainable way. One way is to ensure that the products are designed for longevity.

The last initiative is a return process for reuse and refurbishment of pallets, collars and lids. This will prolong the use of products and save raw material. This return process is a local agreement with the customers thus it is only an initiative between a few customers and is not a standard at SKF. The different initiatives connected to activity (e) can be seen in Table 5.5 below.

Table 5.5: An overview of ongoing initiatives/activities within SKF with regards to activity (e).

Ongoing initiatives/activities within SKF
Circular economy center
Condition monitoring including FOS
Lubrication service
Rotation as a service
RecondOil
Aquisition of Laser Cladding Venture (LCV)
Sustainability Design Aspects
Return process for reuse and refurbishment of pallets, collars and lids

Examples of good practices at other companies

In recent years the number of companies working with prolonging the use of products has been growing significantly. One company that has been working with this for a long time is CAT, which has been doing remanufacturing of their products for 50 years, where the cost is lower, less raw material is used and in addition they give a warranty on the products (CAT, 2023).

Another example of a company working with prolonging the use is Tesla which prioritise battery life extension before battery recycling as they suggest longevity is the more sustainable option (Tesla, 2022). Tesla has in addition also established internal ecosystems to re-manufacture batteries coming from the field to their Service Centers.

Lastly, a company working with sharing products is Volvo Cars that have a mobility service called Volvo On Demand, where an external study has shown that one Volvo On Demand car can replace up to 11 privately owned cars (Volvo Car Group, 2023).

Improvement potentials within SKF

An improvement potential for activity (e) has been found by looking at what SKF is currently doing and what other companies are doing. It involves increasing the remanufacturing business at SKF. To enable a more circular business it is important to increase the revenues from circular activities. This improvement is identified as important, thus it prolongs the lifetime of the use phase and is a good way of going from a linear take-make-waste system to a circular economy system.

Another improvement possibility is to implement Laser Cladding of bearings in SKF operations in order to increase the re-usability and repairability, because of its ability to add material to parts that have been worn out instead of discarding those parts. This initiative is also considered as important as it enables the repairing of bearings that are discarded today. However, the use of laser cladding is still on a small scale but it would be of interest to increase the use of the technology since it increases the repairability.

Lastly, it is important to increase the usage of RecondOil and implement it on a larger scale than what it is today to really make a difference. Oil is widely used within SKF and increasing the usage of RecondOil will save resources by decreasing the extraction of fossil oil and thereby large carbon dioxide reductions.

5.1.4 Circular end-of-life

In this subsection, the activities that connects to the last phase in the life cycle, circular end-of-life, will be presented.

5.1.4.1 Activity (f)

(f) increases the use of secondary raw materials and their quality, including by high-quality recycling of waste;

Circular initiatives within SKF

To increase the use of secondary raw material, Sustainability Design Aspects is a part of this solution by designing the product in a way where secondary raw material is used to a larger extent. This can only be applied when designing new products and not for existing products.

The other initiative connected to activity (f) is the SKF Proof-box where SKF changed from a blue box made from virgin material to a black box to enable use of recycled material. This also resulted in a cost reduction for SKF. The different initiatives connected to activity (f) can be seen in Table 5.6 below.

Table 5.6: An overview of ongoing initiatives/activities within SKF with regards to activity (f).

Ongoing initiatives/activities within SKF
Sustainability Design Aspects
SKF Proof box

Examples of good practices at other companies

Many companies are focusing on increasing the amount of recycled content in their products. One such company is Apple which is working a lot on decreasing its amount of raw material. In fiscal year 2021, they more than doubled the use of recycled tungsten, rare earth metals and cobalt (Apple, 2022). In total, all Apple products contain nearly 20 percent recycled content.

Improvement potentials within SKF

Improvement potentials that have been identified in connection to activity (f) are to use recycled content instead of virgin material whenever it is feasible in order to increase the use of secondary raw materials. It is also important to try to achieve an as high-quality recycling as possible when increasing the use of secondary raw materials, so that the material do not become downgraded and can not be used to the same extent. This improvement has been identified as crucial as it is important to take care of used products and make use of the material over and over again instead of disposing of it as waste. This is an important step towards a circular economy.

5.1.4.2 Activity (h)

(h) increases preparing for the re-use and recycling of waste;

Circular initiatives within SKF

There are some initiatives within SKF that takes preparing for re-use and recycling into account. The first activity is grinding swarf pressed into briquettes. Grinding swarf is a residual being produced when the products are honed, where the residual consists of abrasive grain and emulsion solution. By pressing the grinding swarf into briquettes, it increases the preparing for recycling by separating flows of metal and emulsion.

Reusable trays for safe and sustainable shipments to a car manufacturer is another initiative that increases the preparation for re-use by having reusable trays in place. By having these trays in operation the company prepares for increasing the re-use since they have switched from single-use to these new kinds of trays. This initiative occurs within the SKF factory Tudela in Spain.

Another initiative is where SKF has switched to one type of plastic instead of three different types in one application for a packaging material. By considering how the material is going to be recycled in a functioning way already in the designing phase it increases the preparing for recycling.

The last initiative is Sustainable Design Aspects, which takes sustainable design aspects in mind such as designing it to be reused or designing it to be recycled. This can be done by choosing the right type of material. Every activity mentioned above is compiled in Table 5.7 below.

Table 5.7: An overview of ongoing initiatives/activities within SKF with regards to activity (h).

Ongoing initiatives/activities within SKF
Grinding swarf pressed into briquettes; separate flows of metal and emulsion
Reusable trays for safe and sustainable shipments to a car manufacturer
Switched to one type of plastic instead of three different types in packaging material
Sustainability Design Aspects

Examples of good practices at other companies

Tesla is a good example of a company that is working towards increasing preparing for recycling of waste by recycling batteries on-site in their gigafactories (Tesla, 2022). They are planing to re-introduce their recycled materials back into the manufacturing process.

Improvement potentials within SKF

To increase preparing for the reuse and recycling of waste it is important to design new parts and processes with Sustainable Design Aspects as a requirement. To think of reuse and recycling already in the designing phase will enable more products to be reused and/or recycled.

Another improvement potential is to increase the preparing for recycling of waste by improving the sorting by adding more fractions of waste categories and thereby avoiding combined fractions. By adding more fractions of the waste it is possible to gather information that could be used for improving the waste management. Having a system in place where the sorting is optimal will make it easier to increase recycling.

5.1.4.3 Activity (i)

(i) increases the development of the waste management infrastructure needed for prevention, for preparing for re-use and for recycling, while ensuring that the recovered materials are recycled as high-quality secondary raw material input in production, thereby avoiding downcycling;

Circular initiatives within SKF

The first initiative related to activity (i) is the Circular Economy centers which increases the development of reuse instead of discarding products. By doing this and growing this business it increase the development of waste management infrastructure for reuse.

The other activity is a return process for reuse and refurbishment of pallets, collars and lids from customers. By doing this it increases the development for waste management infrastructure for preparing for reuse. The two initiatives connected to activity (i) can be seen in Table 5.8 below.

Table 5.8: An overview of ongoing initiatives/activities within SKF with regards to activity (i).

Ongoing initiatives/activities within SKF
Circular Economy centers
Return process for reuse and refurbishment of pallets, collars and lids

Examples of good practices at other companies

Increasing the development of the waste management infrastructure is a difficult challenge for companies. But one company that has made major advances in this

area is Apple. In 99 percent of the countries where they sell products, they provide and participate in product take-back and recycling collection programs (Apple, 2022).

Volvo Cars is another example of a company that has started to implement waste management infrastructure by working with battery recyclers in China to develop battery material closed loops (Volvo Car Group, 2023).

Improvement potentials within SKF

The most important improvement potential concerning activity (i) is take-back schemes in order to create a loop of only metals from bearings, which enables high-quality recycling. This will develop the infrastructure and enable reuse and recycling of products and packaging materials. One way to start with this is to implement different initiatives concerning the development of the infrastructure regarding reuse and recycling.

Another improvement could be to investigate opportunities for creating support systems that enable material closed loops for not only recycling but also higher up in the waste hierarchy. This is important to enable improving the infrastructure regarding waste management for the entire society and not only for SKF.

5.1.4.4 Activity (j)

(j) minimises the incineration of waste and avoids the disposal of waste, including landfilling, in accordance with the principles of the waste hierarchy;

Circular initiatives within SKF

The first initiative which minimises the incineration of waste is near net shape as it aims at forming the initial production very close to its final shape to minimize the waste that needs to be removed from the final product.

Reusable trays for safe and sustainable shipments to a car manufacturer is another activity that contributes to the minimization of waste by reusing instead of using single-use.

Another activity is reuse of grinding wheels which enables the grinding wheels to be used to its fullest extent before being discarded. This will result in a lower need for new grinding wheels and less waste is generated.

The initiative within SKF to set a target that 80% of the grinding swarf should be recycled will contribute to minimisation of waste that is being incinerated or landfilled.

Condition monitoring is an activity where the products are being monitored in order to detect when an action needs to be taken before the product is being destroyed. This will prolong the use of a product and therefore less waste is generated.

Reusage of CBN indexable inserts used in turning works in a similar way as reuse of grinding wheels. By using it to its fullest extent fewer CBN indexable inserts are needed and thereby less waste is generated.

SKF has fulfilled the target of reaching 100% recycling of metal scrap. This minimizes the waste of metal scrap by recycling which is more preferable than incineration and landfill if looking at the waste hierarchy.

Lastly, this is an initiative regarding return process for reuse and refurbishment of pallets, collars and lids. This gives the products a second life and minimises the waste. The different initiatives connected to activity (j) can be seen in Table 5.9 below.

Table 5.9: An overview of ongoing initiatives/activities within SKF with regards to activity (j).

Ongoing initiatives/activities within SKF
Near net shape
Reusable trays for safe and sustainable shipments to a car manufacturer
Reuse of grinding wheels
Target of 80% recycled grinding swarf
Condition monitoring including FOS
Reusage of CBN indexable inserts used in turning
100% of the metal scrap is being recycled
Return process for reuse and refurbishment of pallets, collars and lids

Examples of good practices at other companies

Many companies are working with minimizing waste, but one company that is a pioneer within this area is Patagonia. They are both working with renting and selling second-hand clothes and when the clothes can not be used anymore it is recycled into new clothes (Patagonia, 2021). This is a great example of a company working according to the waste hierarchy.

Another company working to minimize waste is Tesla, where none of their scrapped lithium-ion batteries go to landfills and 100% are recycled (Tesla, 2022).

Improvement potentials within SKF

Improve the sorting by adding more fractions of waste categories and thereby avoid combined fractions. This will make it easier to recycle and hopefully prevent incineration of waste that can be recycled. Improving the sorting enables recycling instead of just extracting the energy by incineration.

Another potential improvement is to minimise the incineration without energy recovery for the cases when incineration is inevitable. Incineration is one of the least preferred options according to the waste hierarchy but if there is no other option available, it would be beneficial to extract the energy from the waste by using incineration with energy recovery.

5.1.5 Enables circularity during all phases of the life cycle

In this subsection, the activity from the EU taxonomy which enables circularity during all phases of the life cycle will be presented.

5.1.5.1 Activity (l)

(l) enables any of the activities listed in points (a) to (k) of this paragraph in accordance with Article 16;

Circular initiatives within SKF

There are a number of different ongoing initiatives within SKF that relates to activity (l). The first initiative is to have the majority of sites within SKF certified according to ISO 14001 and ISO 45001. ISO 14001 is an internationally agreed standard that involves requirements for an environmental management system. ISO 45001 is an internationally agreed standard that involves health and safety at work. This initiative enables many of the activities listed above.

In January 2023 SKF launched an open innovation initiative with startups. This is an initiative where SKF is working with external entrepreneurs to work with challenging problems such as grinding swarf and also other opportunities in growth areas. This will hopefully help SKF to get a broader picture and new innovative ideas, and can help with supporting many of the other activities in the EU taxonomy.

Another initiative is a target for 2025, where 100% of SKF's major energy-intensive suppliers are certified to ISO 50001 (SKF, 2023). ISO 50001 is an internationally agreed standard that ensures that the organization has an energy management system that enables reducing the energy consumption and the environmental impact. This activity enables activity (a) as it aims to improve the energy management system.

Rotation as a service is an initiative where the customer does not buy a product but instead pays for the service of having a bearing that rotates at all operating hours. This initiative relates to all of the phases in the life cycle. In the designing phase, the bearing is designed to last as long as it is predicted to be operating. The bearings are also monitored and service is performed whenever needed. Lastly, when

it has reached the end-of-life, it can be recycled in a proper way as SKF owns the product.

Renewable Energy 100 initiative, RE100, is a global initiative involving the world's most influential businesses committed to using 100% renewable energy. This initiative enables sustainable sourcing.

Steelzero is an initiative that SKF joined in 2021. This initiative brings together industrial users of steel committed to the decarbonization of the global steel industry by 2050. By 2030 SKF will ensure that at least 50% of all sourced steel is either: certified steel certified, coming from steel companies with approved SBTi targets, or low embodied carbon steel. This initiative enables activities within sustainable sourcing.

Another initiative that SKF is about to finalize is their Supplier Sustainability Standard that aims to cover SKF's requirements and expectations in respect of social responsibility and human rights, health and safety, and environmental protection. In the Supplier Sustainability Standard, SKF have set different expectations for suppliers regarding the environmental protection section, but SKF have not set many requirements for the suppliers in this section. For further details regarding the Supplier Sustainability Standard, see section 2.1.

The last activity concerns renewable energy. In 2022, more than 50% of the energy used in SKF's operation was generated from renewable sources such as solar and wind. SKF is also investing in both solar and wind to help the growth of renewable energy sources. This is connected to sustainable souring, which is one of fourth areas in the life cycle. The compiled initiatives connected to activity (l) can be seen in Table 5.10 below.

Table 5.10: An overview of ongoing initiatives/activities within SKF with regards to activity (l).

Ongoing initiatives/activities within SKF
Majority of sites certified according to ISO 14001 and ISO 45001
Launched an open innovation initiative with startups, where SKF invite external entrepreneurs to work with us on challenging problems and opportunities in growth areas
Target for 2025; 100% of major energy intensive suppliers certified according to ISO 50001
Rotation as a service
RE100
SteelZero
Supplier Sustainability Standard
Renewable energy

Examples of good practices at other companies

There are many companies working with circularity and sustainability on a higher level in order to improve a broader spectrum. For instance, Tetra Pak has an Advisory Panel within the area of sustainability, where independent external advisors help to shape and inform a pioneering sustainability agenda (Tetra Pak, n.d.-a).

The company Valmet launched "Beyond Circularity", a new R&D and innovation program where Circularity is at the core of the program and aims at accelerating the green transition (Valmet, 2023).

Lastly, a company that has a high focus on circularity is ABB. Firstly, they have a circularity approach, where they are defining clear key performance indicators (KPIs) for every stage of the product life cycle, from design to end-of-life (ABB, 2023). Secondly, ABB has launched an EcoSolutionsTM label that provides full transparency on the circularity value and environmental impact of our products. ABB EcoSolutions products carry either an environmental product declaration (ISO 14025) or an independently verified product lifecycle assessment (ISO 14040). Lastly, ABB's business areas are gradually raising the bar for supplier qualification and management processes by requiring suppliers to address the circularity of supplied materials and components.

Improvement potentials within SKF

To enable any of the activities listed in activity (a) to (k) is important to improve

some areas. First of all, it is important to reach 100% ISO 14001, ISO 45001, and ISO 50001 certified sites within SKF. As the ISO standards consider many perspectives in the life cycle it is of great importance to certify as many sites as possible and thereby many improvements are being made.

Another important thing is to set requirements for suppliers to use a certain amount of sustainable sources of raw material like for instance use renewable materials, recycled content, or a low-carbon footprint. Today, SKF is planning to launch its Supplier Sustainability Standard. In order to drive further improvement, it is important to continually improve the standard by adding additional aspects and strengthening the requirements related to environmental performance. This improvement is vital as the extraction of raw materials causes enormous environmental consequences like carbon dioxide emissions, land use change, scarcity, etc.

The rotation as a service is also important to improve, in order to begin the transition to a circular business model where the product is not sold but instead, a service is sold. However, this service is currently not feasible to apply for all types of bearings, like the bearings of smaller sizes which only account for a minor part compared to the other components in products. It is better to put the main focus on customers with larger bearings where the downtime is very expensive.

The last improvement could be to join associations such as Ellen Macarthur Circulytics, WBCSD, CTI to be a part of the circular economy movement and to show dedication to circularity. This is also important in order to get momentum and because together it is possible to make larger impacts.

5.2 The developed objectives & indicators

The result from the development of objectives and the associated indicators will be presented, explained, and motivated in the following section. As in the previous section, the results are divided into the life cycle phases and the objectives and indicators will therefore be presented in their respective area belonging.

5.2.1 Sustainable sourcing & circular design aspects

Objective: Suppliers fulfill the environmental part of the Supplier Sustainability Standard

The first objective is connected to the sustainable sourcing part of this life cycle phase. This objective was developed because it was identified in the mapping of SKF that there was a lack of requirements regarding the sourcing of components and materials which often have a large impact on the environment. Therefore, this objective aims at setting an environmental standard for suppliers regarding sourcing.

The suppliers have to fulfill the environmental part of the Supplier Sustainability Standard, as explained in the sections 2.1, 5.1.5.1, in order to become a supplier for SKF. This will possibly help SKF in becoming a more circular business since the suppliers have to fulfill the sustainability requirements which also affects the circularity of the sourced materials. For instance, in the environmental part in the Supplier Sustainability Standard there are different areas that the suppliers should strive towards fulfilling and one of the examples are to improve their circularity in the business model, product design and operations through using recycled materials and designing products to enable recycling and repairing.

The current Supplier Sustainability Standard has potential for improvements regarding the environmental perspective and it would be of interest to develop the standard in this area in order to increase the circularity at SKF. Examples of improvements could be to set requirements for suppliers to fulfill certain parts that is now only a expectation from SKF, see section 2.1 for more detailed explanation of requirements and expectations. For instance, currently it is only expected that the suppliers should have a continual improvement to reduce negative environmental impact over time, but it could be improved by instead setting a requirement. In addition to the requirement, it could also include specific numbers on how much the suppliers should improve in regards to reducing their negative environmental impact over time.

Setting requirements for suppliers could be expected as relatively feasible as there possibly are more strict upcoming regulations within EU that probably will require the suppliers to do more to decrease their environmental impact. However, it may be more difficult to put these requirements on suppliers outside of EU since those suppliers not have these possible upcoming regulation to relate to. In addition, it will become of interest for SKF to implement standards for suppliers since upcoming regulations probably will affect the whole value chain and this objective will therefore help the suppliers to be more prepared for the future.

The objective may however only cover major suppliers when it is first implemented since the major suppliers affect the sourcing the most but the aim is indeed that all of SKF's suppliers should fulfill the requirements. Therefore, this objective covering major suppliers is believed to be a possible short-term target. To be able to measure the progress of the objective it is important to use indicators, and the following indicator is presented below:

$$\frac{\text{Suppliers fulfilling the environmental part in the Supplier Sustainability Standard}}{\text{Total amount of suppliers}}$$

This indicator is suitable as it measures the share of suppliers that have been fulfilling the environmental part of the Supplier Sustainability Standard. When the quota is one, the objective is fulfilled. But the limitation of this indicator is that it does not measure if the Supplier Sustainability Standard makes any improvement within the

area of sustainability only if the supplier fulfills the standard or not. However, the indicator gives an indication of the progress of suppliers fulfilling the standard.

Objective: Sustainable sourcing by increasing the share of low carbon footprint materials

The second objective within the sustainable sourcing & circular design aspects phase is connected to the first part of the life cycle, the sourcing. This objective is connected to the previous objective since it also considers the sourcing from suppliers, however this objective instead specifically focuses on the material sourced to SKF. It was found in the mapping of SKF that there was a lack of requirements regarding the sourced material. Currently, it is not mandatory for the suppliers to have e.g., a share of the produced materials consisting of recycled material or material from renewable sources. Therefore, this objective aims at increasing the share of low carbon footprint materials by sourcing materials more sustainably. A low carbon footprint material is defined as a material that does not add to, or minimizes the amount of carbon dioxide entering the atmosphere. Examples of such materials are renewable materials, recycled materials and some virgin materials such as fossil-free steel.

An objective like this will set the scope of the sourcing of materials and thereby bring awareness to decrease the use of virgin materials with a high carbon footprint. However, this objective is closely related to the previous objective since the standard could include requirements on the type of material used. But in order to track the progress of the material used in SKF production and not only how many suppliers that fulfill the Supplier Sustainability Standard it was of interest to include this objective as well. The following indicator is used to measure the progress of the indicator:

$$\frac{\text{Material with a high carbon footprint (ton)}}{\text{Production volume (ton)}}$$

This indicator measures how the use of materials with a high carbon footprint decreases (or increase), as the desired outcome is to use as little materials with a high carbon footprint in relation to the production volume. To improve the quota it is desired to use low carbon footprint material and to decrease the overall use of materials. The low carbon footprint concept has to be evaluated further in order to define the exact definition of the concept and set a specific number for what can be considered as low carbon footprint. The aim of this indicator is to decouple the production volume from high carbon footprint material use.

Objective: Products are designed with Sustainability Design Aspects guidelines

The third objective within the sustainable sourcing & circular design aspects phase is connected to the latter part of this life cycle phase. This objective was developed since it was found in the mapping of SKF that several of the example activities from

EU could more easily be achieved by having design guidelines. In addition, it is in the designing phase that you have the most freedom of deciding what aspects that should be taken into consideration. Therefore, this objective aims at increasing the awareness of the designing phase by ensuring that the products that are developed are designed with circularity and sustainability in mind. Thus, the company should make it mandatory for products to be designed with the Sustainability Design Aspects guideline in mind, see section 2.1. However, in some cases it is not feasible to follow the guideline if for instance the quality of the product is affected. In that case it is important to give a motivation to that particular choice that deviates from the given guidelines. An objective like this will set the scope regarding the circularity implemented in the designing phase which often is the phase where most changes can be made to enable circularity perspectives.

Because SKF already has a Sustainability Design Aspects guideline in place but it is currently not mandatory to use the guideline, implementation of such an objective is expected to be relatively feasible. Therefore, the objective is believed to be a possible short-term target. Even though this objective is expected to be relatively easy to achieve there might be hindrances that are explained in the following paragraph. This objective is measured by using the indicator below:

$$\frac{\text{Number of products designed with Sustainable Design Aspects}}{\text{Total number of products designed}}$$

By using this indicator it can be seen to how large extent Sustainability Design Aspects are considered in product development. If the result is not satisfactory enough further actions need to be taken in order to improve this quota to eventually reach one. The drawback with this indicator is that it could be difficult and time-consuming to follow up and see if everyone has followed the guideline. It will also require more competencies within product development to be able to make choices in terms of what is most sustainable. The competence gap could either be solved by educating the development team on which choices to be made in regards to Sustainability Design Aspects or an expert within the area of sustainable design could be hired to the team that gives valuable input and controls that everything is done correctly according to the guideline in the Sustainability Design Aspects. However, it would be beneficial to implement a follow-up system that ensures that all products are designed according to the guideline since SKF has a large product portfolio.

5.2.2 Resource optimized operations

Objective: Resource optimized operations by re-usage of oil

The first objective in the life cycle phase of resource optimized operations is connected to the RecondOil business that SKF acquired in 2019, see section 5.1.3.1. This objective aims at spreading the use of a technology that is beneficial from a resource minimization perspective since the use of virgin oil will decrease by applying

this technology. When identifying the improvements in the EU taxonomy matrix it was found that the technology is only implemented at a few test locations which is a reason why this objective is important in order to increase the use of this technology in all of the organisation.

Because the technology already is tested at a few locations and the outcome was positive it is believed that implementation of the RecondOil at all sites where it is feasible would be an achievable objective within a relatively short-term perspective. External usage of RecondOil by customers is also important to increase but will probably require more time and is thereby a possible long-term target. An objective like this will set the agenda for expanding the use of RecondOil in the organisation and thereby contribute to more resource optimized operations. It should however be noted that this objective is narrow and does not make up a large part of SKF's operations, but since SKF already has many initiatives in place in this phase of the life cycle an objective like this is relevant. To be able to monitor this objective, the indicator below is used:

$$\frac{\text{Numbers of sites where RecondOil system is implemented}}{\text{Total number of sites where implementation is possible}}$$

This indicator measures the increase (or decrease) in the implementation of RecondOil at SKF's sites where implementation is possible. Where implementation is possible means that all of the sites which are using oil in their operations have the possibility to implement RecondOil system, unlike sites that are not using oil in their operations. It is important to measure this, as SKF have had RecondOil in their portfolio for a couple of years now but the implementation is very limited and not utilized to its fullest extent. The disadvantage with this indicator is that it does not show the final desired outcome which is how much oil is saved and thereby also how much carbon dioxide is saved. It is also difficult to define the word implemented that is used in the indicator as there can be various degrees of implementation, so the definition of implementation has to be defined firstly. However, the indicator is a good starting point to increase the implementation of RecondOil, even though it is not measuring everything that could be interesting to measure.

Objective: Packaging material is recycled with high-quality

The second objective within the resource optimized operations phase is connected to the optimization of resource use of the incoming packaging materials that are used in the transporting of goods for SKF's production. This objective was developed since an improvement potential was identified that the sorting could be expanded to enable high-quality recycling. High-quality recycling means that the material should not be downgraded when recycled and should maintain its properties so it could be used in the same application again.

So, by developing an objective that aims at achieving high-quality recycling of packaging materials it is believed that the sorting also has to be expanded to reach the

objective. By separating the waste into more fractions it is easier to recycle with high quality. Another way of ensuring that the recycling is done with a high quality is to use as few different materials as possible, for example when using plastic it is beneficial to use the same type of plastic to easier recycle it without downgrading. It should however be noted that this objective is narrow and does not make up a large part of SKF's operations, but since SKF already has many initiatives in place in this phase of the life cycle an objective like this is relevant.

This objective aims at setting the scope for which requirements the recycling of materials should include. By striving towards recycling with as high quality as possible and thereby avoiding downgrading the company can improve their resource optimization. However, it should also be mentioned that reuse of packaging material is the most preferable option of recycling and reuse since reuse is higher up in the waste hierarchy from the EU, but if recycling is used it is important to ensure high-quality recycling of materials to avoid downgrading of materials. This objective may have difficulties in application since it is difficult to ensure that materials actually are recycled with high quality. Another difficulty regarding this objective is that recycling is dependent on the available technologies for recycling in the area, where the packaging material is recycled, which may be a hinder since SKF is located in many parts of the world. To be able to measure the progress within the objective the following indicator is chosen:

$$\frac{\text{Amount material recycled without downgrading from site}}{\text{Total amount recycled from site}}$$

This indicator measures the share of the recycled amount that is recycled without downgrading which is important in order to be able to use the material multiple times. But it is important to notice that it does not include all of the waste generated site. For instance, it does not take into account the amount of waste that is being put on landfill. Another limitation with this indicator is that it is hard to acquire the needed data, as SKF has no control of the disposed material when leaving the factory except for choosing the company which takes care of the waste. However, in the future this data may be possible to acquire as companies is starting to get more transparent with their partners.

5.2.3 Efficient & optimal use phase

Objective: Prolonging the use phase by expanding the remanufacturing business

The first objective within this life cycle area is connected to using the products to their fullest potential. This objective aims at increasing the remanufacturing business that SKF already have implemented in their business model. When identifying the improvement potential in the mapping of SKF's circularity it was found that the remanufacturing business does not make up a large share of the total revenues which is a reason behind the development of this objective.

By having a remanufacturing business it is possible to use the bearings to their fullest potential and not discard bearings when some parts have broken down and thereby save large amounts of resources and emissions related to the production of new bearings. Thus, if SKF wants to achieve a more circular business model it is believed that the remanufacturing business has the potential for contributing to that.

Since SKF already has an ongoing remanufacturing business the objective will focus on increasing the already existing business to increase the work towards circularity. This objective will have a long-term perspective since the expansion of the remanufacturing business will require changes in the whole business model of SKF and therefore it will require continuous work towards achieving the objective. Firstly, it will be important to ensure that SKF prepares for an increasing remanufacturing business for example by establishing circular economy centers, in appropriate locations, that enables remanufacturing of bearings. It would also be of interest for SKF to inform customers about the possibility to perform remanufacturing on the bearings to increase the demand for remanufacturing services. In addition it will also be important to educate employees in the area of remanufacturing in order to effectively and with the right methods prolong the use phase of bearings. To ensure progress within the remanufacturing business it is important to measure it by using an indicator, like the following:

$$\frac{\text{Revenues from remanufacturing (SEK million)}}{\text{The total revenue (SEK million)}}$$

This indicator is targeting the objective and shows the desired outcome by measuring the revenues from the remanufacturing business and dividing that by the total revenue of the company. However, some minor errors could occur in the measuring as the data from remanufacturing mostly are grouped together with other activities involving prolonging the lifetime. But it is ongoing work within SKF to sort the data better in order to have more control of the revenues from each activity.

However, this indicator can only reach the value of one if SKF stops to produce new bearings. In order for SKF to reach the value one a new business model would have to be implemented where no new bearings are produced or sold, and no other kinds of activities are generating revenues. It could therefore be of interest for SKF to set a target of how much of the total revenue that is reasonable to derive from the remanufacturing business as a way to increasing the remanufacturing. Since it would require large readjustments in SKF's business model to reach the value of one it would be reasonable to set this target where a part of the total revenue is dedicated to remanufacturing, since it would make it more achievable.

Objective: More efficient use phase by using condition monitoring

This objective aims to increase the use of condition monitoring which is when the bearings are monitored to ensure that the bearings can continue to operate optimally.

By increasing the use of conditioning monitoring, errors can be identified before a breakdown. But this objective is only helpful in becoming more efficient in the use phase if an action is taken after an error is identified. If no action is taken, the breakdown will occur and result in downtime. This will cause both loss of revenues and will eventually damage the product so it may have to be discarded.

When trying to increase the revenues from condition monitoring it is important that the customer understands the importance of having an additional budget for when the monitor is indicating that an action needs to be taken. Otherwise, it is useless to invest in condition monitoring. Currently, only around 20-25% of the customers that have condition monitoring installed are using it in a correct way, that is by having an action plan and budget in place for future identified errors. The focus of increasing the revenues from condition monitoring should therefore be aimed at informing the customer of the importance of having the budget and knowledge for using the monitoring devices and interpreting the data correctly. This will both benefit the customer and SKF since the customer will have a more optimal operating time while SKF has a satisfied customer.

This objective can be applicable to a number of different customers. Both customers that have a high budget for condition monitoring and for those with a lower budget. For those with a higher budget, there is digital monitoring where the data is controlled continuously. For those who have a smaller business, they can invest in a manual condition monitor where they have to do the monitoring by hand. This objective is believed to be a long-term target, depending on how much the condition monitoring should increase. This objective is measured by using the indicator below:

$$\frac{\text{Revenues from conditioning monitoring (SEK million)}}{\text{The total revenue (SEK million)}}$$

An indicator like this will measure how the business within conditioning monitoring is increasing or decreasing in relation to the total revenue. However, it does not say anything about if the circularity is increasing by increasing the condition monitoring, but it is at least a good starting point to use this indicator as the data is easily available. It is also difficult to say what number this indicator can grow to, but it will probably never reach close to the value of one. Therefore, it would be relevant to set a target of how much of the total revenue that is reasonable to derive from the condition monitoring because it is unlikely that the value ever will reach one, to make the indicator achievable.

5.2.4 Circular end-of-life

Objective: Support the implementation of infrastructure to enable reuse and recycling of products and packaging material

The first objective in the life cycle phase of circular end-of-life is connected to developing the systems for handling products and packaging materials when they have

reached its end-of-life. This objective both applies for the waste management directly from production but also for the end-of-life after the bearings have been used at the customer. This objective was developed since it was identified in the EU taxonomy matrix that it was a lack of initiatives at SKF for developing the infrastructure in order to reuse and recycle products and packaging material. Therefore, this objective aims at contributing to the development of infrastructure in society, to achieve a more circular end-of-life.

An objective like this will indicate the direction for what the company wants to achieve regarding the development of infrastructure in order to enable reuse and recycling of both products and packaging material. However, since this objective is quite broad in terms of what actions that should be taken and because this is a first step towards increasing the circularity at end-of-life it is believed that this objective will be a long-term target.

A first step in the process of achieving this objective could be to investigate the opportunities for implementing systems that enables both reuse and recycling. For example by looking into the waste streams of used bearings or packaging materials and identify where there are hindrances in the waste management. It would also be of interest to collaborate with relevant companies that either uses the products or companies that takes care of the products and materials after its use phase in order to jointly work towards implementing infrastructure that enables both reuse and recycling. This objective can be difficult to measure in a quantitative way, but to see progress the indicator was chosen as the one below:

Initiatives that support the implementation of infrastructure regarding reuse and recycling

This is an absolute indicator where an increase in initiatives is seen as something positive. However, it does not tell anything about how large the initiatives are or what kind of difference they make. But as a start towards supporting the implementation of the infrastructure regarding reuse and recycling it is an opportunity to measure what can be measured and see some kind of progress. A starting point would be to investigate in what locations or countries there currently is a larger need for improving or creating infrastructure for recycling and reuse and focus on these locations first.

Objective: If incineration is used as waste treatment allow only incineration with energy recovery

The second objective in the life cycle phase "circular end-of-life" is connected to using incineration as waste management of the waste coming from SKF's production. This objective was developed since it was found in the mapping of SKF's activities that some sites sends their waste to incineration without energy recovery when handling the waste from production. Therefore it was of interest to develop an objective that sets the agenda for incineration as waste management and thereby increases the circularity by recovering the energy from the incineration.

It was however noted that incineration with energy recovery is not available as a method at all locations where SKF has sites and therefore it may not be feasible to require all sites to implement incineration with energy recovery. But the aim is indeed that incineration with energy recovery will be used if incineration is used as waste management. This objective could be supported by lobbying for that energy recovery always should be used when incinerating waste and also always choose to send the waste to facilities where energy recovery is used. It would also be of interest to investigate the locations where incineration without energy recovery currently is being used and support the implementation of incineration with energy recovery. It would however be important to weigh the benefits and drawbacks from supporting the implementation of such a facility since the building of a facility like this also could affect the environment.

However, it should also be mentioned that incineration is one of least the preferred options in regards to the waste hierarchy and other options to handle the products at end-of-life should firstly be evaluated. But since incineration still is used as a waste management method it is of interest to develop an objective that shows the direction of what SKF wants to work towards. The associated indicator to measure the progress of this objective is shown below:

$$\frac{\text{Waste incinerated without energy recovery}}{\text{Total amount of waste incinerated (with and without energy recovery)}}$$

By using a numerator and a denominator in the indicator it gives a share of how much of the waste that is incinerated which is incinerated with energy recovery. This is a good way to initially see the current state of the objective and then eventually be able to improve those cases where incineration is used without energy recovery and see if it is possible to shift to incineration with energy recovery. However, this indicator do not consider if for example more of the waste that previously was sent to incineration without energy recovery now is being sent to landfill, since this would affect the indicator in a positive way since less waste is being incinerated without energy recovery. But in reality the waste has gone from being incinerated without energy recovery to now being put on landfills. Therefor, it would be important to be cautious when interpreting the results of the indicator.

Objective: Zero waste to landfill, where compatible with local regulations

The third objective within the circular end-of-life phase is as well connected to waste management from SKF's production. This objective was developed since it was identified in the EU taxonomy matrix that SKF sends some wastes to landfill. Because landfill is the least preferred option in the waste hierarchy and also the least preferred option for handling waste at SKF it was of interest to develop an objective that decides the direction of SKF's intentions regarding waste management.

Therefore, this objective aims at minimizing the waste that is sent to landfill so that in the end zero waste is sent to landfill. However, the objective excludes the

waste that according to local regulations has to be sent to landfills. There are different regulations regarding waste in different regions of the world and therefore it is important to evaluate what kind of waste is applicable to the considered region. Waste that can be sent to landfills are for example materials that are classified as poisonous, carcinogenic or hazardous and could for example in Sweden be certain oils, solvents or electronics. Even though landfill is the least preferred option and other ways of handling materials and products at end-of-life should be considered first, it was important to include an objective like this to ensure that circularity is considered at all levels.

To achieve the objective of zero waste to landfill it would be of interest for SKF to investigate the opportunities of decreasing the grinding swarf, which is a mix of small metal particles and abrasives mixed with emulsion. Currently some parts of the grinding swarf is being sent to landfill which is why it would be of interest to decrease the amount of grinding swarf. Otherwise it would be of interest to investigate the opportunities to separate the components in the grinding swarf in order to enable recycling or implement other circular strategies to handle the waste. The indicator below was chosen to measure the progress of the objective:

Waste to landfill (ton)

The indicator waste to landfill measures all the waste that is sent to the landfill except for the waste that needs to be sent to the landfill due to local or regional regulations. It was decided to not include the waste that is sent to landfill due to regulatory reasons because the main objective is to reach zero waste to landfill, and that is never achievable if including that type of waste. It is most suitable to use an absolute value here as the desired information is to know how much is sent to landfills.

5.2.5 Enables circularity during all phases of the life cycle

Because some of the activities in the EU taxonomy matrix enable circularity during all phases of the life cycle and do not belong to one specific phase, this section will present the objectives that connects to all phases of the life cycle.

Objective: SKF sites certified according to ISO 14001

The first objective that enables circularity during all phases of the life cycle is connected to the standardisation of environmental management systems. This objective aims at increasing the number of sites that are certified according to ISO 14001 at the SKF group and thereby enable circularity during all phases since it sets out criteria for an environmental management system that includes circularity in all phases of the life cycle. An objective like this will show the direction of SKF's ambitions and set the scope for what actions should be taken. Since SKF has the majority of all the sites certified according to ISO 14001 it is believed that the objective can be described as a possible short-term target.

Firstly, it would be of interest for SKF to investigate the locations where the sites are not certified according to ISO 14001. Thereafter, make a plan of how the sites will make its way to being ISO 14001 certified and follow-up if the sites are working towards achieving the certification. To measure the progress of the objective the following indicator is used:

$$\frac{\text{ISO 14001 certified sites}}{\text{Total number of sites in scope for ISO 14001 at SKF}}$$

To fulfill and measure the objective above it is suitable to use an indicator that measures the share of ISO 14001 certified sites through the total number of sites. This makes it visible how SKF is progressing. However, since a site can include several manufacturing facilities and also include sales offices depending on which site it is, it would be of interest to investigate what facilities are included in the different sites. An improvement potential could be to evaluate if the scope should be broadened to include all facilities at a site as this currently can vary from site to site what is included in the scope at SKF.

Objective: Expanding the use of circular business models by rotation as a service

This objective aims at increasing the use of the rotation as a service business which is when the customer instead pays for the service of having a bearing that rotates all operating hours instead of buying a bearing, see section 5.1.5.1. This is believed to increase the circularity highly by changing the business model from selling a product to selling a service. This enables SKF to have control over the entire value chain and in addition possibly earn more money by charging the customer for the additional service that they are receiving.

This is an objective that can be challenging to expand in all applications. Most of the customers still have an old mindset where they want to own their products and not have a monthly payment to make. But as the whole of society is shifting to own less, the companies might as well change. This objective is considered to be a long-term target due to the challenge mentioned above. To support this objective it would be important to inform the customers about the rotation as a service agreement and what benefits this business model provides. It would also be important to ensure that SKF is prepared for selling a service instead of selling a product, thus ensuring that employees have the right knowledge. In addition it would be of interest for SKF to investigate the changes in the system a reorganisation would require when going from a linear business model to a circular. To measure the progress of this objective, the following indicator is used:

$$\frac{\text{Revenues from rotation as a service (SEK million)}}{\text{The total revenue (SEK million)}}$$

This indicator measures how the share of revenues from rotation as a service in-

creased or decreased compared to the total revenue. Reaching the value of one in this indicator is only possible when no products are sold to the customer and when only services are available. To reach the value of one for this indicator would require SKF to change its current business model into a new business model where selling services are in focus. It could therefore be of interest for SKF to set a target of how much of the total revenue that is reasonable to derive from the rotation as a service business as a first step in increasing this business. Since it would require large readjustments in SKF's business model to reach the value of one it would be reasonable to set this target where a part of the total revenue is dedicated to rotation as as service, since it would make it more achievable.

6

Discussion

The aim of the study was to contribute to an evaluation of the current situation in regard to circularity and develop objectives that aims at increasing the circularity. Furthermore, contributing to analysing the possibilities to measure the circularity at a manufacturing company and thereby provide recommendations on how a company should act to become a more circular business. In this chapter, the result of the study will be discussed in order to see if the research questions have been fulfilled. Further, the limitations of the study and the recommendations will be discussed.

6.1 Mapping of SKF's circularity

The result concerning the mapping of SKF's circularity was aimed at covering the whole organisation and thereby doing a complete analysis of the current activities and initiatives at SKF. But due to the large size of the company and lack of knowledge of all SKF's operations, it is highly uncertain if the mapping has covered all possible circular activities and initiatives within SKF. It is also possible that an activity or the extent of the activity may have been misinterpreted. This can lead to incorrect results and could thereby possibly affect the objectives and indicators. In order to minimise this risk, employees at SKF have been consulted about the activities, and have been asked to verify the results of the mapping.

When the mapping of SKF's circularity had been performed it was noted that SKF generally has more circular activities and initiatives implemented in the second life cycle phase "Resource optimized operations" and the third life cycle phase "Efficient and optimal use phase". Therefore, it would be of interest to increase the circular initiatives in the first life cycle phase "Sustainable sourcing & circular design aspects" and the fourth life cycle phase "Circular end-of-life". The Sustainability Design Aspects was an activity that was brought up numerous times in the mapping process because of its ability to enable circularity. This shows the importance of including the circularity perspective already at the beginning of the life cycle phase since the designing aspects are considered in the first phase.

From the result of the mapping, it is shown that SKF does many activities in regard to circularity. However, in some cases, the activities are only implemented at a few sites in SKF's operations. In order to increase the overall circularity at the

company it is important to expand the use of these activities or initiatives over the whole organisation.

6.2 The developed objectives & indicators

The use of pre-determined sets of indicators was investigated in the study to measure the overall circularity at SKF. From this investigation, it can be noted that it is difficult to measure the overall circularity since the concept of circular economy includes many perspectives. Many of the pre-determined sets of indicators mostly considered recycling and not the higher levels of waste management according to the waste hierarchy, which was seen as a disadvantage since circularity should be addressed at all levels.

In order to measure the circularity at a company it would be relevant to use multiple sets with pre-determined indicators that not only consider recycling but also reuse and prevention. The way of measuring circularity that has been used in this study is to develop indicators instead of using pre-determined sets of indicators since it is possible to formulate indicators that cover not only recycling but a wider perspective of circularity. However, a disadvantage of developing indicators separately instead of using pre-determined sets is the ability to compare the circularity progress with other companies. Since the pre-determined sets of indicators are set to measure the same aspects it will be easier to compare the circularity progress against other companies' progress if they also use the same set of indicators.

A disadvantage of the developed objectives and indicators is that they are very specific to SKF's operations. A possible improvement of the objectives and indicators could be that they are adapted to a more general perspective. This would enable comparing of circularity progress among other companies. Another disadvantage of the developed objectives is that only three people working at SKF got the opportunity to give feedback on the objectives. An improvement for reassuring that the objectives are more suitable for SKF, is to invite a diversity of people from both SKF and knowledgeable people within measuring to discuss the benefits and disadvantages with different types of objectives and indicators.

Some indicators that were developed have weaknesses since they do not consider if the increase of decrease of a value is due to an actual improvement or if the change is due to that the material or waste is being handled differently. An example is the indicator "waste incinerated without energy recovery" divided by "Total amount of waste incinerated (with and without energy recovery)" where the indicator do not consider if for example more of the waste that previously was sent to incineration without energy recovery now is being sent to landfill instead. However, by using all the objectives and indicators together the weakness of the indicators will minimise since it would show in the results if no actual improvement is made because it would affect another indicator in a negative way.

The developed objectives and indicators do not cover the whole SKF organisation.

Since the objectives were developed from the identified improvement potentials, only objectives from these areas have been considered. A disadvantage of choosing this approach is that there will be no tracking of the progress in the areas in which SKF did not need improvements. Therefore, it would be meaningful to set objectives for all company areas.

Some of the objectives that were developed are narrow in perspective to how large a share they make up of SKF's operations. However, these objectives were still chosen as relevant due to the fact that SKF already have many initiatives implemented in some of the life cycle phases. Although these objectives possibly will not make major contributions, they were still seen as important since circularity should be addressed at all levels.

An interesting and important parameter that was identified during the study is that SKF lacks some data in order to measure useful indicators. So a possible improvement potential is to expand the data collection and to measure the data separately, as some data is aggregated today. Examples of such data that is aggregated are different kinds of waste flows, contracts with customers containing both products and different types of services.

6.3 Measuring circularity at a manufacturing company

From the results of the external interviews in combination with studying other companies' annual reports, the overall impression is that most companies are working with circularity in some way. But most of the companies that were studied were only working with this on a small scale and had no plans on changing the whole business model from a linear to a circular business model. The circular business was usually only an additional part of the main business. However, some companies have come further than others and it is therefore beneficial to study those companies' strategies that are forerunners to obtain inspiration.

The cause of this is presumably that it would be too risky to change the whole business model from a linear model to a circular model as most of the companies have always been doing business the linear way. They do not know how to change and what the consequences might be if changing the business model. It is also necessary that society is ready for this shift, as a circular business model requires collaboration between all actors in the product's life cycle. In order to minimize the risk when changing to a circular business model is to do it step by step and have both business models before phasing out the linear business model.

From the external interviews, there was particularly one company standing out from the other in terms of their circularity work, this company is ABB. ABB has not only set ambitious goals but also has a well-founded strategy that aims at having broad goals in order for it to be applicable to every division of the company. They also have at least one person at each division working with circularity that perform follow-ups

on each division to ensure that everyone is on track.

An overall impression from the study is that not enough actions are taken to achieve a more circular society. It can therefore be necessary to have political regulations that put pressure on companies in the transition to a circular economy. As explained in the theory chapter, there are already many regulations and more are coming. It may therefore be important that companies already now have started to prepare for the upcoming regulations in order to be well prepared for the future.

7

Conclusion

From the mapping of SKF, it can be concluded that the main focus regarding the implementation of circular activities should be put within the first and fourth phases in the life cycle, Sustainable sourcing & circular design aspects, and Circular end-of-life. This is due to a larger number of already existing initiatives within the other two phases of the life cycle. It was also noticed that some of the circular initiatives were only implemented at one or a few sites at the company. In conclusion, it will be important to expand the implementation of the circular initiatives over the whole organisation in order to increase the overall circularity and to make a considerable impact.

The EU taxonomy framework is concluded to be an appropriate framework for developing objectives. The framework includes all phases of the life cycle but some phases are more covered in the EU taxonomy than others. The activities within the EU taxonomy framework were applicable to SKF and were therefore suitable to use. However, since the objectives were developed from areas of improvement it does not cover all perspectives since areas that already are successful were not included.

The developed objectives and indicators set the future ambition of the circularity work and measure the progress of the implemented circular activities. However, since the overall circularity has not been measured it is uncertain how the objectives and indicators will contribute to the overall circularity at SKF. As each specific objective and indicator is focused on a particular area.

For the indicators, it was noticed that it is difficult to measure the overall circularity by using pre-determined sets of indicators. This was either because of needing an extensive amount of data that not was available or that the pre-determined sets of indicators only were considering some circular strategies such as recycling which not was the intended outcome of using the indicators, since all levels of the waste hierarchy were intended to be considered. It was therefore decided to develop company specific indicators. This resulted in it becoming more difficult to compare the circularity with other companies as the indicators are developed specifically for SKF.

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Appendix A

EU taxonomy

Article 13

Substantial contribution to the transition to a circular economy

1. An economic activity shall qualify as contributing substantially to the transition to a circular economy, including waste prevention, re-use and recycling, where that activity:

(a) uses natural resources, including sustainably sourced bio-based and other raw materials, in production more efficiently, including by:

  (i) reducing the use of primary raw materials or increasing the use of by-products and secondary raw materials; or

  (ii) resource and energy efficiency measures;

(b) increases the durability, reparability, upgradability or reusability of products, in particular in designing and manufacturing activities;

(c) increases the recyclability of products, including the recyclability of individual materials contained in those products, inter alia, by substitution or reduced use of products and materials that are not recyclable, in particular in designing and manufacturing activities;

(d) substantially reduces the content of hazardous substances and substitutes substances of very high concern in materials and products throughout their life cycle, in line with the objectives set out in Union law, including by replacing such substances with safer alternatives and ensuring traceability;

(e) prolongs the use of products, including through reuse, design for longevity, repurposing, disassembly, remanufacturing, upgrades and repair, and sharing products;

(f) increases the use of secondary raw materials and their quality, including by high-quality recycling of waste;

(g) prevents or reduces waste generation, including the generation of waste from the extraction of minerals and waste from the construction and demolition of buildings;

(h) increases preparing for the re-use and recycling of waste;

(i) increases the development of the waste management infrastructure needed for prevention, for preparing for re-use and for recycling, while ensuring that the recovered materials are recycled as high-quality secondary raw material input in production, thereby avoiding downcycling;

(j) minimises the incineration of waste and avoids the disposal of waste, including landfilling, in accordance with the principles of the waste hierarchy;

(k) avoids and reduces litter; or

(l) enables any of the activities listed in points (a) to (k) of this paragraph in accordance with Article 16.

Figure A.1: The twelve examples of activities presented in the taxonomy regulation (European Commission, 2020a).

Appendix B

Interview questions

Below is a compilation of the questions that were asked during the external interviews. However, this compilation do not include all the questions that were asked since the interviews were adapted to the interviewee and therefore also included specific questions regarding the interviewed company.

How does your company define circularity?

What does the concept of circular economy include at your company?

Is circularity measured at your company?

Does the company use any specific tools for measuring? If yes, what tools?

Do the company currently have any measures of how circular the business is?

What are the biggest challenges when working towards a fully circular business?

Appendix C

Indicators

Below is the collection of indicators that were considered in the study. Some of the indicators already exist at SKF whereas the rest are developed from the methodology used in the study. All indicators are categorised under their respective life cycle phase belonging.

C.1 Sustainable sourcing & circular design aspects

$$\frac{\text{Amount of suppliers fulfilling the environmental part in the Supplier sustainability standard}}{\text{Total amount of suppliers}}$$

$$\frac{\text{Number of products designed with Sustainable Design Aspects}}{\text{Total number of products designed}}$$

$$\frac{\text{Revenue (SEK million)}}{\text{virgin material use (ton)}}$$

$$\frac{\text{Material with high carbon footprint (ton)}}{\text{Production volume (ton)}}$$

$$\frac{\text{Production volume (ton)}}{\text{virgin material use (ton)}}$$

C.2 Resource optimized operations

$$\frac{\text{Numbers of sites where RecondOil system is implemented}}{\text{Total number of sites where implementation is possible}}$$

$$\frac{\text{Amount material recycled without downgrading from site}}{\text{Total amount recycled from site}}$$

$$\frac{\text{Electricity use (GWh)}}{\text{Revenue (SEK million)}}$$

$$\frac{\text{Water use (ton)}}{\text{Production volume (ton)}}$$

Water use (ton)

$$\frac{\text{The cost of scrapped material and losses in materials at Standard Cost (SC) value}}{\text{Total value of produced parts and products in Standard Cost}}$$

C.3 Efficient & optimal use phase

$$\frac{\text{Revenues from remanufacturing (SEK million)}}{\text{The total revenue (SEK million)}}$$

$$\frac{\text{Total amount of reused oil at customer (ton)}}{\text{total amount of virgin oil sold (ton)}}$$

Total amount of reused oil at customer (ton)

$$\frac{\text{Total amount of reused oil at site (ton)}}{\text{total amount of virgin oil bought for self-use (ton)}}$$

Total amount of CO2 avoided from remanufacturing (ton)

$$\frac{\text{Revenues from conditioning monitoring (SEK million)}}{\text{The total revenue (SEK million)}}$$

C.4 Circular end-of-life

$$\frac{\text{Amount recycled grinding swarf}}{\text{Total amount grinding swarf}}$$

$$\frac{\text{Amount recycled metal scrap}}{\text{Total amount metal scrap}}$$

Waste to landfill (ton)

$$\frac{\text{Waste incinerated without energy recovery}}{\text{Total amount of waste incinerated (with and without energy recovery)}}$$

Initiatives that support the implementation of the infrastructure regarding reuse and recycling

C.5 Enables circularity during all stages of the lifecycle

$$\frac{\text{Renewable energy use (GWh)}}{\text{Total energy use (GWh)}}$$

$$\frac{\text{ISO 14001 certified sites}}{\text{Total number of sites in scope for ISO 14001 at SKF}}$$

$$\frac{\text{Revenues from rotation as a service (SEK million)}}{\text{The total revenue (SEK million)}}$$

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