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School of Engineering Science
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EVALUATING ALTERNATIVE WAYS TO PROMOTE RECYCLING AND CIRCULARITY IN ST. PETERSBURG'S WASTE MANAGEMENT

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ABSTRACT

Lappeenranta-Lahti University of Technology LUT
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Waste Management, Municipal Solid Waste, Recycling, Circular Economy, Citizen science, Sustainability

This thesis aims to support the AWARE project and find sustainable ways to engage citizens to recycle and promote the sustainability in St. Petersburg. Waste management is an important worldwide issue and very critical as almost 33% of annual Municipal Solid Waste (MSW) is not managed in an environmentally safe way. Current estimates highlight that 2.0 billion tons of MSW are globally generated per year. Globally, the most common way to handle MSW is still dumping or disposing the waste to landfills. There is significant potential in waste recovery as approximately 75% of waste in Europe and central Asia could be recovered and utilized with the right processes. As the amount of waste increases and the fossil fuel reserves are exploited to meet the energy demand, it is important to focus on efficient waste management and promote Circular Economy. The importance of circular economy and recycling is also acknowledged as the usage of secondary materials and recycling limits the needs of primary materials and resources.

This thesis analyzes global recycling case examples and the current waste management status in St. Petersburg. The thesis provides recommendations on models that could be imported into Russian context. This thesis provides an overview of St. Petersburg's waste management status using available literature and industry reports. The status is further validated with selected experts. Literature review of circular economy and a benchmark of two successful digital citizen science projects are provided. Already commercialized recycling and circularity related examples are also presented. Finally, recommendations will be provided for the AWARE project on how to engage consumers to recycle in the current setting.

Sustainability and circularity have been widely acknowledged over the past years. At the same time the amount of waste is increasing globally as well as locally in Russia. Without proper waste management strategy and processes, materials are not efficiently circulating and there is inefficient use of resources and unwanted environmental impact due to poor waste management. The social aspect of increasing waste and sustainability related awareness in St. Petersburg is important and initiatives like AWARE Project have an important role in promoting these topics. Increasing the awareness, providing easy access to recycling and engaging the citizens to decision making are good ways to increase the recycling activities.

TIIVISTELMÄ

Lappeenrannan-Lahden teknillinen yliopisto LUT
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Tuotantotalouden koulutusohjelma

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ERI KIERRÄTYS- JA KIERTOTALOUSHALLIEN ARVIOIMINEN PIETARIN JÄTTEENKÄSITTELYSSÄ

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Tämän diplomityön tarkoituksena on analysoida ja tutkia kestäviä tapoja, jotka voivat innostaa kaupunkilaisia kierrättämään Pietarissa. AWARE Projekti voi hyödyntää tämän diplomityön löydöksiä. Maailmalla syntyy noin kaksi miljardia tonnia kotitalousjätettä vuosittain. Arviolta lähes 33 prosenttia vuotuisesta jätteestä käsitellään ympäristölle harmillisella tavalla. Yleinen tapa käsitellä jätteitä maailmanlaajuisesti on niiden vieminen kaatopaikoille. Jäteprosesseja kannattaisi kehittää ja jätettä tulisi hyödyntää paremmin myös raaka-aineena. Ennusteiden mukaan lähes 75 % Euroopan ja keski-Aasian jätteestä voitaisiin hyödyntää. Jätteen määrän sekä fossiilisten polttoaineiden käytön kasvaessa, olisi hyvä keskittyä tehokkaaseen jätehuoltoon. Kiertotalouden ja kierrätyksen tärkeys onkin tunnustettu viime aikoina, varsinkin kun kyseessä on tehokkaammat hyödyntää resurssien käyttöä.

Tässä diplomityössä keskitytään Pietarin jätehuollon tilanteeseen, analysoidaan globaaleja kierrätysesimerkkejä ja tämän pohjalta annetaan suosituksia malleista, jotka voitaisiin implementoida Venäjällä. Tässä työssä analysoidaan Pietarin jätehuollon tilaa käytettävissä olevan kirjallisuuden ja raporttien avulla. Tilanteesta keskustellaan tämän jälkeen asiantuntijoiden kanssa. Työssä on myös kirjallisuuskatsaus kiertotaloudesta ja analyysi kahdesta hyväksi todetusta ”citizen science” projektista. Työssä tutkitaan kaupallistettuja kierrätysesimerkkejä, jotka osaltaan edistävät kiertotaloutta. Näiden elementtien seurauksena AWARE Projektille annetaan suosituksia siitä, miten kaupunkilaiset voitaisiin motivoida kierrättämään, ottaen huomioon jätehuollon nykytilanteen.

Kestävyyteen ja kiertotalouteen liittyvät teemat ovat saaneet paljon huomioita viime vuosien aikana. Samalla varsinkin kotitalousjätteen määrä on kasvanut globaalisti, mutta myös paikallisesti Venäjällä. Jotta käytössä olevat resurssit voidaan hyödyntää mahdollisimman tehokkaasti ja ympäristöystävällisesti, on tärkeää huolehtia tarvittavista jätestrategioista ja –prosesseista. Jätteisiin liittyvän tietoisuuden lisääminen on tärkeää ja organisaatioilla, kuten AWARE Project, on tärkeä rooli. Tietoisuuden lisääminen, kierrätyksen saatavuuden helpottaminen ja kansalaisten sitouttaminen päätöksentekoon ovat hyviä tapoja lisätä kierrätystoimintaa.

FOREWORDS

Little did I know about waste management before starting one seminar work with my friend Petra in October 2019. One year later, I can be proud of myself after completing my thesis regarding the waste management. Thank you, Petra, for reminding me on how to study after a long break.

Ari Happonen was supervising our seminar work and I will always remember the sentence “Paskasta kultaa” as he described the global waste management status and opportunities within the industry. After the seminar work with Petra I have individually continued to study the waste management topic, mainly remotely from Hong Kong. I am so thankful for all the supervising and guidance I have received during the year 2020 from Ari. I’m 100% sure there is no professor like Ari. He is always available, always helping and so humble. So, thank you so much Ari! Thank you also Ville Ojanen for being the first supervisor of this thesis. Also, I would like to take this opportunity to thank three interview participants who contributed to this thesis.

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11.11.2020

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ABBREVIATIONS

AI	Artificial Intelligence
AWARE	Against Waste: Activate Research and Education
CE	Circular Economy
CSR	Corporate Social Responsibility
EU	European Union
G7 countries	Canada, France, Germany, Italy, Japan, the UK, and the US
HSY	Helsinki Region Environmental Services Authority
LUT	Lappeenranta-Lahti University of Technology LUT
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
USA	United States of America
WtE	Waste to Energy

1 INTRODUCTION

Waste management industry growth follows the trends of general economic development. Consumption and production increase together with economic growth translating into increased amount of waste and trash. Thus, it has been argued that the current economic growth in many markets leads to attractive opportunities in municipal solid waste (MSW) business. (Sjöström & Östblom, 2010) (Rogoff & Screve, 2012) Current technological solutions are being adopted in the waste management industry. For example, Artificial intelligence (AI) can boost the circularity of new products (Ghoreishi & Happonen, 2019a) (Ghoreishi & Happonen, 2019b), which in turn could reduce the effects of waste generation, based on the reality of economic growth.

MSW recycling rates differ around the world. The global leaders are Germany, Austria, South Korea and Wales. These countries recycle approximately 52 – 67 % of their MSW. These countries have government policies supporting recycling making it easy for citizens to recycle. In general, different regulations and consumer awareness have transformed waste management industry towards more sustainable approach (Eriksson, et al., 2005). The recycling rate in Finland is approximately 42% (Eurostat, 2020). Majority of the remaining waste is going to heat and energy production through incineration process, which are improved to be more sustainable through technology investments (Auvinen et al. 2020) and finally only 1% of waste is going to landfills (Yle, 2019). Based on the numbers, Finland has 7th best position in the Global Waste Index 2019 ranking (Sensoneo, 2019). However, there are many countries without sufficient waste management and recycling practices. For example, the recycling rate in Russia is relatively low and Russia's waste management industry is comparable with developing countries. Eurostat does not provide recycling rate data for Russia. However, based on Suomalais-Venäläinen Kauppakamari's study (2019a), Russia's MSW recovery rate is very low and approximately 93 – 97 % of MSW is transported to the landfills. This means that only around 5 – 7 % of the MSW is being recycled in Russia. (Eunomia, 2017)

This study focuses on generic motivational sources on how to engage citizens in different communities with different initiatives. Already commercialized and successful circularity and recycling related case examples and models will be studied and finally, recommendations will be given for the AWARE Project on the most potential models that could be ideologically implemented in the St. Petersburg. This first chapter introduces the importance of the topic, goal setting and structure of the research.

1.1 Background

Solid waste related research and studies have increased. Bibliometric study by Fu et al. (2010) estimated that the number of solid waste related articles in 2013 would be double the number of articles in 2008. The bibliometric study highlighted that the main research fields have been in environmental science and environmental engineering. Often, the studies have been focusing on the basic waste management methods, such as recycling, landfilling, composting and Waste to Energy (WtE). During 1993 – 2008, the developed group of seven (G7) countries produced approximately 50% of the articles and the US was contributing the most in the independent and international cooperation articles. However, when comparing number of articles produced by country, China had major increase in their numbers and produced more articles in 2008 than the US. (Fu, et al., 2010)

More recent bibliometric study focused on municipal solid waste management (MSWM) in circular economy. The study utilized a database of 413 published articles. The outcome of the study proposes that in the future five of the following themes will be studied: incineration, life cycle assessment, plastic waste, sorting of solid waste and sustainability. This is also valid information when implementing waste management related practices. From the geographical point of view, Africa and North America are continents where MSWM and CE are not yet that widely studied compared to other continents. (Tsai, et al., 2020)

Waste management is an important worldwide issue. Urban waste management is expensive but very crucial as almost 33% of annual MSW is not managed in an environmentally safe way. Current estimates indicate that 2.0 billion tons of MSW are generated per year globally and the estimate is that by 2050 the amount will increase to 3.4 billion tons as highlighted in Figure 1 Projected Global Waste Generation (The World Bank, 2018). Another interesting indication is the amount of waste generated per person per day which is on average 0.7 kilogram (kg). However, it differs from 0.1 to 4.5 kg depending on the country. High income countries tend to have higher waste amounts. (The World Bank, 2018)

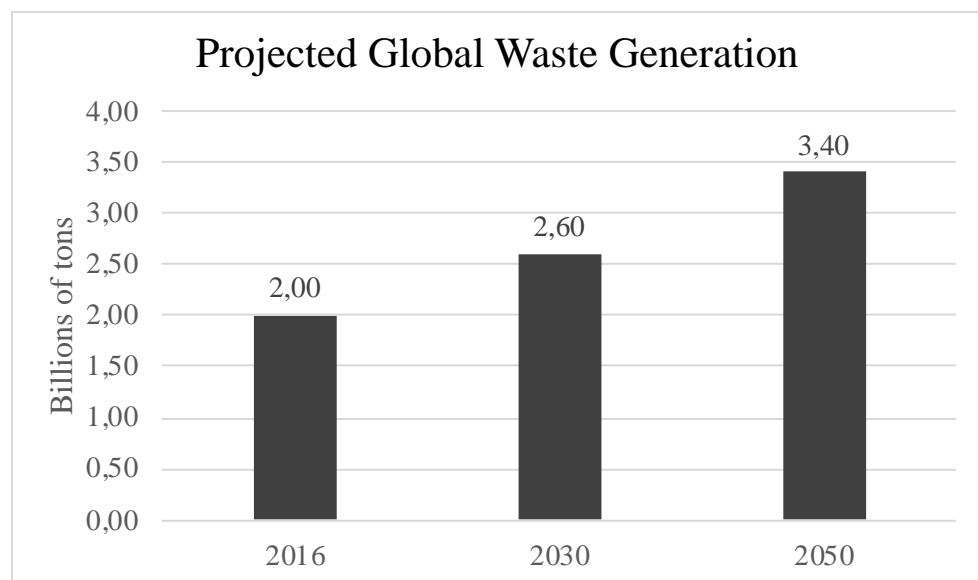


Figure 1 Projected Global Waste Generation (The World Bank, 2018)

Globally, the most common way to handle MSW is still dumping or disposing waste to landfills. There is significant potential in waste recovery, it has been estimated that 75% of waste in Europe and central Asia could be recovered and utilized with the right processes. The recovery rate is currently only around 30%. Part of the waste management is also collection and transportation of the waste. Approximately 96 % of the waste is collected in Europe and Central Asia. However, there is a difference between cities with collection rate of 96% and rural areas with the collection rate of only 55%. The main waste collection method is door-to-door collection. If waste is not correctly collected, it could lead to environmental issues and further have impact on public health. Waste industry requires a lot of manpower

in different parts of the lifecycle. Table 1 summarizes the key municipal solid waste management information from different regions. (The World Bank, 2018) The information provided represents averages. Within the regions, there might be variation country by country. Russia is part of the “Europe & Central Asia” region. However, more detailed analysis on St. Petersburg’s waste management will be given in chapter 2 as the focus of this thesis is to understand the current waste management status in St. Petersburg’s and to provide recommendations on how to engage citizens in promoting circularity and recycling.

Table 1 Regional MSW Management Information (The World Bank, 2018)

	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	North America	South Asia	Sub-Saharan Africa
Amount of waste in 2016 (mm tons)	468	392	231	129	289	334	174
Average amount of waste per capital per day (kg)	56	1,18	0,99	0,81	2,21	0,52	0,46
Waste composition	53% organic waste 30% dry recyclables	36% organic waste 31% dry recyclable	52% organic waste 30% dry recyclable	58% organic waste 30% dry recyclables	55 % recyclables 28% organic waste	57% organic waste	43% organic waste 30% inert waste
Average Waste collection coverage	71 %	90 %	85 %	90 %	99,7 %	44 %	44 %
Most common waste disposal methods	landfilling (45%) incineration (24%) open dumping (18%)	open dumping (26%) landfilling (20%) incineration (18%)	sanitary landfilling (52%) open dumping (27%) controlled landfilling (15%)	open dumping (53%) controlled landfilling (14%) sanitary landfilling (11%)	sanitary landfilling (54%) recycling (33%) incineration (12%)	open dumping (75%) composting (16%)	open dumping (69%) landfilling (23%)
Recycling rate	9 %	20 %	4,5 %	9 %	33 %	5 %	6 %
Development initiatives	Source-separation & recycling	Waste collection solutions, disposal site construction, closure of open dumps	Evaluating WtE technologies	Reducing food waste, high income countries exploring WtE technology	Advanced technology	Implementing policies, development of sanitary landfills & evaluating recycling possibilities	Building the waste infrastructure

As the amount of waste increases and the fossil fuel reserves are exploited to meet the energy demand, it is important to focus on efficient waste management. Waste management industry has developed towards more modern and sustainable direction. The importance of recycling is also acknowledged as the usage of secondary materials and recycling limit the needs of primary materials and

resources. Not only the amount of waste is increasing but also the complexity and content of the waste is changing. There are different methods to treat waste in an efficient way. Countries are in different phases of waste management and recycling and are looking for solutions to solve the waste management related issues. This leads to the fact that more tailor-made solutions are needed in order to reach the set waste management goals and targets. (Brunner & Rechberger, 2015)

To address the challenge described above, efforts have been made to create a wide range of technical, ideological and structural models. One of these models is Circular economy (CE), that tries to holistically tie technologies, processes and operating models. The concept of circular economy is gaining wider interest particularly in Europe. European Commission has published CE action plan to support the agenda of sustainable growth. The action plan has both legislative and non-legislative actions for the targeted areas. (European Commission, 2020) It is important to evaluate how waste generation could be minimized and waste streams could be utilized as a source of secondary materials. So, the focus is shifting from waste disposal to holistic waste management. Circular economy highlights the environmental benefits and is a good concept for understanding the different recycling options, practices and technologies. It is essential to keep the resources circulating. (Halkos & Petrou, 2016)

This thesis will study the current waste management status in St. Petersburg, analyze global recycling case examples and provide recommendations on models that could be imported into Russian context. There are different kinds of experiments to make general public more knowledgeable about different waste and society challenge related problems and to allow them to join to civic activities to help in these challenges (Palacin-Silva, et al., 2019). Also, a lot of research effort has been put into studies on how to boost recycling activity in different society classes. One particular case example is young students using gamification-based software application that targets to educate and inspire students to recycle more (Santti, et al., 2019).

1.2 Objectives and scope

The purpose of this study is to analyze global recycling case examples and the current waste management status in St. Petersburg in order to provide recommendations on models that could be imported into Russian context to promote circularity and to increase recycling awareness. LUT University is part of the three-dimension Russia AWARE (Against Waste: Activate Research and Education) Project. The purpose of the AWARE Project is to offer sustainable waste management knowledge and expertise for Russian educators and higher education students as waste management is an important issue to be solved. The project aims to increase the “environmental awareness of residents, university teachers, researches, students, administrator and businessmen”. There have been studies on most efficient waste facilities and more technical topics in a collaboration with the AWARE project. However, the potential migration of already commercialized and working models that are promoting the circularity and recycling, especially from the areas that are close to Russia, have not yet been studied. The AWARE project has five prioritized focus areas and goals. This thesis aims to support the AWARE project and find new and sustainable ways to engage consumers to recycle in Russia. The purpose of this study has a close connection to the focus point number two “Improved capacity of Finnish and especially young Russian students to seek and cease business opportunities in the area of waste management, recycling and re-purposing of materials, others might consider as waste.” (AWARE Project / ResearchGate, 2020)

The expected outcome of this thesis is to provide case examples and material for the AWARE project that can be utilized in their activities, such as the Winter Camp university courses for Russian students in 2021. In more detailed, the agreed objectives with the AWARE project are:

- 1) Gather and analyze the current waste management status and underlying structures in St. Petersburg

- 2) Utilizing global context and best practices to evaluate people's motivations for recycling and how to potentially engage Russian citizen to recycle

The main research question of this thesis is:

1. What are the means, methods and ways based on circular economy and citizen participation to increase the individual consumers' recycling awareness in St. Petersburg?

The sub research questions of this thesis are:

1. Based on public literature and reports, what is the current waste management and recycling status in St. Petersburg?
2. What are the waste reduction related success factors based on the circular economy and citizen participation?
3. Based on the current waste situation and global recycling and models, what are the most promising models that can be imported to Russian context?

As highlighted before, waste management practices might differ between cities and rural areas. Therefore, the first limitation is that this study will focus only on St. Petersburg that is part of the Leningrad region, and is the most important city for the AWARE project. Therefore, the waste management outlook focuses on this particular area and recommendations are given with this limitation in mind. Second limitation is that the focus of this study is only on MSW which is the main waste citizens generate. MSW is defined by European Union's (EU) Landfill Directive as "waste from households, as well as other waste which, because of its nature or composition, is similar to waste from households." In short, MSW refers to general trash or garbage which consists of items that are disposed by consumers. It includes durable goods, non-durable goods, containers and packaging and other waste of which many could be recycled. (Addiss, 2018) From MSW, often easy and most

valuable to recycle are metal, paper, glass and plastic. Final limitation is that this study leaves political aspects aside.

1.3 Research methodology

To secure a comprehensive and interesting study, the idea of this thesis is to conduct analysis for each sub research question in a dedicated chapter and then analyze and summarize the findings in the discussion chapter. The aim is to provide answer to the first sub-research question by providing a brief outlook of St. Petersburg area's current waste management status. In this section, articles and different literature sources will be combined and qualitatively analyzed as it is difficult to obtain accurate data on Russia's waste management practices. The outcome of this part is validated by conducting interviews with carefully selected specialists. More detailed information about the interview process and the key findings will be provided in section 2.2. Additionally, the outcome of waste management status and results from the interview will be analyzed and summarized in section 2.3.

The second sub-research question will be answered with a literature review. The theoretical framework of this study focuses on circular economy and citizen science. First, the circular economy will be studied as it is a current topic and a comprehensive theme promoting recycling and efficient use of resources. Literature review is selected as a research method in order to provide an overview of the existing waste management status considering the lack of reliable data. The literature review process is described in chapter 3.1. The findings of the review will be utilized in other parts of this thesis in order to combine and provide a meaningful recommendation for the AWARE project on how to motivate recycling in order to answer the first research question. Chapter 3.2. focuses on the motivational aspect related to consumers' sustained participation in digital citizen science projects. Benchmarking of two successful case studies will be utilized.

In order to provide an answer to the third sub research question, an analysis and benchmark of already commercialized recycling related cases will be conducted.

The focus of this section will mainly be on Finnish cases. However, a few global state-of-the art case examples will be selected in order to give inspirational material for the AWARE project. The findings of this part can be utilized in the upcoming “waste crash course” called Winter Camp that the AWARE project will conduct in the beginning of 2021 for university students in St. Petersburg.

After analyzing and answering the sub-research questions, the findings will be analyzed and combined in the discussion part as a meaningful recommendation for the AWARE project. A product vision board template will be utilized as a part of the recommendations in order to provide some visual material for the AWARE Project.

1.4 Structure of the thesis

This thesis has six chapters as illustrated in the Figure 2. Chapter two will provide an overview of St. Petersburg and Leningrad region’s waste management. Chapter three provides the theoretical background of circular economy and motivational drivers of consumers’ recycling habits. Fourth chapter analyses the existing recycling case studies. Fifth chapter is for the discussion and finally, sixth chapter summarizes the thesis.

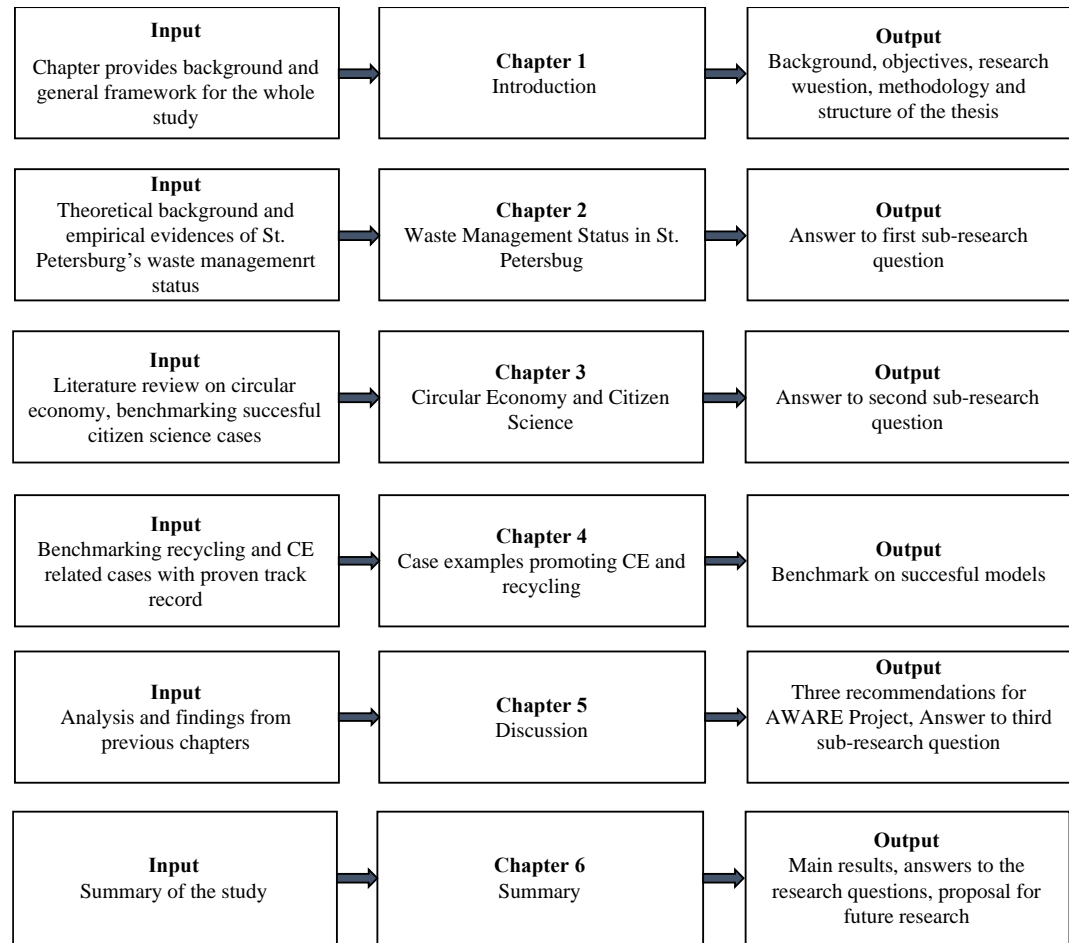


Figure 2 Structure of the thesis

2 WASTE MANAGEMENT IN ST. PETERSBURG

Purpose of this chapter is to provide a brief outlook on St. Petersburg waste management status. Chapter 2.1 focuses on available literature and chapter 2.2 is based on the AWARE Project specialists' interviews.

2.1 A review based on publicly available material

Based on public documents, Russia's MSW recovery rate is very low and approximately 93 – 97 % of MSW is transported to the landfills. This means that only around 5 – 7 % of the MSW is recycled (Suomalais-Venäläinen Kauppakamari, 2019b). As comparison, EU Member states have MSW recovery rate on average of 60%. The existing waste management processes are inefficient as resources are not used in an efficient way and it leads to unwanted environmental effects. As existing landfills are reaching their limits, MSW disposal capacity needs to be doubled without proper strategy to improve the waste management practices. The EU Member States have strategic focus on sustainability focused waste management practices. The highlighted themes of EU Members States are 1) access to quality waste management services 2) safe MSW treatment 3) recovery of valuable resources 4) limiting the use of raw materials when possible. It is worthwhile noticing that the urban areas in Russia are comparable with the EU Member States when benchmarking the population, density, industry and business. The themes mentioned above should also be prioritised focus areas in Russia's waste management strategy. Naturally, this translates into large investments into the waste management industry as multiple improvements should be made. (IFC, 2012)

Approximately 70 million tons of MSW is generated annually in Russia. The amount of MSW rises on average 3 – 5 % per year. Majority (ca 95%) of the MSW is disposed to landfills or even in some cases to illegal dumps. It has been evaluated that almost 30 % of the current landfills are not operated in a way that would fulfil the sanitary requirements. This is because majority of the existing landfills have

been operational for more than 20 years (IFC, 2012). As the amount of waste increases annually, new landfills are required, and 0.4 million hectares of land is assigned as new landfill areas. If Russia's waste management processes continue without any changes, there is a risk of ecocatastrophe and other unwanted environmental and health related effects. (Fedotkina, et al., 2019)

Clearly, more efficient waste management would be beneficial for Russia and MSW management sector will be an attractive and expanding industry in the near future. It is good to acknowledge that only approximately 30% of the sector is operated by private companies and majority of these private companies are serving small dedicated areas. The two highlighted problems in Russia's waste industry are administrative and financial issues. The ongoing waste reform is briefly explained in the latter part of this section. However, when analysing potential business opportunities within the waste industry in Russia, these obstacles should be carefully evaluated. The role of end-users (citizens) should not be underestimated. The support from citizens is key to success when implementing new waste management related projects in Russia. In general, public awareness should be increased and chapter 3 focuses on this area from circularity point of view. (IFC, 2012)

St. Petersburg, one of the major industrial hubs, is the second largest city in Russia after Moscow. The population of St. Petersburg is approximately 6.9 million. Economic growth has led to increased amount of MSW and approximately 1,5 million tons of MSW is generated in St. Petersburg. In total, approximately 2,0 million tons of MSW is generated when combining the St. Petersburg and Leningrad region's numbers. Figure 3 illustrates the forecasted MSW amount until 2025. There are 10 landfill areas around the St. Petersburg and more than 70% of the MSW is disposed to surrounding landfill sites. 75% of MSW is generated by household sector and 25% generated by commercial. In general, there is not separated waste material collection for consumers available. North-Western part of Russia has been identified as a major source of pollution around Baltic Sea. The key waste management challenges in St. Petersburg are poor handling and storage

of waste as well as extensive transportation distances. (Nakata & Rodionov, 2011)
(South-East Finland - Russia CBC Programme, 2015)

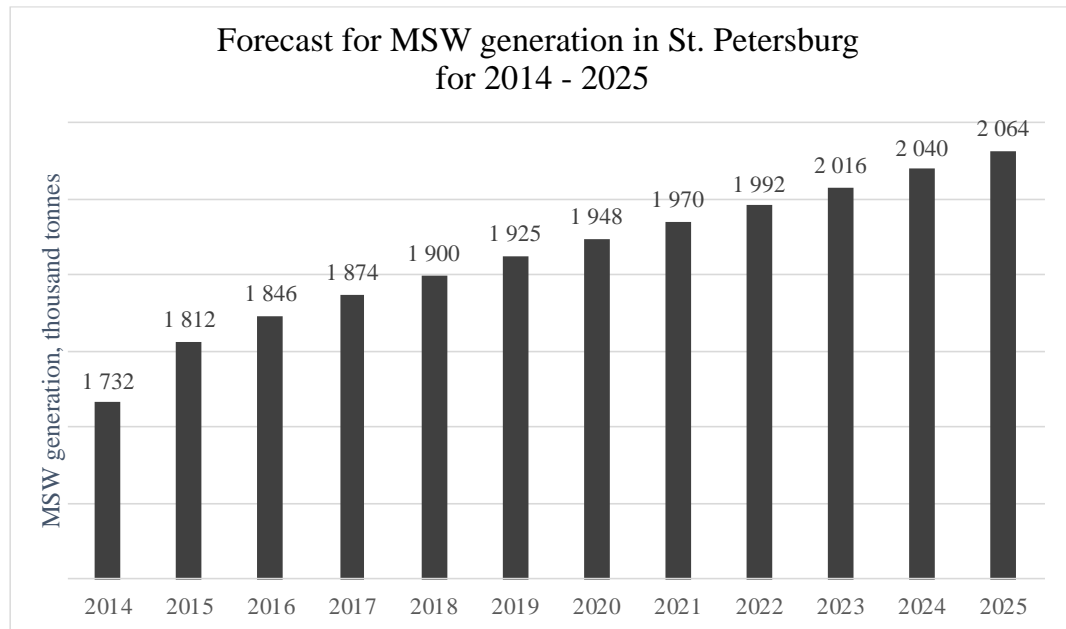


Figure 3 Estimation of MSW Generation in St. Petersburg (Woima Corporation, 2020)

Chusov, A. et al. (2018) studied waste management in the St. Petersburg area and faced the issue that there were no current data available from the composition of MSW. Hence, they analysed the average morphological composition of MSW in St. Petersburg in 2000 and resulted with estimated composition of MSW in 2016, which is represented in Figure 4 below.

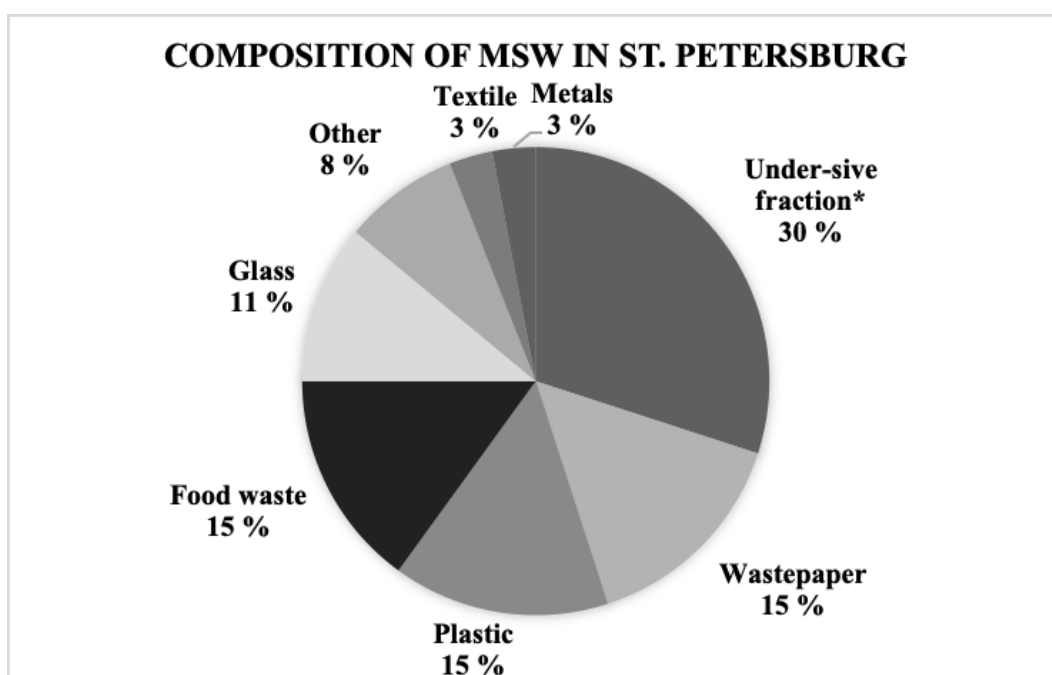


Figure 4 Composition of MSW in St. Petersburg Adapted from Chusov, A et al., 2018.

*mixture of dust, sweepings, gravel, food wastes, plastic and paper particles that could not be sorted manually

The domination fraction of the composition of MSW is under-sieve fraction which represents minor (less than 8 cm) pieces of trash which is a mixture of dust, sweepings, gravel, food wastes, plastics and paper particles that could not be separated manually. The following fractions are wastepaper (15%), food waste (15%), plastic (15%), and glass (11%).

Majority of the MSW is collected into the standard containers of varied capacity. Approximately 40% of the houses that are built between 1950 and 1980 have the garbage chute. St Petersburg has two-stage transportation of MSW where the first step is to gather the MSW from containers into larger containers and then transport it to waste facility. Ideally, approximately 70-75% of the generated MSW could be recycled into marketable components. Recycling would decrease the need of new landfills and also some of these components could potentially be profitable for later use. However, the key issue with processing the potential secondary resources is the combined waste collection and transportation of MSW as one fraction group may harmfully impact the quality of the other. So, for example if paper becomes

contaminated by biowaste, it is no longer that valuable secondary resource. (Chusov, et al., 2018)

MSW collection and transportation is conducted by multiple different private companies. Some estimates propose that 53 different companies are somehow involved in these activities. There are some waste sorting facilities but often the sorting business is not generating any income. Additionally, there are processing plants that are focusing on the bio-waste treatment. However, the technology in these facilities has been argued to be outdated and also, there are no established operations to collect bio-waste from households. (Suomalais-Venäläinen Kauppakamari, 2019a)

There are bring-in centres that are collecting different waste materials separately. Citizens can bring their waste to the centres free of charge. Citizens recycle their hazardous waste, paper, cardboard, glass, metals, textile and plastics in these centres. These materials are then sold to recycling operators. Many organizations are actually promoting the recycling and transition of MSW separation at its' source. Some organizations are arranging events where citizens can bring and recycle their waste. (Suomalais-Venäläinen Kauppakamari, 2019a) One example of this kind of organization is Razdelnyi Sbor that has been established in 2011 as a voluntary organization in St. Petersburg arranging recycling events monthly (see Figure 5). Razdelnyi Sbor also provides service via their webpage where citizens can find separate waste sorting points. Some local companies have started to support recycling and are providing separate waste sorting collection points. For companies, this is one way to promote their sustainability agenda. However, recycling is often very difficult as the distance to the nearest collection point can be very long and the citizens have very limited space in their apartments to store the waste. (Venäjän Aika, 2019)



Figure 5 Razdelnyi Sbor recycling event (Venäjän Aika, 2019)

Some citizens in St. Petersburg are very environmentally conscious. Inspiring example is “EcoTaxi” that is a service established by one man and his family, collecting and driving citizens’ waste to nearest recycling point. EcoTaxi is operating in the northern suburb of St. Petersburg. EcoTaxi is collecting a small fee from its’ customers in order to keep the business up and running. EcoTaxi has already established partnerships with some local operators like with a charity store that handles clothes collection. This kind of initiative illustrates that there are citizens who are actually willing to pay to get their waste separated and recycled in a correct way. (Russia Beyond, 2019)

As described above, the existing capacity of region’s landfills are reaching their limits as the amount of waste increases. At the same time, the waste reform has been postponed in St. Petersburg and Leningrad region. According to the reform, there should be a regional operator but there have been issues regarding the selection process of St. Petersburg’s operators. St. Petersburg should have two operators, one for southern part of the city and another for the northern part of the city. The regional operator of Leningrad is JSC “Upravlyaushaya kompania po obracheniyu s othodami v Lenoblasti” (UKOLOO) that is ready to start its operations under the new reform. However, due to the close linkage to St.

Petersburg and issues with the selection process, the reform is postponed for both areas. UKOLOO has already invested into the infrastructure and is planning to upscale its operations. The company has experienced some cooperation issues with local landfill owners. (Suomalais-Venäläinen Kauppakamari, 2019a)

Potential opportunities in the Russian MSW markets could be related to MSW logistics, MSW Eco-techno parks, developing new landfills or improving the existing ones and establishing education and competence centers. Especially the opportunities for Finnish companies have been highlighted. It has been proposed already in 2012 that the Finnish expertise and knowledge should be conceptualized and promoted. (Tekes, 2013) Ongoing waste management projects in Russia should be monitored and supported.

Based on the literature, available reports and other sources, it is possible to summarize that proper changes are needed in order to secure efficient waste management processes in the future. Close collaboration between all relevant stakeholders should be secured and potential technological solution should be reviewed.

2.2 Confirming the waste management status by conducting interviews

The purpose of this chapter is to summarize interviews with waste management specialists from different backgrounds and connections to Russia. These interviews are utilized to get validation for the previous chapter's findings related to the waste management status in St. Petersburg. This approach is selected as the amount of St. Petersburg's waste management and recycling related literature and reports available in English are quite limited. These interviews are a suitable way to compliment this qualitative study.

This thesis utilizes semi-structured theme interview. This method was selected as the themes are clearly defined. There are a few questions that are asked from all the participants. However, there is an opportunity for free discussion providing

possibility to hear different viewpoints from the participants. In theme interview, the participant can provide answers freely and there are no pre-decided answer options. Interviewer has also possibility to adjust the wording of the questions during the interview. (Hirsjärvi & Hurme, 2001)

Semi-structured interviews are often used in qualitative research. The interviewer needs to be well prepared prior to the interview and secure that all the relevant topics are covered. It is good to acknowledge that in semi-structured interview the responses might be difficult to compare as there are no pre-defined answers that would allow more systematic approach. (Eriksson & Kovalainen, 2008) This theme interview is divided into three different themes and a PowerPoint presentation is utilized to facilitate the interview.

Detailed interview process utilized is described in this chapter. First, candidates for the interviews were selected and contacted. In total three interviews were held. The interviews were conducted over Microsoft Teams and participants received an instruction e-mail and PowerPoint slides (See attachment 1) prior to the interview. The approach provided the participants an option to review the materials ahead of the interview and familiarize themselves with the topic, however, pre-work was not mandatory. The interview method was semi-structured theme interview as highlighted above. The PowerPoint slides were used to highlight the key discussion points and to facilitate the conversation. The interview had three main themes. First, St. Petersburg's waste management status. Second, recycling related case examples from St. Petersburg. Finally, proposals for the AWARE project (see discussion chapter). The interview was designed in a way that first the selected theme was presented and after that discussed with the interviewee in more detail. There were a few pre-made questions that could have been used, but the idea was to have an open discussion with the participant and to hear different viewpoints and personal experiences.

Interviews are confidential and the permission for recording the interviews was asked from the participants. Interview recordings were utilized when analyzing the

interviews. However, the interviews were not transcribed. Interviews were conducted in October 2020. The date for the interview, short participant introduction and duration of the interview is provided in Table 2.

Key findings are categorized to tables. Findings from the first two themes are provided in this section. The results from the third theme discussion is provided in chapter five.

Table 2 Interview participants

Interview	Date	Participant introduction	Participant identifier	Duration of the interview
1	20.10.2020	Waste management specialist working in Finnish government department. Has lived in St. Petersburg	P1	60 min
2	21.10.2020	Finnish Development manager with passion on waste management. Has recently lived in St. Petersburg	P2	40 min
3	27.10.2020	AWARE Project member. Lives in St. Petersburg	P3	50 min

The first theme focused on the waste management status in St. Petersburg. First the key findings were presented and then participants were asked to describe the waste management status from their own viewpoint. All participants agreed with the presented status. Participants also provided further insight on the current status of the waste management in St. Petersburg. P1 informed that new sorting facilities are being built and many people are recruited to work in these facilities. Sorting station approach has been selected over an option where waste is being sorted at its origin. P1 also briefly underlined the local waste reform plans as a relevant source of information for the future research. P1 assumed that St. Petersburg citizens would like to recycle more, however, infrastructure to support recycling efforts is missing. There have been cases when citizen have sorted their waste at the origin to multiple containers, but one collection truck has picked up all the waste. Naturally, the

citizens have been very disappointed and motivation to continue waste sorting is very low. There are some organizations supervising this kind of behavior.

Additional findings from P2 were related to the amount of waste. In general, the amount of packaging waste is very high compared to Finland. For example, all the groceries are packed into multiple packages. In one grocery store (comparable to Stockman in Finland) the cashier is packing groceries to small plastic bags and then to large plastic shopping bags. However, P2 has noticed that there are zero waste shops in St. Petersburg, that are behaving completely opposite. Zero waste shops are popular among the young citizens of St. Petersburg.

Third participant, P3, also confirmed the current waste management status. It was discussed that citizens have very limited access to separate waste collection containers in some particular areas. Travelling to dedicated waste sorting places usually requires significant amount of time. In theory, citizens can recycle plastic, small batteries and hazardous waste, but there is no separate recycling container for paper available at all. Often the containers for plastic are full, indicating that citizens are motivated to recycle. Additionally, the access to data to get accurate MSW amount or recycling related figures was briefly discussed. P3 confirmed that there is no perfect database to get exact numbers and if there is some data available, it might be hard to utilize. Summary of the discussions around the first theme is highlighted in Table 3

Table 3 Summary of the first theme

Participant	Confirmed the presented waste management status	Additional information
P1	Yes	New sorting facilities are being built and people are hired to these facilities to sort the waste. This approach has been selected over sorting the waste at its' origin.
P2	Yes	In general, there is much waste and especially a lot of packaging waste.
P3	Yes	There are limited possibilities for recycling. No accurate data of MSW amount and recycling rates available.

In the second part of the interview, participants were presented two case examples that are described in chapter 2.1. First example was Razdelnyi Sbor and the second one EcoTaxi. Table 4 illustrates if the participants had heard about the cases before. Participants were also asked if they knew about similar case examples. Razdelnyi Sbor was more recognized than EcoTaxi. It is worthwhile to highlight that Razdelnyi Sbor operates in other cities as well. Some additional cases were also provided by the participants. For example, Ikea (see Figure 6) offers separate waste collection point at their St. Petersburg location in collaboration with supermarket Mega. According to P2, there are bars and restaurants showcasing forerunner status and promoting sustainability by having separate waste collection bins.



Figure 6 Separate waste collection, Ikea St. Petersburg (Kudako, 2020)

P3 provided interesting insights to large companies' waste management services. However, in order to analyze these services further, Russian language is required.

Smaller recycling related initiatives might not be financially sustainable. Therefore, P3 assumed that in the future there will be collaboration between the larger waste management companies and smaller recycling companies.

Table 4 Summary of the second theme

Participant	Recognized Razdelnyi Sbor	Recognized EcoTaxi	Additional examples from St. Petersburg
P1	Yes	Yes	Ikea provides separate waste collection bins at their St. Petersburg store
P2	Yes	No	Some bars and restaurants providing and marketing separate waste collection bins
P3	Yes	No	Large companies providing waste management services. E.g. Петро Васт

In the last part of the interview, participants were presented three most promising ideas that could be implemented in Russia. These findings will be presented as a part of the discussion chapter.

2.3 Summary of St. Petersburg's waste management status

St. Petersburg's waste management status is relatively poor based on the available literature and reports. Majority of the households are not recycling, and waste ends up to landfills. Majority of these landfills are reaching their limits. Some of the landfills are relatively old and not meeting the sanitary requirements leading to unwanted environmental effects and inefficient use of resources. The waste reform is ongoing in Russia, but it is postponed in St. Petersburg area. Citizens have very limited possibilities to recycle their waste as there is no proper infrastructure in place. Majority of the MSW is collected into the standard containers and then transported to landfills. The waste collection and transportation should be improved in order to achieve efficient recycling. However, there are some voluntarily based initiatives ongoing to promote the recycling and circularity of materials.

Three interviews were conducted to validate the findings from the 2.1 chapter. Participants were carefully selected, and they were able to validate and provide further insight about St. Petersburg's waste management status. Participants agreed with the presented status and gave very detailed examples from their own experiences. All participants noted the key to improve St. Petersburg's waste management status is to build a proper infrastructure. Today recycling is heavily depended on voluntarily organizations and active individuals. Some citizens might use multiple hours to transport across the city to sort and recycle their waste. It could be summarized that there are active citizens ready to recycle and fight against the waste issues, but collaboration between all the relevant stakeholders is needed.

3 CIRCULAR ECONOMY AND CITIZEN SCIENCE

This chapter focuses on circular economy and motivational drivers for recycling.

3.1 Literature review of circular economy

This chapter studies the theory of circular economy and its' connection to recycling. A literature review was selected as a research method to get a comprehensive overview on available research and factors explaining the connection between circular economy and recycling. The purpose of this section is to focus more on the social aspect of circular economy and recycling rather than technological solutions improving the waste sorting. AWARE project can utilize the findings from this section when they are facilitating courses for university students.

Relevant literature was searched from Scopus database and university's library source, LUT Primo. To secure a relevant search and results, the "advanced" search was used, and key words were searched only from the title. In the first search from Scopus key words "circular economy" and "recycl*" were searched from titles and search was limited to articles. In total 77 articles were found. Figure 7 Scopus Search 8th September 2020 illustrates that the number of CE and recycling related articles has spiked in recent years. Thus, the topic of this thesis is timely.

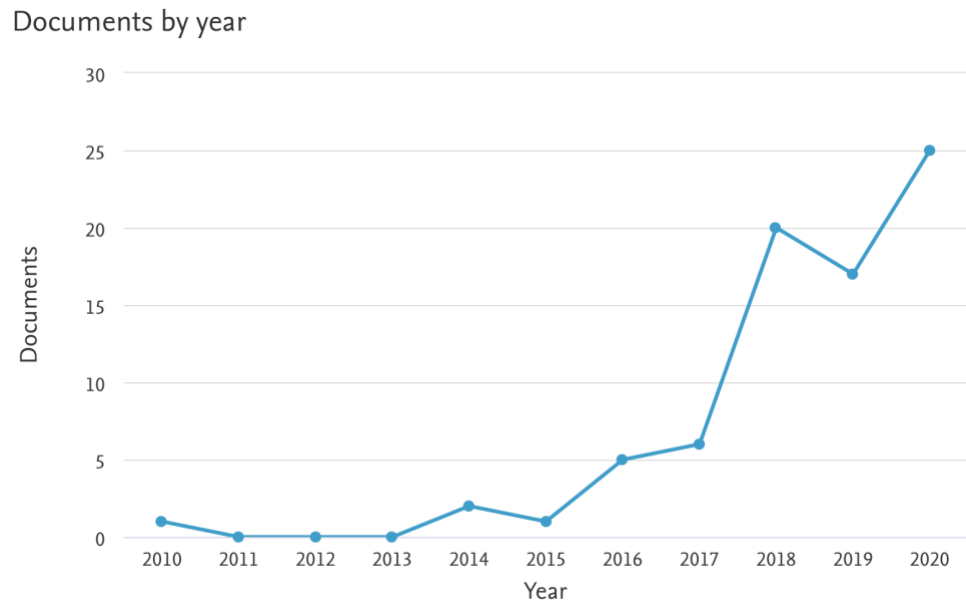


Figure 7 Scopus Search 8th September 2020

After the Scopus database search the articles were searched from university's library source, LUT Primo with different search combinations including the key words "circular economy" and "recycling". The search was limited to include articles that are written in English and publicly available with university's account. Additionally, references were reviewed, and some articles were handpicked. The titles and abstract of the articles were reviewed. Some articles were excluded because of the focus on industrial waste or detailed technological solutions. The selected articles were read, and the relevant ones included into this literature review. In the end 25 articles and two additional sources were selected to be part of this literature review and further analyzed.

According to Ellen MacArthur foundation (2020) "A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems." The concept of CE aims to minimize the waste and optimize the resources in a way that the materials keep their economic value as long as possible, leading to more sustainable approach (Tukker, 2015). The CE concept has been widely acknowledged over the last decades. Generally, the focus towards CE has increased because of the rising evidence of potential demand-supply mismatch and limited amount of available resources. The approach has been

argued to have a key role in countries' and companies' sustainability strategies. (Goyal, et al., 2016) Circular strategies and business models have been identified as potential solutions reducing the unwanted environmental impacts and increasing efficiency. Also, consumers have important role in promoting the CE principles and collaborating with various stakeholders. (Happonen, et al., 2020) Therefore, consumers' motivational aspect is studied in more detailed in chapter 3.2.

Figure 8 describes the concept and key principles of circular economy which has also been utilized by Giurco et al. (2014). The circulation of renewable and non-renewable resources through the economic system is illustrated in the figure. The purpose is to design out waste, meaning that products should be designed in a way that they fit the materials cycle and non-renewable resources should be designed in a way that they can be re-used with minimal energy. Also, when designing products, modularity, versatility and adaptivity as a product feature should be prioritized. Energy used in the circular processes should be from renewable sources and systems thinking should be embraced. On the renewable resources side of the cycle, products and materials are circulated back to the environment through non-toxic, restorative loops. Additionally, the quality of the products can be improved via upcycling on the non-renewable side. From the concept's value creation point of view, savings can be achieved when there are tight circles closer to the user. Also, one potential way to create value is to keep products or materials circulating longer in the economy by e.g. designing more sustainable products. However, products or materials can be cascaded to be used as a secondary raw material, lowering the material costs. One example is utilizing old clothes as a fiber for furniture. Finally, removing harmful materials or product components might secure "easy to separate" design which may help to create efficient recycling processes and therefore generate value (Ellen MacArthur Foundation, 2013)

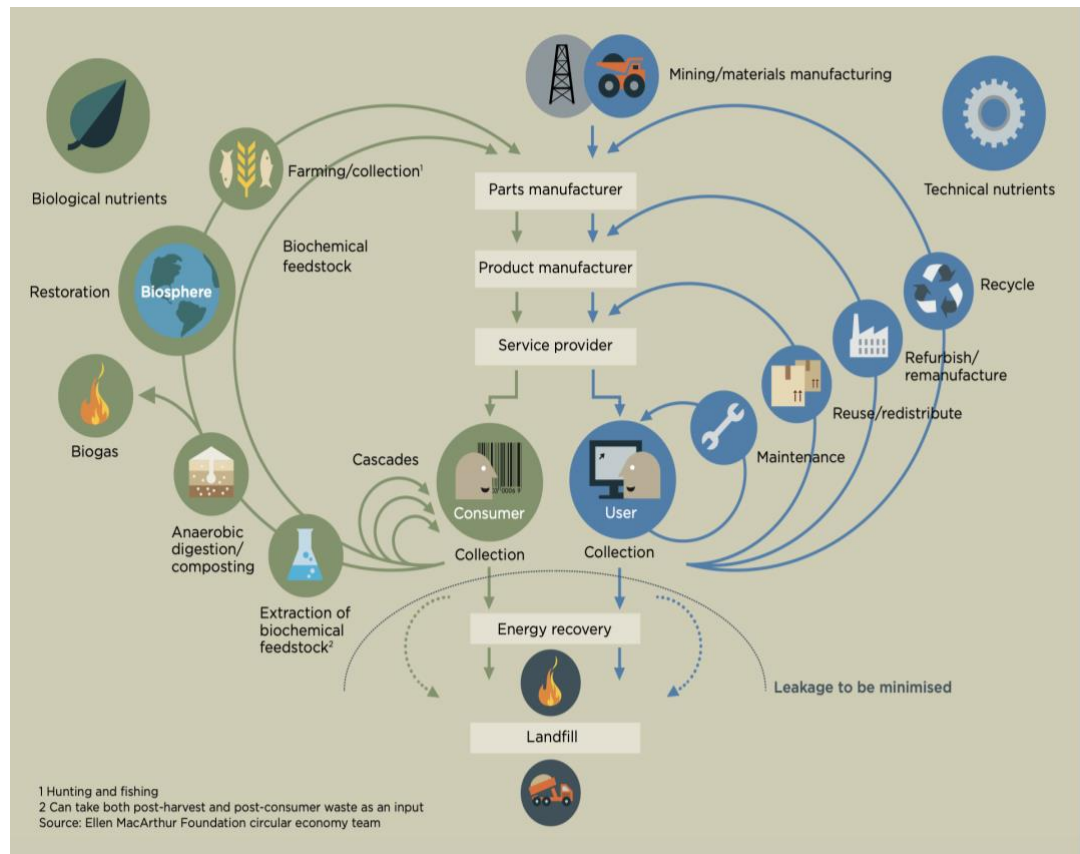


Figure 8 Concept of Circular Economy (Ellen MacArthur Foundation, 2013b)

Kirchherr et al (2017) conducted a systematic analysis on 114 different articles with CE definitions and as an outcome, there was in total 95 different CE definitions. Three definitions that were used more than once (Preston, 2012) (Ellen MacArthur Foundation, 2013) (Li, et al., 2010) are highlighted in the Table 5 as well as the definition proposed by the authors. The analyses indicate that both the definition and understanding of the CE concept varies between scholars and major organizations or companies. The CE is often represented as a combination of 3R principle, but it is not highlighted enough that the implementation demands a systematic shift. Also, only approximately 30% of the studied articles included the waste hierarchy to the CE concept definitions and this finding has not been that widely recognized before. (Kirchherr, et al., 2017)

Table 5 CE Definitions

Author	Definition
Kirchherr, et al., (2017)	"A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level(products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations."
Ellen MacArthur Foundation (2013)	"A circular economy aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital. It is based on three principles: design out waste and pollution, keep products and materials in use, regenerate natural systems."
Prespont (2012)	"A 'circular economy' (CE) is an approach that would transform the function of resources in the economy. Waste from factories would become a valuable input to another process – and products could be repaired, reused or upgraded instead of thrown away."
Li et al. (2010)	"Circular economy broadly accepts that an economic growth and development system to integrate economy with resources and environmental factors is based on the material metabolism mode of "resource-product-regenerated resource", which incorporates a mechanism of efficient resource use and waste stream feedback, while its metabolism is compatible with the whole ecosystem."

As highlighted above, CE is often linked with the 3R principle: "Reduce, Reuse and Recycle". This principle provides a good guidance on how to apply CE in practice. Therefore, it is possible that someone's waste becomes a valuable resource for others while material and energy is recovered. Before the CE approach, a linear model has been used. There are companies that have already established CE business models. However, more focus on sustainability is needed in a wider scale. Therefore, for example EU has launched a "Circular Economy Package" in 2015. The goal is to motivate and promote sustainable growth and to promote the elements that are also highlighted in the 3R principle. However, Fitch-Roy et al. (2020) argues that creating the policy conditions, such as EU "Circular Economy Package" might require tougher actions than what has been seen so far. Also, the society has an important role in achieving the goal to become more sustainable. Especially

schools and universities have key role affecting the future generations' mindset by providing environmental education. (Buil, et al., 2017) Cultural, market and regulatory related barriers might impact the success rate of CE implementation. Examples of the cultural barriers are lack of consumer interest & awareness and also hesitant company culture. (Kirchherr, et al., 2018)

The literature review by Winans et al. (2017) categorizes the current CE concepts into three thematic categories: 1) policy instruments and approaches 2) value chains, material flows & product-specific applications and 3) technological, organizational, and social innovation. The third theme is the most relevant one for this thesis. CE concept related innovations are often seen technical and economically feasible. A successful implementation of these innovations requires close collaboration and involvement of various stakeholders. Different organizations and consulting companies are providing tools and mechanisms supporting the implementation of innovations related CE. Engaging the community, providing education and having valid media coverage, are key components of a social innovations that promote the CE concept. Also, highlighting the economic benefits, waste reduction and environmental impacts are important for achieving the buy-in from stakeholders. (Winans, et al., 2017)

Efficient waste management processes, including recycling, are the key components towards sustainability. CE and recycling have been studied from the educational point of view. Pelău & Chinie (2018) summarize that the consumers' level of education has positive impact on the recycling rate of MSW. It is also recommended that when developing CE, increase in the consumers educational level is endorsed. Especially positive correlation between university education and recycling rate has been found (Starr & Nicolson, 2015). Therefore, it is important to provide sustainability, CE and recycling related education for students in order to increase their awareness. Awareness and education can impact students' recycling behavior but also have wider impact as university students might have political decision-making roles later in the future and possibility to promote sustainability related targets. (Pelău & Chinie, 2018)

Implementing zero waste targets is related to CE as it is a potential way to keep products and resources circulating for a longer period of time by utilizing recycling. This naturally limits the amount of disposed waste, saves natural resources, limits the need for virgin raw materials and energy consumption. Additionally, recycling decreases the environmental and economic costs and unwanted environmental impacts (Kinnamann, 2006).

In order to achieve recycling targets, a comprehensive waste management strategy and a separate waste collection is needed. Separate waste collection is the basis for the recovery, reuse and recycling and reduces the amount of waste that is disposed to landfills or incinerated. (Agovino, et al., 2020) When resources are circulating, this means that waste becomes a resource itself. Innovative instruments are needed to secure resource efficiency. One potential instrument is the zero waste targets that was mentioned above. It sends convincing policy signals highlighting e.g. the importance of secondary raw materials and also provides long-term guidance for investment and change. (Wilts, et al., 2016)

The importance of separate waste collection was highlighted above. In order to secure effective separate waste collection processes and systems, support from local institutions are needed. This means that resources, policies, processes, technological solutions and monitoring are provided for the particular area. On top of the support and guidance from the local institutions, the active role of citizens is needed. In practice this means that citizens need to separate their waste and follow the given guidelines. (Agovino, et al., 2018) Citizens are likely adapting the mindset that promotes CE and recycling if they have some incentives. (Tonglet, et al., 2004) Also, if citizens have opportunities, services and understanding about recycling, the more likely they are to promote environmentally friendly behavior. Best results in the waste management processes are achieved when citizens and local institutions or organizations are having close collaboration. Both the awareness raising campaigns and easy access, such as kerbside collection, have been seen as effective methods to promote the recycling among citizens. (Agovino, et al., 2020)

The role of Waste-to-Energy solutions have not been described in the previous articles and it is argued that technological WtE solutions should be evaluated also from the CE point of view. Utilizing different WtE solutions could be beneficial in transition to CE. It is also worth of highlighting that some WtE technologies such as pyrolysis and gasification provide the potential to recover products from the waste stream that is not part of the complete incineration. In general, waste should be treated as a resource and political will has been seen as a key driver in the change towards CE. Also, the collaboration between the local waste management authorities and different institutions responsible for waste management should be established in order to have holistic waste management approach. (Malinauskaite, et al., 2017)

Implementing the CE approach, especially in developing countries, requires proper change management and close collaboration between all relevant stakeholders. It is important to have different stakeholders such as institutions, companies, organizations, civil society organizations and consumers to change their mindset and to have a systematic behavior supporting the CE. Companies in developing countries like India are designing business models that promote the CE principles “reduce, reuse and recycle”. (Goyal, et al., 2016)

Table 6 provides a brief overview of other relevant studies that discuss CE and waste management (Platnieks, et al., 2020) (Zhong & Pearce, 2018) (Lin, 2018) (Lonca, et al., 2020) (Huysveld, et al., 2019). These articles could be relevant if a reader would like to get more information and case examples from the circular economy and sustainability point of view.

Table 6 Further readings

Author	Title of the article	Overview of the article
Platnieks et al. (2020)	Sustainable tetra pack recycled cellulose / Poly (Butylene succinate) based woody-like composites for a circular economy	Recycled cellulose recovered from Tetra pack packaging.
Zhong & Pearce (2018)	Tightening the loop on the circular economy: Coupled distributed recycling and manufacturing with recyclebot and RepRap 3-D printing	Utilizing post-consumer products to produce new products with recyclebot and 3D printing.
Lin (2018)	User experience-based product design for smart production to empower industry 4.0 in the glass recycling circular economy	User experience focused product design to support the circular economy in the glass recycling industry.
Lonca et al. (2020)	Assessing scaling effects of circular economy strategies: A case study on plastic bottle closed-loop recycling in the USA PET market	Analyze if increasing the rPET usage in the plastic bottles leads to higher material efficiency and environmental performance
Huysveld et al. (2019)	Advancing circular economy benefit indicators and application on open-loop recycling of mixed and contaminated plastic waste fraction	Evaluating the net benefit of recycling plastic waste compared to disposal.

3.2 Consumers' motivational drivers for sustained participation in citizen science

The role of active society in promoting sustainability was highlighted in the section 3.1. Also, the educational aspect was emphasized. The outlook for waste management status in St. Petersburg was given in chapter 2.1. with the outcome that the status is relatively poor. Therefore, it would be interesting to understand how citizens of St. Petersburg could be involved and educated to become more sustainable and to acknowledge the need for recycling as efficient waste management solution.

This section focuses on citizen science platform and motivational aspect on how to sustain the active citizen participation in different initiatives or projects. Hence, this section will provide a brief summary of the case study that was conducted in Finland

and Japan to analyze the drivers of participation on digital citizen science initiatives. The latter part of this section analyzes how these kinds of initiatives could be utilized from the waste management point of view.

The increase of mobile devices with different sensors (camera, motion detector, GPS etc.), web services and increased usage of online social networks has led to situation where people are collecting and sharing information more than before. This means that people are sensing and sharing some of the aspects from their life that has not been widely shared before. “Participatory sensing is data collection and interpretation” and it often involves citizens and other relevant groups. The scale of participatory sensing can differ from few private observations to a dataset of thousands of observations, often revealing some patterns. Participatory sensing has different models, such as collective design and investigation, public contribution and personal use and reflection. These models are briefly described in Table 7. The process and frameworks of participatory sensing can be easily found but how to engage and inform the active citizens should be carefully evaluated. (Goldman, et al., 2009)

Table 7 Participatory sensing models (Goldman, et al., 2009)

Participatory Sensing Models	Definition
Collective design and investigation	Participant community owning the end-to-end participatory sensing process. Participants deciding what, where, why and how to sense, collect and process the data. Participants having important role in investigation process.
Public contribution	The goal of the public sensing project defined by different party (individual or organization) than individuals who are collecting the data. By engaging with active individuals, organizers can achieve larger data sets than without help from the participants.
Personal use and reflection	Data collection for individuals' own purposes. Individuals could log information related to themselves and that might show some patterns. Data and findings can be private or shared e.g. via blogs.

Citizen science projects vary from large-scale projects to smaller scale research engaging non-professional researches to join. Combining the historical data with community of citizens could lead to unique results with different viewpoints. Citizen science has been especially used in ecological and environmental research. (Dickson, et al., 2012)

National Geographic defines citizen science in a following way “citizen science is the practice of public participation and collaboration in scientific research to increase scientific knowledge. Through citizen science, people share and contribute to data monitoring and collection programs. Usually this participation is done as an unpaid volunteer.” (National Geographic, 2020) In the simplest form of citizen science citizens are gathering the observations. Currently, technological solutions, services and the way people interact have made it easy to report the findings. (Skarlatidou, et al., 2019)

Palacin et al. (2020) studied the values and motives of continuous participation in digital citizen science projects, utilizing the frameworks from the social psychology. Article focuses on two digital citizen science case studies that have been ongoing for a while. The first one, Safecast is a Japanese initiative where participants collect radiation data and get information on how to build own device for the radiation data collection purposes. Safecast is being the largest monitoring initiative and was established after the nuclear energy accident in the Fukushima power plant which caused mistrust on the local government. Safecast is run by volunteers. (Brown, et al., 2016) The second one, Järviwiki is a Finnish initiative, where participants are mainly monitoring lakes and posting the information (water temperature, surface status etc.) via the platform. The platform was established by Finnish Environment Institute as they received lot of observations from citizens. Järviwiki is maintained by the Finnish government but the volunteers are in charge of running the operations. (Järvi&Meri Wiki, 2020) (Palacin, et al., 2020)

Palacin et al. (2020) studied the values & motivations of joining and sustaining participation in the digital citizen science initiatives. It is interesting to understand why people are voluntarily joining these initiatives without compensation. The authors found out that for both of the case studies, integrated and identified motivations are the key for sustained participation. However, the results indicate that the intrinsic motivation was also important driver in the Järviwiki case study. The definitions of these key motivations are summarized in Table 8. The outcome of the study proposes that citizens are participating in the initiatives as the activity is perceived as important and also, citizens might have some personal targets and interests. However, for some participants, joining the digital citizen science initiatives is more like a hobby. When designing digital citizen science initiatives, it is crucial to understand the participants' goals and interests to secure their active and sustained participation. (Palacin, et al., 2020)

Table 8 Key Motivations by Ryan & Deci (2000). Adapted from Palacin et al. (2020)

Motivation	Definition
Identification	"Actions on behalf of a goal that is of personal importance, so activities conducted are accepted as one's own"
Integrated	"Activities that are fully assimilated to the self. These motivations share qualities with intrinsic motivations but are extrinsic because they are still conducted for an outcome that is separate from the behavior, even though is valued by the self"
Intrinsic	"Behavior that is completely self-determined and, in contrast to extrinsic motivation, not a means to an end but rather pursued for its own sake. Intrinsically motivated behavior is sustained by the experience of interest and enjoyment"

Another interesting finding from the two case studies, is that the values and motivations might differ depending on the stage of participation. Once the participant is joining the initiative, self-direction and stimulation are important values. Nevertheless, sustaining participation was associated with more values such as stimulation, hedonism, achievement, security, tradition, benevolence, universalism & self-direction. The definition of the values is available in Table 9. Interesting finding was that the power related value was not influential driver for the participation. Often the incentive mechanisms are related to the power and achievement and that should be carefully evaluated. (Palacin, et al., 2020)

Table 9 Basic human values by Schwartz (2003). Adapted from Palacin et al. (2020)

Value	Definition
Universalism	"to pursue understanding, appreciation, tolerance and protection for the well-being of everyone and for nature"
Benevolence	"to pursue the preservation and enhancement of the welfare of the people we know"
Tradition	"to pursue respect, commitment and acceptance of traditional practices aligned with culture or religion"
Security	"to pursue safety, harmony, and stability of society, of relations and of self."
Power	"to pursue social status and prestige, control or dominance over people and resources."
Achievement	"to pursue personal success through demonstrating competence according to social standards"
Hedonism	"to pursue pleasure and sensuous gratification for oneself."
Stimulation	"to pursue excitement, novelty and challenge in life."
Self-Direction	"to pursue independent thought and action, choosing, creating, exploring."

The findings of these two case studies could be utilized in the waste management context. In case a digital citizen science approach would be utilized, it is essential to analyze and evaluate the underlying values and motives of the potential participants. Especially the values universalism and benevolence are associated with social and environmental aspect and this combined with correct motivational drivers, participants are likely to contribute in the project in a sustained manner. It is essential to acknowledge that this section of this thesis focuses heavily on the study of Palacin et al. (2020).

There are some waste management related digital citizen science projects ongoing. In New York, citizens can track plastic waste and find educational materials from Debris Tracker app that is established in collaboration with Morgan Stanley, National Geographic Society and the University of Georgia to increase the plastic

waste awareness. The app provides data for citizens, but also highlights the plastic litter findings and inspires upstream design. Citizen-science tools are seen as powerful way to increase the awareness and public interest and also as a way to gather better data. (Solidwaste & Recycling, 2020)

Potential digital citizen science projects in the waste management field could be for example initiatives where citizen input data on full waste collection points, or incorrect usage of collection points or informs about the illegal landfills or dumpsites. If the data gathered would be in open source format, it may provide other commercial use cases for various stakeholders including municipalities, start-ups or regulators.

4 CASE EXAMPLES PROMOTING CE AND RECYCLING

European waste hierarchy illustrates the waste management approaches from most attractive to least attractive actions from environmental perspective as illustrated in Figure 9. Sustainability requires integrated approach throughout the whole waste management lifecycle, therefore it is important not only to focus on the technical waste management solutions. The most sustainable action is to prevent the waste generation. Also, EU Member states should promote the re-use of products and promote high quality recycling. Recovery can be referred as incineration process where energy is recovered. Disposal, being the least attractive, is often referred as landfilling but that should be done in a way where protecting human health and environment is possible. (European Commission, 2008)

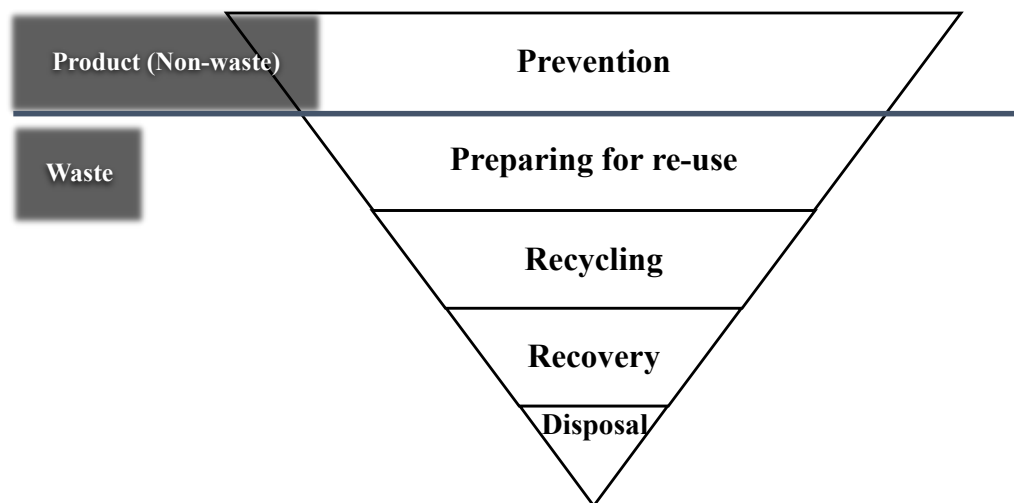


Figure 9 Waste management hierarchy adapted from European Commission (2008)

To secure successful waste management practices, active citizens are needed to ensure public engagement and trust towards the agreed practices. Citizens also have a crucial role as they can reduce the amount of waste, have the possibility to separate the waste at its origin and of course dispose the waste in a proper manner. (The World Bank, 2018) Additionally, understanding the motivations for sustainable waste management from consumer point of view is an important topic. According to Wheeler (2019) “images of putrefying waste in landfill sites, generating greenhouse gas emissions and polluting the environment, are one of the most

compelling reasons to recycle”. Abbott et al. (2011) concluded in their study that the recycling rate increased in UK after introducing extended kerbside collection. One of the key findings highlighted in Kattoua et al. (2019) study was that Gaza households would feel more motivated about recycling if they had further information about recycling.

The purpose of this chapter is to present inspirational reuse and recycling ideas mainly from Finland. There are in total 14 cases selected that are live, commercialized and well recognized. The cases are categorized to six different categories that are illustrated in Figure 10. First five categories are effortless recycling, scrap metal recycling, second-hand online marketplaces, circular economy linked to CSR and education. Final category, global examples focuses on inspiring examples worldwide. Each section provides a brief explanation of selected examples and a summarizing table.



Figure 10 Illustration of case example themes

4.1 Effortless recycling

The first three examples illustrate how recycling can be made easy for consumers. HSY waste collection vehicle is a service provided by Helsinki Region Environmental Services Authority (HSY) that operates in the capital area of Finland around the year. The service is very convenient for the consumers as the collection car makes multiple stops around the city with HSY staff supporting the citizens. Consumers can dispatch their domestic hazardous waste, electrical devices and scrap metal to these vehicles free of charge. (HSY, 2020)

The second example is Kalasatama neighborhood in Helsinki that has recently established pipeline-based waste collection system. Instead of traditional waste bins, Kalasatama citizens dispose their waste at the waste points and dedicated hatches. Currently there are hatches for biowaste, paper, cardboard, mixed waste and plastic. After the disposal, the waste continues the journey via underground pipe network to central waste collection points. Trucks gather full containers of waste from these collection points to further treatment. It is convenient for the consumers to have wide sorting possibilities in their buildings or neighborhood and there is less waste truck traffic in the area as waste is gathered centrally from full containers. (Kalasataman jätteen putkikeräys Oy, 2020)

Finland has deposit-based return system for beverage packages. Return rates for different kind of packages are almost 90%. (Suomen Palautuspakkaus Oy, 2020) (Sitra, 2017) Finnish company Reinto has developed a mobile application called Canit. It is a platform where users can sell and buy empty bottles and cans that are part of the deposit system. The purpose of the application is to increase the recycling rate and provide comfortable way of recycling the bottles and cans. It is a good way for e.g. younger people to earn some money by collecting and returning the bottles and cans to the vending machines. The seller will get small compensation of the returned items. Even if single consumer is unmotivated to return the bottles and cans to recycling point, the application allows other willing consumers to recycle

and earn small money. These examples are summarized in Table 10 below. (Reinto, 2020)

Table 10 Effective recycling examples

Name	Description	Impact
HSY collection vehicles	Consumers can dispatch their domestic hazardous waste, electrical devices and scrap metal to collection vehicles free of charge	Specials waste collection brought close to consumers
Kalasataman Imu	Pipeline-based waste collection system	Effortless recycling
Canit	Mobile application for consumers to buy & sell empty bottles and cans that are part of deposit system	Some single consumers might be unmotivated to recycle, but others are willing to do it due to the deposit system

4.2 Scrap metal recycling

Recycled metals can be used as a raw material for new metal products. This limits the need to use nonrenewable mineral resources. It is also beneficial from the financial perspective as the recycled materials are cheaper than producing the metals from the scratch. Additionally, recycled materials are not that volatile to the price changes in international markets. (Jain, 2012)

Romukioski is a Finnish company providing scrap metal (aluminum, brass, copper, stainless steel, iron) recycling services for consumers, companies and industries. Customer receives compensation based on the weight of the scrap metal and agreed price. Romukioski has three self-service points, traditional offices and a truck as a moving mobile office. Hence, customers have multiple options provided for easy and efficient service. (Romukioski, 2020)

Another similar example for scrap metal recycling is a Finnish company called Aurek that is based in Luumäki. Consumers can recycle their scrap metals and precious metals (gold, silver, platinum and palladium) and get refund again based on the weight of the material. Company has five locations in Eastern part of the Finland where consumer can visit and bring the materials for recycling. Aurek is also providing postal and pick-up services for consumers. Aurek provides customer service in multiple channels, such as WhatsApp. Company has made it very easy for consumer to recycle both small and large metal products or items and to get the compensation. (Aurek, 2020) Scrap metal recycling examples are summarized in Table 11.

Table 11 Scrap metal recycling examples

Name	Description	Impact
Romukioski	Scrap metal recycling services in three different ways. Company has self-service locations.	Scrap metal recycled in an efficient way and money motivates consumers to recycle
Aurek / Metallit Rahaksi	Scrap metal and precious metal recycling services in Eastern part of Finland. Company provides postal and pick-up services.	Scrap metal recycled in an efficient way and money motivates consumers to recycle

4.3 Second-hand online marketplaces

Second-hand marketplaces are great examples of operators that promote the CE principles such as “re-use” and “recycle”. These marketplaces provide a great way for consumers to re-use and recycle the clothes and other apparels. Often a consumer receives financial compensation of sold products or can buy reused items with lower price compared to a new product.

Tori is the largest online marketplace for consumers in Finland. Consumers have the possibility to buy or sell all kinds of goods such as furniture, electronics and cars. Tori has over 2,5 million users monthly and the largest user group is middle-

income people over the age of 35 living in a two-person household. Consumers can submit their ad to the marketplace free of charge. In 2019 there was over 11,3 million ads and over 3,5 million deals via Tori marketplace. Consumers can utilize Tori marketplace when they would like to give furniture for the next person free of charge. (Tori, 2020) (Sitra, 2017) Similar to Tori, dedicated Facebook neighborhood recycling groups are effective ways to buy or sell old goods. One great example is the Facebook group called “Kallio kierrättää” that has over 53 000 users, being one of the most active neighborhood recycling groups in Helsinki. (Facebook, 2020)

Zadaa is “the world’s first marketplace to make selling and buying secondhand as simple as in an online store.” Consumers can buy and sell clothes and accessories via the mobile application and get the same experience than in other online stores. Zadaa is an international marketplace that currently operates in Finland, Denmark and Germany. Zadaa collects variable commission and a fixed 1€ fee from the buyer. Zadaa operates between the buyer and seller and processes all the payments. Additionally, all the transactions are covered up to 10 000 € with Money Back guarantee. Zadaa users have the possibility to rate other users based on the transactions. (Zadaa, 2020) (Sitra, 2017) Second-hand online marketplace examples are summarized in Table 12.

Table 12 Second-hand online marketplace examples

Name	Description	Impact
Tori	Online marketplace for consumers to buy and sell goods	Large number of users makes it an attractive platform to promote circular economy
Zadaa	Second-hand online marketplace	Simplified marketplace to find modern designer clothes

4.4 Circular economy linked to Corporate CSR

Evolum and Fiskars are great examples of circular economy and companies' Corporate Social Responsibility (CSR). Small Finnish company Evolum utilizes empty glass bottles, such as wine bottles, to create new glass products. The bottles are mainly collected from restaurants in Helsinki. The ideologies behind the company are the environmental issues and recycling. Instead of using new virgin raw material, company uses recycled bottles, thus less energy is needed in the manufacturing process.

Finnish design brand company Iittala has recently launched Iittala Vintage concept where consumers can sell their old Iittala and Arabia tableware products in company's stores. A consumer who wants to sell the old Iittala or Arabia tableware products will get compensation that is based on the current quality of the products. Iittala stores have dedicated area for vintage products and a buyer can get the used product cheaper than new products. In case a quality of the used product is poor, Iittala store can recycle the products on behalf of the consumer. Ceramics products are recycled to be ground material for tiles and glass recycled to be an insulating material for foam glass or glass wool. This is easy service for consumers to buy / sell well-known secondhand products in environmentally friendly way. (Fiskars Group, 2020) (Sitra, 2019) CE linked to corporate CSR examples are summarized in Table 13.

Table 13 Circular economy linked to corporate CSR examples

Name	Description	Impact
Evolum	New glass products from used glass bottles that are mainly collected from restaurants	Using recycled bottles instead of new virgin raw materials
Iittala Vintage	Consumers can sell their old Iittala and Arabia tableware products back to Iittala store	Products are used for longer period of time. Next customer might buy secondhand product instead of new.

4.5 Educational examples

One great example of increasing recycling awareness via educational activities is a gamification pilot experiment done in 2018 for students who live in Kuopio student apartments. In this experiment 90% out of the 250 student apartment residents installed the game called “Fox the Recycler”. After the pilot, the target audience increased their biowaste recycling by 21% and plastic recycling by 59%. This result really indicates that gamification technique is very powerful change management tool. The next step is to pilot the game with primary school students. (Santti, et al., 2019)

HSY that was already mentioned in the section 4.1 has also various different activities promoting recycling and circular economy. These activities are mainly targeted for schools and kindergartens. HSY provides free classes, study materials and information. Another interesting activity is school or kindergarten group visits at HSY locations such as Ämmässuo eco center that has previously been one of the largest landfills in Helsinki. HSY has also created digital games promoting circularity. (HSY, 2020) On top of these two examples, there are multiple sites providing recycling related videos and materials that can be used for education.

In 2019 A Greenreality Homes arranged a test period for voluntary households in Lappeenranta to familiarize themselves with more sustainable everyday living. Different kind of households joined the experiment and as an outcome, the participants reduced the carbon footprint by 11%. The experiment was supported by local companies and for example Etelä-Karjalan Jätehuolto (local waste management company) provided instructions on waste sorting and needed equipment for the experiment. This experiment had multiple aspects, where waste management was one of them. Some of the participants enjoyed the communality feeling of the experiment and sharing the experiences via social media. (Greenreality, 2019) Educational examples are summarized in Table 14.

Table 14 Educational examples

Name	Description	Impact
Fox the recycler	Example of gamification	Pilot increased the biowaste recycling by 21 % and plastic recycling by 59%
HSY Environmental education	Activities for schools and kindergartens	Supporting the teachers and providing inspiring ways to study recycling and circular economy
Greenreality Homes	Test period of sustainable everyday living	Voluntary households to familiarize themselves with sustainable living with less carbon footprint

4.6 Global state-of-the-art cases

Invisible barcode attached to a product would be one way to inform the consumer about the recyclability of the products. In a same way, the sorting machines at the recycling facilities could read the code and sort the product in a correct more effective way. Invisible barcode could be printed to the product and then consumer could read the code with phone or sorting machine with attached cameras as presented in Figure 11 . This technology has been tested in TOMRA's recycling facility in Germany and few companies have collaborated in the pilot. Technology would require companies to implement the invisible codes in their packaging. (BBC, 2019)

**Figure 11** Invisible barcode (BBC, 2019)

Kind of an opposite example compared to the barcode is the government established recycling program in Taiwan. In the beginning of 1990 country was called with the nickname “garbage island” due to the fact that the amount of MSW was increasing and majority of it disposed to landfills. The sanitation conditions were extremely poor, and landfills were reaching their limits. Citizens reacted to the unfortunate situation by having protests against landfills and also against the planned incinerations. In 1998 Waste Disposal Act was established making waste reduction and recycling a priority. Today country has recycling rate of 55% and recycling related policies such as “Pay as you throw” and “extended producer responsibility”. Bins have been mostly removed from the public areas and citizens are advised to recycle. Non-recyclable waste needs to be disposed using the government-certified blue bags that can be bought from stores. Citizens dispose these blue plastic bags to frequently scheduled yellow singing garbage trucks as illustrated in Figure 12. Consumers can track the trucks’ location via mobile app. If citizens don’t follow these rules, fines or a public shaming is used utilizing the security camera videos. The public shaming is considered to be socially harsh penalty in the Asian culture. (BBC, 2020) (Global Citizen, 2016) Global examples are summarized in Table 15.



Figure 12 Taiwan garbage car and blue plastic bags (WSJ, 2016)

Table 15 Global case examples

Name	Description	Impact
Invisible barcode attached to the product	Inform the consumer about the recyclability of the products	Improves the recycling at the facilities and informs consumer about recycling
Government established recycling program	It is mandatory to recycle in Taiwan	Taiwan has reached high recycling rate. In general, the streets are very clean.

This section has provided a brief introduction to already commercialized examples that are promoting circularity and recycling. New inspirational examples are evolving and those should be studied further on when relevant. One concrete tool for further understanding the circular economy and its' potential is to read the "Circular Economy playbook for Finnish SMEs". (Sitra, Technology Industries of Finland and accenture, 2017) Table 16 summarizes interesting global examples for further reading that can be very inspirational (Olioex, 2020) (LiveLoveRecycle, 2020) (Green4Good, 2020) (Renewcell, 2020).

Table 16 Summary of global examples for further reading

Name	Description	Impact
OLIO	Application for neighbor to neighbor food and household items haring	Reduce the food & household waste by providing a platform for neighbors and local businesses to connect
Live Love Recycle	Platform that connects recycling process participants	Free and on demand pick-up service for recyclable items. Recycling made very easy for citizens in Beirut
Green4Good	Sustainable technology disposal service for Canadian companies	Helping companies to manage the IT assets. Providing e.g. reselling or recycling services for used it assets
Renewcell	Improves consumer's access to sustainable fashion by providing new biodegradable material and improved recycling process	Used clothes can be transformed to new material called circulose pulp and used as raw material for new clothes

5 DISCUSSION

LUT university has a key role in the AWARE Project with an objective to provide sustainable waste management knowledge and expertise to Russia. The project aims to increase the environmental awareness of multiple stakeholders. One concrete example of increasing the environmental awareness is the Winter Camp university course for university students in Russia, in the beginning of 2021. The key purpose of the course is to create and present a brief informative waste management presentation to areas' schools. With that in mind, the purpose of this section is to analyze and summarize the findings of this thesis and to provide few recommendations that the university students could utilize in St. Petersburg.

As described in the second chapter, the current waste management status in St. Petersburg needs to be improved. The main waste disposal method is still landfilling with some waste ending up dumped into illegal landfills. Recycling rate is relatively low, meaning that waste is not used as a secondary raw material. Some improvements should be achieved via the proposed waste reform. However, the reform is delayed in St. Petersburg area. As the interviews highlighted, there are active citizens ready to promote recycling, but no proper infrastructure is in place to support the recycling. Active citizens and voluntarily organizations are arranging recycling and circularity related events and activities. The role of active citizens is essential when implementing new waste management processes or transforming the existing ones.

Proper Infrastructure and technical innovations are needed to support the waste reform in St Petersburg. AWARE Project has already analyzed state-of-the-art waste facilities and ways to limit the landfill usage. This thesis has focused mainly on the social & motivational aspect of recycling awareness and circular economy. The key aspects of the CE concept were studied in the third chapter of this thesis. The understanding of CE has increased over the past years but there are still multiple different definitions for the concept. Some of the definitions were presented in Table 5. CE is regularly linked with the 3R principle: "Reduce, Reuse






and Recycle”. In practice it means that someone’s waste could become a valuable resource for others while material and energy is recovered. Securing efficient waste management processes supports sustainability targets. The importance of providing sustainability, CE and recycling related education for students was highlighted as a way to increase recycling and CE awareness and to promote change.

Citizens are likely to start recycling or promote CE related mindset if they have enough information available and some incentives. The active role of citizens and close collaboration of stakeholders were highlighted in chapter three. Best results in the waste management processes are achieved when citizens and local institutions or organizations have close collaboration. The implementation of CE approaches requires proper change management and again, close collaboration between different stakeholders. Systematic mindset change is a key in achieving more sustainable behavior supporting the CE.

The fourth chapter of this thesis presented inspirational reuse and recycling cases mainly from the Finnish market. The selected cases are live, commercialized and well recognized. The purpose of the cases is to provide information and illustrate that there are many great examples and initiatives ongoing, supporting the systematic mindset change and the CE approach. Figure 8 illustrated the categorization of the cases. In total 14 cases were presented in the fourth chapter of this thesis.

As highlighted above, the purpose of this discussion section is to provide recommendations for the AWARE project. Based on the findings of this thesis, the most inspiring and effective ways to promote recycling among citizens are to increase their knowledge, provide an easy way to execute recycling and to have a close collaboration between all the important stakeholders. It is essential to understand that in order to fully transform the waste management field in St. Petersburg, investments into technological solutions and clear guidance from authorities are needed. However, there are activities that citizens could implement already now to promote circularity.

The recommendations will be presented by using a product vision board, a tool that can be used to visualize and validate product vision strategy. Product vision board (see Figure 13) captures the target group, user needs, key product features & business goal. The template is downloaded from Pichler Consulting webpage, but a simplified version is utilized in this thesis. (Pichler Consulting, 2020)

THE PRODUCT VISION BOARD romanpichler			
<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="text-align: center;">  VISION </div> <div> <p>What is your purpose for creating the product?</p> <p>Which positive change should it bring about?</p> </div> </div>			
<div style="text-align: center;">  TARGET GROUP </div> <p>Which market or market segment does the product address?</p> <p>Who are the target customers and users?</p>	<div style="text-align: center;">  NEEDS </div> <p>What problem does the product solve?</p> <p>Which benefit does it provide?</p>	<div style="text-align: center;">  PRODUCT </div> <p>What product is it?</p> <p>What makes it stand out?</p> <p>Is it feasible to develop the product?</p>	<div style="text-align: center;">  BUSINESS GOALS </div> <p>How is the product going to benefit the company?</p> <p>What are the business goals?</p>

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Figure 13 Product Vision Board (Pichler Consulting, 2020)

The first recommendation focuses on increasing consumers' awareness of sustainability and recycling. The proposed solution is to attach a QR code or a barcode (see invisible bar code case example in fourth chapter) to the product. When a consumer is in doubt about the recycling aspect of the product, she or he has a possibility to scan the code to get more information. This kind of solution would require minimal effort from corporates to implement but would provide a very effective and visual way to provide information for consumers. A recent concrete example of the QR code usage is restaurants that have started to use QR codes to provide menu for customers during the Covid-19 pandemic. As QR codes

are used in number of applications already, consumers are used to scanning the codes and it would be feasible to implement the QR codes in other applications.

From the university students' point of view, this would be a good opportunity to support companies implementing QR codes. Students could either produce content to the QR landing pages or support the companies with some innovation related activities. This proposal is visualized in the Product vision board, in Figure 14. Utilizing the QR code and establishing a new channel to communicate with customers, could be later on utilized when for example creating new product features.






 VISION Attach QR-code to a product, consumers to get more information about recycling			
 TARGET GROUP	 NEEDS	 PRODUCT	 BUSINESS GOALS
<ul style="list-style-type: none"> Users: Consumers who are buying products, that needs to be recycled or disposed 	<ul style="list-style-type: none"> Provide an easy way to promote and provide more information about recyclability of the product 	<ul style="list-style-type: none"> QR Code that is attached to product's packaging QR-code landing web-page 	<ul style="list-style-type: none"> For University students: help companies to generate the QR codes and create the QR-code landing page with valid content For companies: easy and cost-efficient way to promote their sustainability targets etc.

Figure 14 Product Vision Board for QR-code attached to a product

The interview participants were asked about their opinion on the recommendations. It was highlighted that in Russia, if you are voluntarily sorting your waste, it is important to know exactly what kind of material you are sorting. For example, different types of plastic are sorted in a different way. Given the complexity of recycling, the interview participants agreed that having QR codes with clear information about materials and its' recyclability would be appreciated. Participants also agreed that this would be a good opportunity for the university students to

support the companies in creating the QR-code landing pages. As majority of the housing complex have only one waste container for all waste, it is essential to acknowledge that it takes a lot of space from individual citizen's home to store the waste before sorting. Information about the recyclability together with improved infrastructure and waste facilities would be an efficient combination to secure efficient waste management processes. P3 highlighted that some cosmetics companies are already utilizing QR codes in their packaging as they want to highlight that they are using environmentally friendly packaging.

The second recommendation focuses on easy and effortless way to reuse and recycle products. As highlighted in the fourth chapter, there are second-hand online marketplaces with proven track record. Those channels provide an easy and effortless way for consumers to recycle and reuse products. Even without well-established waste management infrastructure and processes, consumers can make decisions that follow the CE approach and sustainability. Often consumers can get a particular secondhand product with cheaper price than buying a whole new product. This also reduces the need for completely new products.

The recommended approach is to expand some of the working platform or solution to the St. Petersburg market. Alternatively, there would be a business opportunity for university students to establish their own online second-hand market platform. Especially in the Helsinki area, new second-hand marketplaces are established on a regular basis. One of the latest second-hand marketplaces in Helsinki is a company called Flea, that started as an online marketplace but is in a process of opening a boutique in Helsinki. Flea is focusing on the latest fashion trends and having more "exclusive boutique" feeling compared to traditional second-hand markets. (Flea, 2020) A recommendation for the AWARE Project and university students in Russia is to evaluate the market in case a new second-hand operator would fit into the market. Figure 15 provides the product vision board for the online marketplace platform.






 VISION Establish or promote the usage of a second-hand online marketplace			
 TARGET GROUP	 NEEDS	 PRODUCT	 BUSINESS GOALS
<ul style="list-style-type: none"> Users: Consumers selling and buying used products online 	<ul style="list-style-type: none"> Sellers have possibility to recycle their products for the next user and get compensation Buyers can buy the used product for cheaper price and reduce the use of new resources 	<ul style="list-style-type: none"> Option 1: Establish a new second-hand marketplace platform Option 2: Expand or promote existing platform such as Zadaa 	<ul style="list-style-type: none"> For University students: evaluate the online second-hand marketplaces in St. Petersburg area and plan the next steps accordingly

Figure 15 Product Vision Board for second-hand online marketplace

This recommendation was also presented to the interview participants and they again echoed the approach. In Russia, there is a popular online marketplace (similar to tori.fi) called Avito.ru. Also, some other marketplaces were highlighted as a part of the interviews. The participants believed that amongst the university students, there would be potential to establish a new digital platform as the demand for this kind of service is high. In general, all the participants communicated that there are a lot of activities happening in digital platforms. Interview participant P1 noted there was a good discussion that Finnish social media influencers would be establishing digital online market platforms and there would be a niche for similar operations in St. Petersburg. P3 highlighted that a lot is already happening with second-hand markets, but not that widely within the fashion industry.

The third and final recommendation focuses on the close collaboration between different stakeholders. LUT University and the AWARE project have excessive amount of information related to sustainability, CE and waste management. Educational examples and social experiments such as “Fox the recycler” and “Greenhouse Homes” proved that if consumers have access to proper information and support, they are willing to change their habits, at least during the test or pilot phases.

The importance of increased educational activities leading to better results in achieving CE related approaches were highlighted in the CE chapter 3.1. The technological development and the fact that people are today having access to mobile phones and web services has led to projects where citizens are actively involved and sometimes reporting their findings about surroundings. The motivational drivers of sustained participation in citizen science projects were described in chapter 3.2. By utilizing some of these findings, the AWARE project could facilitate or join some kind of social experiment in St. Petersburg area and have close collaboration with the stakeholders such as students, citizens, local companies and local institutes. Results could be shared e.g. as part of LUT publications as there is limited amount of available literature and articles available related to St. Petersburg waste management and CE.

For university students being part or facilitating an experiment, with focus on promoting the CE approach and increasing the recycling activity, it would increase their understanding of project- and change management. Figure 16 illustrates the Product Vision Board for social experiment or educational initiative.






 VISION AWARE Project to join or facilitate social experimental initiative in St. Petersburg			
 TARGET GROUP	 NEEDS	 PRODUCT	 BUSINESS GOALS
<ul style="list-style-type: none"> St. Petersburg citizens who are willing to pilot recycling experiments University students or AWARE Project participants providing waste management skills and knowledge Other stakeholders 	<ul style="list-style-type: none"> Previous examples have shown good results from waste management related educational and social experiments One potential way to motivate citizens to recycle and learn more about waste management 	<ul style="list-style-type: none"> Initiative with relevant stakeholders and clear goal to promote the recycling in St. Petersburg 	<ul style="list-style-type: none"> For University students & AWARE Project: Promote the existing waste management knowledge, possibility to produce a publication, possibility to achieve good academic results

Figure 16 Product Vision Board for social experiment

The final recommendation was presented more as a high-level idea for the AWARE project to either facilitate or join some kind of social experimental initiative in the St. Petersburg area. However, as part of the interviews it was clearly highlighted that there are citizens who are willing to recycle their MSW but there is no infrastructure in place to support the recycling. Therefore, this recommendation would be to join or facilitate the social experiment with the focus on providing needed tools to enable the waste sorting. This could be done for example by providing separate waste sorting containers for particular housing co-operations and to evaluate how inhabitants would react to these waste containers. This would also be impressive way to showcase the upcoming waste transformation.

6 CONCLUSIONS

The purpose of this thesis was to evaluate current waste management status in St. Petersburg and to analyze global recycling & circularity related models and capabilities in order to provide recommendations for the AWARE project. LUT University is part of the AWARE Project that aims to provide sustainable waste management knowledge and expertise for Russian educators and higher education university students as waste management is an important issue to be solved. The purpose of this thesis was to provide materials and recommendations for the AWARE project. Then assumption was that the findings could be utilized for example facilitating waste management related university courses.

The main research question of this thesis was:

- What are the means, methods and ways based on circular economy and citizen participation to increase the individual consumers' recycling awareness in St. Petersburg?

The sub research questions of this thesis were:

- Based on public literature and reports, what is the current waste management and recycling status in St. Petersburg?
- What are the waste reduction related success factors based on the circular economy and citizen participation?
- Based on the current waste situation and global recycling and models, what are the most promising models that can be imported to Russian context?

The second chapter of this thesis answered the first sub-research question about St. Petersburg's waste management status. It can be summarized briefly that the waste management status is relatively poor based on the available literature and reports. Majority of the MSW ends up to landfills and there is no infrastructure in place to support recycling efforts which leads to inefficient use of resources. However, there are small and voluntarily led recycling projects ongoing. This status was confirmed by three specialists who were interviewed in order to get different viewpoints and

opinions. Russia has established large waste reform, but the results are not yet visible, and the reform is postponed in St. Petersburg area.

Circular economy and sustained participation in digital citizen science were studied in the third chapter, which answered the second sub-research question. The concept of circular economy has been well acknowledged over the last decades. The focus towards CE has increased because of the rising evidence of limited amount of available resources. When implementing circular economy related concepts, systematic approach, structured collaboration between key stakeholders and change management are required. The best results are achieved when citizens and local institutions or organizations are having good collaboration. Often citizens are likely to recycle or adapt CE related mindset if they have access to information or there is some kind of incentive provided. Additionally, two successful digital citizen science case studies were benchmarked as it is interesting to understand what motivates people to join these citizen science projects without compensation. Integrated and identified motivations were highlighted as the key for sustained participation (Palacin, et al., 2020) and described in Table 8. These factors are valid information for AWARE project considering their future assignments.

Existing recycling related case examples with proven track record were introduced in the fourth chapter. The discussion chapter provided recommendations for the AWARE Project based on the available literature, reports and case examples. The recommendations were focusing on models that could be imported to Russian context to promote the recycling and circularity in the existing environment. Product Vision board was used as a tool to visualize the recommendations.

By compiling the answers for the sub-research questions, a holistic answer for the main research question was able to be provided. Sustainability and circularity have been widely acknowledged over the past years. At the same time the amount of waste is increasing globally as well as locally in Russia. Without proper waste management strategy and processes, materials are not efficiently circulating and there is inefficient use of resources and unwanted environmental impact due to poor

waste management. The social aspect of increasing waste and sustainability related awareness in St. Petersburg is important and initiatives like the AWARE Project have an important role in promoting these topics. Increasing the awareness, providing easy access to recycling and engaging citizens in decision making are good ways to increase recycling activities. However, when transforming the existing waste management methods, both social and technical aspects should be carefully evaluated.

The recommendation for the future is to closely monitor the waste management status in Russia and especially in St. Petersburg. Most likely, there will be new technological and social innovations within the waste management industry. In the future, it would be interesting to conduct more detailed analysis of cultural differences in implementing waste or sustainability related innovations to Russian context. This would be one way to secure a successful implementation.

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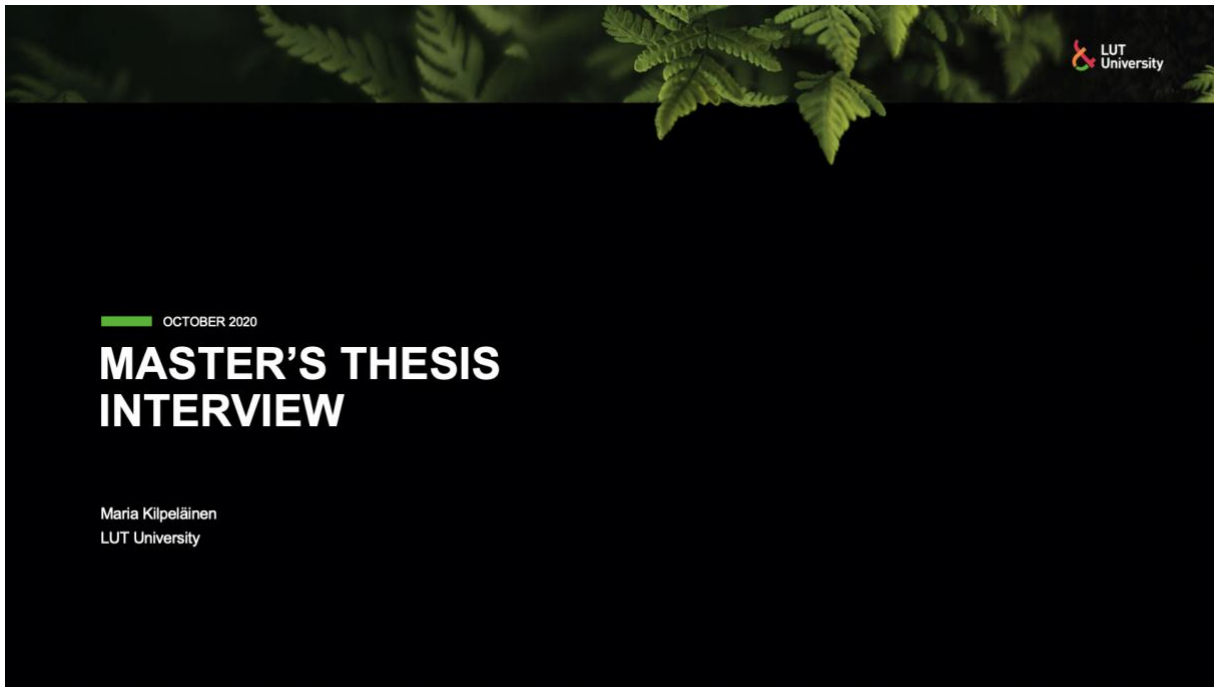
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Attachment 1. Interview slides

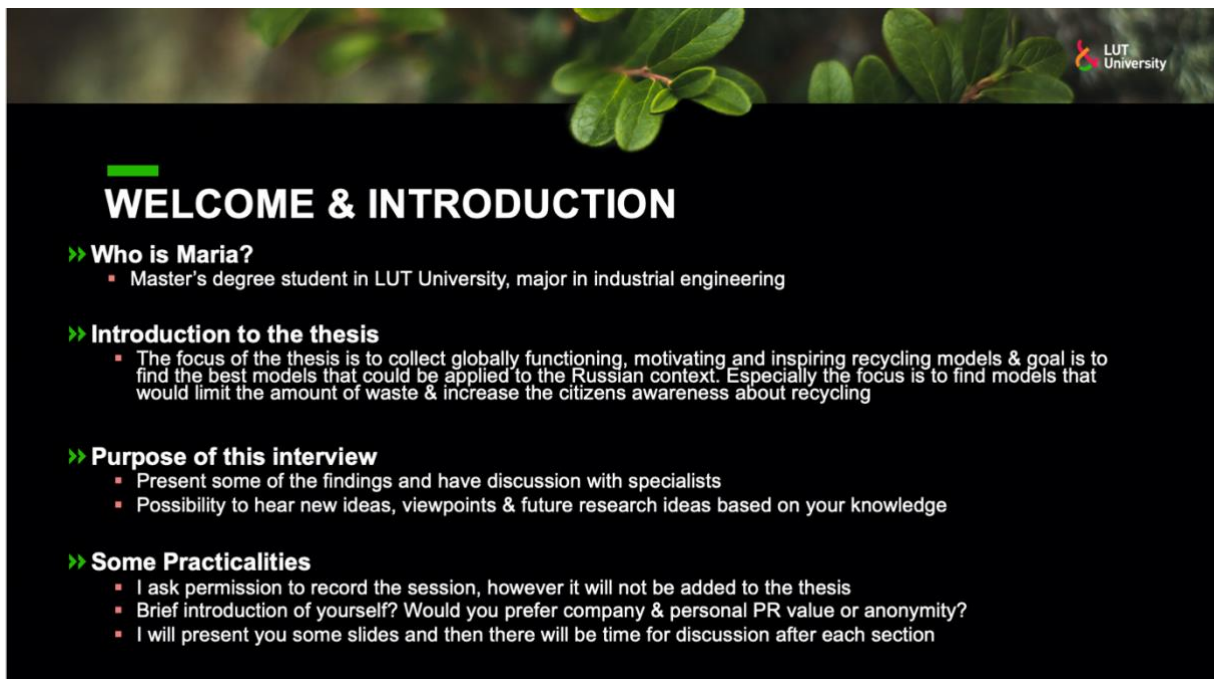


Slide 1: Master's Thesis Interview. The slide features a dark background with a green fern leaf at the top. The LUT University logo is in the top right corner. The text 'OCTOBER 2020' is in small green letters. The main title 'MASTER'S THESIS INTERVIEW' is in large white letters. Below it, the name 'Maria Kilpeläinen' and 'LUT University' are listed.

OCTOBER 2020

MASTER'S THESIS INTERVIEW

Maria Kilpeläinen
LUT University



Slide 2: Welcome & Introduction. The slide features a dark background with a green leaf at the top. The LUT University logo is in the top right corner. The title 'WELCOME & INTRODUCTION' is in large white letters. Below it, there are four sections: 'Who is Maria?', 'Introduction to the thesis', 'Purpose of this interview', and 'Some Practicalities', each with a list of bullet points.


WELCOME & INTRODUCTION

- » **Who is Maria?**
 - Master's degree student in LUT University, major in industrial engineering
- » **Introduction to the thesis**
 - The focus of the thesis is to collect globally functioning, motivating and inspiring recycling models & goal is to find the best models that could be applied to the Russian context. Especially the focus is to find models that would limit the amount of waste & increase the citizens awareness about recycling
- » **Purpose of this interview**
 - Present some of the findings and have discussion with specialists
 - Possibility to hear new ideas, viewpoints & future research ideas based on your knowledge
- » **Some Practicalities**
 - I ask permission to record the session, however it will not be added to the thesis
 - Brief introduction of yourself? Would you prefer company & personal PR value or anonymity?
 - I will present you some slides and then there will be time for discussion after each section



VIEW TO CURRENT WASTE MANAGEMENT STATUS IN RUSSIA BASED ON PUBLIC LITERATURE

Russia's waste management industry	St. Petersburg in more detailed
<ul style="list-style-type: none">» Majority of the households in Russia are not recycling and recycling rate is only 5%» Majority of the municipal solid waste (MSW) is transported to landfills» Landfills are reaching their limits. Some of the landfills are very old & not meeting sanitary requirements» Waste reform ongoing, but it is postponed in some areas. Target level for recycling is 60 % latest by 2030.	<ul style="list-style-type: none">» Majority of the MSW is collected into the standard containers (all waste to one container)» Some of the old houses have garbage chute» Two-step waste transportation process<ul style="list-style-type: none">▪ From containers to large containers and then to landfills» Waste collection and transportation should be improved in order to improve the recycling» Some citizens interested about recycling, examples to follow



TIME FOR DISCUSSION & REFLECTION BASED ON THE PRESENTED FINDINGS ON RUSSIA / ST. PETERSBURG'S WASTE MANAGEMENT

- » Is there some reports / surveys / data sources that I should be aware of?
- » Where would you look for the data / numbers of recycling rates?




RECYCLING CASES FROM ST. PETERSBURG



Voluntary organizations organizing recycling events
(e.g. Razdelnyi Sbor)




EcoTaxi – pick-up service for recyclable waste.
Customers pays small fee of the service









TIME FOR DISCUSSION – HAVE YOU HEARD ABOUT THOSE TWO CASES?

- » In general, what is your view on waste / sustainability initiatives in Russia / St. Petersburg?
- » What are the ways and channels to find more similar examples?
- » What do you think, how much citizens knows are about sustainability / waste related initiatives?









BASED ON FOUND GLOBAL MODELS & CURRENT WASTE SITUATION PRESENTED BY LITERATURE, FOLLOWING EXAMPLES ARE SEEN AS MOST PROMISING TO BE "IMPORTED" TO RUSSIAN CONTEXT (1/3)

 VISION Attach QR-code to a product, consumers to get more information about recycling			
 TARGET GROUP	 NEEDS	 PRODUCT	 BUSINESS GOALS
<ul style="list-style-type: none"> Users: Consumers who are buying products, that needs to be recycled or disposed 	<ul style="list-style-type: none"> Provide an easy way to promote and provide more information about recyclability of the product 	<ul style="list-style-type: none"> QR Code that is attached to product's packaging QR-code landing web-page 	<ul style="list-style-type: none"> For University students: help companies to generate the QR codes and create the QR-code landing page with valid content For companies: easy and cost-efficient way to promote their sustainability targets etc.




BASED ON FOUND GLOBAL MODELS & CURRENT WASTE SITUATION PRESENTED BY LITERATURE, FOLLOWING EXAMPLES ARE SEEN AS MOST PROMISING TO BE "IMPORTED" TO RUSSIAN CONTEXT (2/3)

 VISION Establish or promote the usage of a second-hand online marketplace			
 TARGET GROUP	 NEEDS	 PRODUCT	 BUSINESS GOALS
<ul style="list-style-type: none"> Users: Consumers selling and buying used products online 	<ul style="list-style-type: none"> Sellers have possibility to recycle their products for the next user and get compensation Buyers can buy the used product for cheaper price and reduce the use of new resources 	<ul style="list-style-type: none"> Option 1: Establish a new second-hand marketplace platform Option 2: Expand or promote existing platform such as Zadaa 	<ul style="list-style-type: none"> For University students: evaluate the online second-hand marketplaces in St. Petersburg area and plan the next steps accordingly



BASED ON FOUND GLOBAL MODELS & CURRENT WASTE SITUATION PRESENTED BY LITERATURE, FOLLOWING EXAMPLES ARE SEEN AS MOST PROMISING TO BE "IMPORTED" TO RUSSIAN CONTEXT (3/3)

VISION AWARE Project to join or facilitate social experimental initiative in St. Petersburg			
TARGET GROUP	NEEDS	PRODUCT	BUSINESS GOALS
<ul style="list-style-type: none">St. Petersburg citizens who are willing to pilot recycling experimentsUniversity students or AWARE Project participants providing waste management skills and knowledgeOther stakeholders	<ul style="list-style-type: none">Previous examples have shown good results from waste management related educational and social experimentsOne potential way to motivate citizens to recycle and learn more about waste management	<ul style="list-style-type: none">Initiative with relevant stakeholders and clear goal to promote the recycling in St. Petersburg	<ul style="list-style-type: none">For University students & AWARE Project: Promote the existing waste management knowledge, possibility to produce a publication, possibility to achieve good academic results



TIME FOR DISCUSSION - DO YOU THINK THIS KIND OF INITIATIVES WOULD BE SUITABLE IN ST. PETERSBURG?

» Notes