Tampereen yliopisto

Mika Jaakkola

BUSINESS OPPORTUNITIES OF RECYCLING MATERIAL FLOWS IN CIRCULAR ECONOMY HUBS

Faculty of Engineering and Natural Sciences
Master of Science Thesis
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TIIVISTELMÄ

Mika Jaakkola: Materiaalivirtojen kierrättämisen liiketoimintamahdollisuudet kiertotalouskeskuksissa
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Luonnonvarojen kasvava käyttö, kulutuksen lisääntyminen, sekä materiaalien hinnan nousu pakottavat pohtimaan vaihtoehtoja nykyiselle ”lineaariselle talousmallille”. Kiertotalous nähdään vastauksena näihin haasteisiin, jolloin luonnonvarat ja niistä jalostetut materiaalit saadaan pysymään kierrossa jopa tuotteen käyttöiän päättymisen jälkeen. Kiertotalouden onnistuminen vaatii tehokkaammin valmistettuja tuotteita, sekä käytöstä poistuneiden tuotteiden tehokkaampaa ja järkevämpää käsittelyä. Kiertotalouskeskuksia on syntynyt tietyille alueille, vastaamaan jätteiden käsittelystä ja niistä saatavan uusiomateriaalin jatkojalostamisesta. Myös uusia yrityksiä on syntynyt näille alueille kehittämään kiertotalouden liiketoimintaa.

Tämä tutkimus pyrkii vastaamaan kysymyksiin: Mitä osa-alueita kiertotalouskeskuksissa tulisi kehittää, jotta ne vastaisivat paremmin liiketoiminnan luontiin? Miten tietyt materiaalivirrat määritellään, jotta niillä olisi potentiaalia luoda uusia liiketoimintamahdollisuuksia? Tutkimusstrategiana käytettiin kvantitatiivista tutkimusmenetelmää, joka toteutettiin sähköisenä kyselytutkimuksena lähettämällä kysely sähköpostitse valikoidulle kohderyhmälle. Tämä kohderyhmä koostui yritysjohdosta ja ympäristöasiantuntijoista, sekä julkisella että yksityisellä sektoreilla.

Aiempien tieteellisten tutkimusten tuloksista rakennetaan aihealueen teoria ja pohja tutkimuskysymyksille. Kyselytutkimuksesta saatuja tuloksia verrataan nykyisten Suomessa toiminnassa olevien kiertotalouskeskusten ominaisuuksiin, sekä tutkimuksessa esiintyvien sivuvirtojen potentiaalia liiketoiminnan luomisen näkökulmasta. Samalla tieteellisessä kirjallisuudessa esiintyviä liiketoiminnan luomisen mahdollisuuksia ja esteitä tuodaan ilmi sivuvirroittain. Kyselytutkimuksen tuloksilla järjestetään tärkeimmät kiertotalouskeskuksien kehityskohteet ja tehtävät järjestykseen ja perustellaan tuloksia. Sama toteutettiin sivuvirtojen liiketoimintapotentiaalille.

Tutkimuksen tulokset osoittavat, että kiertotalouskeskusten tärkeimmät tehtävät liiketoiminnan tukemiselle ovat toimivien synergioiden luonti eri sidosryhmien välille, tiedon välitys, sekä alustojen luominen pilotointihankkeille. Eniten kehitystä kaipaavat osa-alueet kiertotalouskeskuksissa ovat kommunikointi alueella toimivien yritysten välillä, läpinäkyvyys yritysten tuottamista ja tarvitsemista sivuvirroista, sekä kiertotalouskeskuksen infrastruktuuri. Sivuvirroista eniten liiketoimintapotentiaalia nähtiin muoveilla (ei sisällä PVC:tä), elektroniikkajätteellä, maametalleilla, sekä puurakennusjätteillä. Jotta materiaalivirrat ovat taloudellisesti järkeviä hyödyntää, niiden pitäisi olla tasalaatuista, materiaalia pitäisi olla paljon saatavilla, ja saatavuuden tasaista. Myös paikallisuus on tärkeää ominaisuus, sillä kuljetuskustannukset lisäävät materiaalin hyödyntämisen hintaa. Materiaalien uusiokäytön esteinä nähtiin osaaminen ja tiedon puute, kierrätysprosessien kallis hinta, kierrätetyn materiaalin kierrättämisen mahdollistavien palveluiden puute sekä materiaalien huono soveltuvuus käyttökohteisiin. Kiertotaloudella toteutettua liiketoimintaa voivat edistää uusien liiketoimintamahdollisuuksien luonti, yritysten strategiat, resurssitehokkuus, ja asiakkaiden vaatimukset.

Avainsanat: Kiertotalouskeskus, liiketoimintamahdollisuus, kierrätys, kestävä kehitys, kiertotalous

Tämän julkaisun alkuperäisyys on tarkastettu Turnitin OriginalityCheck –ohjelmalla.

ABSTRACT

Mika Jaakkola: Business opportunities of recycling material flows in circular economy hubs
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The increasing use of resources, increasing consumption, and material prices are forcing us to consider alternatives to the current linear economic model. The circular economy is seen as the answer to these challenges. It allows resources and the materials processed from them to remain in circulation even after the end of the products life. The success of the circular economy requires more efficiently manufactured products as well as more efficient and rational treatment of end-of-life products. Circular economy hubs have been created in certain areas. They are responsible for waste management and further processing of the resulting recycled material. New businesses have also been created in these areas to develop the circular economy business.

This study seeks to answer the following questions: How should circular economy hubs be developed so they would support the value creation of the businesses? How specific material flows are defined as having the potential for creating new business opportunities? The research strategy used is quantitative research method, which was carried out as an electronic questionnaire, by e-mailing the questionnaire to the selected target group of business executives and environmental experts in the public and private sectors.

Previous scientific studies were used to build the theory of the subject and to provide the basis for research questions. The results of the survey are compared with the characteristics of current circular economy hubs operating in Finland, as well as with the potential of material side streams for business creation. At the same time, opportunities and barriers to circular economy business creation in the scientific literature are highlighted side-by-side with survey results. The results of the survey are then used to rank the main development areas of the circular economy hubs, as well as the tasks in order, and the results justified. The same is done for the business potential of material side streams.

The results of the study indicate that the most important tasks of the circular economy hubs to support the business are to create functional synergies between different stakeholders, to transmit information, and to create platforms for piloting projects. The areas having the most of development needs in circular economy hubs are the communication between the firms operating in the area, the transparency of the side streams produced and needed by the firms, and the development infrastructure of the circular economy hubs. The most business potential in material side streams was seen in plastics (not containing PVC), electronics waste, earth metals, and wood construction waste. To use material side streams economically viable ways, they should be of uniform quality, available in large quantities, and evenly available. The locality of the materials is also an important feature as transportation costs increase the cost of utilizing the material. Expertise and lack of information, high costs of recycling processes, lack of services to re-recycle material, and poor suitability of materials were seen as barriers to reusing materials. Creating new business opportunities, corporate strategies, resource efficiency, and customer requirements drive business development towards the circular economy.

Keywords: circular economy hub, business opportunity, recycling, sustainable development, circular economy

The originality of this thesis has been checked using the Turnitin OriginalityCheck service.

FOREWORD

While I was thinking of the subject of my master's thesis, it became clear that I wanted to do a study related to circular economy business. Since I have a background in Nokia's IT-organization, and recycling of end-of-life electronic devices was included in my daily tasks and the sustainability of the materials needed to manufacture phones was in the eye of consumers and media, the circular economy seemed interesting topic to get involved with. As I raised my interest to my professor Marko Seppänen, he hinted me about a possible project starting in the summer of 2017.

The project itself has been funded by EAKR and the European Union and is named "The Circular Economy Hubs of the Future". It is part of 6Aika city development strategy that includes six major Finnish cities: Helsinki, Vantaa, Porvoo, Turku, Tampere, and Oulu. It has received a funding of 2.2 million euros and targeted from June of 2017 to September of 2019. The objectives of the project are to develop the Circular Economy Hubs of the 6Aika cities, as well as to help identify potential side streams and by-products of manufacturing firms, where opportunities for profitable business may be found. The project also has included building networks between collaborators in the circular economy field, find innovations to help create circular economy business models profitable and help achieve clean energy and climate targets of the cities. (Business Tampere, 2017)

I was able to work for the project from 2017 to 2018 and managed to build interesting relationships with the project participants who helped very much to establish the view on Finlands circular economy business field and provide valuable information on the subject. Without their contribution, it would have been almost impossible to understand how the circular economy in Finland has been implemented in practice.

I would like to especially thank my friends and classmates Krista Sorri and Hannu Johansson, my friend Hannu Hänninen and my son Jesse, who have encouraged me to continue writing when it seemed impossible and supported me in completing my thesis.

In Turku, 18.9.2019

Mika Jaakkola

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LIST OF ABBREVIATIONS

AVG	Average
CITER	Center for Innovation and Technology Research
DUM	Distinct urban mine
EIN	Eco-industrial network
EIP	Eco-industrial park
ELFM	Enhanced Landfill Mining
EPS	Expanded polystyrene
FISS	Finnish Industrial Symbiosis System
IE	Industrial Ecology
LFM	Landfill Mining
LSJH	Lounais-Suomen Jätehuolto Oy
MIBA	Municipal solid waste bottom ash
PVC	Polyvinyl chloride
REE	Rare earth elements
REM	Rare earth metals
SDG	Sustainable Development Goal
WEEE	Waste Electrical and Electronic Equipment
WRAP	The Waste and Resource Action Programme

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1. INTRODUCTION

In this chapter the background and Finland's objectives for reaching the goals for sustainability using the principles of the circular economy in circular economy hubs, research questions, structure. and objectives of the study will be explored.

1.1 Background

Ever since the 1972 publication of the book "Limits to Growth", there has been an ongoing debate among scholars and politicians whether the continuous economic growth, decoupling with increasing material consumption and increasing pollution, will come into an end. While the world population and limited material resource consumption keep increasing, the material stocks are becoming scarce and pollution levels keep increasing. Eventually, this will lead to an economic collapse. The book predicted that if the world continues this kind of "business-as-usual" the limits to growth would be a reality by 2072, which would cause the decline in population and in industrial capacity. (Meadows, Meadows and Randers, 2004) This traditional, linear economic model of "take, make, and dispose" that has been the source of economic growth since the industrial revolution is seen coming to an end. (Ellen MacArthur Foundation, 2015b) The traditional model is based on easily and cheaply available raw materials, resources, and energy. While natural non-renewable resources are globally declining the human population has been increasing and estimates are that it will continue to increase until the year 2100. It is been estimated that in 2015 world population had reached 7.5 billion and by 2050 the population will be as much as 10 billion people until the population growth will start to slow down in 2100 to 11 billion. (United Nations, Department of Economic and Social Affairs, 2017) As more and more people are moving to the middle class, especially in developing countries, their increasing consumption also increases the use of raw materials and energy. By 2030 three billion new middle-class consumers will enter the market (Ellen MacArthur Foundation, 2013a). If there's no action taken by firms to adapt to this situation, it will lead to resource scarcity, price volatility and supply chain risks, which are already noticed by many. (Ellen MacArthur Foundation, 2015b)

According to the United Nations Sustainable Development Goals, the total domestic material consumption has increased from 48.7 billion tons to 71.0 billion tons during the period of ten years, from 2000 to 2010. Within the same period, the global GDP rose from 33.5 trillion USD to 65.9 trillion USD. For sustainable development the decoupling of material use from economic growth is fundamental. (United Nations, 2016; The World Bank, 2019)

Price volatility of commodities have been increasing since the year 2000, and while it is not a unique pattern in history, today most of the price volatility is caused by the demand side. The industrializing countries of China and India are driving the demand for commodities with strong economic growth. Material inventories also fell near historically low levels during the period of 2008-2011, which adds uncertainty to the commodity markets. (The Treasury of Australian Government, 2011). Although there has been a decline in commodity prices after the global financial crisis, the overall trend hasn't changed its course. Supply-side challenges are increasing commodity prices. It is more challenging to extract materials than ever before, and energy costs keep increasing. Energy prices have increased 260% since 2000, metal prices have increased 176%, and food prices 120%, while yield growth has slowed down and droughts, temperature changes, and floods have affected on agricultural supplies. Still, like pointed out before, economic growth, especially in emerging countries are keeping the demand up. (Dobbs *et al.*, 2013; World Bank Group, 2018) Besides these challenges, the environmental costs of the traditional economic model in the form of climate change, pollution and loss of natural habitat keeps rising up.

OECD-countries produce over 21 billion tons of material annually that is never incorporated into the manufactured products. These include mining by-products, fishing bycatch, wood and agricultural losses, construction industry waste and materials from a land excavation. Foodstuff losses in food production chains are high. Approximately one-thirds of all food manufactured ends up as waste. Besides these production chain losses, most of the products, discarded as end-of-life are never re-used or recycled. About 65 tons of raw materials entered into the economic system in 2010, and only 40% of it was ever recycled or reused. (Ellen MacArthur Foundation, 2013a).

According to Ellen MacArthur Foundation, the global turning point for the traditional economic system seems to have been the year 2000, and as an answer, Ellen MacArthur Foundation proposes the new economic model of Circular Economy. This will keep the technical raw materials, as well as biological materials in use in 'closed-loop'-system, creating value and phasing out the waste and minimizing resource and energy use. (Ellen MacArthur Foundation, 2013a)

In this sense, the industrial parks are important areas. They group the areas firms together and enable collaboration and resource efficiency. As industrial parks, in general, are areas which have been planned and developed for serving the purpose of industrial and commercial infrastructure and service, there are positive and negative impacts they generate. While they provide economic growth and social development for the area, they also have negative environmental and social consequences. (World Bank Group, 2017) Industrial parks or residential areas with circular economy activities are described with many different terms, such as eco-industrial parks (EIP), circular economy parks, or circular economy hubs. These terms are reviewed thoroughly in chapter 2.

The EIP's are based on industrial symbiosis, which makes EIP's increase the areas economic efficiency, ensure the long-term availability of material resources as well as answering to environmental regulations, like reducing the waste that is landfilled or CO2 emissions emitted by industrial activity. It is safe to say that these areas increase profitability, reduce the environmental impact generated by industrial activity within the area, as well as increase social wellbeing. (Hein *et al.*, 2015) As the symbiosis in these industrial parks work in levels of firms, across firms, and regional and global, to establish a working exchange of side streams, or manufacturing by-products between actors is sometimes challenging. There may be challenges in other areas as well, like maintaining complex stakeholder relationships or geographic attractiveness of the area. There have been several studies done about how to maximize economic and environmental performance of EIP's by finding material side stream exchange networks. (Hein *et al.*, 2015) This has been the focus also of our research in Finland area.

Finland has its goal to be a leader in the field of circular economy and there are already several great examples of organizations and business areas for being more sustainable, reducing the impact on the environment and the amount of waste they generate. The circular economy is deeply integrated into Finlands Government Program of 2015, which sets the national targets for reducing carbon dioxide emissions, energy use, sustainable use of natural resources, ensure effective waste management and prevent littering (Finlex, 2011; Valtioneuvosto, 2015).

As Finlands latest National Waste Plan links circular economy and waste management tightly together, the need for new innovations in collected material side stream flows is essential. The objectives of the National Waste Plan (Ympäristöministeriö, 2018a) are

- High-class waste management is part of the circular economy.
- Resource efficient production and consumption save natural resources and curb climate change.
- The amount of waste is decreased from the present. Re-use and recycling are on a new level.

- Recycling markets work well. Re-using and recycling generate new jobs.
- Low concentration valuable raw materials are recovered as well.
- Material cycles are harmless and dangerous substances are used less in production processes.
- There are quality research and piloting in the field of waste management and waste expertise is on high level.

There are also four key material side streams that are chosen to be in the center of the plan. These are construction waste, biowaste, municipal waste and electric waste (Ympäristöministeriö, 2018a). These objectives are also supported by the European Commission's Circular Economy Action Plan (European Commision, 2015).

Waste generated in the society is divided into municipal waste, industrial waste, construction waste and waste from agriculture and forestry (Ympäristöministeriö, 2017). Municipal waste is similar to household waste, although it can be generated besides households in production and service sector. A common feature in municipal waste is that it is been generated by end-use consumption in communal areas and are within municipal waste management services. Industrial waste is production waste generated by the manufacturing industry, and sometimes includes the waste from energy production and mining industry. (Tilastokeskus, 2019a) Regional waste management services collect most of the municipal waste generated in Finland as well as process industrial waste. Regional waste management services also manage landfill sites. In the past, the materials now collected to be re-used and recycled was mostly landfilled. In 2016, the total amount of municipal waste was 2,7 million tons. From municipal waste, 83% was exploited. Recycled was 33% of the total amount. From the recycled waste 41%, was biowaste. Total of 50% of municipal waste was incinerated to energy. Still, 17% of the municipal waste was landfilled. (Nygård, 2016) The National Waste Plan is targeted for the year 2030, and by then, the objectives for the total of 3 million tons of municipal waste are recycling rate of 68,2%, waste incineration rate of 30,8% and landfilling rate of 1% (Ympäristöministeriö, 2015). In this study, the waste is not divided into different waste groups, but to individual material side streams, collected mostly as municipal and industrial waste, although understanding the national waste targets is essential, to justify the innovation needs for different side streams.

Even though the circular economy hubs, eco-industrial parks or other industrial parks based on circular economy principles, are not necessarily founded next to landfill sites or other waste treatment centers, these locations offer business opportunities, expertise, synergies and collaboration that other locations do not have. Historically, these sites have attracted firms that already have created their business around waste processing. As waste treatment centers are looking for new ways to re-use and recycle their waste streams, more individual firms are needed to innovate new processing methods and create a new profitable business. Since the target is to increase the amount of waste to be re-used and recycled, it is essential to focus on available material side streams. The material side streams that have been collected in high amounts, and do not have currently profitable re-use or recycling processes are the most important. That way, it is possible to get the vast amount of waste out of incineration or to be landfilled and back into circular economy's closed loop. The high amounts of side streams also make it easier for firms to create a business around the materials, as the availability is one of the key components identified for creating profitable and successful innovation in a long term.

To support firms entering these local business areas, creating them an environment to operate and collaborate with the firms within the area to create industrial symbiosis, infrastructure and management of circular economy hub need to be developed according to needs of these firms and the environmental standards. This will also reduce the environmental and social impact of the area.

1.2 Research Questions

The need to decrease the amount of waste is essential to meet the regulations concerning the amount of waste to be landfilled or incinerated. This means that the recycling and re-use rate of waste, or the material side streams, need to be increased. It has been acknowledged that the effectiveness of the firms in circular economy hubs, working through industrial symbiosis is crucial for generating co-operation and successful environment for achieving economic success (World Bank Group, 2017). In academic research, the economics of recycling or re-using materials is mostly absent, as well as the studies on developing the circular economy hubs as an area to support the circular economy operations of the firms as seen in chapter 2.

To assess these two key elements to create an environment for firms to succeed in, the research questions for this study were defined as the following:

- How should circular economy hubs be developed to support value creation of the businesses?
- How specific material flows are defined as having the potential for creating new business opportunities?

For answering these two research questions, a quantitative online survey was sent out for approximately 2500 recipients in the fields of company leadership, business management, and environmental experts, in both, public and private sectors nationwide in Finland. It was estimated that these groups of professionals have the best abilities and expertise to assess these issues in the fields of business, product development, waste management as well as in environmental awareness. The survey itself included a total of 34 questions including the ones about recipient's background, employer and location, and, of course, questions related for business potential material side streams, and the development of circular economy hubs. The selected set of questions that were related to characteristics of circular economy hubs and the business opportunities of material flows, and collected answers are then processed and analyzed.

1.3 Structure of the Study

This thesis is divided into six chapters. After this introductory chapter, the second chapter focuses on the theory of the main subjects of this thesis. It starts with the short academic review of the theory and frameworks of the circular economy, then continues with a literature review and characteristics of the circular economy hubs. Following these is the description of tasks and characteristics of different circular economy hubs in Finland. Finally, chapter two looks into the literature on circular economy business on specific material side streams, their market barriers, and opportunities.

The third chapter explains the methodology used for this thesis in detail. It describes the research strategy and how the data was gathered with the survey. It goes through the possible inaccuracies in quantitative survey research, as well as the benefits in the online survey research methods. Then it describes the quality of the data gathered.

In the fourth chapter, the results and data generated from the survey reviewed and explained. In this chapter, the answers to research questions are established. The chapter is divided into two sections. First, the results on the circular economy hubs development are reviewed and explained through the information of the results in Finland's perspective. Then, the results related to business opportunities of material flows are reviewed and explained.

In the fifth chapter, the results of the study from the fourth chapter are compared to the literature reviewed in chapter 2. In the final sixth chapter, the conclusions are discussed, the theoretical contribution is examined, and then, the recommendations for conclusive actions and policies are made. Last, the limitations of the research are assessed, and further research on the topics covered in the study is proposed.

1.4 Objectives of the Study

The objectives of the thesis are to find out the production side streams that are most prominent from a business perspective to create new business opportunities in Finland. As the circular economy methods are on focus while identifying these new business opportunities the role of the circular economy hubs, are needed to be studied more carefully. The circular economy hubs are new as a concept, but they are based on previous concepts of business areas that are specialized in recycling and waste management activities. Therefore, the study will go deep into the subject of the circular economy hub and seek solutions on developing the characteristics and tasks of circular economy hubs in a way they would support the value creation for businesses of the identified side streams.

Only a handful of academic research on material side streams or waste processing is focused on economics, business potential or the opportunities and challenges the side streams have on markets. This study creates an overview of these academic studies, as well as summarizes academic research. Then, it focuses on gaining more information on the factors that affect the economics of material side streams. There is no clear distinction in the literature on a different type of business areas that are based on circular economy activities either, so this study creates an overview of this topic as well. The circular economy hub concept is rather new, research is needed to create an efficient environment for firms to create a profitable business around circular economy business models. A quantitative research strategy in a form of an online survey is used to gather data on these topics in Finland, to support the development of circular economy hubs. Similarly, the study looks into different material side streams to find out, how the business opportunities of them are seen in Finland. Although there are several business models the field of the circular economy, this study focuses on recycling and re-using material flows.

2. CIRCULAR ECONOMY HUBS AND MATERIAL FLOW ECONOMICS

For understanding the development needs of circular economy hubs and business opportunities of secondary materials before they end up as waste, the circular economy concept and literature are viewed more thoroughly in this chapter. At first, the chapter focuses on the circular economy at a more general level, then on the most relevant fields of the circular economy concept regarding the subject of this study. The literature review on circular economy hubs then follows. After the "circular economy hub" is the current circular economy hubs and their tasks in Finland will be studied. This includes also the material flows and the business potential they generate.

2.1 Circular Economy

The circular economy concept is an answer to traditional "take, make, and dispose" linear economy model (Ellen MacArthur Foundation, 2013a; Ghisellini, Cialani and Ulgiati, 2016). It is viewed as an interesting concept since it is operationalizing sustainable development by integrating economic activity and environmental wellbeing (Kirchherr, Reike and Hekkert, 2017; Murray, Skene and Haynes, 2017). The main aim of the circular economy is economic prosperity and environmental quality (Kirchherr, Reike and Hekkert, 2017).

The characteristics of the current traditional economic model are firms extracting the resources, then using the resources to manufacture products. While doing it, they use labor and energy. The consumer then buys and uses the product and while no longer needed it is discarded as waste. (Ellen MacArthur Foundation, 2013a)

The current linear economic model has its roots in the uneven distribution of wealth by geographical area (Ellen MacArthur Foundation, 2013a). The consumers of manufactured products have been mainly concentrated in the western countries, while material resources have been exploited globally (Sariatli, 2017). Previously, the material resources and energy have been abundant, hence cheap and the labor has been expensive. This has led to the neglect of recycling and reusing products and materials (Sariatli, 2017). Also, the policies and legislation have been supportive of this kind of business models, since the producers of the goods have not been charged the costs of the externalities (Sariatli, 2017).

In recent years, organizations have realized that the cost of resources has been increasing and becoming less predictable. This has led to higher risks in business operations, although measures have been taken to increase resource efficiency and reduce energy consumption. (Ellen MacArthur Foundation, 2013a)

According to Ellen MacArthur Foundation (2013) the price of metals, food, and non-food agricultural output have been higher in the early 2000s, than any other decade in the past 100 years. The prices will likely remain higher and volatile, as world population increases and more resources are extracted from locations that are harder to reach with more expensive processes. Ellen MacArthur Foundation also estimates that 21 billion tons of materials used in product manufacturing do not end up in the final product. These materials are lost during the manufacturing processes. (Ellen MacArthur Foundation, 2013a) Eurostat 2011 data showed that material input for the European economy was 65 billion tons in 2010. Of the used material, 2,7 billion tons was generated as waste in manufacturing processes and about 40 % of the discarded material was not re-used. (Ellen MacArthur Foundation, 2013a; Sariatli, 2017)

A circular economy is not a new idea. The business models of a circular economy have been known since the 1970s (Stahel, 2013). The circular economy is thought to be ”restorative by intention and design” (Ellen MacArthur Foundation, 2013a). The current linear model is replaced by a model built on resource stock optimization, decoupling wealth and welfare, being more labor-intensive than the current resource consumption (Stahel, 2013). The idea of the concept is that the products are designed as the intended reuse, disassembly, refurbishment and recycling in mind. The extraction of the materials is done from end-of-life products, rather than from natural resources, which is the basis for economic growth. The unlimited resources, like labor, have a more important role in the economic model, than limited resources. These limited resources, like natural supplies of materials, are playing only supporting role. (Ellen MacArthur Foundation, 2013a)

Ellen MacArthur Foundation (2013) has found out that the circular economy concept will transform economic balance in three ways. The number of materials used to manufacture products will decrease and vice versa the use of labor in some cases will increase. The primary extraction of resources and production operations will decrease while the reuse, refurbishing and remanufacturing and recycling sectors will increase, and offer new business opportunities. This study focuses on reverse-cycle processes and business opportunities rather than product design areas of the circular economy.

2.2 Principles of The Circular Economy

Multiple R-frameworks have been developed for the circular economy. The most commonly used principles of circular economy in literature is the 3R framework (Kirchherr, Reike and Hekkert, 2017), although the 4R frame work has been the basis for the EU's Waste Frame Work Directive (EU 2008), and therefore used here. The 3R's stand for "reduce, reuse and recycle" and the fourth 'R' for "recover" (Yuan, Bi and Moriguichi, 2006; Kirchherr, Reike and Hekkert, 2017; Murray, Skene and Haynes, 2017). Even 9R Frameworks have been used (Kirchherr, Reike and Hekkert, 2017; Potting *et al.*, 2017).

The idea of the 4R framework is a coding framework, which defines the core principles or strategies to achieve a circular economy. The first reducing-principle targets to reduce the used resources like energy, raw materials and waste in production and in consumption processes. This is achieved by redesigning products, minimizing environmental impact, extending the lifespan of products and preserving the natural capital with so-called eco-efficiency. (Ghisellini, Cialani and Ulgiati, 2016; Kirchherr, Reike and Hekkert, 2017) The second principle, reuse, targets reusing the end-of-life products by repairing and refurbishing. This is achieved by targeting products, components or materials that are not labeled as waste, but reused in their original purpose. Reusing products in their original use is very interesting in environmental perspective since it requires fewer resources, less energy, and labor than producing new products. (Ghisellini, Cialani and Ulgiati, 2016; Kirchherr, Reike and Hekkert, 2017) The third principle, recycle, is met by remanufacturing the end-of-life products, recycling the materials, and reusing the waste generated when discarding the products (Kirchherr, Reike and Hekkert, 2017). Recycling is targeted to materials that are defined as waste and processed into new products, materials or substances for the original or new purposes (European Commission, 2008). Recycling does not include energy recovery or reprocessing of materials used as fuels. It does include the processing of biomaterials (Ghisellini, Cialani and Ulgiati, 2016). As the fourth 'R' stands for recovery, the European Commission (2008), defines the term as waste or processed waste to fulfill the need of material or replacing other materials in a product.

The circular economy is based on principles of industrial ecology (IE) on the areas of industrial metabolism and optimization, which creates a new economy-wide system on the fields of economic development, production, as well as on distribution and recovery of products. With the principles in industrial ecology, the circular economy drives forward the change from open cycles of materials and energy to closed ones, which leads to more efficient production processes (Ghisellini, Cialani and Ulgiati, 2016; Murray, Skene and Haynes, 2017).

Systems thinking is a core principle of the circular economy (Kirchherr, Reike and Hekkert, 2017). The circular economy distinguishes itself between biological and technical systems (Ellen MacArthur Foundation, 2013a; Murray, Skene and Haynes, 2017). The Ellen MacArthur Foundation conceptualizes the circular economy in the most prominent way (Kirchherr, Reike and Hekkert, 2017). Technical and biological loops are seen in figure 1. This model in figure 1, by Ellen MacArthur Foundation, is called the ‘Butterfly Model’ (Prendeville, Cherim and Bocken, 2018) and used to describe the circular economy in practise. In the model, the technical system focuses on the management of finite resources. The consumption is replaced by use, meaning the product usage is replaced by using services. The materials in the technical system are recovered and restored. The biological system focuses on material flows of renewable resources and materials. In this system, the consumption of resources is done in biological cycles. The circular economy has been divided into three separate principles by Ellen MacArthur Foundation (2015).

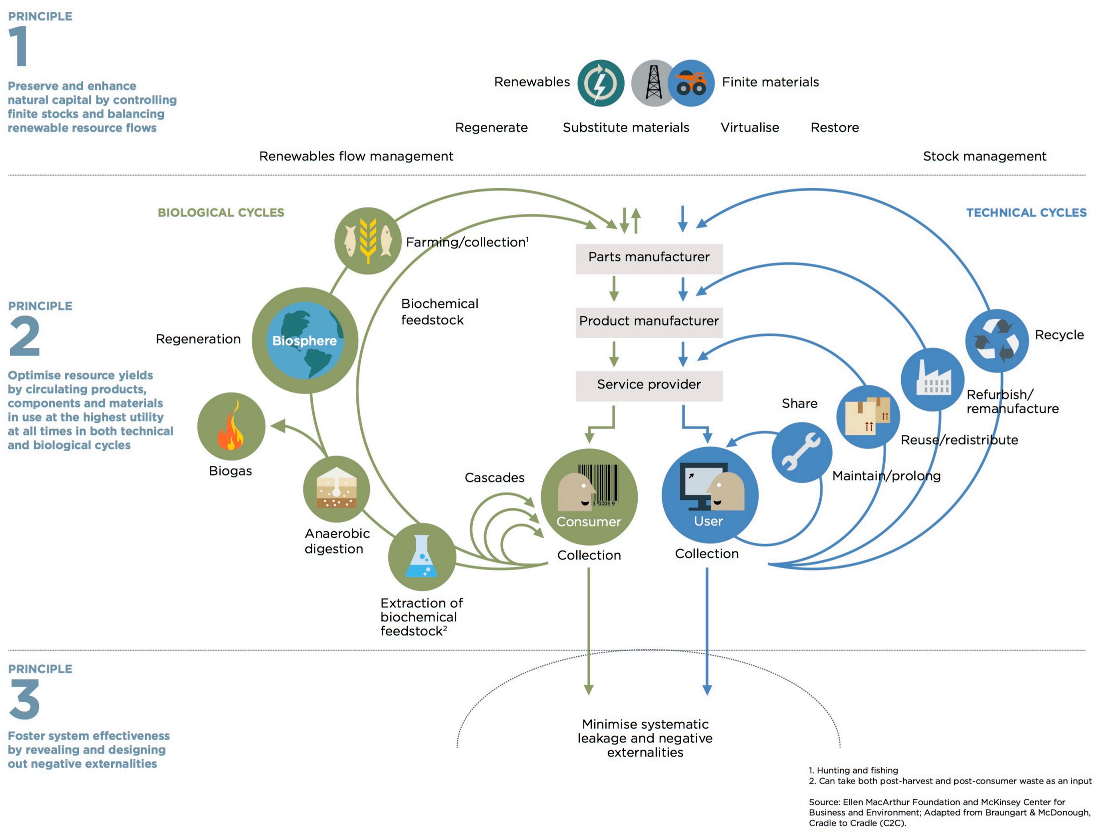


Figure 1. *The Loops of the Circular Economy* (Ellen MacArthur Foundation, 2015b).

The first principle is to “Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows”. This principle means that virtual systems control the distribution of resources. The distribution is done efficiently, and the systems choose processes and technologies that use better-performing resources or renewable resources when possible. When simplified, this means resource, technology, and process optimization. The circular economy also increases the natural capital by encouraging the nutrient flow in the system. (Ellen MacArthur Foundation, 2015b)

The second principle is to “Optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles”. This principle means that technical materials are kept in circulating and contributing to the economy by remanufacturing, refurbishing and recycling continuously the once produced products and materials. (Ellen MacArthur Foundation, 2015b) The circular economy loops are described in the second principle. The tighter inner loops are encouraged, which saves energy other value to other economic activities (Ellen MacArthur Foundation, 2015b). By doing this, the product life is extended and reusing of products and materials is optimized. The shared use of products maximizes also product utilization. (Ellen MacArthur Foundation, 2015b)

As the second principle distinguishes technical and biological loops, in biological loops the circular systems encourage the nutrients re-entering the biosphere. This way the biological material decomposites to valuable material for another cycle in the system. In biological materials, the idea for gaining value from products and materials is to cascade them through other applications, since in linear economic systems, the yield gains need continuous improvement in production methods. (Ellen MacArthur Foundation, 2015b)

The third principle is to “Foster system effectiveness by revealing and designing out negative externalities”. The idea in the third principle is that within the economic activities the damage to environment and ecosystems is as small as possible and the amount of waste is minimal. The areas that the third principle focuses on are food, mobility, shelter, education, health, and entertainment. In these areas, the externalities managed are land use, air, water, and noise pollution as well as releasing of toxic substances. There are several characteristics of the circular economy in the third principle. As in the circular economy, waste doesn’t exist. It is designed as such. All the biological materials in the loops are non-toxic and returned to into biosphere through cycles of composting and anaerobic digestion. On the other hand, technical materials and resources are returned into the system by recovering, refreshing and minimizing the product materials and energy usage. (Ellen MacArthur Foundation, 2015b)

While these three principles describe the circular economy ‘Butterfly Model’, it is still a very simplistic view of the product and material flows (Prendeville, Cherim and Bocken, 2018). For macro-level framework on the circular economy, Ellen MacArthur Foundation proposes ReSOLVE framework that describes six areas of action for businesses and countries (Ellen MacArthur Foundation, 2015a; Prendeville, Cherim and Bocken, 2018). The areas are regenerate, share, optimize, loop, virtualize and exchange. The ReSOLVE framework is meant to complement the ‘Butterfly Model’ and give concrete examples of how businesses and countries can move towards a circular economy. Regenerate stands for the business shifting towards using renewable materials and energy, restoring the health of ecosystems and returning the biological materials into biosphere (Prendeville, Cherim and Bocken, 2018). Share stands for collaborative consumption models in sharing economy, like car sharing or reusing products (Prendeville, Cherim and Bocken, 2018) as well as for prolonging the product life through maintenance and designing products to last longer (Ellen MacArthur Foundation, 2015a). Optimize stands for increasing efficiency and performance of a product, getting rid of waste in supply chains and in production as well as for leveraging big data and automation in production (Prendeville, Cherim and Bocken, 2018). Loop stands for keeping the technical materials and biomaterials as well as products in the loop as long as possible. This includes recycling the materials and remanufacturing products and components as well as digesting biomaterials anaerobically and extracting biochemicals from organic waste (Ellen MacArthur Foundation, 2015a). Virtualize stands for dematerializing products directly and indirectly. For example, virtualizing books and DVDs online or creating online shopping platforms instead of traditional stores (Ellen MacArthur Foundation, 2015a; Prendeville, Cherim and Bocken, 2018). Exchange stands for replacing traditional materials with renewable materials and using new technologies for product manufacturing as well as for choosing new products or services for replacing the traditional ones (Ellen MacArthur Foundation, 2015a).

Stahel (2013) proposes a simpler model for the circular economy. Stahels model does not distinguish between technical and biological loops. The basic principle in the Stahel’s model is the same as in loops in the Ellen MacArthur Foundations model, the smaller the loop, the more profitable and resource-efficient the activity is (Stahel, 2013). Stahel’s model has three loops: the largest, which takes resources as input and results in waste as output. The largest circle connects extracted resources to manufacturing, to distribution, to use, and through innovation to recycling and to the smaller loops. The waste in Stahels model is resource losses, which can partly be recovered through industrial symbiosis. Inside the largest loop is the smallest loop, the most resource and economically effective, reuse, repair and remanufacture. The medium-sized loop is still inside the largest and connects the taking back of the discarded goods from usage to manufacturing. (Stahel, 2013, 2016)

The living systems work as an example of a circular economy. In nature, biodiversity is the key for organisms to survive environmental changes. In the circular economy, diversity is seen building strength in the system. It gives the system versatility and resilience against crises. The energy that is used in the circular economy should be renewable. This helps to minimize energy dependence and increases system resilience towards oil price changes. For the negative externalities, the prices of goods and services should reflect the full costs, so they would be effective. The transparency in negative externalities encourages the economy towards circular. (Ellen MacArthur Foundation, 2015b)

There is little (Murray, Skene and Haynes, 2017) or no waste in a circular economy, but within the transition period, of course, the reverse-cycle business offers opportunities for companies to create value in waste streams markets (Ellen MacArthur Foundation, 2013a). This happens through recycling, refurbishing and remanufacturing activities (Ellen MacArthur Foundation, 2013a). The products that offer the most potential value for these activities today, are the ones that haven't been exploited yet. These products have medium complexity and medium-term product life, from 3 to 10 years. By designing these products with the standards of the circular economy, the economy will benefit in energy and material savings. This will tackle the challenges in global supply chains, like price volatility, high price levels, and other supply risks, while materials become scarce. This way the manufacturer's will become much less dependent on virgin materials. (Ellen MacArthur Foundation, 2013a)

New skills and new technology are needed for deploying reverse-cycle processes in practice to return the materials into the industrial system (Stahel, 2016). These include better in quality and more cost-effective collection of discarded products and waste treatment systems. Development of reverse-cycle processes will also require development in such areas as supply chain logistics, risk management, energy generation, molecular biology and polymer chemistry. With this, the leakage of materials out of the circular system will decrease. (Ellen MacArthur Foundation, 2013b)

The collection of discarded products has to be implemented in the way that is easy to follow. The collection points need to be easy to access, for customers and end-of-life specialists and they need to be built in a way that the quality of materials will not be affected. In biological down streams, the applications needs to cascade in way that the nutrients and value recovery are optimized before releasing nutrients back into biosphere. (Ellen MacArthur Foundation, 2013b) Ellen MacArthur Foundation also suggests (2013b) that private companies would drive this development, while overseeing the development of needed infrastructure is done by the municipalities. The municipalities can organize information events and also push regulations to steer the development into right direction. (Ellen MacArthur Foundation, 2013b)

Recycling is a fundamental part of a circular economy (Murray, Skene and Haynes, 2017). According to Ellen MacArthur Foundation, recycling of products and materials is already profitable globally. In many markets, the reusable product packaging of short-life products generates higher profits and lower emissions than throw-away packaging. Today, companies that face higher costs in virgin materials are preferring to reuse old materials. Also, recycling is encouraged when collection and redistribution infrastructure has low costs and is effective. Widely used packaging type will also help to keep the costs of handling and processing down. For collecting to work effectively, it needs to occur on a large scale. By expanding these solutions more widely to different manufacturers, more opportunities will be created for collectors, distributors and, of course, for consumers. (Ellen MacArthur Foundation, 2013b) Recycling, on other the other hand, is not the most efficient way to promote the circular economy, since the material stock decreases every time materials are recycled (Stahel, 2013). This means that on the perspective of material efficiency, the products and materials should be kept in the "smaller loops" for a longer period, before forwarding to the recycling processes.

2.3 The Types of Industrial Parks based on Circular Economy

Ellen MacArthur Foundation states in its report (2013) that shifting the circular economy to mainstream requires pioneering companies that will develop the capabilities for the reverse-cycle activities in the circular economy. As the current infrastructure doesn't support the circular economy, these pioneering companies are needed to build the infrastructure in regional areas like cities. In this approach, the remanufacturing, re-logistics, storage and information transfer would be built to support the circular economy and keep the materials and components in the circular loops. The business is seen as the primary driver for circularity (Ellen MacArthur Foundation, 2013a). In the early stages of mainstreaming the circular economy, it is more than likely that this approach would be supported by business hubs to create interaction between businesses in the circular economy. While the circular economy needs to be applied on all three levels, micro, meso, and macro (Jackson, Lederwasch and Giurco, 2014; Murray, Skene and Haynes, 2017), the focus in this chapter is at meso-level. The meso-level consists of inter-firm networks

(Suárez-Eiroa *et al.*, 2019), organizations, which interact with each other. This can result in industrial symbiosis (Chertow, 2000). The significant characteristics of meso-level are institutions and actors, who have a strong interest in technological practices (Jackson, Lederwasch and Giurco, 2014). The changes in macro-level may destabilize meso-level, which then again creates new opportunities for micro-level actors to transform or compete with meso-level actors (Jackson, Lederwasch and Giurco, 2014).

While defining the scope of the thesis, it was clear that the meso-level definition of a ‘circular economy hub’ as a concept should be researched more closely. In this chapter, the term is defined by looking into academic articles and research, as well as other sources where the term is used. This chapter also views the academic studies related to the research questions more thoroughly. In many occasions, the term ‘circular economy hub’ represents the previous landfill sites and nearby areas, where materials could be extracted from waste to production use as secondary material. Within these areas, are located the firms that use each other’s side streams as a primary resource for creating their own business. Many times, the storage and processing facilities for previously discarded products as well as waste management facilities are located within the same area. The type of circular economy hubs seems to vary depending on geographical location and the industrial structure of the area. The term ”circular economy hub” is currently widely used in Finland to represent these sites with circular economy activities. it is also well presented in recent EU project applications, where these hubs are being developed. (Jätelaitoisyhdistys ry, 2016; Kemin kaupunginhallitus, 2017) Although the term is not very thoroughly explained in these applications. Similarly, the terms ’eco-industrial park’ and ‘circular economy park’ are used in parallel to describe these same type of business hubs.

To rightfully understand the development needs of current circular economy hubs and the definition of it, the previous academic research based on these hubs needs to have a closer look. At the beginning of the research, the terms to represent the various definitions of the circular economy hub were chosen. The terms focused on the literature review are: ‘urban mine’, ‘landfill mining’, ‘eco-industrial park’, ‘circular economy park’ and ‘circular economy hub’. Table 2.1 below lists the literature reviewed in this study.

***Table 2.1** List of literature defining the circular economy industrial areas.*

Definition	**Authors, Year**	**Research Type**
Urban mine		
	(Ongondo, Williams and Whitlock, 2015)	Introduction of distinct urban mines as sources for electronic materials.
	(Zhou, 2015)	A look into more efficient recycling operations in China.
	(Matsuura and Miura, 2016)	Resource recovery from urban mine.
	(Sun et al., 2016)	Evaluation of recycling metals from urban mines.
Landfill Mining		
	(Krook, Svensson and Eklund, 2012)	Resource extraction from landfill mining.
	(Jones *et al.*, 2013)	How to exploit landfills on resource excavation effectively.
	(Van Passel *et al.*, 2013)	Economics on enhanced landfill mining.
	(Zhou *et al.*, 2015)	Cost-benefit analysis of landfill mining in China.
	(Kieckhäfer, Breitenstein and Spengler, 2017)	Economic assessment of landfill mining.
	(Hölzle, 2018)	Contaminant reduction in landfill soils for re-use.
	(Hölzle, 2019)	Environmental valuation of processing landfill materials.
Eco-industrial parks		
	(Frosch and Gallopoulos, 1989)	Building an industrial ecosystem.
	(Lowe, 1997)	Strategies for eco-industrial parks.
	(Heeres, Vermeulen and De Walle, 2004)	Comparison between eco-industrial parks in the USA and Netherlands
	(Gibbs and Deutz, 2007)	Review of sustainability policies of eco-industrial parks.
	(Romero and Ruiz, 2014)	Proposal for converting industrial areas to eco-industrial parks.
	(Ghisellini, Cialani and Ulgiati, 2016)	A review on a circular economy based economic systems.
	(Bellantuono, Carbonara and Pontrandolfo, 2017)	Characterization of eco-industrial parks.
	(Martín Gómez, Aguayo González and Marcos Bárcena, 2018)	Smart eco-industrial parks, based on industrial metabolism.
	(Song et al., 2018)	Social network analysis of eco-industrial parks.
	(Halonen and Seppänen, 2019)	Review of Eco-industrial parks.
Circular Economy Parks		
	(Song et al., 2011)	Study on coal industry circular economy park.
	(Han et al., 2018)	Ecological and health risks of the circular economy park.
Circular Economy Hubs		
	(Kilkis, 2012)	Circular economy energy in cities.
	(Milmo, 2016)	EU chemical sites moving to the circular economy.

Defining the circular economy hub is anything of a too straight forward of a task. The term is rather new in practical use and in scientific literature, the concept has had several uses with a few different definitions. The idea of use landfill areas for extracting materials into production use is nothing new.

First, the term ”Urban Mines” was used already in the 1960s to promote the idea of ”cities used as mines” by late activist Jane Jacobs (Zhou, 2015). The ‘Urban mine’ did appear on literature through the 1980s, but sparingly. An article on Development and Utilization of Circular Economy and Urban Mining (Zhou, 2015) does give a glimpse of the history of the term but doesn’t explain the term in more detail.

In a study on resource recovery from urban mines (Matsuura and Miura, 2016) the urban mine is described as ”an idea that considers valuable resources in the parts of wasted electronic equipment as minable resources.” The description here is very narrow and doesn’t go more deeply into the subject.

In another study (Sun *et al.*, 2016) the term ”urban mine” is mostly referring only as waste that is formed through a linear process of extracting the raw minerals, usage of the product and after the product becomes end-of-life, discarded as waste. These urban mines consist of the secondary resources of materials that are generated in urban areas and stored, at least in some cases, in landfills. (Sun *et al.*, 2016) Although other options available for storing the secondary materials of urban mines are left open.

In a more detailed overview of the term ”distinct urban mine” (DUM) is defined in study exploiting secondary resources in unique anthropogenic spaces (Ongondo, Williams and Whitlock, 2015). Again, the definition does not refer to materials buried in landfill areas and it is rather different than in previous studies. The spaces studied in the paper, act as spaces where materials can be cyclically used, recycled and then reused. These urban mining activities require systematic management of anthropogenic resource stocks and waste (Ongondo, Williams and Whitlock, 2015). Resources and waste are categorized into different groups. These groups include food, end-of-life vehicles, packaging, and e-waste. These distinct urban mines are considered as uniform spaces for different types of waste. This is not necessary for all urban mines since some of these mines can be rich in other types of products than other mines. The study defines that urban mines can be compared with following criteria: (i) product flows, (ii) material concentration, (iii) material composition, and (iv) external influences, such as areal demographics and disposal behavior (Ongondo, Williams and Whitlock, 2015). The study concentrates to universities as distinct urban mines, but these could also be hospitals, food markets or shopping malls. The study defines the distinct urban mine rather as recycling opportunity where high concentrations of a specific type of waste are readily and cyclically available rather than ”a mine”, in a sense where already discarded waste could be extracted and concentration of waste is already available.

It seems that in scientific literature urban mines distinct themselves from landfills as the primary source for secondary materials. Instead, urban mines are seen as today’s recycling facilities or only as discarded products that are located in urban areas. The idea of urban mine is to extract materials from the discarded products after the product-life ends and before it ends up in a landfill. Extracting materials from landfills are identified as an important and inevitable process for many scarce resources, although they do not explicitly define these sites as urban mines. That being said, the urban mine could be seen as a part of today’s circular economy hub that has various urban recycling facilities integrated within the hubs geographical area. Urban mine can’t necessarily be seen as a synonym to a facility that uses old landfills as mines for its resources as the original idea of a mine, where resources can be extracted.

2.3.1 Landfill Mining

From defining the urban mines, the next step towards today’s circular economy hubs is studying landfill mines and landfill mining (LFM). The academic research on landfill mining has been thoroughly covered by Krook et al. (2012). The term has already been used in 1953 for recovering fertilizers for orchards (Zhou *et al.*, 2015). After that, the term didn’t surface in scientific literature until the 1990s, when environmental awareness started to increase and environmental legislations were developed (Krook, Svensson and Eklund, 2012). Landfill mining is an important concept to examine since as urban mine was solely an idea of using cities as mines (Zhou, 2015), landfill mining is more of a using discarded products buried in landfill sites as a source for the mining of materials (Krook, Svensson and Eklund, 2012). Landfills have been seen as a cheap solution for storing discarded waste, as well as a source for environmental hazards like methane emissions, local pollution and decreasing space in urban development (Krook, Svensson and Eklund, 2012). Landfill mining has been promoted as a solution for these issues and means the excavation, processing, treatment, and recycling of these landfilled materials. Unfortunately landfilling is still the most common way of waste disposal (Krook, Svensson and Eklund, 2012). Landfill mining has great economic potential as well as environmental benefits in recycling materials, recovering energy, reclaiming land and prevent pollution (Zhou *et al.*, 2015).

Landfill mining has developed to enhanced landfill mining (ELFM) while adopting circular economy principles to close the loops of material flows (Jones *et al.*, 2013; Kieckhäfer, Breitenstein and Spengler, 2017). This is done by using advanced technological innovations. In the past, the research on landfill mining has been focusing on the material composition of landfills and sorting and recovery technology. Besides these, the reusability options and processability of these materials, as well as recyclable product markets are also important factors for landfill mining to be profitable (Van Passel *et al.*, 2013). The ecological benefit is also an important factor in landfill mining operations. It is mainly determined by the material composition of buried waste, and waste-to-energy processes, the background energy system and management of landfill gas (Hölzle, 2019). There might be similar energy savings in recovering metals from landfills like in traditional metal recycling. Other important waste streams in landfills are plastics, textiles, and wood for wood production, as well as sand and gravel (Kieckhäfer, Breitenstein and Spengler, 2017). The soil in landfills require special processing before they can be reused or recovered (Hölzle, 2019). There are different types of soil in landfills, some of it will be processed and will be ready for reuse, and some of it is contaminated which has low usability or needs to be disposed of (Hölzle, 2018). Besides the landfills material structure, landfills have to be assessed by taking the infrastructure of the area, like waste-to-energy plants, processing plants, and recycling facilities into account (Hölzle, 2019).

Material flow analysis is used to examine the composition and usability of landfills. It takes the structure of waste, material flows, local infrastructure and markets of the recyclable materials into account. A study (Hölzle, 2019) on analyzing energy consumption on processing the waste of eight different landfills sites points out the importance of working regional infrastructure. This infrastructure consists of the plants for processing waste, waste-to-energy plants, backfilling facilities for ground improvement and the landfills themselves.

Kieckhäfer et. al (2017) have studied the economic feasibility of landfill mining processes from a landfill operator's view. They compare the profitability different actions taken by landfill operator, from material recovering processes to the closure of the landfill site. They concluded that currently, within the sites studied, the closure and aftercare of the landfill site is the most economically preferable option. On the other hand, the increasing price of material, like metal, prices and waste incineration prices will make landfill mining processes more profitable. (Kieckhäfer, Breitenstein and Spengler, 2017)

In a study on cost-benefit analysis of landfill mining, Zhou et al. (2015) found out that the main factors to determine the economic feasibility of landfill mining are the degree of urban development, the extraction of waste fuel, the recycling rate of recovered materials and the creation of new landfill sites. They also found out that the highest cost of landfill mining operations come from the excavation and hauling equipment, and then from the waste processing and transportation. The economic benefits come from incinerating material to electricity first and then followed by benefits generated from land reclamation. (Zhou *et al.*, 2015)

Krook et al. (2012) have identified three main challenges for resource recovery in their review on landfill mining research. These are technological innovations, underlying conditions for implementation and development of a standardized framework for evaluating the performance in landfill mining. (Krook, Svensson and Eklund, 2012)

2.3.2 Eco-industrial parks

Eco-industrial parks (EIP) have been used similarly to describe Circular Economy Hubs (Sorvoja, no date). The EIP concept has been studied extensively since a seminal paper in Scientific American (Frosch and Gallopoulos, 1989) was published.

A recent study on smart eco-industrial parks (Martín Gómez, Aguayo González and Marcos Bárcena, 2018) points out that from a biological perspective the traditional industrial parks are inefficient. At meso-level, the eco-industrial parks are seen as a proper way for the transition from traditional economic models to more sustainable models with the circular economy. Industrial parks concentrate the industrial activity of a specific area. (Martín Gómez, Aguayo González and Marcos Bárcena, 2018)

The EIPs have been promoted across the world since they have been seen as an effective concept of reducing waste and improving resource effectiveness (Song *et al.*, 2018).

The eco-industrial parks are managed by the principles of industrial ecology (IE) (Gibbs and Deutz, 2007; Ghisellini, Cialani and Ulgiati, 2016; Martín Gómez, Aguayo González and Marcos Bárcena, 2018; Halonen and Seppänen, 2019) and industrial symbiosis (Ghisellini, Cialani and Ulgiati, 2016; Song *et al.*, 2018; Halonen and Seppänen, 2019) to increase the usage of urban services for achieving better efficiency. The parks are built as part of the natural systems while minimizing the environmental impacts and being cost-efficient. (Martín Gómez, Aguayo González and Marcos Bárcena, 2018) The circular economy concept in EIPs is based on intelligent sustainable manufacturing that promotes integrated management of material flows and substances, as well as energy and water resources these being linked with the needs of the manufactured products and processes (Martín Gómez, Aguayo González and Marcos Bárcena, 2018).

The goal of the industrial ecology is to create industrial systems that cycle all of the materials used by the industries and the release of minimum amounts of waste to the environment (Gibbs and Deutz, 2007). This is the basis for the eco-industrial parks.

Eco-industrial parks are developed from traditional industrial parks to address the issues seen in the environmental and economic level (Romero and Ruiz, 2014). The industrial ecology is seen as the framework for the circular economy (Ellen MacArthur Foundation, 2013a) and industrial symbiosis is tightly linked to circular economy. The industrial symbiosis engages the traditional individual firms to build competitive advantage by exchanging materials, energy, water and other by-products (Lowe, 1997; Chertow, 2000). The development of the exchange of these resources reduces the number of total resources used and waste generated, as well as it reduces labor intensity and energy consumption (Fiksel, 2003). These strategies are developed within industrial areas to create eco-industrial parks (Romero and Ruiz, 2014).

One of the most recent studies on EIPs (Halonen and Seppänen, 2019) states that the EIPs are still mostly at development stage, the real benefits generated in environmental and economic perspectives are not yet visible. They also estimate, that there are already hundreds of planned EIPs globally, even though operational ones can still be counted in tens. There are number of successful eco-industrial parks already operating, like Kalundborg in Denmark, Guitang in China, and Rhine-Neckar eco-industrial network (EIN) in Germany. Halonen and Seppänen also identifies the characteristics of EIPs. The real difference between traditional industrial park and EIP are the methods of production. EIPs are linked with industrial ecology and industrial symbiosis to circular economy, and they are not isolated from their surrounding environment, but they work in symbiosis as an open system, like natural environment. (Halonen and Seppänen, 2019)

The eco-industrial park is defined as early as 1997 as ”a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials. By working together, the community of businesses seeks a collective benefit that is greater than the sum of the individual benefits each company would realize if it optimized its performance only. The goal of an EIP is to improve the economic performance of the participating companies while minimizing their environmental impact. Components of this approach include the new or retrofitted design of park infrastructure and plants, pollution prevention, energy efficiency, and inter-company partnering. Through collaboration, this community of companies becomes an ’industrial ecosystem’.” (Lowe, 1997) By interacting with each other by the means of IE in EIPs, the firms can improve their environmental performance in a way that it increases their profits and advances their economic development (Gibbs and Deutz, 2007).

The exchange of waste materials as by-products within firms is not good as is if the reduction of the generated waste is more efficient (Lowe, 1997). This may be a challenge for firms using by-products as a resource for manufacturing their products.

The circular economy principles in eco-industrial parks will also face obstacles like interactions and relationships between the firms in the area, environmental impacts, lack of confidence, deficiencies in transmission and lack of reliability of information (Romero and Ruiz, 2014). Several challenges have been identified for implementing effective EIPs. These challenges may be technical, where exchange between side streams and materials is not possible; economic, where the exchange may be economically risky or unreasonable; informational, where the relevant information is lacking; organizational, where corporate structure does not support material exchange; or regulatory, where exchange between firms are not allowed (Heeres, Vermeulen and De Walle, 2004).

The industrial park areas management is responsible for facilitating the information flow and is in charge of activities like infrastructure maintenance, waste management and providing the basic services for the area (Lowe, 1997). These services include an information platform, where all EIP actors can share the qualitative and quantitative by-product information to others, and firms that use waste has the data available (Song *et al.*, 2018).

It is also important to point out that EIP's adopt sustainable principles more likely in practice if they are supported by governmental incentives (Bellantuono, Carbonara and Pontrandolfo, 2017).

2.3.3 Circular Economy Parks

The term ”circular economy park” is quite absent in academic research, which makes describing the characteristics of it a challenging job.

In a study by Han et al. (2018) the term is used for the biggest e-waste recycling park in northern China. The Ziya Circular Economy Park consists of over 150 firms, which focuses on recycling activities and can process more than 100 million tons of e-waste in a year. The park was established after the area became one of the most polluted places in China. The heavy metals from e-waste were absorbed into the soil from discarded products and the health issues were noticed. (Han *et al.*, 2018)

Although mostly absent in academic research, the characteristics of Tashan circular economy park are described in a study by Song et al. (2011). They see the circular economy parks as industrial parks that will achieve material and energy integration, information integration between firms and form metabolic relationships and symbiotic coupling relationship intra-industry. The waste in the area will become other's raw material and energy and all available material will be used. The term ”eco-industrial park” is also used to describe this kind of local industrial hubs as parallel to the circular economy park. The economic model used in the area of the industrial park is circular. The area implements low consumption of materials and energy, low emission rates and high production efficiency while offering high social and economic efficiency. The park has been designed using scientific development concept and technological innovations to deploy a circular economy, so it produces no waste. The resource utilization has been maximized, and while the economy grows, the environmental costs have decreased. (Song *et al.*, 2011)

These two studies offer similar characteristics for a circular economy park as the eco-industrial park has, and these two terms are used in parallel as well. So, between these two terms is safe to say that both mean the same type of industrial area. While the term "eco-industrial park" has been more popular among scholars in the scientific literature in recent years, we might see an increase of the use of the term circular economy park in forthcoming years.

2.3.4 Circular Economy Hubs

At the beginning of the study, it was concluded that the main focus of the thesis are circular economy hubs. The term "circular economy hub" has been widely used by practitioners in Finland (Jätelaitoisyhdistys ry, 2016; Business Tampere, 2017; Ympäristöhallinto, 2017; Pirkanmaan jätehuolto Oy, 2018), but the term is absent in literature. The literature focuses more on defining the characteristics of a "hub", which may refer to innovation hub, technology hub or entrepreneurship hub (Littlewood and Kiyumbu, 2018) or a business hub (Milmo, 2016). Kilkis (Kilkis, 2012) proposes a concept of net-zero energy cities, which in turn is a hub for decentralized energy distribution system between buildings in the cities. This, again, is based on the concept of the circular economy. The result is a low carbon dioxide system that creates energy, economic and environmental savings. In another article (Milmo, 2016) on an article about how ”EU sites aid move to circular economy", European chemical sites and clusters are taken under a scope. These clusters are preparing themselves into the era of low carbon future where materials and products are remanufactured, reused and recycled for giving them additional lifecycles. It is pointed out that European chemical sites and clusters are playing an important role in becoming hubs on the transition to the circular economy. These hubs are processing waste materials of the chemical industry into other chemicals and energy products. These sites are located in the northwest of Europe, where the majority of these sites and clusters are (Milmo, 2016). Otherwise, literature does not include topics on the circular economy hubs. (Kilkis, 2012)

2.4 Circular Economy Hubs in Finland

There are many reasons why the current circular economy hubs are developed in Finland in a way they are. The most advanced circular economy hubs in Finland currently are Topinpuisto circular economy hub, located in Turku, Southwest Finland, Ekomo at Ämmässuo, Espoo in Uusimaa region, and Kolmenkulma Eco-industrial park in Tampere, Pirkanmaa region. Then there are several other sites, which have started developing their circular economy hubs. Circular economy hubs in Finland are shown in figure 2 below.

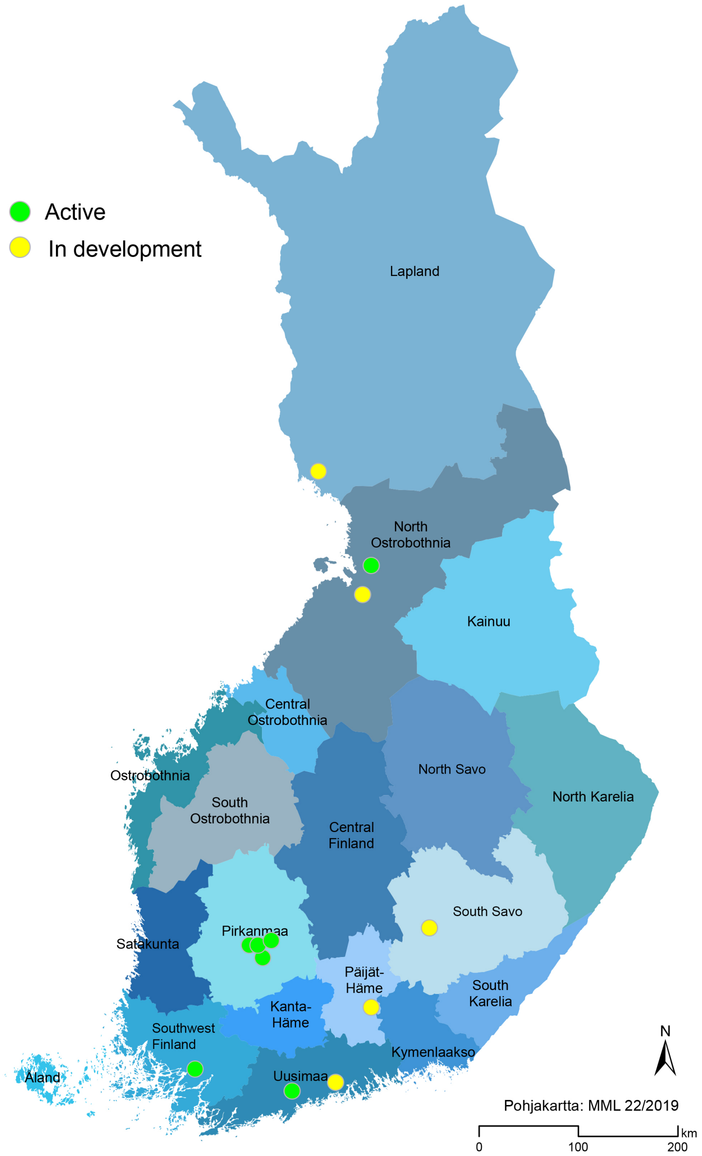


Figure 2. *Circular Economy Hubs in Finland.* (Regional Council of Southwest Finland, 2019)

Topinpuisto

Topinpuisto circular economy hub is managed by Lounais-Suomen Jätehuoltolaitos Oy (LSJH) and located in Southwest Finland region of Finland. LSJH describes Topinpuisto as a collaboration network that develops circular economy value chains (Lounais-Suomen Jätehuolto Oy, 2017a). Topinpuisto's goal is to develop a circular economy business in co-operation with Finnish and international actors in the circular economy field. The circular economy experts of the hub form network of professionals within the area that provides the piloting platform and assistance for companies and institutions for developing circular economy business models and expertise. The Kahmari visitor center in Topinpuisto enables different stakeholders to visit the site and learn about circular economy business, as well as connect with the network of experts and investors.

(Lounais-Suomen Jätehuolto Oy, 2017a) Currently, the Topinpuistos circular economy network has 18 firms and institutions.

Topinpuisto is being operated by LSJH, which's waste treatment services cover seventeen municipalities, including Aura, Kaarina, Kemiönsaari, Lieto, Marttila, Masku, Mynämäki, Naantali, Nousiainen, Paimio, Parainen, Pöytyä, Raisio, Rusko, Salo, Sauvo, and Turku. Their services collect the waste of 415 000 inhabitants, which totals almost 300 000 tons of community and industrial waste each year. (Lounais-Suomen Jätehuolto Oy, 2017b) The waste composes of over 60 different material streams (Lounais-Suomen Jätehuolto Oy, 2017a) and already over 98 % of community waste is recycled (Lounais-Suomen Jätehuolto Oy, 2017b). It is not a coincidence that Topinpuisto is located in Oriketo. As LSJH is operating the areas waste treatment services, there was a landfill site founded in the same area in 1971 (Nygård 2015 p.18), and it is been operating ever since. A few years later, in 1975, a new state-of-the-art waste incinerator was opened nearby (Nygård 2015 p.60). It was estimated that the landfill site would be full in the late 1980s and the expansion of residential area was restricted near the landfill site. As European Union's plans to reduce landfilling of waste, the waste treatment, and management services are developing their processes to recycle most of the collected waste, which has led to implementing circular economy business models in practice.

Ämmässuo, Ekomo

The Ekomo eco-industrial park in Ämmässuo, Espoo is managed by Helsinki Region Environmental Services Authority (HSY) and processes the waste of Helsinki metropolitan area. It is located in the Uusimaa region of Finland. HSY describes the area as a modern crossing of waste management and circular economy. Currently, the areas operators are processing organic waste into dirt and biogas as well as processing ashes and slag. The capacity of 60 000 tons of biowaste can be treated in the area. Ekomos biogas plant has been running since 2017, and it can process 44 000 tons of the collected biowaste. Landfill gas from the landfill site is collected and utilized. The landfill gas plant has been operating since 2010 and provides all the heat for Ekomo areas buildings and generates also electric energy for 15 MW's of power. The contaminated soil from the metropolitan area is treated and purified, as well as loads of waste are sorted and the materials forwarded to reuse. (HSY, 2018)

Ekomo is also been built on an old landfill site. The waste treatment center was established in 1987 as a landfill site for community waste. The landfill waste brought in has been declined since early 2000, while new ways of reusing discarded materials have been invented. (Karisto, 2017)

For businesses the Ekomo eco-industrial park offers basic high-quality infrastructure, telecommunications network and a road network. They also have required environmental permits, areal building plans, and different types of material side streams available for processing. This makes an opportunity for businesses to benefit from industrial symbiosis built between different firms within the area. Already, processing discarded asphalt and concrete has been turned into new business by local firms. HSY offers also possibilities for piloting new business opportunities in Ekomo. There are already pilots ongoing about processing horse manure and sawdust into biofuel and specific emissions measuring activity. HSY's own research and development is focused on developing possibilities for new circular economy businesses and business models that can be used in other regional areas as well. There are currently four related projects ongoing. (HSY, 2018)

Tampere

Pirkanmaa regions waste collection is managed by Tampere Regional Solid Waste Management Limited. It collects waste from 17 different municipalities: Hämeenkyrö, Ikaalinen, Juupajoki, Kangasala, Lempäälä, Mänttä-Vilppula, Nokia, Orivesi, Parkano, Pirkkala, Pälkäne, Ruovesi, Sastamala, Tampere, Vesilahti, Virrat, and Ylöjärvi. Within these municipalities lives 436 000 inhabitants. Two waste treatment facilities are located in the region. One in Koukkujärvi in Nokia, which was founded in 1962 and another in Tarastenjärvi in Tampere which was founded in 1977. These waste treatment facilities collected 683 000 tons of waste in 2017. 207 000 tons of waste was municipality waste and 301 000 tons were rock and soil. 97 % of the collected waste was reused as materials or energy. Less than 2 % of the waste, the ones that cannot be recycled at the moment, end up in the landfills. These are non-combustible insulation wools and tiles. (Pirkanmaan Solid Waste Management Limited, 2019)

In the Pirkanmaa region, are four separate areas with circular economy business activities. Kolmenkulma Eco-Industrial park that is divided between Nokia, Tampere, and Ylöjärvi, Lemene business district in Lempäälä, Taraste Circular Economy District in Kangasala as well as Hiedanranta city district in Tampere. (CircHubs, 2017)

Lemene is located in Marjamäki, Lempäälä. It is described as a self-sufficient business district that provides areas own gas, renewable energy and thermal energy for buildings and organizations. Lempäälän Energia is providing the energy infrastructure to the area through a smart grid with solar panels, biogas plant, and electrical storage batteries for a seamless flow of energy. (Invest in Finland, 2018) It also acts as an operator between the firms within the district (Lempäälän energia, 2018). Lempäälän Energia will provide 4 MW's of power of solar energy as well as biogas energy for the power of 8 MW's.

(Invest in Finland, 2018) The area is under development and will offer office spaces, future pitstop for fuel and electric vehicles, as well as its research and development department. The area is 30 hectares and includes 350 firms. As being energy self-sufficient, the area is built to be energy-efficient as well. The leftover energy from the building is used to heat and power the ones with the need for more, so that the energy is not lost in the process. (Lempäälän energia, 2018)

Kolmenkulma Eco-Industrial Park is located in three municipalities, Nokia, Tampere, and Ylöjärvi as shown in figure 3 below. The ECO3 business area is part of Kolmenkulma Eco Industrial Park and it is described as bio- and circular economy business area. Kolmenkulma Eco-Industrial Park is a joint project, a cleantech area that covers 850 hectares in total mainly for office and industrial use. The goal is to provide a network of firms within the area that collaborates through material and energy efficiency. Kolmenkulma has its city plan and detailed plans ready for new companies. Cleantech business zone has been deployed within the area as well as the energy project report. Renewable energy solutions are in a key role in Kolmenkulma. (Nokian kaupunki, 2019)

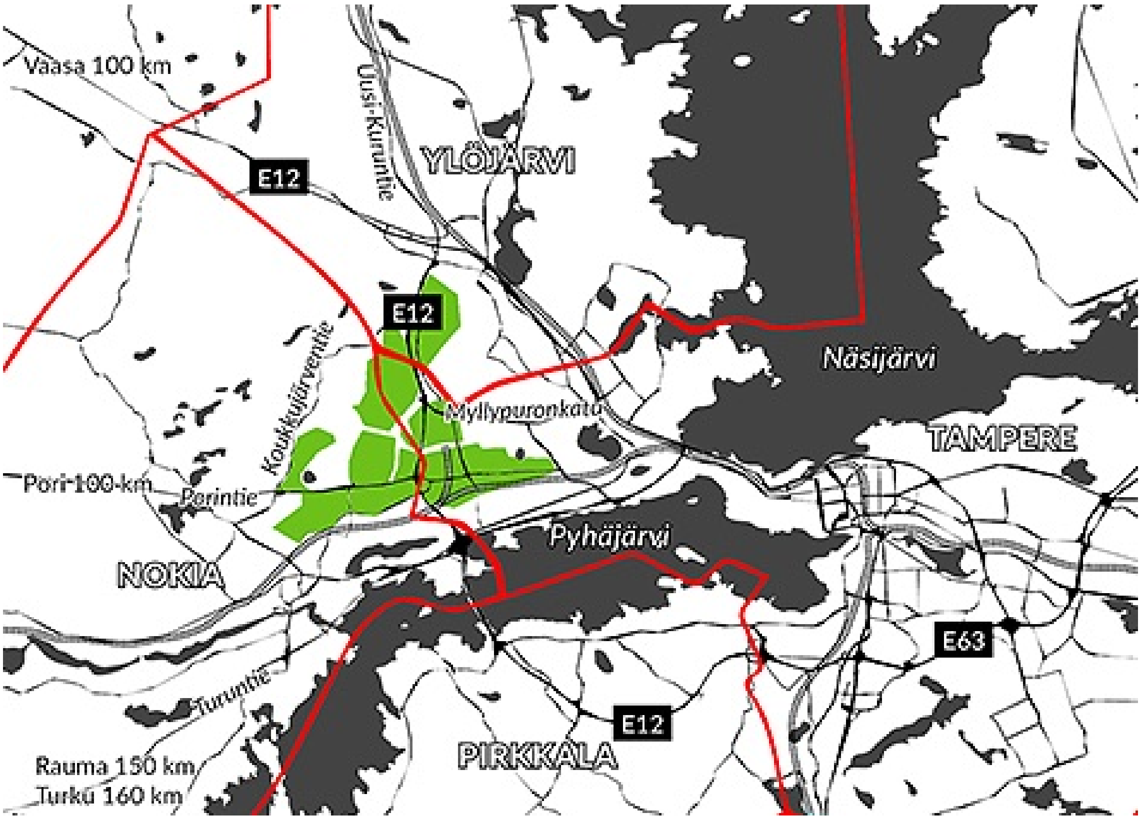


Figure 3. *The Kolmenkulma Eco-Industrial Park.* (Nokian kaupunki, 2019)

There is a piloting environment for testing new business models, technological innovations and new service models in Kolmenkulma Eco-Industrial Park. It is also possible to deploy a new type of innovations for the area after they are commercialized. There are possibilities to build industrial symbiosis between organizations to use "other firms waste as others resource" for making business. The shared electricity distribution network is on place, and smart grid energy systems have been deployed within the area and can be utilized. (Nokian kaupunki, 2019)

The ECO3 bio- and circular economy business area is located within the park, in Kyynijärvi, Nokia (ECO3, 2018). There are several processing facilities located in the area, processing plant for ashes, (Nokian kaupunki, 2019) pyrolysis plant for processing rubber and plastics to fuel and energy (Gaia Consulting Oy, 2017), rubber and plastic waste recycling plant, biogas plant, wastewater treatment plant and biomass terminal, which stores and chips wood for energy use. (ECO3, 2018) In ECO3 bio- and circular economy business area, the nutrient cycles, wood processing cycles, and technical cycles are in key roles. The nutrient cycles are formed from agricultural side streams, bio- and field masses, forest-based products, foodstuff products, and municipal slurries. The processed materials like CO2, fertilizers, milled bone flour, bio slug, ashes are then used again by local farms and plants as their resources for business. The cycles in wood processing at biomass terminal produces heat energy for the city of Nokia. For technical cycles, the separately collected waste, household waste, industrial, construction and agricultural side streams are collected and processed to secondary raw materials for industrial, agricultural and construction use. ECO3 is also using digitalization for boosting the technical cycles. There are currently 28 organizations collaborating at ECO3. (ECO3, 2018)

Taraste Circular Economy District is managed by Tarasten Kiertotalousalue Oy. It is located in Kangasala, Tampere, near Tarastenjärvi. Plans for creating the Taraste Circular Economy District was approved in 2017. The total area of the district is 150 hectares, and the area will be completed by 2028 (Oesch, 2018). It is described as a recycling park on the principles of sustainability and circular economy that focuses on the recycling of material side streams and bio-economy. Biofuels can be handled and stored within the area. Tarastenjärvi waste treatment plant is located next to the Taraste Circular Economy District and synergies will be built with Tampere Region Solid Waste Management Limited and Tammervoima Waste-to-Energy plant. (Kalliosaari, 2017) Side streams from construction activity will be processed and stored in the area. (Oesch, 2018) An industrial area, an office and business district, and a truck park will be built to Taraste to support circular economy business (CircHubs, 2017).

Hiedanranta is a city district located in Tampere, next to Näsijärvi. It is an old industrial area that had a sulfite cellulose factory from 1913 until 2008 (Tampereen kaupunki, 2019). Hiedanranta was bought by the city of Tampere in 2014 and will be converted to a residential and industrial area (Tanninen, 2015). There will be homes for 25 000 residents, as well as jobs for an estimated 10000 employees (Tampereen kaupunki, 2019). The city of Tampere is renting the buildings to communities and firms to develop sustainable urban culture (Tampereen kaupunki, 2017). Sustainability, circular economy, technological intelligence are the key areas on developing Hiedanranta towards negative carbon district that produce more resources than it uses. The collaboration is done between residents, firms, research institutions, and other organizations to achieve solutions that will make everyday life easier. There are already 19 projects ongoing within the area. Business opportunities are being researched for processing of zero fiber that was dumped into Näsijärvi by sulfite cellulose factory, as well into processing other high-volume side streams. Other projects include utilizing Mobility as a Service (MaaS) to bring more efficient mobility and transportation services for the residents of the area, ecological filtering of urban runoffs, advanced urine use as fertilizer and data gathering on long term effects of its use, use of urine nutrients on growing algae and the further processing of it. Biological cycles are piloted when phosphor and nitrogen are segregated in lavatories and collected for further use. Besides these, there are several circular economy related projects ongoing within Hiedanranta. (Tampereen kaupunki, 2019) There is also a pyrolysis plant that produces bio-coal from woodchips. The first residents will move to the area in the beginning of 2023. (Kiiski, 2018)

Oulu

In Oulu, located in North Ostrobothnia, the regional waste management service is Kiertokaari Oy. Kiertokaari operates the Rusko area waste treatment centre and landfill site. The waste treatment centre covers the area of 42 hectares. The waste collection covers 13 municipalities, including Hailuoto, Ii, Kempele, Kiiminki, Lumijoki, Oulu, Pudasjärvi, Raahe, Siikajoki, and Simo. Only 0,15 % of the collected waste ended up in the landfill site. Most of the waste was recycled or burned as energy. (Kiertokaari Oy, 2019)

Ruskonniitty in Oulu is managed by Kiertokaari Oy. There is an area for new firms to build and test their business and business models. Kiertokaari will provide them with piloting platforms and support in their circular economy activities. (CircHubs, 2017) A biogas plant is located in the area, and the gas is collected from Rusko landfill site. The goal is to advance the reduction of municipality waste, recycling, and utilizing the waste into secondary raw materials. Kiertokaari is part of the Finnish Industrial Symbiosis System (FISS) and encouraging effective utilization of waste and industrial side streams. Also, energy efficiency is developed and promoted as well. (Kiertokaari Oy, 2019)

There are other areas in Finland, where circular economy business models are planned to be deployed. These are in the city of Tyrnävä in North Ostrobothnia region (Reinikainen-Laine, 2017), circular economy and bio-economy hub in the city of Kemi in Lapland region (Helenius, 2018; Lapin liitto, 2018), Circular economy hub of Lahti in Päijät-Häme region (Lahden Ammattikorkeakoulu, 2017), in the city of Mikkeli in South Savo region (Mikkelin kaupunginhallitus, 2018), and in the city of Vantaa in Uusimaa region (Ympäristöhallinto, 2017). Several other cities are also thinking of establishing circular economy hubs, but there are no accepted plans available yet.

The characteristics and services provided by different circular economy industrial areas in Finland vary depending on the location and the environment where they have been established. The areas actor's operations are based on circular economy business models, and that they are seeking environmental, social and economic benefits. Besides specific recycling processes used in the areas, the infrastructure network usually provides renewable energy, or waste heat used to heat areas buildings. The visitor centres provide the possibility for stakeholders to familiarize themselves with areas services and the circular economy concept in practice, and piloting environments encourage the firms of the area to try out new business.

2.5 Material Flows for Circular Economy Business Opportunities

While understanding the business opportunities the side streams offer, it should be emphasized that few characters of material side stream flows are essential for these materials to be used in making of the business. These characteristics are the purity of the materials, the consistent quality of the materials, the steady availability of the materials, the number of materials available and locality of the resources. At the beginning of this study, there were several side streams identified that have these characteristics and therefore, the business potential identified.

These identified materials were textile waste, the parts of construction waste that could be reused, wood separated from construction waste, plastics from community waste, sludge from wastewaters, sludge from septic tanks, manure, PVC plastics, expanded polystyrene (EPS), electrical waste, zero fiber, ashes and slags from waste incineration, soil and rocks, biomasses, fiber clay slurry and oil-contaminated soil. Other materials were considered as well. These were earth metals, fiberglass boats, glass wool, furniture, banderols, park trees, motorcycle accessories, car recycling, and books.

At the beginning of this study, the 6Aika members, HSY, LSJH, Turku University of Applied Sciences, Business Tampere and Kiertokaari Oy compiled a report about how much of these side streams are collected annually. The report covers the regions of Uusimaa, Southwest Finland, Pirkanmaa and North Ostrobothnia. The included material side streams and each region studied in the report are shown in table 2.2 below.

Table 2.3 *Material side streams collected annually by regional waste treatment services.*

Material Side Stream	Uusimaa	Soutwest Finland	Pirkanmaa	North Ostro-bothnia	Total
Textile Waste	11 000	6 200	7 500	4 000	28 700
Construction	172 000	85 700	39 900	38 300	335 900
Wood	61 000	23 900	14 300	13 700	112 900
Plastics	30 000	13 800	20 800	20 000	84 600
Waste Water	87 000	47 600	27 200	36 000	197 800
Septic Tank	0	20 000	0	0	20 000
Manure	92 000	2 300 000	0	0	2 392 000
PVC	1 600	900	0	2 100	4 600
EPS	0	0	0	0	0
Electrical Waste	15 000	4 700	5 700	3 400	29 900
Ashes and Slags	71 000	0	35 000	24 000	130 000
Soil and Rocks	4 400 000	350 000	351 500	0	5 101 500
Biomasses	0	0	0	0	0
Fiber Clay Slurry	0	0	0	25 000	25 000
Oil-contaminated Soil	0	88 000	0	15 000	103 000

Separately collected waste, or material side streams that have recycling targets set for the year 2030 are waste paper and paperboards (95 %), bio and garden waste (95 %), glass waste (99 %), metal waste (98 %), plastic waste (95 %), textile waste (95 %), and other waste (99 %). From mixed waste, 99 % will be incinerated and rest landfilled. (Ympäristöministeriö, 2015)

Varsinais-Suomen Liitto has identified the following material flows to have business potential for increasing the extent of value-added in Southwest Finland area. These are manure, straw, other plant side streams, offal, ashes, construction, and demolition debris, the community's separately collected biowaste, and community's separately collected textile waste. (Varsinais-Suomen Liitto, 2017) The material flows have been chosen by the estimated amount of production; for products of a lower degree of processing more than 100 000 tons/year, and for products of a higher degree of processing more than 10 000 tons/year. There is real potential value identified in material side streams, which is higher than their current use. The synergies needed by the processing of the side streams are within the area. Also, the needed information about the side streams should be available, which is crucial in estimating the possible potential value. There are other potential side streams identified in Southwest Finland area as well, like the ones in the metal processing industry and pharmaceutical industry, but the lack of information on these sectors makes it difficult to study these side streams further. (Varsinais-Suomen Liitto, 2017)

Literature was reviewed to show any research done to reveal potential business opportunities for specific material side streams. The database the search was performed to was ScienceDirect and keywords used, were “recycling” and “reuse” followed the specific side stream. The key material side streams chosen were the ones with the business potential already identified and these were used in the survey, which was the basis for this thesis. The business opportunities for re-using and recycling waste material side streams were explored. Of course, there are other business opportunities on circular economy perspective in product design, manufacturing and production processes, but this thesis focuses on the re-use and recycling of material flows. There are two measurements to analyze the recycling of discarded products, these are recycling potential and recyclability. The recycling potential of discarded products is analyzed from the economical perspective where recycling profits exceeds the costs of waste collection, transportation and processing of the waste, even though it does not necessarily include the whole processing costs (Zeng and Li, 2016). The recyclability is a theoretical probability of material being recycled and indicates how easy or hard material is to recycle. Weight percentage is the standard measurement of recyclability, but it seems that it may lead to unreliable results. (Zeng *et al.*, 2017) Technological innovations are important in recycling processes (Ueda, Nishino and Oda, 2003) since recycling is labor-intensive and leads to higher costs. The transportation costs of recyclable material are also high, and technological innovations require investments, which are important to evaluate while studying re-use or recycling of materials. The economics of material side streams found from literature can be seen in tables 2.4 and 2.5 below.

Table 2.4 *List of literature on circular economy business opportunities on selected material flows.*

Material	Authors, Year	Research Type
Plastics		
	(Magnier, Mugge and Schoormans, 2019)	Consumer evaluation of ocean plastics.
	(Faraca, Martinez-Sanchez and Astrup, 2019)	Environmental life cycle cost assessment on hard plastics.
	(Milios et al., 2018)	Value chain market analysis.
E-waste		
	(Cucchiella et al., 2015)	Economic assessment of e-waste streams.
	(Dias, Bernardes and Huda, 2019)	Best practices and cost analysis of e-waste.
	(Kissling *et al.*, 2012)	Reuse operating models of electrical equipment.
	(Kissling *et al.*, 2013)	Success factors and barriers to reusing electrical equipment.
	(Zeng *et al.*, 2017)	Method for recycling potential of e-waste.
REE		
	(Jowitt *et al.*, 2018)	Recycling potential of REE.
	(Swain and Mishra, 2019)	Recovering REEs from secondary resources.
	(Fernandez, 2017)	REE market overview.
Construction waste		
	(Lai *et al.*, 2016)	Overview of management and recycling of construction waste in Taiwan.

***Table 2.5** List of literature on circular economy business opportunities on selected material flows.*

Material	Authors, Year	Research Type
Waste incineration by-products		
	(Silva *et al.*, 2017)	Review on using bottom ashes in several applications.
	(Yang *et al.*, 2018)	Recycling waste incineration by-products in China.
	(Silva *et al.*, 2019)	Environmental impacts of bottom ashes.
Ashes and sewage slags		
	(Esmeray and Atıs, 2019)	Brick production from recycled materials.
Sewage sludge		
	(Khwairakpam and Bhargava, 2009)	Recycling sewage sludge to fertilizers.
Manure		
	(Achat *et al.*, 2014)	Possibility of substituting commercial fertilizer with phosphorous from pig manure.
	(Leach *et al.*, 2015)	Benefits and risks of recycling manure as cow bedding.
	(Scarlat *et al.*, 2018)	Spatial analysis of biogas from manure.
	(Esteves *et al.*, 2019)	Review on manure biogas production.
PVC		
	(Sadat-Shojai and Bakhshandeh, 2011)	Recycling of PVC waste.
Textiles		
	(Hole and Hole, 2019)	Review on recycling textiles.
	(Leal Filho *et al.*, 2019)	Review of social-economic advantages in textile recycling.

Plastics: other plastics

Plastics are more complicated materials to recycle than many others, like glass and metals (Faraca, Martinez-Sanchez and Astrup, 2019). While plastics, in general, have a significant market value, the recycled plastic markets are fragmented and underdeveloped (Milios *et al.*, 2018). When discarded plastics are not collected and processed properly, they become a serious environmental hazard. Plastics have the potential to be recycled many times. In value chain market analysis of plastic recycling in Nordic countries, it was found out that low demand on recycled plastic products originates from price, low traceability of transactions in the value chain as well as design flaws in recyclability of plastic products. There is also low demand for recycled plastics from consumers. The quality of plastics needed in the manufacturing processes is set on contracts, therefore the proof of quality is on the re-processing, which again increases the price of recycling of plastics. (Milios *et al.*, 2018) Impurities in plastic waste may also decrease the desirability of recycled plastics in technological and economic perspectives. The lower quality in recycled plastics results in lower profits. (Faraca, Martinez-Sanchez and Astrup, 2019). There is a need for more effective ways to recycle plastic material side streams for municipal waste and technological innovations have a crucial role in it. The insufficient sorting capacity and lack of technological innovations currently reduce the recycling of plastic. (Milios *et al.*, 2018) In a study on Danish recycling of hard plastics, it was found out that recycling of plastics may be profitable if the quality of recycled plastic is high (Faraca, Martinez-Sanchez and Astrup, 2019). According to a study done on recycled ocean plastics, it was viable that consumers that are sustainability-conscious are willing to pay more on products made from ocean plastic, than others. The barriers that other consumers seem to have were concerns about recycled product quality and risk of contamination of the products, even though the probability of contamination risk is very low. (Magnier, Mugge and Schoormans, 2019)

Waste Electrical and Electronic Equipment

Waste Electrical and Electronic Equipment (WEEE) is one of the most increasing types of waste with an annual growth rate of 3 % - 5 % (Cucchiella *et al.*, 2015). WEEE is a source of highly valuable materials, but also hazardous ones (Zeng and Li, 2016; Dias, Bernardes and Huda, 2019). E-waste contains many different materials and metals, like copper, aluminum, iron, gold, silver, palladium, and indium (Zeng *et al.*, 2017). In a study on recycling of e-waste in developed countries, it was found out that domestically recycled discarded computers were the only products that had any significant value in them. In this case, no external subsidies were applied in the process. Another important find was that labor costs for dismantling and sorting the e-waste were over 90 % of the whole recycling process. That is why the first stage of recycling should be performed in countries where the cost of labor is low. (Dias, Bernardes and Huda, 2019) Maximum recycling is the preferred way to tackle the problems e-waste generates (Sun *et al.*, 2016). Recycle potential of e-waste is depending on existing condition, the toxicity of substances used, economic condition as well as the technical condition of the waste (Zeng *et al.*, 2017). In a study conducted by (Cucchiella *et al.*, 2015), on the economic assessment of e-waste, potential revenues for different electrical products are ranked. These include CRT monitors, Smartphones, LCD monitors, Cell phones, LCD notebooks, HDD drives, CRT TVs, LCD TVs, Tablets, LED TVs, SSD drives and PV panels. The study also estimates potential revenues these products generate in the future. (Cucchiella *et* *al.*, 2015) Apart from using specific materials extracted from WEEE, re-using the products are also crucial in reducing environmental impact and in material efficiency. In a study exploring success factors and barriers of re-using electrical equipment (Kissling *et al.*, 2013) it was concluded that factors emphasizing electrical equipment re-use are the quality and process quality of electronic products. Similarly, most intense barriers were insufficient quality and lack of access to sufficient amounts of used products. Also, the need for legislation to support and incentivize re-using electronic products was seen currently as a barrier. (Kissling *et al.*, 2013) In a previous study on re-use operation models of electrical products, Kissling points out that electrical products have more economic advantages when re-used, compared to direct recycling of the WEEE materials. According to the study, re-use organizations are part of the closed-loop life cycle and value chain. Re-using requires some level of sorting and disassembly operations that add value to the products, like remanufacturing defective units, and forwarding the defective parts and units to recycling and disposal. (Kissling *et al.*, 2012)

Rare Earth Elements

Rare earth elements (REE), or rare earth metals (REM), are usually used in small quantities in many different technologies (Jowitt *et al.*, 2018; Swain and Mishra, 2019). These metals are Scandium (Sc), Yttrium (Y), Lanthanum (La), Cerium (Ce), Praseodymium (Pr), Neodymium (Nd), Promethium (Pm), Samarium (Sm), Europium (Eu), Gadolinium (Gd), Terbium (Tb), Dysprosium (Dy), Holmium (Ho), Erbium (Er), Thulium (Tm), Ytterbium (Yb) and Lutetium (Lu) and labeled as strategic minerals, because of their significance for economy (Fernandez, 2017) . In a study on recycling potential of REE, the many sides of REE recycling were discovered. Even though rare earth elements are the most crucial to modern society and technology, currently only 1 % is recycled from end-of-life products. Because of the significantly low amount of recycled REE available on markets, it is hard to say, how recycled materials would affect the market pricing of these materials. There's currently a balance problem in REE markets, since Lanthanum and Cerium are overproduced, and Neodymium and Dysprosium are undersupplied. Currently, REE demand is steadily increasing. Recycling these materials could tackle the problem with undersupplied REE's. The difficulties in REE recycling is that there is usually very small quantities of REE used in products. The use varies between milligrams to grams and used in very complex products, where it is difficult to separate the REE from the rest of the materials. It is estimated that if lamps, magnets, phosphors, nickel-metal-hydrides are recycled for REE, they might yield for 5633 tons to 10683 tons of REE in 2020. There is a significant potential laying in the recycling of REE, but new processes and research is still needed for recycling being effective. (Jowitt *et al.*, 2018). In a study on recovering REEs from secondary resources, several methods of extraction were examined. After pre-processing of WEEE for REEs it was found out that the solvent extraction method was currently the only economically viable method (Swain and Mishra, 2019).

Construction waste

According to a study about construction waste management and recycling in Taiwan, most of the construction waste can be recycled or reused. Materials that can be used for recycling include concrete parts, bricks, tiles, steel, plastics, rubber, wood, glass, and asphalt. Materials that can be reused include mud, clay, soil, sand, and gravel. Mainly, waste wood could be utilized for composting or fuel, metals could be recycled and reused. Soil materials could be utilized in road building. The recycled material as roadbed aggregates had the highest economic value. (Lai *et al.*, 2016) The literature related to business opportunities in recycling or reusing construction waste is very low in numbers, and therefore a broader view was hard to establish.

Slags and ashes from waste incineration

As the EU pushes legislation to reduce landfilled waste to 10 % in 2030, the importance of waste incineration cannot be dismissed. Many dangerous particles are developed in the incineration process. These are sulfur chlorides, fluorine, PCBs and heavy decomposable organic materials and heavy metals. The major by-products of waste incineration are slags and ashes, which are solid residues. (Blahuskova, Vlcek and Jancar, 2019) These include fly ash and municipal solid waste bottom ash (MIBA). Ashes from waste incineration can be used in types of cement and in road building as an aggregate substitute, as well as in ceramic products. In an economic perspective, bottom ashes have the potential to replace natural resources, since in usual cases, the ash producer does not charge from the by-product. (Silva *et al.*, 2019) MIBA is seen as valuable material, but more research from an economic standpoint is needed (Silva *et al.*, 2017). Fly ash carries up with smoke from waste incineration through plants smoke stack and is not burned in the process. It can be used in brick manufacturing to improve the properties of the bricks when mixed at certain ratios with clay. This also reduces the costs of brick manufacturing. (Esmeray and Atıs, 2019) In a study conducted about recycling waste incineration by-products in China, it was estimated that fly and bottom ashes could save a significant amount of materials in concrete production, and therefore reduce carbon dioxide emissions, as well as bring economic befits in concrete and cement manufacturing (Yang *et al.*, 2018). Even though there seem to be many studies done on slag and ashes of waste incineration, they usually focus on used applications, technological and environmental aspects of these materials. More studies of the economic benefits are needed to get a proper picture of the business potential of these side streams.

Sludge from sewage treatment plants

Sewage sludge is semi-solid material from industrial and municipal wastewaters. It has been used as a material substitute in brick manufacturing, even though it has been concluded that it makes the brick more fragile. Therefore, it is recommended to use it currently in construction sector products. (Esmeray and Atıs, 2019) Processed sewage sludge can also be used as an effective fertilizer, by using vermicomposting process, where specific earthworm species are used to compost the material. (Khwairakpam and Bhargava, 2009) More research on sewage sludge recycling and use is needed. (Esmeray and Atıs, 2019)

Manure

Manure, as a livestock residue, can be used in biogas production to produce energy and to produce fertilizers. (Esteves *et al.*, 2019) Biogas production has huge potential. It can substitute fuels for heating, power, and transportation. (Scarlat *et al.*, 2018) The phosphorus from manure can be utilized as an effective fertilizer, to substitute the natural resource of using phosphate rock deposits. (Achat *et al.*, 2014) Then again, solid parts from manure can be used also as cow bedding in farms, at least on dry climate, but the health risks of this type of cow bedding need more evaluation. The economic calculation must be done at the farm level, to get proper costs of equipment, farm running costs and bedding materials for a specific location. It is possible to gain economic benefits of using manure solids as cow bedding on farms. (Leach *et al.*, 2015) Most of the academic research on manure recycling is related to manure treatment processes and much less on an economic perspective. More studies are needed to conclude the economically beneficial ways of manure recycling.

Plastics: PVC

Polyvinyl chloride, or PVC, is one of the most used thermoplastic materials in the world. Due to the recent increase in consumption, PVC materials are also increased in waste streams. By conducting scientific research as well as research done in firms, new ways of using recycled PVC has been found. Recycled PVC can be turned into plastic pipes and fittings, as well as into other products. It can replace also virgin PVC materials since recycling does not affect in profile properties. Only a small amount of PVC is currently recycled, even though the amount has been increasing for several years and it is the largest single polymer currently recycled. PVC is suitable for mechanical and chemical recycling, as well as energy-recovery technologies can be used on it. The costs of different recycling methods vary, as energy-recovery being the cheapest, mechanical recycling being middle-cost, and chemical recycling the high-cost processes. (Sadat-Shojai and Bakhshandeh, 2011) On a study on recycling PVC (Sadat-Shojai and Bakhshandeh, 2011), it is found that energy-recovery as waste-incineration of PVC is not economical since it needs an optimal combustion environment in high temperatures. Mechanical recycling is preferred when plastic waste is homogenous enough, and sufficient quantities are available. It includes mechanical separation, feeding and grinding of the plastic waste in recycling equipment, and does not change the chemical construction of the material. Even though mechanical recycling of PVC is economically viable, the factors that determine the true costs of the secondary material are available quantity of PVC, the quality of the waste, and sorting and generation processes. Using chemicals for PVC recycling will help to get cleaner secondary materials by chemical treatment. These processes break up the polymers in PVC, which can be used instead of coke in steel manufacturing. Currently, there are only a few plants that use chemical recycling processes, since these processes are more expensive than mechanical recycling. The study concludes that further development of waste separation methods in PVC recycling will lead to more economically viable recycling processes. (Sadat-Shojai and Bakhshandeh, 2011) Again, the lack of more detailed economic studies of PVC material flows processed for recycled secondary materials is evident. The literature focuses mainly on life-cycle-assessment, environmental impacts and mechanical or chemical processing of PVC, rather than an evaluation of economic viability.

Textile

Currently, the textile industry has very low recycling rate, even though the industry value has been estimated as a $3 trillion each year. In Europe, the textile recycling rate is about 25 % and in the United States 16,2 %. Total of 73% of textile products ends up in landfills. It seems that there have been recently several examples of bringing textiles into markets that have been manufactured from recycled materials. The consumers, on the other hand, have low demand for recycled textiles. They are more concerned about the brand, and the care instructions. The advantage is that consumers do not care if the clothing is made from recycled materials (Hole and Hole, 2019), so using recycled materials may bring economic benefits for the textile industry. In many cases, recycling materials like glass, metal, paper, and plastic have governmental policies controlling them, which encourages recycling of these materials. On clothing, there isn’t, which leaves the responsibility of textile recycling on consumers and firms. (Hole and Hole, 2019) In a study about socio-economic advantages of textile recycling (Leal Filho *et al.*, 2019) it is pointed out that textile recycling brings economic benefits, and boosts the nation's economy. As waste recycling brings jobs in waste collection, sorting, transportation and recycling, which mostly benefits small businesses. Through textile recycling, it is possible to enhance material efficiency in textile production. Recycled clothing can be used in many different products by the automotive industry, furniture industry, sailing industry and by insulation industry. Some of the waste generated in spinning and weaving can be used for fiber recovery and forwarded back in the manufacturing processes adding value. (Leal Filho *et al.*, 2019) Since there is uncertainty at some textile markets, there is a need for adding fiber-to-fiber recycling into textile production. In this study, the statistics are given by The Waste and Resources Action Programme (WRAP) in England is cited. Their estimates are that UK markets top recycled materials in value are insulation, automotive felt, cloths made from cotton, which are used for cleaning purposes, flocking fabrics, which are used as stuffing in furniture and mattresses, and fiber to fiber and chemical recycling divided into two categories of Polyamides and Polyesters. (Leal Filho *et al.*, 2019)

In the case of every material side stream studied here, the trend in literature was similar. Most of the research was focused on environmental impacts of the specific side steams or recycling processes, mechanical and chemical processing of the waste to extract the materials for further use. Also, the focus regarding the circular economy was mainly on recycling materials, rather than re-using them. Economics or business potential of the side streams are not studied extensively in scientific research. Similarly, there were few if any theoretical frameworks on circular economy activities regarding waste or materials from an economic perspective.

3. METHODS AND DATA

In this chapter, the research strategy of this study is examined in more detail. At first, the research design and methods are reviewed, with justification for using questionnaire research methods on this type of research. The survey question operational chart follows, and then research tactics in a form of data collection and analysis are reviewed. In the end, the collected data and process to analyze it are gone through, with examples of survey questions and data shown.

3.1 Quantitative survey

There was already a significant amount of background information within CITER -team on the economic aspects of the circular economy, and the 6Aika project team had years of experience of material side streams collected in different municipalities in Finland by waste management companies. The research team wanted to understand the positioning of several key characteristics of circular economy hubs and material flows in Finland and therefore, the quantitative research strategy was chosen for this study. Quantitative research usually focuses on gathering numerical data through surveys or questionnaires (Creswell, 2003). As this research is looking to answer the following research questions:

- How should circular economy hubs be developed so they would support the value creation of the businesses?
- How specific material flows are defined as having the potential for creating new business opportunities?

By answering these research questions, the evaluative study provides numerical information on the material flows in Finland and how important they are seen from a business perspective, what challenges there is in these materials for creating the business, as well as the opportunities that these materials provide. To process these materials effectively in economic, environmental and social perspectives, it is important to understand the development needs of the circular economy hubs so that the environment of these hubs would support the circular economy operations in the firms.

This study takes into account only the material side streams included in the survey conducted within the “6Aika Tulevaisuuden kiertotalouskeskukset” -project. Although it is important to list the other identified side streams, as done in chapter 2.5, to get the complete understanding of the side streams available in Finland, even though they are excluded from the final results.

At the early stages of the research, it was determined that the online survey questionnaire method will be used. According to Bryman and Bell (2015), this approach gives a few advantages for the researcher. These are cheaper and quicker to administer, there are no interviewer effects to provide a bias in replies, neither there is interviewer variability from different interviewers asking questions differently. There is also the convenience for the responder to answer any time they prefer, as well as take the time they need to complete the survey. (Bryman and Bell, 2015) These advantages of survey questionnaire supported the targets of the research. The idea was to collect data on how the respondents rate the different side streams from the business potential perspective. Also, the rating of different characteristics of the circular economy hubs would provide important information on how they should be developed in the future. As the 6Aika and CITER teams already had empirical observations and measures to be used to gather objective data from respondents, which made the quantitative survey questionnaire perfect method for the research (Creswell, 2003). By using questionnaire, it was easier to reach out to as many respondents as possible and give the possibility of repeating the survey, later, to check, if there is more variation in responses during a different point of time. This study focuses only on the survey conducted during September and October of 2017. The quantitative survey questions are supported by the few qualitative open-ended questions, to gather a better understanding of the options that might have been missed from the questions while designing the survey. The approach used in this study may be referred to also as a mixed-methods approach, or sequential explanatory mixed-methods approach, but as the analyzing of the survey results is based on quantitative method, the data will be quantified to better suit the purpose of the research (Saunders, Lewis and Thornhill, 2016).

The quantitative research strategy is based on positivism or interpretivist philosophies, although it may be used with a twist from realist or pragmatist philosophies. In most cases quantitative research is deductive, meaning that the data acquired will be used to test a theory. It may also be inductive, where the data is used to build a new theory. (Saunders, Lewis and Thornhill, 2016) In this study, the research is deductive, since the theories are already there and this study is acquiring information to rank the characteristics of circular economy hubs, as well as the pre-defined material side streams to rank them by the most potential for business opportunities. These are then compared to other characteristics of creating business potential from recycled materials to establish a broader view of the subject. The surveys are also good for establishing relationships between variables (Saunders, Lewis and Thornhill, 2016), but as in this study that is not the case, since it relies on ranking the data and comparing it to the theory and frameworks reviewed in chapter 2. Quantitative research supports also the statistical analyzing of the data (Saunders, Lewis and Thornhill, 2016) which suits its use in this research well.

There are also a few disadvantages in questionnaire research design that the researcher needs to be aware of, to assess them properly. In the sent online questionnaire the interviewer cannot help the respondent in case of any obscurity in answering the questions, there is no possibility for probing clarification in open-ended questions, there is a possibility that respondents become tired of questions that as not salient to them and will not complete the survey. Open-ended questions should be limited to few and easy to answer, otherwise, there is a risk of survey not being completed. Bryman and Bells (2015) recommendation is that the respondents cannot read the survey as a whole before answering. This may lead to some questions not being answered, and questions are answered in a different order than the researcher's intention is. In questionnaires, the researcher does not know who the respondent is. The real respondent may be an individual, who is not part of the intended population group of the respondents. Additional data cannot be obtained in questionnaires, a lot of questions cannot be asked, because the respondent may get bored and not complete the survey. The risk for missing data is higher in questionnaires, as well as the lower response rate. The classification for response rates in postal questionnaires are set to following: excellent is over 85 % response rate, good 70-85 %, acceptable 60-70 %, barely acceptable 50-60 % and not acceptable is below 50 % response rate. (Bryman and Bell, 2015). On online questionnaires, it is estimated that response rates are 11 % lower than average (Bryman and Bell, 2015). Although lower response rates are allowed and accepted, the lower response rate should be taken into account when determining the response bias (Creswell, 2003; Saunders, Lewis and Thornhill, 2016).

Quantitative questions questionnaire

The original idea of the survey was to target individuals in the area of 6Aika-cities, those being Helsinki, Vantaa, Espoo, Turku, Tampere, and Oulu. This changed during the rollout of the survey since Business Tampere had their target group collected from individuals all over the country, and they forwarded the survey to all their undisclosed contacts. Similarly, Business Tampere, Finnish Environment Institute, Turku Chamber of Commerce and Oulu Chamber of Commerce forwarded the questionnaire to their undisclosed number of contacts. CITER research team of the Tampere University of Technology gathered a list of proper respondents, which consistent total of 995 individuals. The population size couldn't be determined precisely but thought to be approximately 2500 individuals. All of the target population had few characteristics that were essential for replying to the survey. They worked in the fields of company leadership, business management and environmental expertise in public or private sectors in Finland. The reason for choosing this kind of target group was the assumption that these individuals either are familiar with the firms manufacturing processes, the side streams and waste streams, the development of local region towards circular economic goals or otherwise know the common areas related to principles of the circular economy. The answers given by the chosen population would be the best possible available.

The data collection instrument used was Webropol survey and analysis tool version 2.0. It had features to automatically calculate the exact number of respondents, who completed the survey, which was 183.

There was one fault discovered in answers on questions that used semantic differential-type scaling. Although the scale ranged from 1 to 5, the Webropol tool used scaling of 1-7, leaving the real answers ranging from 2-6. This was because of the tool included the agree/disagree phrases to the scale. The same error was not noticed on multiple choice-scaling. This flaw had to be taken into account when analyzing the data, therefore Excel was the best solution to do it, to offer many ways to handle the data. The questionnaire consisted of 34 questions, the first seven questions probing the background information of the respondent. The questions 8th to 19th were focusing on manufacturing organizations current use of material side streams and how they plan to manage the side streams in the future. The questions 20th to 26th were focusing on material side streams in general, the development needs of circular economy hubs, and included two questions about the development of national online market place for material side streams. The questions 27th to 34th was respondents organizational background and willingness to provide specific information about themselves. The final version of the questionnaire included 10 semantic differential scale questions, with 3 of these having open-end text box to include a choice for answering the CITER team had not concluded in pre-assigned answers, 17 multiple choice questions, 4 open-ended questions, 2 binary questions and 1 question for contact information.

The survey was completed by the September of 2017 and piloting of the questionnaire was conducted within 6Aika team participants on 7th of September. On 8th of September face-to-face interview was conducted with Heikki Jousi from Hj Jousi Oy. This was done to assess the probable issues participants may have while answering to questions, and to receive as detailed and useful data as possible. Based on the piloting feedback, some of the wording of the survey questions were modified to be more understandable, and two of the questions were converted as multiple-choice questions, instead of using a Likert scale. The questionnaire was ready to be sent out on 28th of September 2017. The survey included a cover letter that told the respondents the details of the questionnaire, time to respond, the details of the usage of the data gathered and who is responsible for the survey and research as well as the institutions that fund the project. On first phase, on the 28th of September 714 respondents received dedicated personal email and response link to the questionnaire through Webropol tool. Business Tampere sent a general link for the survey, including cover letter via e-mail to their approximately 1500 contacts on 29th of September. At the same day, Oulu Chamber of Commerce sent out the general link and cover letter via e-mail to 40 respondents, as did the Finnish Environment Institute to their undisclosed list of contacts. On 2nd of October Turku Chamber of Commerce sent out the general link for the questionnaire and cover letter via e-mail to an undisclosed list of recipients. On the second phase, by 9th of October, Webropol online survey and analyzing tool had collected 80 responses. On the same day, a reminder was sent out via Webropol to 675 respondents of the original 714 respondents, which had not yet completed the questionnaire. This was done to ensure a high response rate as possible. Also, 281 more individuals were added to the recipient's list on the same day on Webropol tool, making a total of 995 respondents in the tool, with the dedicated link for the questionnaire. Also, the Finnish Environment Institute and Business Tampere sent out reminders via e-mail. On the third phase by 12th of October, 152 replies were collected. The third and last reminder was sent out. By the 17th of October, a total of 183 replies had been collected from approximately 2600 respondents. The total response rate was 7,04 %.

In table 3.1 below is the operationalization chart of the survey questions linked to specific research questions. The table shows the questions from the survey included in this research.

Table 3.1. *Operationalization chart of the survey questions.*

Research Question	Item on survey
-	4. What is your organizations relationship with circular economy hubs? 32. What is your job description in your organization?
How specific material flows are defined as having the potential for creating new business opportunities?	5. How important do you see the following side streams for creating a business? 6. To what extent do you see the following challenges hindering the use of recycled materials in products? 7. How do you see the following factors contributing to the transition towards circular economy business?
How should circular economy hubs be developed to support the value creation of the businesses?	24. What do you think is the role of following circular economy hubs' tasks in support of business? 25. How important is the development of the following areas in circular economy hubs?

Questions 4 and 32 are providing the background information of the respondents. They were constructed with multiple choice-type of scaling for pre-defined options. The Webropol analyzing tool provided the results for these questions in a numerical format as the number of replies for each option. These were later transformed into percent of replies each option received of the overall number of respondents. Questions 5, 6, 7, 24 and 25 are directly linked to providing data for the research questions. Questions 5, 6 and 7 to "How specific material flows are defined as having the potential for creating new business opportunities?" and questions 24 and 25 for "How should circular economy hubs be developed so they would support the value-creating of the businesses?". Each of these five questions represent semantic differential-type of scaling. They included predefined options and scaling each option from 1 to 5. Each number on scale received coding of the exact number set on a scale. As there were flaws in how Webropol analyzed the data on semantic differential-type questions, the data were exported as a Microsoft Excel sheet and analyzed in Excel. In semantic differential-type questions, the results were converted into an average. In some questions (5, 25, 32) open-ended answer options were used. In these cases, the qualitative answers were looked through and, if possible, merged into pre-defined answer results. If this couldn't be done, they were grouped to resemble a response of missing option and analyzed using quantitative methods as in other quantitative questions.

Usually, in quantitative research, the independent and dependent variables are defined. In this study, there were no independent variables. The questionnaire results are not analyzed towards independent variables like age, meaning that how respondents in specific age groups answer to different questions. In this study, the results are ranked from the top-scoring answer option to lowest scoring option. Variables assigned for circular economy hub related research question were: Importance of tasks of circular economy hubs and development of tasks in circular economy hubs. These were both dependent variables. Then the dependent variables for understanding the business opportunities of material flows were the importance of specific side streams, the challenges hindering the use of recycled materials and factors contributing to the transition towards circular economy business. These variables are analyzed in the results chapter.

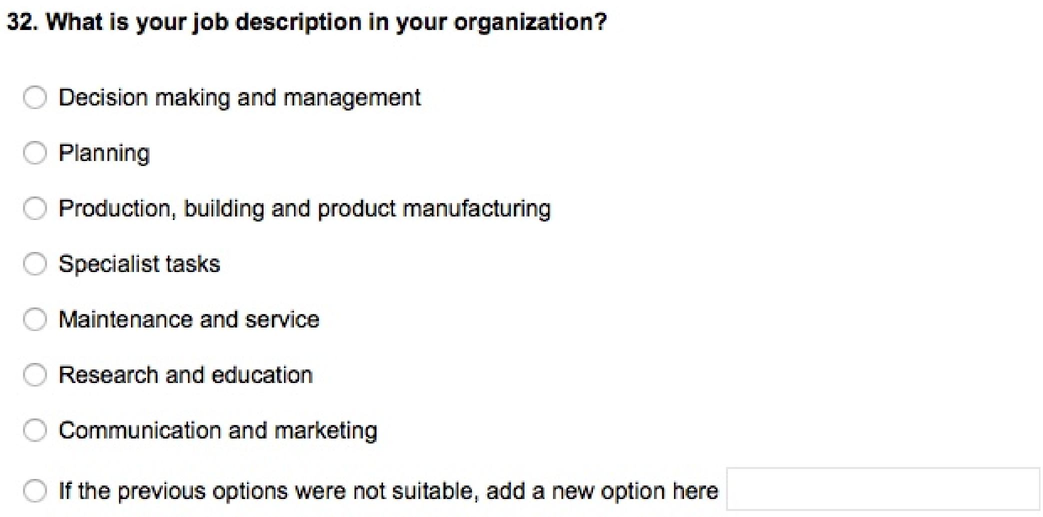
3.2 Description of data

As pointed out in chapter 3.1, there were 183 respondents in the questionnaire. The responses between questions (see table 3.1) varied a bit, since all of the questions studied in this research, were not mandatory. The number of responses between questions varied between 179 and 183 respectively. As the target group was being selected as respondents in the fields of company leadership, business management, and environmental experts, in both, public and private sectors nationwide in Finland, we can see from the question 32 in table 3.2 that respondents who responded to the survey, were considered as being the target group defined at the beginning of the study. Total of 92,3 % of respondents worked in the fields of specialists, managers or research and education, and only 2,7 % worked on the previously undefined areas.

Table 3.2. *Example of survey background data from multiple choice survey question.*

32. What is your job description in your organization?	Percentage (%)
Specialist tasks	47,5
Decision making and management	36,6
Research and education	8,2
Other	2,7
Planning	2,2
Production, building and product manufacturing	1,6
Maintenance and service	0,5
Communication and marketing	0,5

As in an example question 32 in table 3.2, the data was obtained through Webropol Survey and Analysis Tool 2.0. In the questions, a multiple-choice method was used, with one open-ended answer option, where the respondent could type in the proper choice to answer if not suitable answer was found, see figure 4. The multiple-choice questions used both, single, and multiple-choice answer option. The coding of the options was defined starting from number 1 and ending to last option, in this example to number 8.



32. What is your job description in your organization?

- Decision making and management
- Planning
- Production, building and product manufacturing
- Specialist tasks
- Maintenance and service
- Research and education
- Communication and marketing
- If the previous options were not suitable, add a new option here

Figure 4. *Example of multiple-choice survey question with open-ended option.*

The data was then exported to Microsoft Excel format and analyzed in Excel. The percentage was calculated so that the open-ended answers, were investigated in more detail. In question 32 there were 12 answers on the open-ended option of number 8. These were “HSE”, “Sales”, “Stakeholder tasks + other”, “Support tasks of production”, “Student”, “Customer service”, “Strategy and development”, “Customer service”, “All of the above”, “One-man company, specialist, management, communications, marketing, planning”, “Hardware sales consulting” and “Specialist”. These were then categorized under specific pre-defined answer option if possible. The answers “Strategy and development”, “All of the above” and “One-man company, specialist, management, communications, marketing, planning” were categorized under “Decision making and management”, since all of them are related to company management. The answer “Support tasks of production” were categorized under “Production, building and product manufacturing”, since it is closely related to production. The answers “HSE”, “Specialist” and “Specialist”, were categorized under option “Specialist tasks”, since, they are all specialist job tasks. Other 5 answers that couldn’t be categorized under any pre-defined options and were categorized under “Other”. The question had 183 answers in total, which means that all respondents responded to the question. The percentage of each category were then calculated using the number of respondents in this specific question. The results are visible in table 3.2.

The example of a semantic-differential-scale question is shown in figure 5 below. The question is number 7, which gathers the data on the factors contributing to the transition towards circular economy business.

7. How do you see the following factors contributing to the transition towards circular economy business?

	Not at all	1	2	3	4	5	Very much
Business consolidation (protection against fluctuations in natural resource prices)		○	○	○	○	○	
Implementing cost savings in the firm's operations		○	○	○	○	○	
Creating new business opportunities		○	○	○	○	○	
Implementing resource efficiency (more thorough use of existing resources)		○	○	○	○	○	
The firm's strategic goals support the principles of the circular economy		○	○	○	○	○	
Implementing resource efficiency (more thorough use of existing resources)		○	○	○	○	○	
Customers want products manufactured according to sustainable development principles		○	○	○	○	○	
Current employees require sustainable business from employer		○	○	○	○	○	
Competitors invest in sustainable development, and the firm must keep up with the competition		○	○	○	○	○	
The expectations of laws and regulations or policies to change the firm's business practices		○	○	○	○	○	
Low availability of materials needed for current production		○	○	○	○	○	
Stricter requirements from other actors in the value chain		○	○	○	○	○	
Owners' requirements for increasing a wider value (other than profits from the business)		○	○	○	○	○	
Customers willing to pay more for a product based on sustainable development		○	○	○	○	○	
Maintaining the business license requires it		○	○	○	○	○	

Figure 5. Example *of semantic differential-type survey question.*

For the respondents, a scale from 1 to 5 was visible, and respondent could rate each of the factors on each row on the scale of 1 to 5. The data Webropol collected was then again exported as Microsoft Excel -format and analyzed in Excel. There were 178 responses on question 7. On figure 6 below, the semantic differential-scale survey question data is shown.

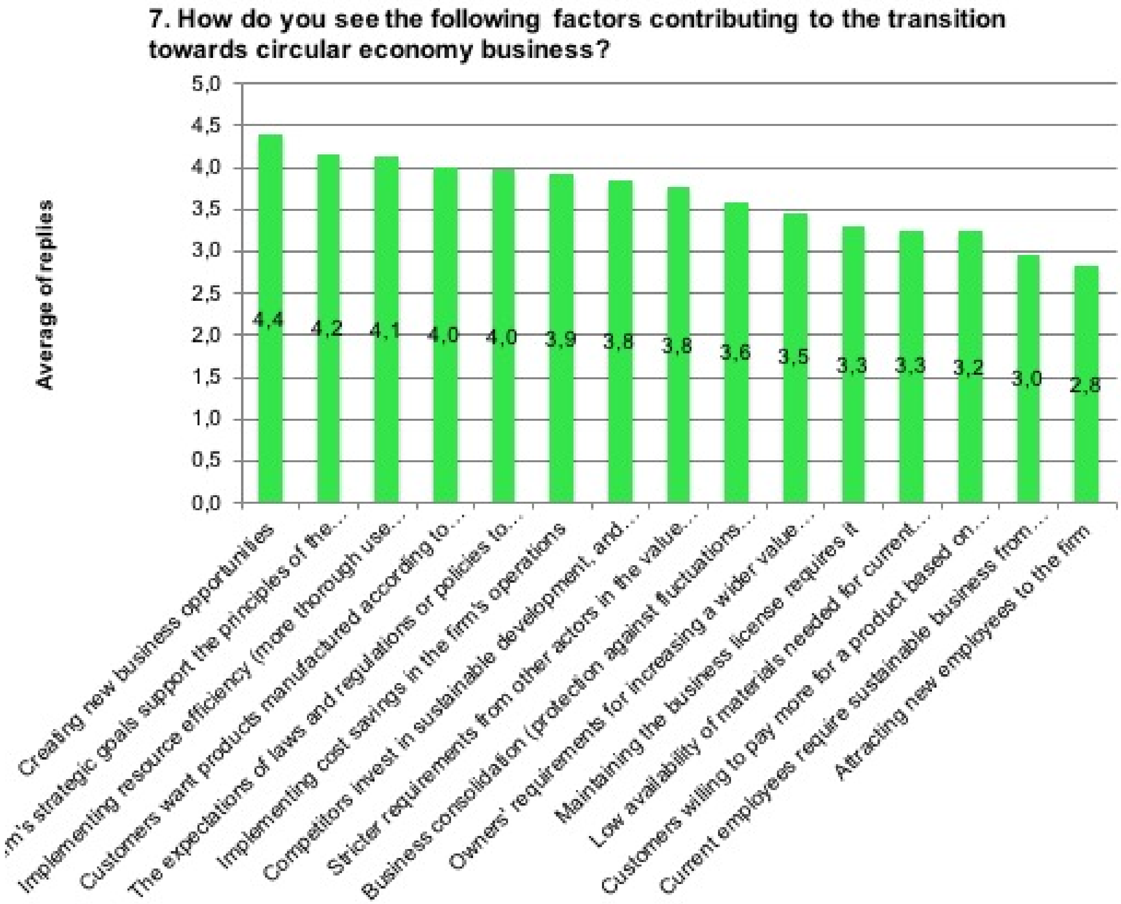


Figure 6. *Example of data from semantic differential-scale survey question.*

When analyzed on Excel, the problems on Webropol survey tool were taken into account. As coding of the answer options in Webropol varied in a scale of 2 to 6, in Excel, the coding was modified as the following: 2 was 1, 3 was 2, 4 was 3, 5 was 4, 6 was 5. Then the average of each option was calculated for each factor. This way, the difference between responses was clearer. On table 3.3 below, the coding on Webropol, the modified coding on Excel on the factor "Business consolidation (protection against fluctuations in natural resource prices)" and the number of replies for each option is shown.

Table 3.3. *Coding and number of replies on the factor "Business consolidation (protection against fluctuations in natural resource prices)" on survey question 7.*

Coding on Webropol	Modified coding on Excel	Number of replies
2	1	2
3	2	18
4	3	60
5	4	65
6	5	29
Total number of replies		174

The average was calculated so that modified coding of each option was multiplied with the number of replies the option received, and the results when then summarized together. Then the sum was divided with the total number of replies the question received. This was then repeated to each factor in the survey question, and then the results were sorted so that the highest-scoring result was on the top and lowest scoring result on the bottom. Then the results were turned into the graph seen in figure 6.

The response bias and validity

Response bias is the probable change in survey results if the non-respondents would have answered the survey (Creswell, 2003). The response bias is determined by the response rate, which in this study was 7,04 %. As the target population was 2500 respondents, and the number of responses 183, the response bias would be more than 5 % according to Saunders et al. (2016). The higher the response rate is, the lower the possibility of response bias is, even though low response rate does not necessarily mean that the response bias is high, but it is just more likely (Saunders, Lewis and Thornhill, 2016). The response rate was only 7,04 %, which qualifies as low response rate since reasonable response rate is usually between 35 % and 50 % according to Saunders, Lewis, and Thornhill (2016) and acceptable over 50 % according to Bryman and Bell (2015). Since the questionnaire was sent to a selected group of respondents, which consisted of people in the fields of company leadership, business management, and environmental management, in both, public and private sectors nationwide and therefore, the representative sample is 92,3 %, as seen in table 3.2, makes the bias low.

The probable threat to the validity of the study in the answers may have come from unclear questions or answer options that the respondent has not fully understood. To address this there were several iteration rounds on the spelling of the survey questions and answer options to minimize the risk of respondents not understanding the phrases properly. This was also addressed with the piloting testing phase with face-to-face interviews.

4. RESULTS

The development of circular economy hubs and the business opportunities of specific material side streams collected and processed by waste management facilities and businesses located in circular economy hubs, using circular economy principles are the main focus of this thesis. In this chapter, the results of the survey are viewed and analyzed in more detail. First, the multiple characteristics of circular economy hubs are reviewed, and then key tasks and the development needs of these hubs are reviewed through the results of the survey, which are analyzed. Then, the business opportunities on the specific material side streams are reviewed and analyzed.

4.1 Identified development needs of the circular economy hubs

The many characteristics and tasks of industrial areas using circular economy principles are reviewed in chapter 2. As the survey conducted for this study indicated, there are several key services that circular economy hubs should provide over others, and several key areas the respondents thought should be developed in circular economy hubs. These key areas would support the circular economy business value creation in the circular economy hubs in general. This was assessed in research question "How should circular economy hubs be developed so they would support the value creation of the businesses?" through survey questions and answer options shown in the operational chart in table 3.1 in chapter 3.

Based on survey responses, it was clear that communication between actors in the circular economy hub was the most important key area that needs development and was seen also as an important factor to support the business activities within the area with receiving average (AVG) scoring of 4,2 by rating the "transmission of information between actors in the area" and the "communication between firms operating in the area" receiving AVG of 4,4. The results are seen in figures 7 and 8 below.

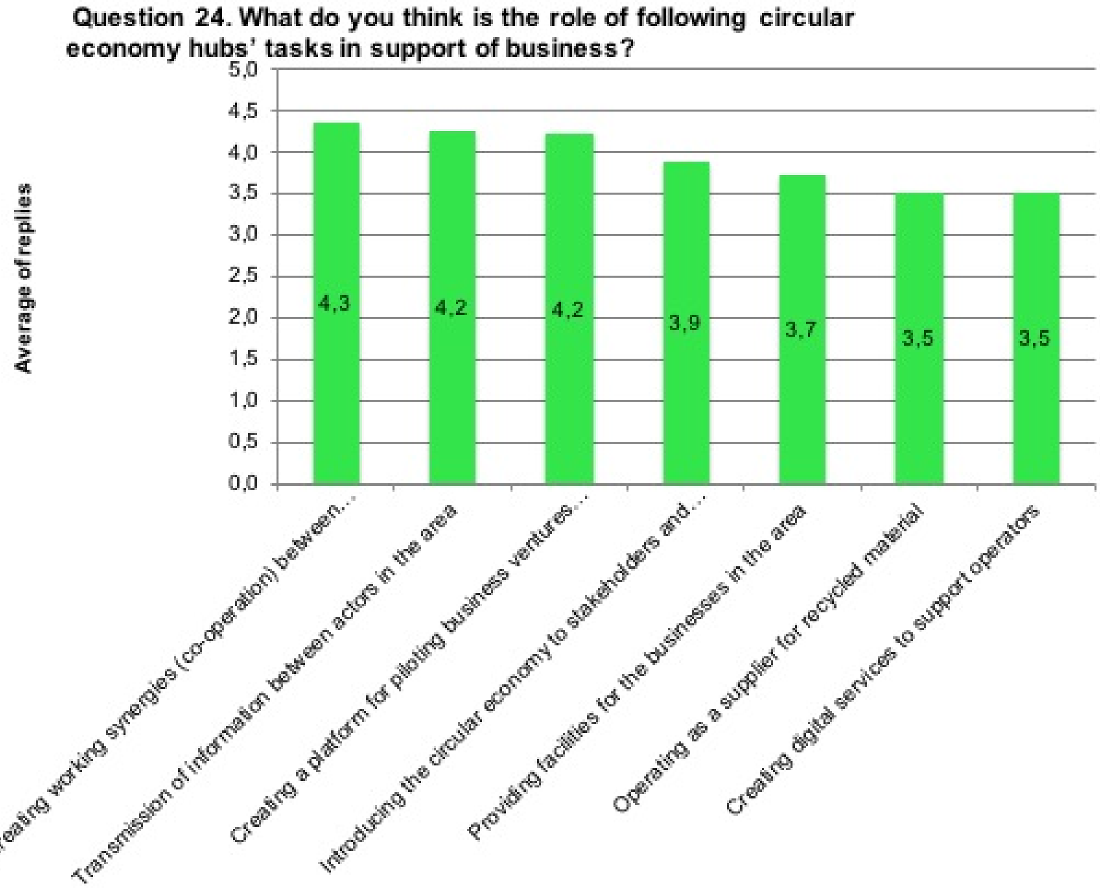


Figure 7. *Question 24, What do you think is the role of following circular economy hubs' tasks in support of business?*

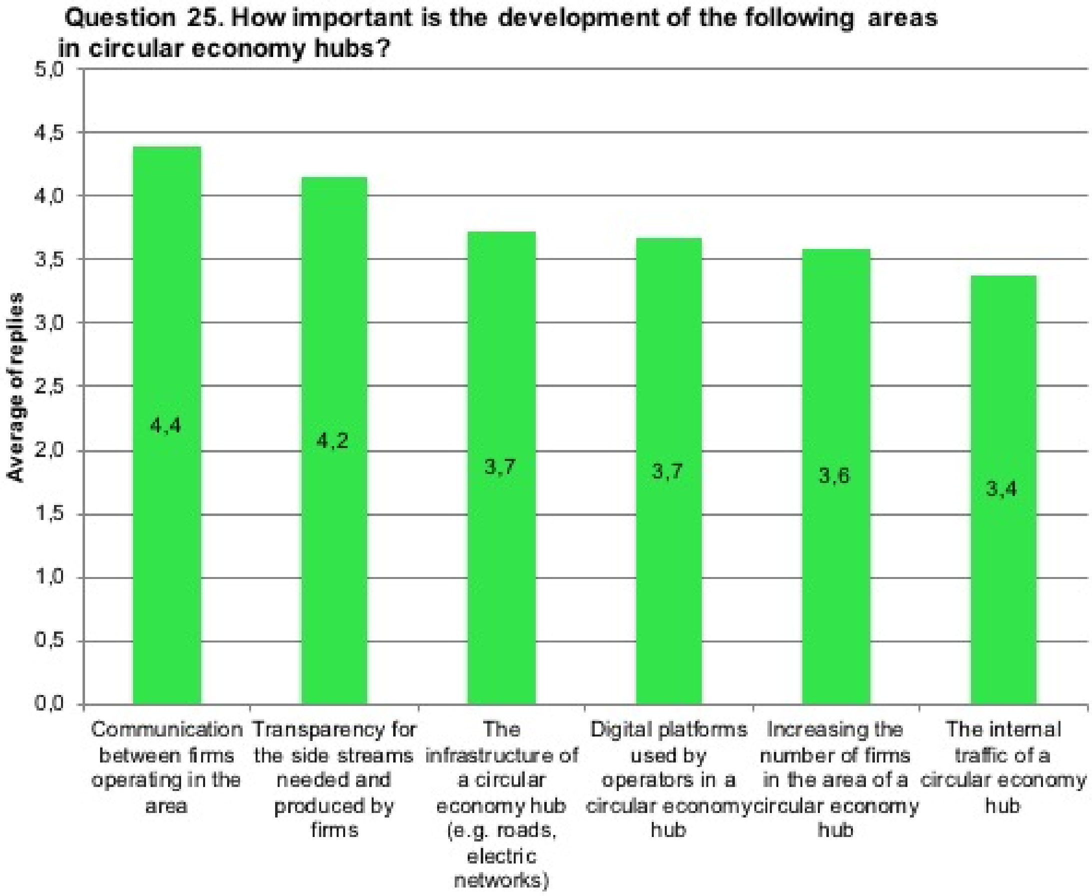


Figure 8. *Question 25, How important is the development of the following areas in circular economy hubs?*

This is not a surprise, as communication is seen usually as the one that fails or needs improvement. But in the circular economy business, the visibility in available and needed material flows is also crucial for businesses to establish stable resource availability and of course, new business opportunities again for other's side streams, or their by-products. While the respondents saw the communications as a responsibility of circular economy hub management services, there has been development ongoing on increasing material side stream visibility through digitalization in Finland (Valtioneuvosto, 2018). Finlands Ministry of Environment has had a development project with Motiva about an electronic market place where available material side streams, waste, and services related to recycling and circular economy can be offered for sale or requested for purchase. The "Materiaalitori" service was launched as a pilot in April 2019, but it will be mandatory to use by 2020 by the waste producer as a primary way to request waste management services before turning to services provided by municipality's own public waste management services. (Motiva, 2019) The service will improve visibility between actors on material side streams and waste between circular economy actors and waste producers, and therefore improve communication, as well as build more efficient industrial symbiosis. There was, however, a concern brought up that visibility on material side streams produced by a specific firm, may expose the firm's production size to competitors. This may lead to reluctance to register the amount and quality of the firm's material side streams and waste into a public database.

As being said, linked closely to communications and visibility on material side streams, the development of working synergies within the circular economy hub is seen as the most essential task of circular economy hub management services. This was rated by the respondents with AVG of 4,3. Of course, the circular economy hub's management services cannot be responsible of this key area only by themselves, but to take the lead on assuring the most effective processes to drive the working synergies forward in their location. This key area also needs the willingness and co-operation of existing institutions and firms within the area and the field of the circular economy that are working together with enhanced visibility of each other's operations. To support nationwide industrial symbiosis and the creation of working and effective synergies in Finland, Motiva has created Finnish Industrial Symbiosis System (FISS) -operating model (Motiva, 2015). FISS's goal is to find organizations and other actors to build more effective mutual exploitation of resources and to create new business. While Motiva coordinates the nationwide FISS network in Finland, the regional organizers are responsible for activating and engaging firms, exchanging and networking resources and implementing symbiosis through workshops. Workshops are the key tool to activate businesses, pooling resources and identifying synergies. Through these workshops, the regional organizers help firms to identify synergies and create these in practice. Similarly, regional organizers are responsible for helping firms and other actors to create new business opportunities. Currently, the regional organizers are scattered around municipalities. In Southwest Finland, The University of Applied Sciences, Valonia and Turku Science Park are the regional organizers of FISS -operating model. In Helsinki Metropolitan Area, Motiva Oy is the responsible regional organization of FISS -operating model. In Satakunta municipality, Prizztech Oy and the City of Rauma are the responsible organizations. In Riihimäki, Hyvinkää, Mäntsälä area, which belongs to Uusimaa municipality, the responsible regional FISS-organizer is Suomen ympäristöopisto Sykli Oy. In Päijät-Häme municipality, it is Lahti University of Applied Sciences. In North Savo, the regional FISS-organizer is Navitas Business Services Oy. In North Ostrobothnia, it is Oulu University of Applied Sciences. In North Karelia, the organizers are PIKES, KETI and Joensuu Science Park Ltd. In

South Karelia, the local regional FISS-organizers are Wirma and Lappeenranta University of Technology. In the South Savo region in Mikkeli, the responsible organizer is Mikkeli Development Miksei Ltd. In Lapland municipality, the regional organizer is Digipolis Oy. In Central Ostrobothnia, the regional organizer is Centria University of Applied Sciences. In Central Finland, the FISS organizers are Jyväskylä University of Applied Sciences and The Central Finland Energy Agency. (Motiva, 2015) As the respondent's rate the most important task of the circular economy hubs creating working synergies between businesses and other actors in the circular economy field, it might be worthy of considering centralizing the FISS -operating model organizers to circular economy hub management services. This way, the businesses, and other stakeholders would get the whole service from the same organization, which would make the service easier to use and more seamlessly working for the customers, businesses and other partners.

While the creating working synergies (AVG of 4,3) and transmission of information between actors (AVG of 4,2) in circular economy hubs were seen as the most important roles of the circular economy hubs, and the communication of firms in the area (AVG of 4,4), and the transparency of side streams needed and produced by firms (AVG of 4,2) as the top factors that needs development, creating a piloting platform for business ventures was ranked third with AVG of 4,2 in factors of most important tasks of circular economy hubs. Since circular economy business and business models are quite new, and many small companies are entering to circular economy business it is crucial to support these companies and their efforts in the field for them to be able to create a profitable business. The piloting itself is about linking the academic research into the practice of creating new business. In many cases, this is achieved with digitalization and technological development. Since the Finnish businesses haven't adopted the circular economy business models as expected, and most of the Finnish businesses are small and medium-sized firms, the resources of these firms are limited. Therefore, the piloting environment is seen as important to provide the needed resources for the firms, as well as the needed space within the circular economy business hubs. This would bring together the expertise of circular economy professionals, the other businesses in the field, as well the coordination of circular economy hubs management services. There have already been several circular economy-related pilot projects in Finland, usually, at least partly, funded by the public sector. After the piloting phase, the data and results of the pilot, as well as the business should be used as a self-sustainable business to provide economic, environmental social benefits. By providing a piloting platform, the circular economy hub management services would be concentrating as much of the services in the field as possible under one organization. This would make it easier and more effective for the firms and other stakeholders to get the circular economy-related services and expertise in use to enter the markets with circular economy business.

These tasks were scored as the most important tasks (AVG of 4,0 or higher) that circular economy hub should provide to firms and other stakeholders and were seen as the tasks that need more development to support the businesses in the area. While considering to contrate these services to circular economy hubs, the available resources and expertise of circular economy hubs management services should be taken into account. As important is to review the funding mechanisms, since currently the circular economy activities are usually, at least partly, funded by the public sector.

With little less attention in the survey (AVG of lower than 4,0) received the introducing circular economy to stakeholders (AVG of 3,9) and providing facilities for the business in the area (AVG of 3,7) as important roles of circular economy hubs. Even though rated higher than AVG of 3,5, the respondents saw these two tasks less crucial for creating economic, social or environmental benefits for the area. It is understandable, since as seen in table 4.1 below, a total of 97,2% of respondents and their organization is already familiar with the circular economy business, or the concept itself, so the introducing the circular economy to stakeholders is not necessary. As circular economy hubs are seen to have economic, social and environmental benefits, the area of circular economy activities shouldn't and cannot only be restricted within the specific area. The actors working within the field usually are spread to other sectors as well, and even the businesses cannot always reside in this kind of business area, even though it might be theoretically optimal. Depending on the firm's business, the location is usually chosen based on many different factors. These may include available space, pricing of available space, customer location, resource location, or if circular economy experts are residing in a certain institution elsewhere, moving just one team to the circular economy hub, may not be the optimal solution for the whole entity.

Table 4.1. *The relationship of the respondent's organization to circular economy hubs.*

4. What is your organizations relationship with circular economy hubs?	**Percentage (%)**
We already operate in a circular economy hub and co-operate with firms in the area	31,9
We do not operate in a circular economy hub, but our operations are linked to circular economy hubs in the form of co-operation	28,0
We operate in a circular economy field, but our operations are not located in circular economy hubs or related to their operations	20,9
We do not operate in any circular economy hub at the moment, but we are interested on it	10,4
We do not operate in any circular economy hub and it isn't our concern	6,0
I cannot say	2,7

The least scored roles of circular economy hubs were seen as operating as a supplier for recycled materials and creating digital services to support operators, both scoring AVG of 3,5. This was a surprise since the circular economy hubs are usually located by the waste collection centers and the waste management services are responsible for circular economy hubs management services as well. While the idea of providing needed materials for firms to create a business is not the desired role of the circular economy hub, the stable and predictable price, quality and amount of material flows are of course crucial for a profitable business. It is been already pointed out that the material flows of firms should have visibility for the ones needing specific materials before they are collected by waste management services, which might explain the scoring of circular economy hubs acting as a provider of materials. Therefore, the amount of waste collected would also decrease, since the side streams would never be labeled as waste. Which, then again would be in line with the Finland's national targets of reducing waste and increasing recycling. The role of providing digital services for the circular economy hubs actors was ranked as low as well. Usually, the digital services needed by the companies are maintained by the companies themselves and chosen based on the needs of the firm. There's a slight contradiction between not providing digital services, but then again, the role of creating synergies and visibility of material side streams, since these usually are done with the digital platforms. It may be that the respondents excluded the platform of exchanging material flows from the idea of digital services, or then understood the question differently than the intention of the questionnaire has been. Either the case, the need for providing other digital services are not seen as a role for the circular economy hub.

Analyzing the results on the tasks needing development in the circular economy hubs, the less development needed (AVG of lower than 4,0) were development of the infrastructure of a circular economy hub (AVG of 3,7), the digital platforms used by the circular economy hub (AVG of 3,7) and increasing the firms in the area of a circular economy hub (AVG of 3,6). As the area of a circular economy hub is usually under construction and expansion, the infrastructure development conforms with the territorial expansion and building of the hub. Therefore, the infrastructure itself is not the top priority of the list of development needs of circular economy hubs. Also, it was seen that the, like in the roles of the circular economy hubs that digital platforms are not seen as the top priority of needing development. The digital services and platforms are not regarded as important tasks for circular economy hubs.

The least scoring development needs are the internal traffic of the circular economy hub (AVG of 3,4). Even though much of the traffic is heavy traffic, trucks, the respondents didn’t rate it to be an issue in the circular economy hub area. The infrastructure is well built to support the traffic in the circular economy hubs, even though the weight of materials carried to processing facilities is high and causes stress to the road network in cases where waste treatment facilities and landfill sites are located within the circular economy hub area.

As the circular economy hubs provide spaces and services for the firms that operate in them, the hub management services usually are acting as a waste management operator within the area, and is responsible for collecting household and municipal waste, so they have deep knowledge of what material streams and how much each of these streams are collected. Also, the Finlands recycling and waste-reducing targets have to be met, so new business opportunities for specific material side streams has to be found. With the knowledge and expertise of 6Aika – Tulevaisuuden kiertotalouskeskukset project members the specific material side streams were mapped. These included the materials that were collected most in municipalities. The traits of successful business based on material processing were identified as consistent stream and availability of materials, high amounts of available material, consistent quality of materials and predictable price of materials. Therefore, the project members were able to create of list of most potential side streams from the business perspective.

4.2 Identified business opportunities on material side streams

Answering to the research question of how specific material flows are defined as having the potential for business opportunities three questions with pre-defined answers were constructed into the survey. The questions are seen in table 3.1 in chapter 3, and the variables measured were the importance of specific side streams, the challenges hindering the use of recycled materials and factors contributing to the transition towards circular economy business.

The results for the question “how important do you see the following side streams for creating a business” can be seen in figure 9 below. The most important answer options were scored as AVG of 4,0 or more, the less important less than 4,0 and 3,5 or more. The least scored with AVG of less than 3,5, which were considered as non-important options according to respondents. The importance of specific material side streams included 18 different side streams scored by the respondents.

The identified material side streams

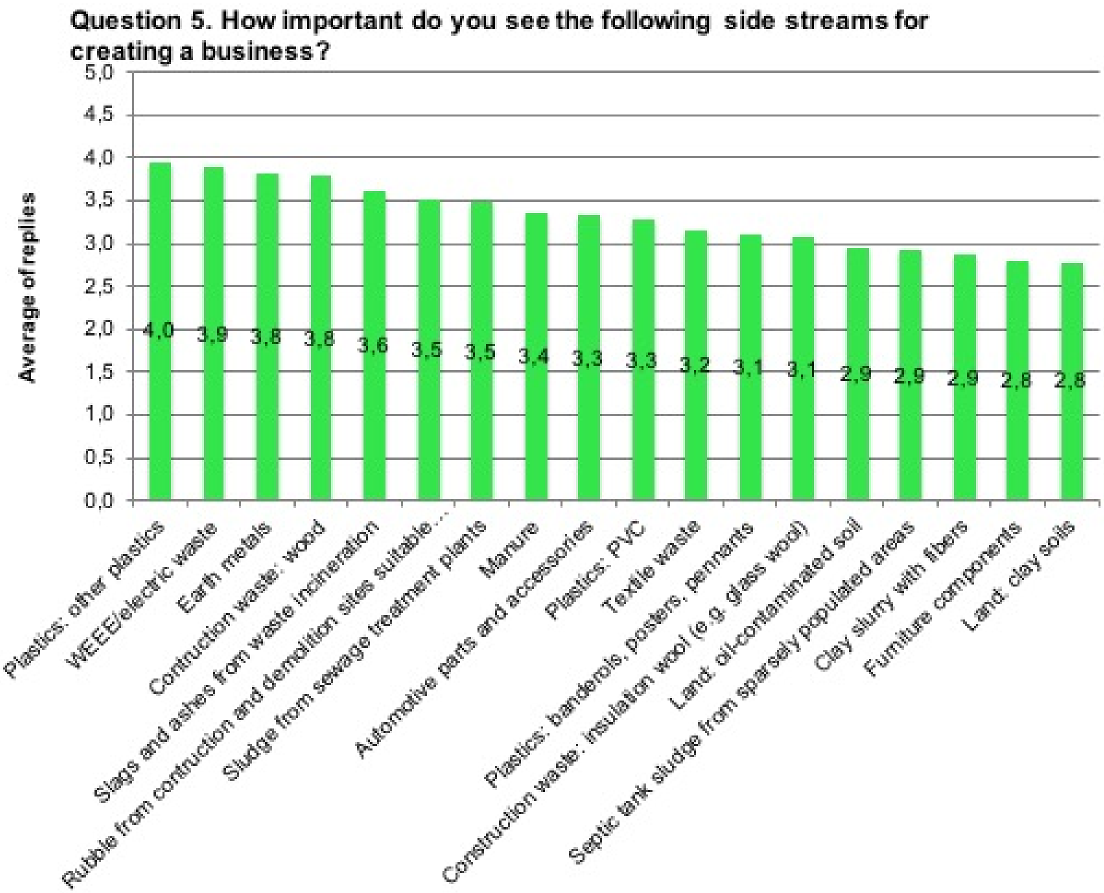


Figure 9. *Question 5, How important do you see the following side streams for creating a business?*

The most important side streams for creating business was considered being plastics not including PVC (AVG of 4,0). As the plastic use has increased in recent years, reducing the amount of virgin plastic used in production the replacing it with recycled materials is essential (Eskelinen *et al.*, 2016). Simultaneously, the need to reduce the number of plastics used is also a key for environmental perspective. Challenges that recycling plastic waste face, is the mix of different types of plastics in collected waste as well as it is impurity, odor and the separation of differently colored plastics. In 2012 in Finland, there was 36 000 tons of separately collected plastic waste, of which had a recycling rate of 19,4%, while the rest of the separately collected plastic waste was incinerated as energy (Eskelinen *et al.*, 2016). Most of the plastic waste in Finland is generated from packaging materials. Currently, it can be said that using recycled plastic can reduce the material costs 20 % - 25 % compared to using virgin materials, similarly, the carbon footprint is lower and can bring benefits for product branding and company image (Sitra, 2017).

Currently, collected plastic waste is used for plastic packaging materials, in agriculture and construction products, in other industrial products and for other plastic products like buckets and composters (Eskelinen *et al.*, 2016). It is been estimated that the amount of plastic waste in Finland will increase between 6,5% to 31,9% by 2030 (Eskelinen *et al.*, 2016).

While the most potential material side stream was rated being plastics excluding PVC, the second-highest measured results was WEEE/electric waste (AVG of 3,9) as well as the earth metals with AVG of 3,8. Earth metals or rare earth metals are usually used in electric equipment and labelled as WEEE as well. In 2015, there was 63 000 tons of electric waste collected in Finland (Ympäristöministeriö, 2018a) with increasing rate. The separately collected electric waste has a good collecting rate, since only 1,2% of electric waste ends up in mixed waste, although re-using and recycling rate was 23 % in 2013 (Ympäristöministeriö, 2018a). As electric waste includes many strategic metals, the recycling potential is high. Processing and separating the desired metals from the waste are challenging, because of the small amounts of the materials used and the current technology cannot separate the materials efficiently. Because of the economic potential of WEEE and recovering the precious metals from it, there have been development-projects of new extraction methods of the metals from electric waste. (Teknologiateollisuus, 2016) The new technology is based on the hydrometallurgy process including the advantages of digitalization and robotics since currently, processing of WEEE is labor-intensive and therefore high in cost. There is a need for increasing the recycling rate and development for more efficient recycling processes of WEEE, since the global usage of precious and rare metals used in electric equipment is increasing, and price volatility is evident.

Similarly, with rare earth metals, wood from construction waste was scored with AVG of 3,8. In 2015 280 000 tons of wood waste from construction by-products were collected. The target is to reduce the amount of collecting construction waste and increase the recycling rate to 70% for the year 2023. From the construction waste, the largest single waste category is mineral-waste, and the second-largest is wood waste. (Ympäristöministeriö, 2018a) In waste generated in house building, the single largest waste material is wood. Currently, most of the wood waste is incinerated, because of its low quality. In 2011 250 000 tons of wood waste were burned to energy. (Ympäristöministeriö, 2014) Therefore, innovations in processing and recycling wood waste are needed. In collected wood waste the quality and impurities are currently the biggest challenges, but there is however a business potential existing in wood waste, because of the vast amount collected.

With the AVG of 3,6 slags and ashes are rated as a fifth important material side stream in business perspective by respondents. Ashes and slags are by-products of energy production through the incineration process in waste incineration plants. The variation in the quality of incinerated waste and probable contaminants, like heavy metal contents, determine its possible use. (Ympäristöministeriö, 2017) Ashes and slags cover 20%-30% of the by-products from waste incineration (Lounais-Suomen Ympäristökeskus, 2009). The total amount of waste incinerated for energy in 2017 was 1,6 million tons (Tilastokeskus, 2019b), which makes the Finland's annual amount of ashes and slags produced each year approximately 320 000 to 480 000 tons. Ashes and slags can be used in several applications. They can replace the soil used in earthworks, be used in farming as fertilizers, or in concrete production to substitute parts of cement used (Lounais-Suomen Ympäristökeskus, 2009). UPM has announced that they are able to recycle ashes to replace part of the calcium carbonate used in the paper manufacturing process. This will decrease the CO2 emissions, decrease energy usage and also decrease heavy traffic in the area. Currently, UPM has delivered the ashes produced by bioenergy production to landfill sites for further processing. (UPM, 2019)

As the sixth of most important material flows rated by the respondents, were rubble from construction and demolition sites, with AVG of 3,5. In 2011 construction sector generated 2,2 million tons of waste, not including soils. Usually, this type of waste includes glass, paper, and metal material side streams. In statistics, usually also rock and soils, as well as wood waste are included. Wood waste cover 41% of total construction waste, minerals and rocks covers 33% and dangerous waste covers up to 1,8% of the total amount of construction waste. Three areas generate specific amounts of construction waste. These are demolition, 27%, house building, 16% and repair, 57%. (Ympäristöministeriö, 2014) While effective way to decrease the amount of construction waste is material efficiency, new ways of processing construction waste are needed, since targeted recycling rate of construction waste is 70%, instead of current 26%. Currently, metal waste is highly recycled, demolished concrete with steel enforcements removed can be used in earthworks and when manufacturing new concrete. (Ympäristöministeriö, 2014)

Sludge from sewage treatment plants received a rating of AVG of 3,5 and therefore is on the 7th of the material side streams that respondents have seen business potential. Currently, about 650 000 – 900 000 cubic meters of wet sludge is collected annually, which is about 125 000 – 160 000 tons of dry solids material. Currently, all of the sludge material has been successfully treated, utilized, recycled or placed. It is been used in agriculture products in fertilizers, in landscaping the closed landfill sites and in energy production. There have been some challenges to utilize the sludge from waste treatment plants, since major foodstuff firms and landscaping operators are hesitating to use the end products according to quality standards, like heavy metals and organic contaminants. Sludge contains 11%-14% of phosphor, which is strategic material for agriculture. The annual potential harvested amount phosphor from sludge is 3000 - 3800 tons annually. Most of the phosphor used in the EU is imported, and therefore using phosphor recycled from sludge, would increase the Finland's and EU's equity ratio and stabilize the markets. (Ympäristöministeriö, 2018b) It is important to develop innovations to increase the quality and purity of sludge so it could be used in applications requiring high-quality standards.

Lower than 3,5 ratings received manure (AVG of 3,4), automotive parts and accessories (AVG of 3,3), plastics: PVC (AVG of 3.3), textile waste (AVG of 3.2), plastics: banderols, posters, pennants (AVG of 3,1), construction waste: insulation wool (e.g. glass wool) (AVG of 3,1), land: oil-contaminated soil (AVG of 2,9), septic tank sludge from sparsely populated areas (AVG of 2,9), clay slurry with fibers (AVG of 2,9), furniture components (AVG of 2,8), land: clay soils (AVG of 2,8). The material streams receiving lowest scores are either too specific for the responders, like separating banderols posters and pennants from plastic waste, or have already several projects and recycling processes innovated already, as for textile waste, even though re-using and recycling textile waste is still needing more innovations.

Several other notable side streams from the business perspective have been identified, these are, bio waste, waste paper, and paper boards, garden waste, metal waste from Finland's national waste plan (Ympäristöministeriö, 2017), expanded polystyrene (EPS), zero fiber, soil and rocks, biomasses, fiberglass boats and park trees from 6Aika project teams material flow review, and straw, other plant-based side streams, and animal waste from report by Varsinais-Suomen Liitto (Varsinais-Suomen Liitto, 2017) were excluded from this research.

Factors hindering the use of recycled materials in products

To understanding the respondent's views for using material side streams for business and creating new products or process them for further use in economically viable ways, the barriers of creating a business from recycled materials were mapped by asking respondents to rate the importance of pre-defined factors hindering the use of recycled materials in products. The results can be seen in figure 10 below.

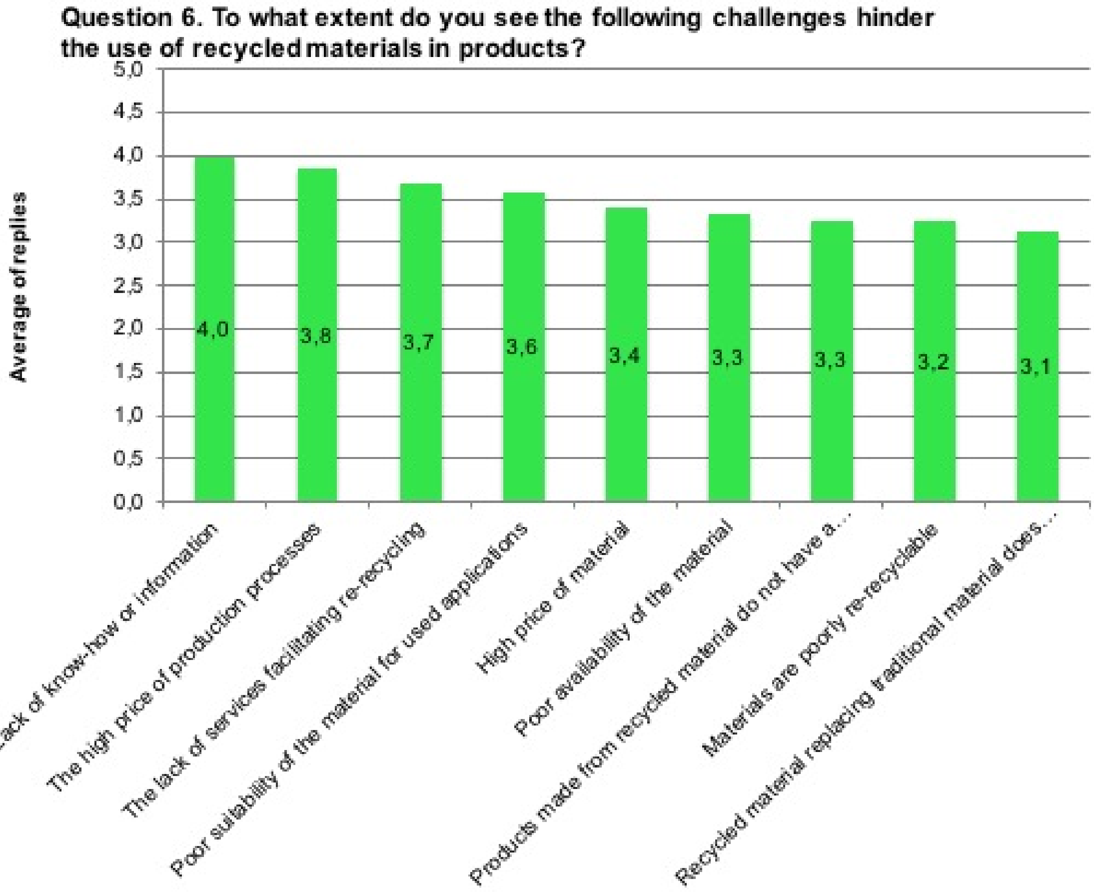


Figure 10. *Question 6, To what extent do you see the following challenges hinder the use of recycled materials in products?*

Respondents criticized the “lack of know-how or information” with AVG of 4,0 as the most important, or the biggest challenge, for using recycled materials in products. It can be then said that there is a lack of expertise in developing new products that use recycled materials as well as a source for information to help new product development. For the second biggest challenge, the respondents rated “the high price of production processes” with AVG of 3,8. The product development and processing waste materials seem not to be cost-efficient enough to compete with virgin materials. This, of course, depends on the specific material side streams used, or the process and process technology. There have been some projects with public funding, like UPM’s and Yara’s joint-project of creating fertilizer from sewage treatment plant sludge as a part of the Ministry of Environments RAKI2-project (UPM and Yara, 2018). The target was to create a product that exploits sludge, and phosphor to create fertilizers which are easy to store, transport and can be spread evenly to fields. The conclusion was that the end-product is not cost-efficient enough to have any significant market value or business opportunity. Even though UPM’s and Yara’s project was a failure in an economic sense, the piloting, testing, and innovation is needed through failure and success. When the funding is partly provided by the public sector, the firms can use their expertise to seek solutions for creating new products even though there is no certainty of financial profitability. As the results are public, others can also view them, and see the cost structure and where the processes need development to be more financially efficient.

The third biggest challenge rated was the “lack of services facilitating re-recycling” with AVG of 3,7. While the product may be manufactured from recycled materials, after the end-of-life of the product, recycling it further, is something that hasn’t been given much thought. As the materials face resource losses in the recycling process, and recycling gets more difficult, it is essential to develop these processes as well, to keep the materials in the loop of circular economy and prevent them from ending up to landfills or waste incineration plants.

The “poor suitability of the material for used applications” was rated as the fourth biggest challenge to hinder the use of recycled materials in products, with AVG of 3,6. As the materials may face challenges for having a less consistent quality or too high level of contaminants to be used in sterile packaging in foodstuff industry, or pharmaceutical industry, there may be other unwanted features that prevent the use of recycled materials.

Less than AVG of 3,5 ratings received the “high price of material” with AVG of 3,3, the “poor availability of the material” with AVG of 3,3, the “products made from recycled material do not have a market demand” with AVG of 3,3. The lowest scoring received the “materials are poorly re-recyclable” and the “recycled material replacing traditional material does not exist” with AVG of 3,2. Therefore the respondents do not see these factors having the effect of hindering the recycled material use in new products. They do not see the waste material having a too high price, but instead the production process to produce suitable substitutive material. Also, the products made from recycled materials do have market demand, or there seem to be no issues where customers are avoiding the purchase of a product made from recycled materials. The recycled materials and products have been used in Finland for years, and therefore, the customers are used to these products. It is evident that products made with sustainability principles are gaining more and more market demand and popularity among customers. The respondent’s views on re-recycling conflicts a bit, with the challenges and efforts mostly centralizing on recycling of products manufactured from virgin materials, instead of re-recycling products and materials made from secondary materials already recycled. It could be that the respondents have not understood the “lack of services facilitating re-recycling” correctly and confused the term “re-recycling” with “recycling”, which would urge to respond the need of establishing services facilitating recycling processes.

Factors contributing to the transitions towards the circular economy

The last question on the survey questionnaire was for establishing a better understanding of why firms would pursue developing their businesses towards the circular economy and using recycled materials in their products. This was mapped with the question “How do you see the following factors contributing to the transition towards circular economy business?”. The results can be seen in figure 11 below.

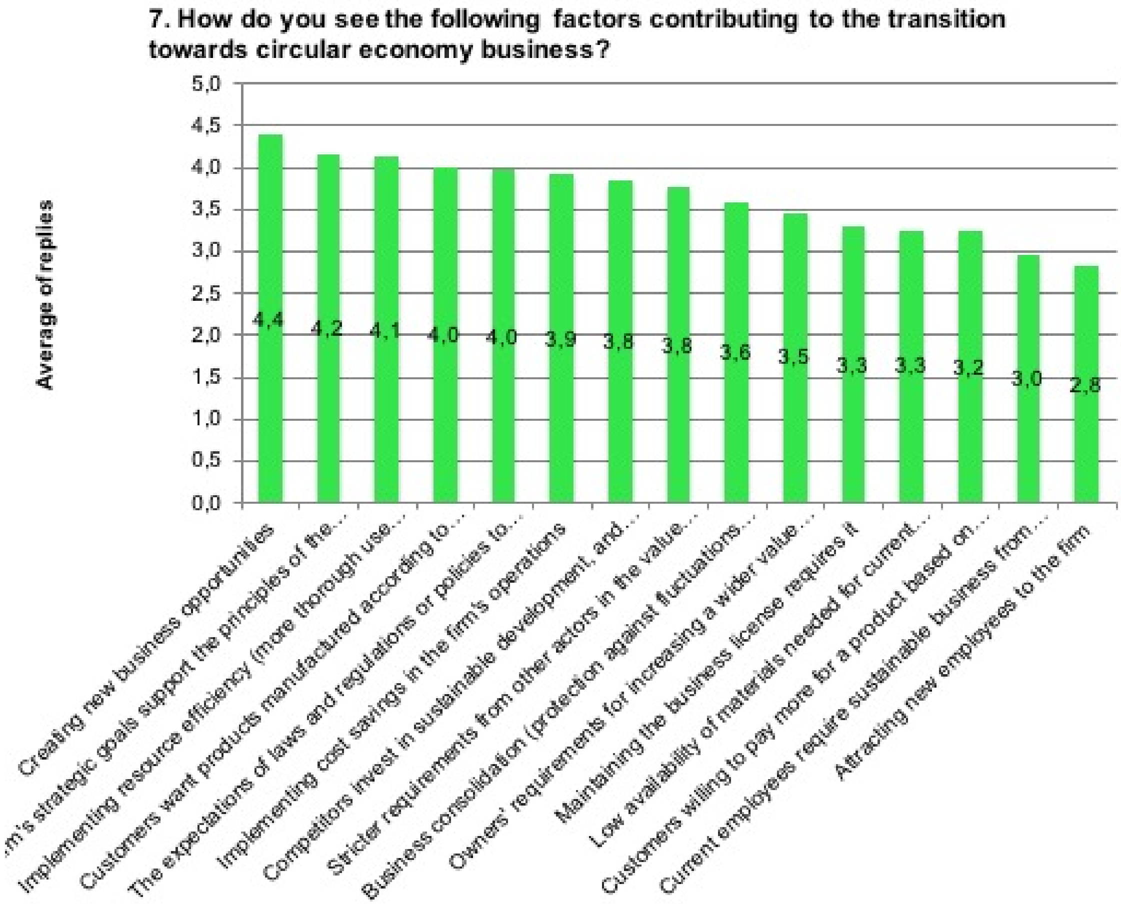


Figure 11. *Question 7, How do you see the following factors contributing to the transition towards circular economy business?*

The most important, or the highest scoring received, the “creating new business opportunities” with AVG of 4,4. Firms, even though many are already engaged of sustainability and responsible business, sees that the most important reason for making business decisions and products according to sustainability principles is that they see the business opportunities in it. While the reducing the amount of waste generated, energy used, and CO_2 emissions released are in Finlands governmental targets, and customer demand for sustainable products are increasing the firms seek the profitability and new business in the field. While the customer demand and governmental policies drive the need for sustainable products, the firms are also preparing for the more sustainable future operating environment. Oil and fuel companies of today are seeking new business on biofuels and recycling to produce new, more sustainable fuels, from plastics or waste, as the demand for decreasing fossil fuel consumption is rising.

As the second most important factor contributing to the transition towards circular economy business was the “firms strategic goals support the principles of the circular economy” with AVG of 4,2. This is seen as very important for firms in Finland. Many major, international firms that are based in Finland have their sustainability organizations, which contribute heavily to company strategy. Many smaller or middle sizes firms have also recognized the need for sustainability in their strategies, even though it may not be the most important aspect yet. Then there are new start-ups or other small firms that have their whole business based on circular economy or sustainability.

The third most important factor was rated “implementing resource efficiency (more thorough use of existing resources)” with AVG of 4,1. Through resource efficiency, firms can to respond to the price volatility of material resources, similarly, the threat on a decrease in material stocks and therefore increase in material price can be avoided. Resource efficiency also reduces the material cost of a single product, which allows the company to lower the price of the product and gain a competitive edge over its competitors.

With the AVG of 4,0 the factors “customers want products manufactured according to sustainable development principles” and “expectations of laws and regulations or policies to change the firm’s business practices” were scored as the fourth most important in rating factors contributing to the transition towards circular economy business. In Finland, this customer behavior has already been noticed, although the trend is not too strong yet. Even though customers are requesting sustainable manufactured products, they are not willing to pay more from them. The low price and ease of purchasing the goods are the determining factors when making purchasing decisions (Yle, 2017). Also, the responding to governmental regulations, like the “circular economy law” of 2011 (Finlex, 2011) is rated high, since adapting to the regulations is lower in cost and easier, and in many times mandatory, than to not adapt. It also ensures the longevity of business practices.

Lower than AVG of 4,0 received the rest of the pre-defined factors in the survey question. The “implementing cost savings in the firm’s operations received the rating of AVG of 3,9. With this rating, the factor scored as the fifth most important in the survey question.

Through the circular economy business, the achieving of cost savings is seen as a desirable objective. This is possible through material efficiency, reducing the amount of waste generated and reducing energy and water consumption.

The sixth most important factor was rated the “competitors invest in sustainable development, and the firm must keep on with the competition” with AVG of 3,8. The trend of firms moving towards the circular economy and sustainable business is noticed among the firms and causing pressure among competitors. Therefore, the competitors must react and provide the goods according to these principles. Similar ratings received the “stricter requirements from other actors in the value chain”, with again, the AVG of 3,8. As value chains are built with many third-party actors, these outsourced actors have their specific needs through standards and other requirements. With the complexity of these value chains, it is hard to respond to the requirements, as it is to monitor the compliance of these requirements.

With the AVG of 3,6, the “business consolidation (protection against fluctuations in natural resource prices)” was rated as the seventh most important factor on the transition towards circular economy business. As was noted previously, the price volatility of natural resources as well as the decrease of the natural resource stocks and therefore material price increase will raise concerns in business longevity. Business consolidation can be achieved through material efficiency, through using more recycled materials in products or developing new materials to substitute the scarce materials in the markets.

The “owners’ requirements for increasing a wider value (other than profits from the business)” scored eighth the most important factor with AVG of 3,5. As the profits are seen as the most important of business’s value creation, and prerequisite of a working business, there are other factors of gaining value. These may be the values for the business itself that attracts customer engagement for longer-term, like the social and environmental values that are also important for the customers.

Lower than AVG of 3,5 scored the “maintaining the business license requires it” and “low availability of materials needed for current production” with both scoring AVG of 3,3. The least important factors for transitioning towards circular economy were the “customers willing to pay more for a product based on sustainable development” with AVG of 3,2, the “current employees require sustainable business from employer”, with AVG of 3,0 and the” attracting new employees to the firm” with the AVG of 2,8. These factors were rated as the least important of the ones encouraging the business’s transitioning towards circular economy business.

5. DISCUSSION

The circular economy hubs are gaining popularity in Finland at the moment (CircHubs, 2017; Lounais-Suomen Jätehuolto Oy, 2017a; Reinikainen-Laine, 2017; Helenius, 2018; Lapin liitto, 2018; Mikkelin kaupunginhallitus, 2018), but there is currently no clear definition to distinct circular economy hubs from eco-industrial parks or circular economy parks. Mainly, it can be said that the circular economy park and circular economy hub is the same type of industrial area, and the term is used side by side to describe an industrial area (Sorvoja, no date) with sustainability and circular economy business models and activities to gain more environmental and economic benefits for the area, than traditional industrial or business area. The eco-industrial park bears the same activities, mainly, but is built rather around industrial ecology and industrial symbiosis, than directly to circular economy business activities (Ghisellini, Cialani and Ulgiati, 2016; Halonen and Seppänen, 2019).

As the circular economy hubs are seen essential for the industrial activity to gain economic, social and environmental benefits (Hein *et al.*, 2015; World Bank Group, 2017) , understanding the development needs and the desired core activities of circular economy hubs to support creating value for the businesses is important. Only this way, the firms and other actors within the area can gain the maximum benefits operating in the circular economy hub area.

The most important tasks for the circular economy hubs to support business activities is to create working synergies within the area. As the industrial symbiosis is one of the core principles of the circular economy hubs (Ellen MacArthur Foundation, 2013a), working synergies and symbiosis are essential. These two define the circular economy hubs as being one, and without working synergies or symbiosis, the firms and other actors in the area cannot exchange their resources, like materials, energy or water, and other by-products to gain a competitive advantage over traditional companies and reduce the environmental impact of the area (Lowe, 1997; Heeres, Vermeulen and De Walle, 2004; Hein *et al.*, 2015; Prendeville, Cherim and Bocken, 2018).

As the transmission of information and successful communication are top tasks of the circular economy hubs, it is also identified as the field that usually fails and needs development for hubs to work efficiently (Heeres, Vermeulen and De Walle, 2004; Song *et al.*, 2011, 2018). This is the responsibility of the circular economy hubs management services (Lowe, 1997), as well as few other basic services, like providing the platform for area actors to communicate the available by-products. The actors of the area may not be willing to provide all the information of side streams, since it may reveal the actual production figures to competitors.

Creating a platform for piloting business ventures is also one of the top tasks of the circular economy hub. Without the possibility of piloting the circular economy business models, the startups, small- and middle-sized companies have little possibilities to enter the circular economy business. Therefore, it is essential to provide this kind of service to provide an environment where they can produce and test their products or services before entering wider markets (Ympäristöministeriö, 2018a).

The communication of the developments in the circular economy field and related activities to the firms and other stakeholders in the area is also essential. The developments in the governmental objectives, policies, and the success and failures in the business of different firms in the field bring valuable information to the actors in the area.

The least important tasks for the circular economy hubs were to operate as a supplier for recycled material and creating digital services to support operators. These were not seen as essential tasks, even though the material is collected by regional waste management services, which is usually the organization that provides the circular economy hubs services, at least in the areas, where circular economy hubs are located within waste management services and landfill sites (Kalliosaari, 2017; Karisto, 2017; Lounais-Suomen Jätehuolto Oy, 2017a; Kiertokaari Oy, 2019). The firms rely on that they will get their resources and materials through other firms and sources, rather than the waste management services. Also, digital services are something that firms provide for themselves based on what they need.

The development in the key areas was seen as essential for circular economy hubs to support the areas business activities. The most important areas were communication and transparency for the side streams needed and produced by firms. The firms need more and better communication between the actors in the circular economy hub to gain better synergies and more predictable availability and the need for materials. This will help the firms better to predict their own production and if they have to be prepared to purchase materials from other sources. Successful communication is the responsibility of the circular economy hubs management services.

Currently, in Finland, the communication of available materials has been organized by local organizations, like universities of applied sciences, regional business development organizations through access to SYNERGie -material sharing platform (Motiva, 2015).

This causes problems getting the needed information since usually, these regional organizations are the only ones with access to the information about the material flows. As of 2019, Motiva and Ministry of Environment have provided a national electric market place and sharing platform for firms and other organizations to use (Motiva, 2019). This platform, as well as the need to register the waste and by-products generated by the firms, will be mandatory to use in 2020. All of the registered firms have access to the material flows and the needs for participating firms. Also, the information about the circular economy services is currently been scattered to many different organizations through the Finland's regions. The services should be focused as much as possible so that the firms and stakeholders would find the needed information as efficiently as possible.

Internal traffic of the hubs does not need development. The areas are usually built around industrial firms and activity and developed for the need of services that use heavy traffic. Therefore, the road infrastructure is already aligned to the needs of the local enterprises as well and will hold the expansion plans of the hubs as well.

Even though there were no direct implications in the literature of linking the circular economy hub concept to business opportunities on specific material flows, the idea of the circular economy hub and material processing is important. In many cases in Finland, the circular economy hubs were established within the regional waste management collection facilities (Kalliosaari, 2017; Karisto, 2017; Lounais-Suomen Jätehuolto Oy, 2017b; Kiertokaari Oy, 2019), and therefore the circular economy hub's management services provided by the regional waste management services. The waste management services have great expertise on the different material flows collected in the region. These include the amounts of different material flows collected, the quality of the waste and the periodicity of the waste streams collected. As locality of the activities and materials are key factors (Hein *et al.*, 2015) in the circular economy since transportation is usually high-cost and high-emission (Zhou *et al.*, 2015; Zeng and Li, 2016), there's noone with a better understanding of these areas than circular economy hub management services, or waste management services, which usually are the same service.

Nationwide, in Finland, several specific material flows are seen having the potential for creating new business opportunities through several key areas. In literature, it is referred to as materials recycling potential, which is viewed from an economic perspective (Zeng and Li, 2016). Recyclability, then again, is the term used describing how easy or hard the material flow is to recycle (Zeng *et al.*, 2017). As recyclability is measured in weight percentage, it is important also from an economic perspective that the materials are collected in vast amounts for processing.

Material side streams seen as having the most business potential over others were plastics (excluding PVC and banderols) which is produced 36 000 tons annually (Eskelinen *et al.*, 2016), electric waste, which is produced 63 000 tons annually (Ympäristöministeriö, 2018a), rare earth metals which are included in small quantities in electrical waste. Other materials having high business potential is wood from construction waste, 280 000 tons collected annually of which are mostly incinerated as energy at the moment (Ympäristöministeriö, 2018a). Slags and ashes from waste incineration, collected annually 320 – 480 000 tons (Tilastokeskus, 2019b), rubble from construction and demolition sites, collected annually 2,2 million tons (Ympäristöministeriö, 2014), and sludge from sewage treatment plants collected 125 000 - 160 000 tons of solid material each year (Ympäristöministeriö, 2018a). Each of these materials has few characteristics in common. They are collected in high amounts, need innovations for more effective recycling methods and new ways of re-using the recycled materials into new products to gain economic benefits and reduce the total amount of annual waste generated. The labor intense recycling processes are also high-cost, and therefore reduce the viability of material processing and recycling, there's an urge to consider moving the material processing to low labor countries or invest in processing technology (Dias, Bernardes and Huda, 2019). This will lower the costs of waste processing and make recycled material side streams more profitable.

Having the least potential from a business perspective were manure, automotive parts, and accessories, PVC-plastics, textile waste, banderols, posters, and pennants made from plastics, insulation wool from construction waste, oil-contaminated soil, septic tank sludge from sparsely populated areas, clay slurry with fibers, furniture components, and clay soils. For example, Manure is collected approximately 2 392 tons in areas of Uusimaa and Southwest Finland. Most of it from Southwest Finland, because of high agricultural production. Therefore, the recycling of manure is not seen as important in a survey covering Finland nationwide. These low-business potential material side streams are generated from local markets and are not collected in vast amounts nationwide, even though they may be regionally significant.

The lack of know-how and information is the biggest barrier for bringing products with recycled materials into markets. As the information sharing is an important task for circular economy hubs management to establish effectively (Heeres, Vermeulen and De Walle, 2004), and the one needing development, it is important to provide the information also about recycled materials in product development, as well as link the specific organizations who have the knowledge of processing specific material streams to the firms who need the expertise on their product development.

The high cost of the production processes is also a barrier for developing products which use recycled materials. Therefore, innovations for new processes and technology is needed (Dias, Bernardes and Huda, 2019). Big data and automation of the recycling processes will provide more efficient and cost-efficient processes (Prendeville, Cherim and Bocken, 2018). These should be targeted to the areas of supply chain logistics, energy generation, molecular biology, and polymer chemistry (Ellen MacArthur Foundation, 2013b). Sharing the data and knowledge of production processes would help new firms entering the business. Again, the circular economy hubs management services should be able to point the correct network of experts and knowledge of different processing methods. this way the firms wouldn't have to start developing the processing methods from scratch, and similarly avoid making the same mistakes as others have done. There may be, of course, some challenges for co-operating with other firms that are seen as competitors, but effective synergies require knowledge sharing and will cut costs as well.

Re-recycling of secondary materials or the materials that have already recycled once usually reduce the properties of the materials, the quality and the possible recycling rate of the collected waste. As the current waste processing services and development of waste processing are focused mainly on recycling products made from virgin materials, the recycling of products made from secondary materials has been left in the dark. By re-recycling, the manufacturers will be less dependent on virgin materials and the materials will be kept in the circular economy loop longer. In general, the better in quality, and more cost-efficient collection processes of discarded materials are needed.

The barrier of using the recycled materials in products, because of the poor suitability of recycled materials should be regarded as well. In many cases, the purity, or the fear of contamination from recycled materials is important, but it should be based on real research on the topics, rather than feelings and thoughts. Especially in foodstuff and medical packaging these concerns are valid. The material quality, in general, may also significantly reduce the usability of the materials in new products, but again, more efficient waste processing methods are needed and new ways of getting these materials back into the circular economy loop.

It is clear that firms seek new business opportunities while seeking ways of using recycled materials in their products, and while doing that, they'll enter to circular economy business (Ellen MacArthur Foundation, 2013a; Zeng and Li, 2016). Being said, the most potential business opportunities are the ones that haven't been exploited yet. In the field of circular economy business, the estimation is that the products, with most business potential, would have medium complexity and medium-term product-life, meaning 3 - 10 years (Ellen MacArthur Foundation, 2013a). The firms have sustainable development embedded into their strategic goals, as they have noticed the change in customer behavior. Through quality standards, like ISO 14001, and sustainability reporting firms communicate to customers and other stakeholders that they are taking the social and environmental issues seriously. They are looking for new ways for resource efficiency to save in material costs, respond to global price volatility and depletion of material stocks. This can be achieved through the circular economy's 3R or 4R principles (Yuan, Bi and Moriguichi, 2006; European Commission, 2008; Kirchherr, Reike and Hekkert, 2017; Murray, Skene and Haynes, 2017), or with new business models emphasizing service business through digitalization (ECO3, 2018).

As the international and national environmental regulations tighten, and new policies are put into place firms need to respond to these changes. In Finland, new waste laws, governmental programs, and national waste plan emphasize taking mandatory actions against waste and environmental issues. The amount of municipal waste is estimated to increase to 3 million tons by 2030, the recycling rate is targeted to increase to 68,2 %, waste incineration rate to 30,8 % and landfilling rate decrease to only 1% (Ympäristöministeriö, 2015), which means that firms need to take voluntary actions to seek new opportunities through using secondary materials, reducing resource use, applying more effective production processes and using material side streams in production. By doing this, firms will prepare themselves for adjusting to the future business environment and gaining a competitive advantage over firms that are not willing to participate.

6. CONCLUSIONS

In this chapter, the conclusions of the study are reviewed. First, the theoretical contribution of the thesis for the academic field is reviewed in section 6.1. Then, the actions that are recommended by the results of the study as practical implications are reviewed in section 6.2. That is followed by the assessment of the research, where the validity of the study is discussed in section 6.3. Last, the areas of research that came up while conducting this study and are needing further research are examined in section 6.4.

6.1 Theoretical contribution

As the circular economy hubs are quite a new concept, and in literature yet not covered much, this study builds a link between landfill mining, urban mines, eco-industrial parks, circular economy parks, and circular economy hubs. It defines the characteristics of each of these concepts found from literature and establishes an overview of the circular economy hub. As the characteristics of the circular economy hubs are overlooked, the main activities that a circular economy hub should provide for the firms and stakeholders of the area defined, and the development needs of the hubs are assessed. By doing this, the recommendations for developing circular economy hubs in Finland can be built. This will create the most effective environment for the firms to operate within the circular economy hub area for contributions to social, environmental and economic development.

Through Finland's circular economy hubs to the theoretical perspective of the research of economic assessment of circular economy business and recycling activities are something that hasn't been studied in numbers. Mostly the research in re-using and recycling products and materials are focused on both biological and technological ways of processing waste and materials further or environmental impacts of waste and waste processing. Therefore, the research on these areas is more than welcome. This study gathers together an overview of the current scientific contribution of the selected material flows from a business perspective, the market opportunities and barriers found for using secondary materials in manufacturing as well as any economic data found from literature. Then, with the questionnaire, which has been the basis of this study, it rates the possible business opportunities of the material flows in Finland and the information on the pros and the cons of creating new business with recycled materials.

6.2 Managerial implications and policy recommendations

The study's results implicate that the most important task for the circular economy hub to support the value creation of areas firms is creating working synergies between firms in the area. This will help the firms to generate working business using circular economy business models. This cannot be successful without effective communication about the visibility of needed and produced material flows and the current developments in the circular economy field between the firms and stakeholders in the area. For the smaller and middle-sized firms, a piloting platform of new business is essential. This will lower the barrier to innovate and try out new business. The lead on these actions should be taken by the circular economy hub's management services team with the co-operation of areas firms and other stakeholders. The reason for this is that currently, the institutions pushing the circular economy forward in Finland's municipalities are rather widespread and there isn't a centralized service providing the services for the firms and other stakeholders.

The business opportunities for circular economy business models and recycling lies in the characteristics of materials. These are the purity of the materials, the consistent quality, and the steady availability of the materials, the number of materials available and locality of resources. When these characteristics are met, the cost-effectiveness of the recycling process is essential. Of course, the environmental challenges the specific end-of-life materials pose, contribute also for the need of finding solutions for re-using or recycling them. Plastic waste (excluding PVC) was rated the most important material side stream for creating new business. Following plastics, was the electric waste, rare earth elements from electric waste, wood from construction waste, slags and ashes from waste incineration, rubble from construction sites and sludge from sewage treatment plants. Hindering the use of recycled materials in new products was the lack of know-how and information, the high price of recycling and production processes, absence of the re-recycling services and the poor suitability of the recycled materials for the production purposes. These results should be assessed as, again, easily available and comprehensive information and communications for the firms and individuals who are interested in creating a business in circular economy field. Investments and research on processing these specific material flows should be emphasized with the help of the public sector. This would also contribute to the reducing of the amounts of waste and follow up the national waste plan to increase the nations recycling rate.

The main goal of using recycled materials in products was creating new business opportunities. This was followed by the firm's strategic goals are supporting the principles of the circular economy, implementing resource efficiency through more thorough use of existing resources, the customers are wanting more products manufactured according to sustainable development principles and expectations of national legislation and policies to change firm's business practices. By assessing these factors through research and development, production processes and company policies, the firms can respond to the market demand, as well keeping up with the competition and making long term business decisions for being able to operate in national and global markets. The firms will also be able to gain a competitive advantage against the competitors who neglect prior findings.

6.3 Assessment of the research

While using a quantitative online survey as basis of the research, it became clear that the questions and answer options should be as precise as possible, so that respondents would not misunderstand them, and could answer as truthfully as possible. There's a concern that, while answering the survey rapidly, some respondents have misunderstood or misread the phrases, or were not familiar with the terms used in the survey. This should not distort the received data much since the survey was thoroughly tested with face-to-face interviews before sending it to the respondents. In this type of survey, there is also a flaw that gathering additional information is not possible. While open-ended answer options were used in some questions, the specific reason for respondent choosing a specific answer option for each question remains unclear. Therefore, it was essential that the survey was constructed by professionals at CITER -research team and 6Aika project team. While the response rate of 7,04 % may seem low, there were 186 responses received, and most of the respondents were in the target group. It can be said that the validity of the data is appropriate.

Mapping the material side streams with the highest potential from a business perspective in quantitative survey assess few problems. As the materials were pre-defined, rating the side streams gives only a limited amount of information on business potential. Again, the information of why the respondents rated the materials side streams as they did, remains unclear. There are different reasons why respondents may have chosen the answer options they did. Possible reasons are that the material side stream price is so high that it should be exploited, the specific material side stream is collected in plenty and availability is high, or the material poses a high environmental risk and needs to be processed for further use. The survey cannot respond to these questions, nor to the fact how the material should be exploited to gain the maximum business potential.

6.4 Further research

The study raised several questions and research on these topics would bring valuable information on circular economy business opportunities, as well as on reducing the environmental impact of many waste side streams.

The circular economy hubs in both, Finland and worldwide are gaining popularity as sustainable industrial areas where firms and other actors are co-operating and creating working synergies. It is important to establish a clear definition of circular economy hubs through research, as well as explore the real economic, social and environmental benefits of these industrial areas. By doing this, it would be possible to develop even more effective areas and unleash the full potential of circular economy business in Finland. The research on this field would also help to justify the usefulness of the areas to governmental organizations as well as to other key actors in the circular economy field to relocate their activities to the circular economy hub area.

While writing the literature review section of this study, it was clear that there was a lack in the current research in exploiting the different material side streams from an economic point of view. These would be important topics to cover, and by doing this, the clear picture of the market value of recycled material side streams would be established, and the real cost of processing the waste materials to secondary materials known. The processing methods are continuously developed and knowledge on the field is increasing, therefore it is important to make the cost analysis also, to gain the complete picture of exploiting possibilities of the materials.

REFERENCES

Achat, D. L. *et al.* (2014) 'Plant-availability of phosphorus recycled from pig manures and dairy effluents as assessed by isotopic labeling techniques', *Geoderma*. doi: 10.1016/j.geoderma.2014.04.028.

Bellantuono, N., Carbonara, N. and Pontrandolfo, P. (2017) 'The organization of eco-industrial parks and their sustainable practices', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2017.05.082.

Blahuskova, V., Vlcek, J. and Jancar, D. (2019) 'Study connective capabilities of solid residues from the waste incineration', *Journal of Environmental Management*. doi: 10.1016/j.jenvman.2018.10.112.

Bryman, A. and Bell, E. (2015) *Business Research Methods*. 4th edn. New York: Oxford University Press.

Business Tampere (2017) *Hankehakemus 303586 - 6AIKA: Tulevaisuuden kiertotalouskeskukset*.

Chertow, M. (2000) 'Industrial Symbiosis: Literature and Taxonomy', *Annual review of energy and the environment*. doi: 10.1016/j.wasman.2008.06.036.

CircHubs (2017) *CircHubs*. Available at: https://circhubs.fi (Accessed: 4 February 2019).

Creswell, J. W. (2003) *Research Design - Qualitative, Quantitative, and Mixed Methods Approaches*. 2nd edn. Thousand Oaks, London, New Delhi: Sage Publications, Inc.

Cucchiella, F. *et al.* (2015) 'Recycling of WEEEs: An economic assessment of present and future e-waste streams', *Renewable and Sustainable Energy Reviews*. doi: 10.1016/j.rser.2015.06.010.

Dias, P., Bernardes, A. M. and Huda, N. (2019) 'Ensuring best E-waste recycling practices in developed countries: An Australian example', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2018.10.306.

Dobbs, R. *et al.* (2013) *Resource revolution: Tracking global commodity markets*. Available at: https://www.mckinsey.com/business-functions/sustainability/our-insights/resource-revolution-tracking-global-commodity-markets.

ECO3 (2018) *ECO3 – Älykäs ja ekologinen*. Available at: http://www.eco3.fi (Accessed: 6 February 2019).

Ellen MacArthur Foundation (2013a) *Towards the Circular Economy Vol. 1: Economic business rationale for an accelerated transition*, *Ellen MacArthur Foundation*. doi: 10.1162/108819806775545321.

Ellen MacArthur Foundation (2013b) *Towards The Circular Economy Vol. 2: Opportunities for the consumer goods sector*, *Ellen MacArthur Foundation*. doi:

10.1162/108819806775545321.

Ellen MacArthur Foundation (2015a) ‘Delivering the Circular Economy: A Toolkit for Policymakers’, *Ellen MacArthur Foundation*.

Ellen MacArthur Foundation (2015b) *Towards a Circular Economy : Business Rationale for an Accelerated Transition*, *Greener Management International*. doi: 2012-04-03.

Eskelinen, H. *et al.* (2016) *Muovien kierrätyksen tilanne ja haasteet*. Helsinki. Available at: https://www.syke.fi/download/noname/%7B5903968F-2B4E-4BEA-BC45-099C7D210D36%7D/117935.

Esmeray, E. and Atıs, M. (2019) ‘Utilization of sewage sludge, oven slag and fly ash in clay brick production’, *Construction and Building Materials*. doi: 10.1016/j.conbuildmat.2018.10.231.

Esteves, E. M. M. *et al.* (2019) ‘Life cycle assessment of manure biogas production: A review’, *Journal of Cleaner Production*, 219, pp. 411–423. doi: https://doi.org/10.1016/j.jclepro.2019.02.091.

European Commision (2015) ‘An EU action plan for the circular economy’, *Com*, 614, p. 21. doi: 10.1017/CBO9781107415324.004.

European Commission (2008) ‘Directive 2008/98/EC of the European Parliament and of the Council of 19 november 2008 on waste and repealing certain directives’, *Journal of the European Union*. doi: 2004R0726 - v.7 of 05.06.2013.

Faraca, G., Martinez-Sanchez, V. and Astrup, T. F. (2019) ‘Environmental life cycle cost assessment: Recycling of hard plastic waste collected at Danish recycling centres’, *Resources, Conservation and Recycling*, 143, pp. 299–309. doi: https://doi.org/10.1016/j.resconrec.2019.01.014.

Fernandez, V. (2017) ‘Rare-earth elements market: A historical and financial perspective’, *Resources Policy*. doi: 10.1016/j.resourpol.2017.05.010.

Fiksel, J. (2003) ‘Designing Resilient, Sustainable Systems’, *Environmental Science and Technology*. doi: 10.1021/es0344819.

Finlex (2011) *Jätelaki 646/2011*, *Lainsäädäntö*. Available at: http://www.finlex.fi/fi/laki/alkup/2011/20110646 (Accessed: 21 August 2018).

Frosch, R. A. and Gallopoulos, N. E. (1989) ‘Strategies for Manufacturing Waste from one industrial process can serve as the raw materials for another, thereby reducing the impact of industry on the environment’, *Scientific American*. doi: 10.1038/scientificamerican0989-144.

Gaia Consulting Oy (2017) *Tulevaisuuden yrityspuisto - Loppuraportti selvitystyöstä seutukaupungeille*. Available at: http://sek.suupohja.fi/images/seutu-ohjelma/Tulevaisuuden yrityspuisto - loppuraportti %28julkaistu%29 18.9.2017.pdf.

Ghisellini, P., Cialani, C. and Ulgiati, S. (2016) ‘A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems', *Journal of Cleaner Production*, pp. 11–32. doi: 10.1016/j.jclepro.2015.09.007.

Gibbs, D. and Deutz, P. (2007) 'Reflections on implementing industrial ecology through eco-industrial park development', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2007.02.003.

Halonen, N. and Seppänen, M. (2019) 'Eco-Industrial Parks', in Leal Filho, W. et al. (eds) *Responsible Consumption and Production*. Cham: Springer International Publishing, pp. 1–13. doi: 10.1007/978-3-319-71062-4_5-1.

Han, W. *et al.* (2018) 'Ecological and health risks assessment and spatial distribution of residual heavy metals in the soil of an e-waste circular economy park in Tianjin, China', *Chemosphere*. doi: 10.1016/j.chemosphere.2018.01.043.

Heeres, R. R., Vermeulen, W. J. V and De Walle, F. B. (2004) 'Eco-industrial park initiatives in the USA and the Netherlands: First lessons', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2004.02.014.

Hein, A. M. *et al.* (2015) 'A Conceptual Framework for Eco-Industrial Parks', in *Volume 4: 20th Design for Manufacturing and the Life Cycle Conference; 9th International Conference on Micro- and Nanosystems*. doi: 10.1115/DETC2015-46322.

Helenius, J. (2018) *Lapista mallia Kiinan kiertotalouden kehittämiselle - 'Tavoitteena globaalin mallin luominen'*, *Sekes ry*. Available at: https://www.sekes.fi/lapista-mallia-kiinan-kiertotalouden-kehittamiselle-tavoitteena-globaalin-mallin-luominen/ (Accessed: 7 February 2019).

Hole, G. and Hole, A. S. (2019) 'Recycling as the way to greener production: A mini review', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2018.12.080.

Hölzle, I. (2018) 'Dry screening – Assessing the effectiveness of contaminant reduction in recovered landfill soils', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2017.11.225.

Hölzle, I. (2019) 'Analysing material flows of landfill mining in a regional context', *Journal of Cleaner Production*, 207, pp. 317–328. doi: https://doi.org/10.1016/j.jclepro.2018.10.002.

HSY (2018) *Ekomo – Ämmässuon ekoteollisuuskeskus*. Available at: https://www.hsy.fi/fi/asiantuntijalle/jatehuolto/jatteenkasittelykeskus/Sivut/default.aspx (Accessed: 24 January 2019).

Invest in Finland (2018) *Finnish Lemene Smart Energy System – A Unique Implementation in the World*. Available at: https://www.investinfinland.fi/-/finnish-lemene-smart-energy-system-a-unique-implementation-in-the-world (Accessed: 4 February 2019).

Jackson, M., Lederwasch, A. and Giurco, D. (2014) 'Transitions in Theory and Practice: Managing Metals in the Circular Economy', *Resources*. doi: 10.3390/resources3030516.

Jätelaitoisyhdistys ry (2016) *Kiertotalouskeskukset nousevat Pirkanmaalle*.

Available at: http://vanha.jly.fi/tiedote.php?tiedote2_id=556.

Jones, P. T. *et al.* (2013) ‘Enhanced Landfill Mining in view of multiple resource recovery: A critical review’, *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2012.05.021.

Jowitt, S. M. *et al.* (2018) ‘Recycling of the rare earth elements’, *Current Opinion in Green and Sustainable Chemistry*. doi: 10.1016/j.cogsc.2018.02.008.

Kalliosaari, K. (2017) ‘Kangasalan uusi kiertotalousalue Tarastenjärvelle – Tuo jopa satoja työpaikkoja’, *Aamulehti*. Available at: https://www.aamulehti.fi/uutiset/kangasalan-uusi-kiertotalousalue-tarastenjarvelle-tuo-jopa-satoja-tyopaikkoja-200408202.

Karisto, E. (2017) ‘Ämmässuo 30 vuodessa kaatopaikasta ekoteollisuuskeskukseksi’, *Kuntalehti*. Available at: https://kuntalehti.fi/uutiset/tekniikka/ammassuo-30-vuodessa-kaatopaikasta-ekoteollisuuskeskukseksi/.

Kemin kaupunginhallitus (2017) *Vireillä olevia ajankohtaisia asioita 4/00.02.01/2017*.

Khwairakpam, M. and Bhargava, R. (2009) ‘Vermitechnology for sewage sludge recycling’, *Journal of Hazardous Materials*. doi: 10.1016/j.jhazmat.2008.04.088.

Kieckhäfer, K., Breitenstein, A. and Spengler, T. S. (2017) ‘Material flow-based economic assessment of landfill mining processes’, *Waste Management*. doi: 10.1016/j.wasman.2016.06.012.

Kiertokaari Oy (2019) *Kiertokaari - kestävän kiertotalouden edistäjä*. Available at: https://kiertokaari.fi (Accessed: 7 February 2019).

Kiiski, T. (2018) ‘Tampereen Hiedanrannassa toimii jättimäinen kuivakäymälä – teollisuushallissa on jo nyt tehty ekohistoriaa’, *Aamulehti*. Available at: https://www.aamulehti.fi/a/200959686.

Kilkis, B. (2012) ‘Net-zero energy cities: A hub for decentralized energy for better environment’, *International Journal of Energy Research*. doi: 10.1002/er.1917.

Kirchherr, J., Reike, D. and Hekkert, M. (2017) ‘Conceptualizing the circular economy: An analysis of 114 definitions’, *Resources, Conservation and Recycling*. doi: 10.1016/j.resconrec.2017.09.005.

Kissling, R. *et al.* (2012) ‘Definition of generic re-use operating models for electrical and electronic equipment’, *Resources, Conservation and Recycling*. doi: 10.1016/j.resconrec.2012.04.003.

Kissling, R. *et al.* (2013) ‘Success factors and barriers in re-use of electrical and electronic equipment’, *Resources, Conservation and Recycling*. doi: 10.1016/j.resconrec.2013.07.009.

Krook, J., Svensson, N. and Eklund, M. (2012) ‘Landfill mining: A critical review of two decades of research’, *Waste Management*. doi: 10.1016/j.wasman.2011.10.015.

Lahden Ammattikorkeakoulu (2017) *Kohti kiertotaloutta*. Available at: https://www.kohtikiertotaloutta.fi (Accessed: 7 February 2019).

Lai, Y.-Y. *et al.* (2016) 'Management and Recycling of Construction Waste in Taiwan', *Procedia Environmental Sciences*. doi: 10.1016/j.proenv.2016.07.077.

Lapin liitto (2018) *Euroopan komissio on valinnut Lapin mallialueeksi - maakunta on noussut klusteritoiminnan edelläkävijäksi koko Euroopan Unionissa*. Available at: http://www.lappi.fi/lapinliitto/ajankohtaista/sisalto/-/view/416475 (Accessed: 7 February 2019).

Leach, K. A. *et al.* (2015) 'Recycling manure as cow bedding: Potential benefits and risks for UK dairy farms', *The Veterinary Journal*, 206(2), pp. 123–130. doi: https://doi.org/10.1016/j.tvjl.2015.08.013.

Leal Filho, W. *et al.* (2019) 'A review of the socio-economic advantages of textile recycling', *Journal of Cleaner Production*, 218, pp. 10–20. doi: https://doi.org/10.1016/j.jclepro.2019.01.210.

Lempäälän energia (2018) *Lemene*. Available at: http://www.lempaalanenergia.fi/content/fi/1/20126/LEMENE.html (Accessed: 4 February 2019).

Littlewood, D. C. and Kiyumbu, W. L. (2018) '"Hub" organisations in Kenya: What are they? What do they do? And what is their potential?', *Technological Forecasting and Social Change*, 131, pp. 276–285. doi: https://doi.org/10.1016/j.techfore.2017.09.031.

Lounais-Suomen Jätehuolto Oy (2017a) *Mikä on Topinpuisto*. Available at: https://www.topinpuisto.fi/info/ (Accessed: 21 January 2019).

Lounais-Suomen Jätehuolto Oy (2017b) *Vuosikatsaus*. Available at: https://lsjh.e-julkaisu.fi/vuosikatsaus2017/ (Accessed: 21 January 2019).

Lounais-Suomen Ympäristökeskus (2009) *Etelä- ja Länsi-Suomen jätesuunnittelu - Taustaraportti - Tuhkat ja kuonat*. Available at: https://www.ymparisto.fi/download/noname/%7B5B065099-7562-4D60-A785-12877BE196A9%7D/93080.

Lowe, E. A. (1997) 'Creating by-product resource exchanges: Strategies for eco-industrial parks', *Journal of Cleaner Production*. doi: 10.1016/S0959-6526(97)00017-6.

Magnier, L., Mugge, R. and Schoormans, J. (2019) 'Turning ocean garbage into products – Consumers' evaluations of products made of recycled ocean plastic', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2018.12.246.

Martín Gómez, A. M., Aguayo González, F. and Marcos Bárcena, M. (2018) 'Smart eco-industrial parks: A circular economy implementation based on industrial metabolism', *Resources, Conservation and Recycling*. doi: 10.1016/j.resconrec.2017.08.007.

Matsuura, Y. and Miura, O. (2016) 'Fundamental Study for Resource Recovery from Urban Mine by Magneto-Archimedes Effect', *IEEE Transactions on Applied*

Superconductivity. doi: 10.1109/TASC.2016.2547878.

Meadows, Donella, Meadows, Dennis and Randers, J. (2004) *Limits to Growth - The 30-Year Update*. Chelsea Green Publishing Company.

Mikkelin kaupunginhallitus (2018) *Pöytäkirja*. Available at: http://mikkeli.cloudnc.fi/download/noname/%7Ba65cf163-305e-4f5a-939a-f8d45f7499fa%7D/63242.

Milios, L. *et al.* (2018) 'Plastic recycling in the Nordics: A value chain market analysis', *Waste Management*, 76, pp. 180–189. doi: https://doi.org/10.1016/j.wasman.2018.03.034.

Milmo, S. (2016) 'EU sites aid move to circular economy', *ICIS Chemical Business*, 298(7), p. 2.

Motiva (2015) *FISS - Teolliset symbioosit toimintamalli Suomessa*. Available at: https://www.teollisetsymbioosit.fi (Accessed: 26 April 2019).

Motiva (2019) *Motiva ja YM: Materiaalitorilla tavataan – etsi ja ilmoita jätteet, sivuvirrat ja palvelut uudella digitaalisella alustalla*, *Tiedotteet 2019*. Available at: https://www.motiva.fi/ajankohtaista/tiedotteet/2019/motiva_ja_ym_materiaalitorilla_tavataan_-_etsi_ja_ilmoita_jatteet_sivuvirrat_ja_palvelut_uudella_digitaalisella_alustalla.14023.news (Accessed: 25 April 2019).

Murray, A., Skene, K. and Haynes, K. (2017) 'The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context', *Journal of Business Ethics*. doi: 10.1007/s10551-015-2693-2.

Nokian kaupunki (2019) *Kolmenkulma Eco-Industrial Park*. Available at: https://kolmenkulma.fi (Accessed: 4 February 2019).

Nygård, H. (2015) *Polttava kysymys, Orikedon jätteenpolttolaitos ja yhdyskuntajätehuollon kehitys Suomen Turussa*. Turun seudun jätehuolto oy.

Nygård, H. (2016) *Kuopasta kiertotalouteen, Suomen yhdyskuntajätehuollon historia*. Jätelaitosyhdistys ry.

Oesch, H. (2018) *Tarasten Kiertotalousalue Oy*. Available at: http://circhubs.fi/wp-content/uploads/2018/03/Taraste-Tamperetalo_HarriOesch.pdf.

Ongondo, F. O., Williams, I. D. and Whitlock, G. (2015) 'Distinct Urban Mines: Exploiting secondary resources in unique anthropogenic spaces', *Waste Management*. doi: 10.1016/j.wasman.2015.05.026.

Van Passel, S. *et al.* (2013) 'The economics of enhanced landfill mining: Private and societal performance drivers', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2012.03.024.

Pirkanmaan jätehuolto Oy (2018) *100 ympäristötekoa - kiertotalouskeskuksissa materiaalit ja yhteistyö virtaavat*. Available at: http://pjhoy.fi/Yhtio/100kiertotalouskeskukset.

Pirkanmaan Solid Waste Management Limited (2019) *Pirkanmaan Jätehuolto Oy*. Available at: http://pjhoy.fi (Accessed: 6 February 2019).

Potting, J. *et al.* (2017) 'Circular Economy: Measuring innovation in the product chain - Policy report', *PBL Netherlands Environmental Assessment Agency*.

Prendeville, S., Cherim, E. and Bocken, N. (2018) 'Circular Cities: Mapping Six Cities in Transition', *Environmental Innovation and Societal Transitions*. doi: 10.1016/j.eist.2017.03.002.

Regional Council of Southwest Finland (2019) *Maakunnat*, *Suomen maakunnat*. Available at: https://www.varsinais-suomi.fi/fi/maakunta/maakunnat (Accessed: 8 February 2019).

Reinikainen-Laine, S. (2017) 'Yrittäjät ja päättäjät - ajatuksia kier-to-ta-lou-des-ta', *Kaleva*. Available at: https://www.kaleva.fi/ppy/yrittajat-ja-paattajat-ajatuksia-kiertotaloudesta/779866/.

Romero, E. and Ruiz, M. C. (2014) 'Proposal of an agent-based analytical model to convert industrial areas in industrial eco-systems', *Science of the Total Environment*. doi: 10.1016/j.scitotenv.2013.08.049.

Sadat-Shojai, M. and Bakhshandeh, G. R. (2011) 'Recycling of PVC wastes', *Polymer Degradation and Stability*. doi: 10.1016/j.polymdegradstab.2010.12.001.

Sariatli, F. (2017) 'Linear Economy Versus Circular Economy: A Comparative and Analyzer Study for Optimization of Economy for Sustainability', *Visegrad Journal on Bioeconomy and Sustainable Development*. doi: 10.1515/vjbsd-2017-0005.

Saunders, M., Lewis, P. and Thornhill, A. (2016) *Research Methods for Business Students*. 7th edn. Essex: Pearson Education Limited.

Scarlat, N. *et al.* (2018) 'A spatial analysis of biogas potential from manure in Europe', *Renewable and Sustainable Energy Reviews*. doi: 10.1016/j.rser.2018.06.035.

Silva, R. V. *et al.* (2017) 'Use of municipal solid waste incineration bottom ashes in alkali-activated materials, ceramics and granular applications: A review', *Waste Management*. doi: 10.1016/j.wasman.2017.06.043.

Silva, R. V. *et al.* (2019) 'Environmental impacts of the use of bottom ashes from municipal solid waste incineration: A review', *Resources, Conservation and Recycling*. doi: 10.1016/j.resconrec.2018.09.011.

Sitra (2017) *Käytetty muovi uusioraaka-aineeksi*. Available at: https://www.sitra.fi/caset/kaytetty-muovi-uusioraaka-aineeksi/ (Accessed: 9 May 2019).

Song, H. *et al.* (2011) 'Empirical study of coal industry circular economy park', in *International Conference on Management and Service Science, MASS 2011*. doi: 10.1109/ICMSS.2011.5998691.

Song, X. *et al.* (2018) 'Social network analysis on industrial symbiosis: A case of Gujiao eco-industrial park', *Journal of Cleaner Production*. doi:

10.1016/j.jclepro.2018.05.058.

Sorvoja, A.-K. (no date) *OPPORTUNITIES FOR YOUR COMPANY AT KOLMENKULMA ECO-INDUSTRIAL PARK*, *Kolmenkulma*. Available at: https://kolmenkulma.fi/en/eco-industrial-park/opportunities-for-your-company-at-kolmenkulma-eco-industrial-park.

Stahel, W. R. (2013) 'Policy for material efficiency - Sustainable taxation as a departure from the throwaway society', *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*. doi: 10.1098/rsta.2011.0567.

Stahel, W. R. (2016) 'The Circular Economy', *Nature*. doi: 10.1038/531435a.

Suárez-Eiroa, B. *et al.* (2019) 'Operational principles of Circular Economy for Sustainable Development: Linking theory and practice', *Journal of Cleaner Production*. doi: https://doi.org/10.1016/j.jclepro.2018.12.271.

Sun, Z. *et al.* (2016) 'Recycling of metals from urban mines - A strategic evaluation', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2015.10.116.

Swain, N. and Mishra, S. (2019) 'A review on the recovery and separation of rare earths and transition metals from secondary resources', *Journal of Cleaner Production*. doi: https://doi.org/10.1016/j.jclepro.2019.02.094.

Tampereen kaupunki (2017) *Väliaikainen Hiedanranta*. Available at: https://valiaikainenhiedanranta.fi (Accessed: 7 February 2018).

Tampereen kaupunki (2019) *Hiedanranta*. Available at: https://www.tampere.fi/asuminen-ja-ymparisto/kaupunkisuunnittelu-ja-rakentamishankkeet/hiedanranta.html (Accessed: 6 February 2019).

Tanninen, J. (2015) 'Tampereella jälleen vanha teollisuusalue asunnoiksi', *Yle*. Available at: https://yle.fi/uutiset/3-8020935.

Teknologiateollisuus (2016) *Sähkö- ja elektroniikkaromu on kultakaivos*. Available at: https://teknologiateollisuus.fi/fi/ajankohtaista/uutiset/sahko-ja-elektroniikkaromu-kultakaivos (Accessed: 9 May 2019).

The Treasury of Australian Government (2011) *Commodity price volatility, Economic Roundup Issue 1,2011*. Available at: https://treasury.gov.au/publication/economic-roundup-issue-1-2011/economic-roundup-issue-1-2011/commodity-price-volatility/ (Accessed: 15 February 2019).

The World Bank (2019) *World Bank national accounts data - GDP 2000-2010 (current US$)*. Available at: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?end=2010&start=2000 (Accessed: 14 February 2019).

Tilastokeskus (2019a) *Käsitteet*. Available at: https://www.stat.fi/meta/kas/index.html (Accessed: 25 June 2019).

Tilastokeskus (2019b) *Yhdyskuntajätekertymä 2017*. Available at: https://www.stat.fi/til/jate/2017/13/jate_2017_13_2019-01-09_tau_001_fi.html

(Accessed: 15 May 2019).

Ueda, K., Nishino, N. and Oda, S. H. (2003) 'Integration of economics into engineering with an application to the recycling market', *CIRP Annals - Manufacturing Technology*. doi: 10.1016/S0007-8506(07)60524-1.

United Nations, Department of Economic and Social Affairs, P. D. (2017) 'The World Population Prospects: The 2017 Revision', *World Population Prospects The 2017*. doi: 10.1017/CBO9781107415324.004.

United Nations (2016) *Goal 12: Ensure sustainable consumption and production patterns*.

UPM (2019) *Läpimurto tuhkan kierrätyksessä*. Available at: https://www.upm.com/fi/ajankohtaista/artikkelit/2019/05/lapimurto-tuhkan-kierratyksessa/?fbclid=IwAR3yoCPOsd4xZSgzV-_14PtFHHFJ9OykTN52418ICgFx4J42ngJfF96pG3k (Accessed: 15 May 2019).

UPM and Yara (2018) *Kierrätysravinnepohjaisten lannoitevalmisteiden kehittämienn ja käyttökokeilu - loppuraportti*. Available at: https://www.ym.fi/download/noname/%7B9C575F26-26F5-45F9-9D56-CDC95CE7BE8A%7D/143307.

Valtioneuvosto (2015) *Programme of Prime Minister Sipilä's Government*. Available at: http://valtioneuvosto.fi/en/sipila/government-programme.

Valtioneuvosto (2018) *Jätteiden ja sivuvirtojen sähköinen markkinapaikka - hanke*. Available at: https://valtioneuvosto.fi/hanke?tunnus=YM016:00/2018 (Accessed: 24 April 2019).

Varsinais-Suomen Liitto (2017) *Varsinais-Suomen materiaalivirtojen potentiaali kiertotalouden näkökulmasta*. Available at: https://www.varsinais-suomi.fi/images/tiedostot/Tietopankki/Julkaisut/2017/V-S-materiaalivirtojen-potentiaali.pdf.

World Bank Group (2017) *An International Framework for Eco-Industrial Parks*. Available at: https://openknowledge.worldbank.org/handle/10986/29110.

World Bank Group (2018) *Commodity Markets Outlook - Oil Exporters: Policies and Challenges*. Washington DC. Available at: http://pubdocs.worldbank.org/en/271041524326092667/CMO-April-2018-Full-Report.pdf.

Yang, Z. *et al.* (2018) 'Recycling of municipal solid waste incineration by-product for cement composites preparation', *Construction and Building Materials*. doi: 10.1016/j.conbuildmat.2017.12.081.

Yle (2017) *Vastuullinen kuluttaminen lisääntyy, mutta suurinta osaa kiinnostaa eniten hinta ja helppous*. Available at: https://yle.fi/uutiset/3-9930079 (Accessed: 22 May 2019).

Ympäristöhallinto (2017) *YIT Infra Oy:n Kiilan kiertotalouskeskus, Vantaa*. Available at: https://www.ymparisto.fi/KiilankiertotalouskeskusYVA (Accessed: 7 February 2019).

Ympäristöministeriö (2014) *Rakentamisen materiaalitehokkuuden edistämisohjelma*. Helsinki. Available at: http://hdl.handle.net/10138/135172.

Ympäristöministeriö (2015) *Jätemäärien ennakointi vuoteen 2030*. Helsinki. Available at: https://helda.helsinki.fi/handle/10138/155189.

Ympäristöministeriö (2017) *Valtakunnallinen jätesuunnitelma vuoteen 2023*. Helsinki. Available at: https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/79699/SY_03_2017.pdf.

Ympäristöministeriö (2018a) *Kierrätyksestä kiertotalouteen - Valtakunnallinen jätesuunnitelma vuoteen 2023*. Helsinki. Available at: http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/160441/SY_01_18_FI_Kierratyksesta_kiertotalouteen.pdf.

Ympäristöministeriö (2018b) *Puhdistamoliete – nyt!* Helsinki. Available at: https://www.ym.fi/download/noname/%7B059832A4-E06F-43C4-AA08-B96669A148EF%7D/136830.

Yuan, Z., Bi, J. and Moriguichi, Y. (2006) 'The circular economy: A new development strategy in China', *Journal of Industrial Ecology*. doi: 10.1162/108819806775545321.

Zeng, X. *et al.* (2017) 'A simplified method to evaluate the recycling potential of e-waste', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2017.06.232.

Zeng, X. and Li, J. (2016) 'Measuring the recyclability of e-waste: An innovative method and its implications', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2016.05.055.

Zhou, C. *et al.* (2015) 'A cost-benefit analysis of landfill mining and material recycling in China', *Waste Management*. doi: 10.1016/j.wasman.2014.09.029.

Zhou, X. L. (2015) 'Development and Utilization of Circular Economy and Urban Mining - Chengdu City Based Renewable Resource Industry Survey', *Applied Mechanics and Materials*, 768(June 2015), pp. 644–651. doi: http://dx.doi.org.libproxy.tut.fi/10.4028/www.scientific.net/AMM.768.644.

ATTACHMENT A: SURVEY

6Aika - Tulevaisuuden kiertotalouskeskukset - kysely

1. Mitä tahoa organisaationne edustaa?

1. Yritys
2. Kunta
3. Valtio
4. Järjestö tai säätiö
5. Koulutusorganisaatio tai tutkimuslaitos
6. Joku muu

2. Millä alalla organisaationne pääasiassa toimii?

1. Valmistavassa tuotannossa
2. Palvelualalla
3. Molemmissa edellisistä
4. Materiaalien tai aineiden prosessointi

3. Miten tuttu kiertotalous on sinulle käsitteenä?

1. En ole kuullut kiertotaloudesta ennen tätä kyselyä
2. Olen kuullut kiertotaloudesta, mutta en tiedä tarkalleen mitä kaikkea se pitää sisällään
3. Olen kuullut kiertotaloudesta ja tunnen sen periaatteet jollain tasolla
4. Olen kuullut kiertotaloudesta ja tunnen sen periaatteet tarkasti
5. Kiertotalous on minulle tuttu opintojeni tai työni kautta

4. Mikä on organisaationne suhde kiertotalouskeskuksiin?

1. Emme toimi missään kiertotalouskeskuksessa, eikä asia koske meitä
2. Emme toimi missään kiertotalouskeskuksessa tällä hetkellä, mutta olemme kiinnostuneita asiasta
3. Emme toimi kiertotalouskeskuksessa, mutta toimintamme linkittyy kiertotalouskeskusverkostoihin
4. Toimimme kiertotalouskentällä, mutta toimintamme ei sijoitu fyysisiin kiertotalouskeskuksiin tai liity niiden toimintaan
5. Toimimme jo kiertotalouskeskuksen alueella ja teemme yhteistyötä alueen toimijoiden kanssa
6. En osaa sanoa

5. Miten tärkeinä näette seuraavat sivuvirrat liiketoiminnan luomisen kannalta?

Arvioi asteikolla 1-5: Merkitykseltään vähäinen - Erittäin tärkeä

Tekstiilijäte
Korjaus- ja purkukohteiden uudelleenkäyttöön soveltuvat rakennusosat (mm. ovet, elementit)
Rakennusjäte: eristevillat (mm.lasivilla)
Muovit: banderollimuovit (mm. suuret mainokset ja julisteet, viirit)
Muovit: PVC
Muovit: muu muovi
SER/Elektroniikkajäte
Maametallit
Haja-asutusalueilla syntyvä sako- ja umpikaivoliete
Jätevedenpuhdistamoilla syntyvä liete
Lanta, Kuitusaviliete

Maamassat: öljyllä pilaantunut maa
Maamassat: savimaa
Jätteenpolton tuhkat ja kuonat
Lasikuitu, Huonekalujen osat
Ajoneuvojen osat ja varusteet
Mikäli sopivaa vaihtoehtoa ei löydy, voit lisätä kenttään uuden sivuvirran 1...
Mikäli sopivaa vaihtoehtoa ei löydy, voit lisätä kenttään uuden sivuvirran 2…
Mikäli sopivaa vaihtoehtoa ei löydy, voit lisätä kenttään uuden sivuvirran 3…

6. Missä määrin näet seuraavien haasteiden haittaavan kierrätysmateriaalien käyttöä tuotteissa?

Arvioi asteikolla 1-5: Ei ollenkaan - Erittäin paljon

Osaamisen tai tiedon puute
Materiaalin kallis hinta
Materiaalin huono saatavuus
Materiaalin huono soveltuvuus käyttökohteisiin
Perinteisen materiaalin korvaavaa kierrätysmateriaalia ei olemassa
Tuotannon prosessien kallis hinta, Materiaalista valmistetuilla tuotteilla ei kysyntää markkinoilla
Materiaalit heikosti uudelleen kierrätettäviä
Uudelleen kierrätyksen mahdollistavien palveluiden puute

7. Miten näet seuraavien tekijöiden edistävän siirtymistä kohti kiertotaloudella toteutettua liiketoimintaa?

Arvioi asteikolla 1-5: Ei ollenkaan - Erittäin paljon

Liiketoiminnan vakauttaminen (luonnonresurssien hintojen vaihtelulta suojautuminen)
Kustannussäästöjen toteuttaminen yrityksen toiminnassa,
Uusien liiketoimintamahdollisuuksien luominen
Yrityksen strategiset tavoitteet tukevat kiertotalouden periaatteita
Resurssitehokkuuden toteuttaminen (olemassa olevien resurssien säästäväisempi käyttö)
Asiakkaat haluavat kestävän kehityksen periaatteiden mukaan valmistettuja tuotteita
Nykyiset työntekijät vaativat kestävän kehityksen mukaista liiketoimintaa
Kilpailijat panostavat kestävään kehitykseen ja yrityksen pysyttävä mukana kilpailussa
Lakien ja säädösten tai politiikan odotukset yrityksen toimintatapojen muuttamiselle
Nykyiseen tuotantoon tarvittavien materiaalien vähäinen
saatavuus
Arvoketjun muiden toimijoiden tiukemmat vaatimukset
Omistajien vaatimukset laajemman arvon lisäämiselle(enemmäin kuin liiketoiminnasta saadut voitot)
Uusien työntekijöiden houkutteleminen yritykseen
Asiakkaat valmiita maksamaan enemmän kestävän kehityksen periaatteella valmistetusta tuotteesta
Organisaation toimiluvan pitäminen edellyttää sitä

8. Mitä sivuvirtoja organisaatiossanne syntyy? (Valitse yksi tai useampi vaihtoehto)

Tekstiilijäte
Korjaus- ja purkukohteiden uudelleenkäyttöön soveltuvat rakennusosat (mm. ovet, elementit)
Rakennusjäte: puu
Rakennusjäte: eristevillat (mm. lasivilla)
Muovit: banderollimuovit (mm. suuret mainokset- ja julisteet, viirit)
Muovit: PVC
Muovit: muu muovi
SER/Elektroniikkajäte
Maametallit
Haja-asutusalueilla syntyvä sako- ja umpikaivoliete

Jätevedenpuhdistamoilla syntyvä liete
Lanta
Kuitusaviliete
Maamassat: öljyllä pilaantunut maa
Maamassat: savimaa
Jätteenpolton tuhkat ja kuonat
Lasikuitu
Huonekalujen osat
Ajoneuvojen osat ja varusteet
Mikäli sopivaa vaihtoehtoa ei löydy, voit lisätä kenttään uuden sivuvirran 1...
Mikäli sopivaa vaihtoehtoa ei löydy, voit lisätä kenttään uuden sivuvirran 2...
Mikäli sopivaa vaihtoehtoa ei löydy, voit lisätä kenttään uuden sivuvirran 3...

9. Miten mahdollisena näette, että voisitte käyttää toisen yrityksen tuottamaa sivuvirtaa omassa liiketoiminnassanne kehittäessänne uusia tuotteita?

1. Ei ollenkaan mahdollisena
2. Ei kovinkaan mahdollisena
3. Ei mahdollisena, muttei mahdottomanakaan
4. Mahdollisena
5. Erittäin mahdollisena
6. En osaa sanoa

10. Miten mahdollisena näette, että toinen yritys voisi käyttää teidän yrityksenne tuottamaa sivuvirtaa hyödyksi omassa liiketoiminnassaan?

1. Ei ollenkaan mahdollisena
2. Ei kovinkaan mahdollisena
3. Ei mahdollisena, muttei mahdottomanakaan
4. Mahdollisena
5. Erittäin mahdollisena
6. En osaa sanoa

11. Oletteko selvittäneet sivuvirtojen hyödyntämistä liiketoiminnassanne niin, etteivät ne päätyisi jätteiksi?

1. Emme ole selvittäneet asiaa, eikä sitä ole suunnitelmissakaan
2. Emme ole selvittäneet asiaa, mutta koemme selvittämisen tärkeäksi
3. Olemme tehneet selvityksiä asiasta, emmekä näe syytä jatkotoimenpiteisiin
4. Olemme tehneet selvityksiä asiasta ja toimintamallia on muutettu selvityksestä saatujen tietojen perusteella
5. En osaa sanoa

12. Oletteko pohtineet kierrätettävien materiaalien tai aineiden käyttöä tuotteissanne?

1, Ei missään tuoteportfoliossa
2. Yhdessä tuotteessa
3. Alle puolessa suunnitelluista tuotteista
4. Yli puolista suunnitelluista tuotteista
5. Kaikissa tuotteissa
6. En osaa sanoa

13. Kuka hyödyntää sivuvirtojanne tällä hetkellä? (Valitse yksi tai useampi vaihtoehto)

1. Yritys itse, omassa tuotannossaan
2. Toinen yritys tuotannossaan
3. Kierrätykseen erikoistunut yritys
4. Paikallinen jätehuolto
5. En osaa sanoa

14. Mitä teette sivuvirroille tällä hetkellä?

1. Oma käyttö
2. Myynti satunnaiselle asiakkaalle
3. Kierrätys siihen erikoistuneen yrityksen kautta
4. Poltto energiaksi
5. Toimitus jätteen käsittelyyn
6. En osaa sanoa
7. Mikäli edellisistä vaihtoehdoista ei löytynyt sopivaa, lisää uusi vaihtoehto tähän

15. Miten tärkeänä organisaationne tuotesuunnittelussanne pidetään seuraavia kiertotalouden periaatteita?

Arvio asteikolla 1-5, Merkitykseltään tarpeeton - Erittäin tärkeä

Tuotteiden käyttöiän pidentäminen
Tuotteeseen käytettävien materiaalien määrän vähentäminen
Tuotteiden uusiokäyttö
Tuotteiden helppo kierrätettävyys
Tuotteiden huollettavuus ja korjattavuus
Tuotteiden komponenttien uudelleenkäytettävyys esim. uudelleenvalmistuksessa.

16. Mainitse kolme asiaa, jotka voisivat edistää sitä, että hyödyntäisitte toisten yritysten sivuvirtoja omassa liiketoiminnassanne. (Vastaa lyhyesti omin sanoin alla olevaan tekstikenttään.)

17. Minkälaisia uusia liiketoimintamahdollisuuksia uskotte sivuvirtojen hyödyntämisen yrityksellenne tarjoavan, esimerkiksi tuotekehityksen tai palveluliiketoiminnan puolella? (Vastaa lyhyesti omin sanoin alla olevaan tekstikenttään.)

18. Mielestäni organisaatiollamme on riittävästi tietoa tarjolla olevista mahdollisuuksista uusiutuvan energian käytölle lämmön ja sähkön tuotannossa.

1. Olen täysin eri mieltä
2. Olen osittain eri mieltä
3. En ole eri mieltä, mutten ole samaakaan mieltä
4. Olen osittain samaa mieltä
5. Olen täysin samaa mieltä

19. Mikä on seuraavien energialähteiden merkitys organisaatiollenne?

Arvioi asteikolla 1-5: Merkitykseltään vähäinen - Erittäin tärkeä

Tuotannossa syntynyt hukkalämpö
Alueella tuotettu biokaasu
Aurinko tai tuulivoimalla tuotettu sähköenergia
Puuhakkeella tuotettu energia
Yleinen kaukolämpöverkko
Yleisestä sähköverkosta saatu energia (ei väliä tuotantomuodolla)

20. Mistä sivuvirrasta sinulla on eniten tietoa ja miksi juuri tästä? (Vastaa lyhyesti omin sanoin alla

olevaan tekstikenttään.)

21. Miten tärkeänä näet seuraavat syyt, miksi sivuvirtaa ei kannata hyödyntää tuotannossa?
Arvioi asteikolla 1-5: Merkitykseltään vähäinen - Erittäin tärkeä

Ei tarvetta sivuvirtojen hyödyntämiselle tuotteissa
Hankintahinta on liian kallis
Sivuvirta on epäpuhdasta
Sivuvirran poiskuljetuksesta saa riittävän maksun
Sivuvirtaa syntyy liian pieniä määriä ollakseen hyödynnettävissä tuotannossa
Tarvittavat investointitarpeet sivuvirran käsittelyyn liian korkeat
Mikäli edellisistä vaihtoehdoista ei löytynyt sopivaa, lisää uusi vaihtoehto tähän

22. Miten tärkeänä näet seuraavat sivuvirtojen jatkokäsittelyvaihtoedot?
Arvioi asteikolla 1-5: Merkitykseltään vähäinen - Erittäin tärkeä

Sivuvirrat käytetään itse yrityksen toiminnassa
Myydään sivuvirrat niitä tarvitsevalle yritykselle
Myydään sivuvirrat satunnaiselle asiakkaalle
Kierrätetään sivuvirrat siihen erikoistuneen yrityksen yrityksen kautta
Poltetaan sivuvirrat energiaksi

23. Mitkä seuraavista toimijoista pystyvät mielestäsi parhaiten edistämään yritysten välistä sivuvirtojen hyödyntämistä? (Valitse yksi tai useampi vaihtoehto)

1. Yritysverkostot
2. Jätehuoltoalan toimijat
3. Kaupunki tai kunta
4. Oppilaitokset
5. Alueelliset elinkeino- ja kehitysyhtiöt (Business Tampere, Turku Science Park jne)
6. En osaa sanoa

24. Mikä mielestäsi on seuraavien kiertotalouskeskuksen tehtävien merkitys yritystoiminnan tukena?
Arvioi asteikolla 1-5: Merkitykseltään vähäinen - Erittäin tärkeä

Toimivien synergioiden(yhteistyön) rakentaminen eri toimijoiden välille
Tiedon välittäminen alueella olevien toimijoiden välillä
Alustan(paikan) luominen yritystoiminnan pilotoinneille (kokeiluillle)
Kiertotalouden tunnetuksi tuominen sidosryhmille, sekä aiheesta kiinnostuneille
Tilojen tarjoaminen alueella toimiville yrityksille
Digitaalisten palvelujen tuottaminen toimijoiden toiminnan tueksi
Uusiomateriaalien toimittajana toimiminen
Mikäli edellisistä vaihtoehdoista ei löytynyt sopivaa, lisää uusi vaihtoehto tähän

25. Miten tärkeänä näet seuraavien osa-alueiden kehittämisen kiertotalouskeskuksissa, jotta ne tukisivat yritysten tarpeita paremmin?
Arvioi asteikolla 1-5, Merkitykseltään vähäinen - Erittäin tärkeä

Läpinäkyvyys yritysten tuottamista ja tarvitsemista materiaaleista ja muista sivuvirroista
Kommunikointi alueella toimivien yritysten välillä
Yritysten määrän lisäys kierotalouskeskus-alueella
Kiertotalouskeskuksen infrastruktuuri (tiet, sähköverkot jne)
Kiertotalouskeskusalueen sisäinen liikenne
Digitaaliset alustat(ohjelmistot), jotka ovat kiertotalouskeskuksen toimijoiden käytössä

Mikäli edellisistä vaihtoehdoista ei löytynyt sopivaa, lisää uusi vaihtoehto tähän

26. Miten tärkeänä näet seuraavat ominaisuudet alla mainitussa sähköisessä markkinapaikassa?

Arvioi asteikolla 1-5: Merkitykseltään vähäinen - Erittäin tärkeä

Markkinapaikalla on yksittäinen taho, joka sitä hallinnoi. Yritysten tulee olla tähän tahoon yhteydessä, mikäli he tarvitsevat/tarjoavat sivuvirtoja.
Markkinapaikalla ei ole kaupankäyntiin vaikuttavaa yksittäistä tahoa, vaan yritykset käyvät suoraan kauppaa keskenään.
Sivuvirtoja tarjoavien/tarvitsevien yritysten tiedot ovat kaikkien nähtävillä
Sivuvirtoja tarjoavien/tarvitsevien yritysten tiedot eivät ole julkisia, vaan ne ovat ainoastaan markkinapaikkaa hallinnoivat tahon nähtävillä
Sivuvirtojen tyyppi ja määrä ovat kaikkien nähtävillä
Sivuvirtojen tyyppi ja määrä eivät ole julkisia, vaan ne ovat ainoastaan markkinapaikkaa hallinnoivan tahon nähtävillä

27. Sopiiko sinulle, että otamme yhteyttä ja tiedustelemme tarkemmin sivuvirtoihinne liittyviä asioita?

1. Kyllä
2. Ei

28. Onko teillä tarvetta palveluille, joissa selvitetään liiketoiminnan luontia sivuvirtoja hyödyntämällä?

1. Ei ollenkaan tarvetta
2. Jollain tasolla tarvetta
3. Pidän tarvetta jollain tasolla mahdollisena
4. Tarve palvelulle on olemassa
5. Erittäin suuri tarve palvelulle

29. Mitä toimialaa organisaationne edustaa? (Vastaa lyhyesti omin sanoin alla olevaan tekstikenttään)

30. Mikä on organisaationne henkilöstömäärä?

1. 1-9 henkilöä
2. 10-49 henkilöä
3. 50-249 henkilöä
4. 250 henkilöä tai enemmän

31. Minkä kaupungin alueella päätoimipaikkanne sijaitsee?

1. Espoo
2. Helsinki
3. Oulu
4. Tampere
5. Turku
6. Vantaa
7. Mikäli edellisistä vaihtoehdoista ei löytynyt sopivaa, lisää uusi vaihtoehto tähän

32. Mikä toimenkuvasi on organisaatiossanne?

1. Päätöksenteko ja johtaminen
2. Suunnittelu
3. Tuotanto, rakentaminen ja laitteiden valmistus
4. Asiantuntijan tehtävät

5. Ylläpito ja huolto
6. Tutkimus ja koulutus
7. Viestintä ja markkinointi
8. Mikäli edellisistä vaihtoehdoista ei löytynyt sopivaa, lisää uusi vaihtoehto tähän

33. Haluatko osallistua arvontaan, jossa arvomme kyselyyn vastanneiden kesken kaksi kappaletta kotimaisen Helsieni Oy:n GROW KIT –tuotetta? Mikäli vastaat kyllä, tarvitsemme yhteystietosi mahdollista palkinnonjakoa varten.

1. Kyllä
2. Ei

34. Syöttämällä tietosi voimme ottaa teihin tarvittaessa yhteyttä

Etunimi
Sukunimi
Yritys / Organisaatio
Sähköposti
Puhelin
Postitoimipaikka