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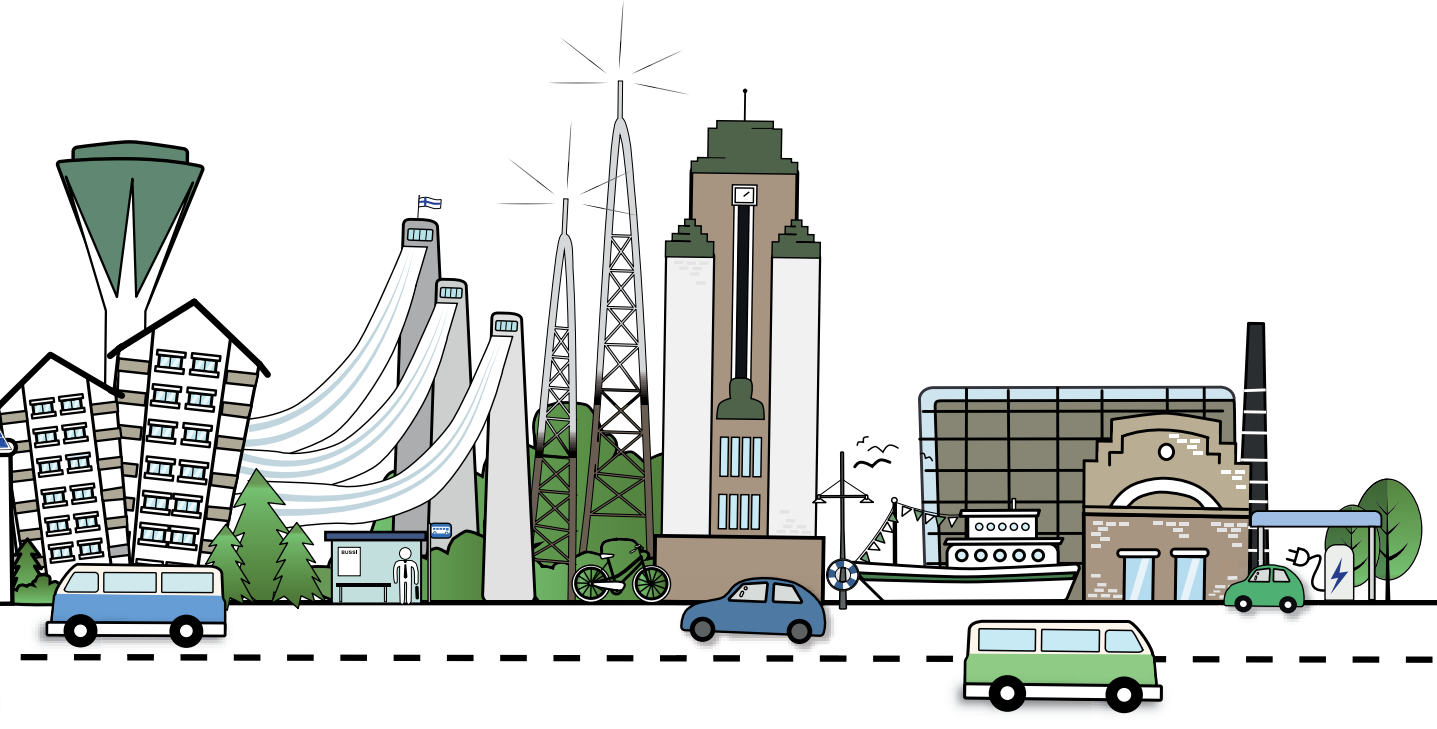

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Kati Manskinen

Foreword

This publication presents the latest interesting research, development and innovation activities in the context of Circular Economy written by experts from Lahti University of Applied Sciences (Lahti UAS) and their partners. It continues a series of successful publications, launched for the first time in 2014, with the name Lahti Cleantech Annual Review. The term Cleantech refers to products, services and technologies that reduce the environmental impacts. However, during recent years, a more comprehensive Circular Economy concept has become popular; besides Cleantech, it also includes other important aspects, such as sharing economy and product design, which are required in our path towards a sustainable use of resources. Nowadays, one focus area of our research, development and innovation projects is circular economy solutions, and therefore, this publication has been renamed Lahti Circular Economy Annual Review.

In the year 2016, the city of Lahti launched a new strategy, which highlights the significance of circular economy. Moreover, the Regional Council of Päijät-Häme recently published a new regional program for the period 2018-2020. It also includes the regional circular economy strategy, which Lahti UAS together with local stakeholders developed as a part of a project called Kiertoliike. The vision for circular economy in the Päijät-Häme region was formulated as "Päijät-Häme – the successful resource efficient region". To reach the vision, these five main goals were identified during the strategy process: 1) Closed loops of technical streams to create added value; 2) Sustainable food systems as a part of bio circular economy; 3) Towards energy self-sufficiency through sustainable transport and energy solutions; 4) Shared economy generating new consumption models and business opportunities; 5) Piloting and demonstrating innovative circular economy solutions. In addition, concrete actions related to each goal were agreed on. This review presents some of the significant actions that have been carried out as a part of our projects in order to reach the goals and promote the transition towards circular economy.

In the first article of this review, the challenges and possibilities in closing the loop of textiles are described by Dr. Kirsti Cura and Dr. Lea Heikinheimo. In their article, they point out the importance of analysing harmful, toxic and hazardous chemicals in order to develop closed loops of textiles, as well as the need for a national ecosystem in this context. Besides textiles, the plastic waste fraction is another interesting technical material that has business potential. In their article, Dr. Sami Luste and Mr. Juho Hilden introduce a possibility to increase recycling volumes and business around plastic waste by means of flexible thermochemical treatment.

The technology solutions in the energy sector are progressing fast. The article written by Mr. Jussi Kuusela and Ms. Erika Korpijaakko describes renewable energy solutions for regional industrial plants and discusses the possibilities to create local energy ecosystems.

Moreover, the importance of energy efficiency actions such as energy audits is pointed out in the article of Ms. Marika Vainio and Dr. Sami Luste, who present interesting energy data of wastewater treatment plants.

The region of Lahti is known as a forerunner in bio circular economy and industrial symbiosis. The article written by Ms. Susanna Vanhamäki et al. presents the seven bio-based circular economy good practices in Päijät-Häme. These good practices include new technologies and solutions, cooperation models, networks and ecosystems. After all, it is the consumers that enable the transition towards circular economy. In their article, Dr. Ville Uusitalo et al. from Lappeenranta University of Technology (LUT) share the results of their study on aspects that affect consumers' purchase and consumption decisions on food-related issues. In addition, Dr. Mirja Kälviäinen and Ms. Vivi Koivisto describe the interesting results of empirical interviews about the barriers and interests the consumers have for tackling underuse and recycling of products.

Nowadays, the benefits of circular economy are acknowledged in many European countries. However, only a few studies have been conducted on the opportunities it offers for developing countries. From the beginning of the year 2017, the city of Lahti and Lahti UAS have continued co-operation with municipalities in Ho, Ghana, and in Rustenburg, South Africa. Ms. Maarit Virtanen, in her article, describes the recognized circular economy opportunities in these countries. The international partnership networks also offer our students a chance to expand their knowledge in an intercultural environment. One of our students, Mr. Albert Mäkelä, together with his professor Pia Haapea, share the results of the study carried out during his internship period in Namibia.

I warmly thank all authors who made it possible to publish this review once again. I am very glad that many of you had a chance to share your latest interesting research and development results in this review. I express my gratitude to the editor of this review Dr. Kirsti Cura for her expertise and to Ms. Maija Varala for correcting the English language of the articles. I hope that this review gives you some new insights and further ideas in the transition towards circular economy society.

Lahti, 10 November, 2017

Dr. Kati Manskinen
RDI Director, Circular Economy Solutions
Lahti UAS

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Kirsti Cura and Lea Heikinheimo

Challenges and possibilities in textile recycling towards circular economy

Why is the recycling of textiles essential?

It has been estimated that in the Nordic countries textiles cause the greatest environmental impact after food, housing and transport. Schmidt and his colleagues have collected an extensive list of textile-related factors that are relevant for the environment and should be taken into consideration when creating strategies for discarded textiles. The most important findings are:

- Two thirds of textile waste end up in mixed waste and is mostly utilised for energy. This fraction is worth investigating for further recycling and reuse.
- Reusing a garment as a garment is always the best option from the environmental point of view; the next best option is recycling, and incineration is the worst option.
- The most important fibres are wool, cotton and polyester (in this order).
- Some hazardous chemicals stay in textiles throughout their lifetime as a garment, and are therefore transferred to reuse and mechanical recycling processes.
- Both hazardous and non-hazardous chemicals/substances may cause problems in chemical recycling processes as they interfere with chemical reactions.

The authors emphasize that their results have great uncertainties. This is typical for all studies related to textile waste. (Schmidt et al. 2016)

Regarding environmental impacts, water consumption in cotton production has the greatest negative environmental impact. Estimates vary, but up to 20 000 litres of water can be needed to produce one kilogram of cotton. It is also estimated that 73 % of cotton is produced by water irrigation. (Living Waters 2017) Cotton is also a very pesticide-intensive crop needing large cultivation areas. Global food production also needs more and more land, so land available for cotton production will get smaller in coming years. In global textile production, polyester has become the most common textile fibre over cotton. The increase of polyester is not good news for the planet, either. Although there are several commercial recycling processes for polyester, both mechanical and chemical, virgin polyester is always derived from fossil fuel. In addition, fleece and a lot of outdoor clothing made from polyester get regenerated into microplastics during use and washing. The problem with microplastics has finally been recognised also in Finland as microplastics have been found in Finnish seas and lakes (Setälä et al. 2017; Ympäristötiedon foorumi 2016).

THE CHAIN OF SORTING AND EXPLOITATION OF TEXTILE WASTE

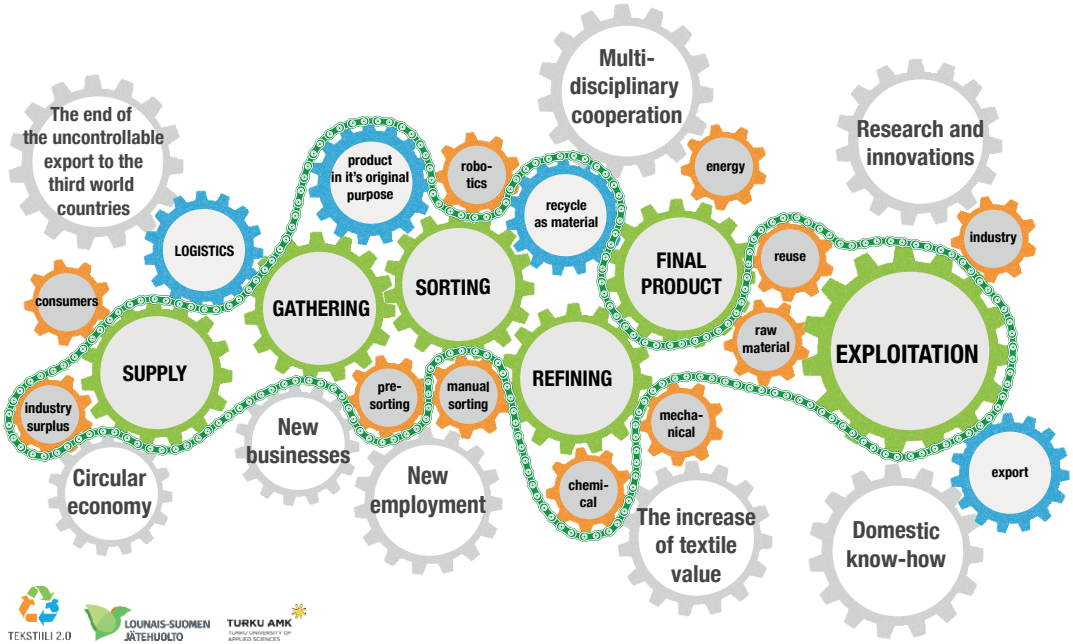

Figure 1. Telaketju chain. (Telaketju 2017)

Building an ecosystem for textile recycling in Finland

In Finland, we produce about 13 kg of discarded waste per person every year, and currently only about 20% of used textiles are collected for reuse (Dahlbo et al. 2015). What is needed to get added value out of Finland's textile waste streams? The answer is: wide and innovative collaboration with consumers, different types of companies, innovators, research institutes, non-governmental organisations (NGOs') and anybody who is connected to textile streams. What does it take to have a textile recycling ecosystem in Finland? This question was raised a couple of years ago in Finland. The answer is: the Telaketju consortium and community. The Telaketju project is by its definition "a chain of sorting and exploitation of textile waste". In this on-going project funded by Tekes (Finnish Funding Agency for Innovation), there are numerous activities through all the stages of the value chain.

The targets of the Telaketju project include development of the processes, products and business operations in participating companies, aiming at new business opportunities based on the circular economy model of textiles, e.g. material recycling and/or service-based business models. It improves the community's readiness for transformation from linear to circular economy. The primary focus is on companies who look for growth and competitiveness especially in the export market.

The most important link in this chain is the consumer and his/her behavior. In order for the ecosystem to work, consumers need to know how to sort different types of textiles and act accordingly. Consumers are known to want transparency of what happens to their textiles. This is a great challenge for all stakeholders, as good examples and practices are the best way to spread information. Unfortunately, there have been cases where well-known fashion brands have collected thousands of kilos of garments from consumers and sent them to waste incineration, although they could have been worn again, reused, or recycled (Heiskanen 2017).

Currently in Finland, there are several ways for textile waste collection and recycling, depending on the area. For example in the Helsinki area, there are collection points of many charity organizations. In addition, there are many vintage shops etc. in the Helsinki area. On the other hand, in Rauma and the East-Uusimaa area there have been no separate collection points for textile waste and it has gone to mixed municipal waste. In a pilot where a group of the Telaketju project conducted a textile waste collection in Rauma and the East-Uusimaa area, they received dirty and mouldy clothes, mouse droppings and even a circular saw blade among "correct" textile waste. (Knuutila 2017) This proves that correct and efficient communication and instructions to consumers are essential to get the whole chain rolling.

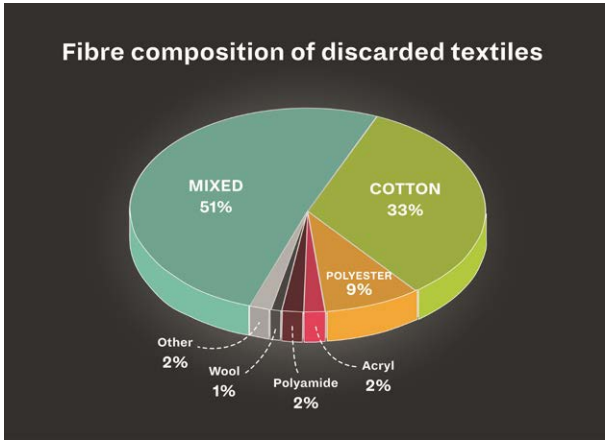

Figure 2. Fibre composition of discarded textiles at Patina. (edited by Oona Rouhiainen)

Studies on the quality and quantity of textile waste at Lahti UAS

During the past two years, two separate studies have been carried out where qualities and quantities of discarded textiles were studied. The results of the first study at Patina were reported in Lahti Cleantech Annual Review 2016 (Cura & Heikinheimo 2016). The amount of collected textile waste was 778 kg, of which 418 kg went for sale and 117 kg went for charity. Hence, the amount of waste textiles that went to recycling and reuse, i.e. discarded textiles, was 238 kg. The fibre composition of the discarded textiles is presented in Figure 2.

A second study was carried out in spring 2017 by a group of students in the Circular Economy learning package. This time 83.5 kg of discarded textiles were sorted and identified both manually and using FTIR spectroscopy. Fibre identification was carried out mainly using washing instructions attached to the garments. FTIR spectroscopy was used to either identify garments without washing instructions or if washing instructions were not clear enough. Figure 3 shows how fibre information can also be marked.

The batch studied (83.5 kg) contained 42% of mixed fibres, 33% of cotton and 14% of polyester. When mixed fibres were examined in more detail, it was discovered that 56% of them contained cotton. In 15% of the batch, the main fibre component was polyester and in 14% of the batch it was polyamide. Garments often contain some elastane as even just a few per cent of elastane gives improved flexibility (for example in hosiery). It was discovered that 33% of the whole batch contained elastane. The students came across a garment which had five different fibres in the same garment (cotton, polyamide, polyester, viscose and triacetate), which is challenging from the identification and especially chemical recycling point of view. (Salojärvi et al. 2017)

Comparison with other studies on discarded waste

The results of the two Lahti UAS studies compare well with each other. In both batches (238 kg and 83.5 kg), the amount of mixed fibres was high: 51% and 42%, respectively. The highest pure fibre fraction was cotton: both batches contained 33% of cotton. The amount of pure polyester was 9% and 14%, respectively.

There are some other quality studies published in Finland recently. During the Poistaripaja project 2013-2014, 23 000 kg of textile waste was collected, of which 35% was reused, 55% was recycled and 10% went to incineration. The composition of the recycled fraction was 60% cotton, 35% polyester and 5% acryl (Dahlbo at al. 2015, 20). It is not mentioned how fibre identification was carried out but it can be assumed it was by naked eye, feel and/or based on washing instruction labels.

In a textile recycling pilot called Textile 2.0 pilot in 2016, Turku University of Applied Sciences and Lounais-Suomen Jätehuolto Oy collected over 90 000 kg of discarded textiles. About a third, 31%, of the collected textiles was utilised by local eco designers, Dafecor and Frankenhuis. In the material-based sorting, 45% was unidentified including mixed fibres, 31% went to energy recovery, 8% was knitted textile, 13% was 100% cotton, 8% was 95% cotton and 3% was 100% synthetic material. Identification was carried out using washing instruction labels attached to garments. (Turku University of Applied Sciences 2017)

Figure 3. Identification of mixed fibres. (photo by Linda Karlström)

It is actually quite challenging to compare the two studies at Lahti UAS with the studies of Poistaripaja and Textile 2.0. There are three main reasons: 1) Lahti UAS used FTIR to identify fibres. The other two studies used either washing instruction labels and/or naked eye and feel. 2) In Poistaripaja's and Textile 2.0's studies, both were collecting knitted garments for Dafecor. This was their first priority. This company uses knitted textiles for making OilStop products and many other products for cleaning the environment. (Dafecor 2017) Their sorting instructions were based on the knit structure, not on the fibre's chemical composition. Therefore, the fraction "knitted textiles" can and does contain wool, a mixture of wool and cotton, and polyester textiles. 3) In the Textile 2.0 study, the amount of unidentified textiles was high and contained mixed fibres. The Poistaripaja study contained 60% cotton and there were no mixed fibres mentioned in the study. This is hard to believe to be true as it is known that normally about 30% of the batch is pure cotton.

It has to be noted that washing instruction labels do not always tell the truth nor are always informative enough, as Figure 3 shows. It is estimated that for example 10-15% of 100% wool jumpers are other than 100% wool. In

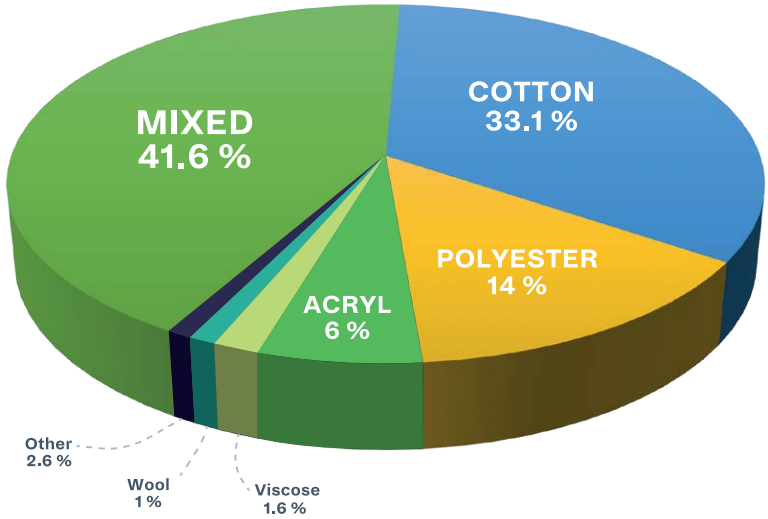

Figure 4. Fibre composition of discarded textiles at Finnish Red Cross Kontti. (edited by Oona Rouhiainen)

addition, many consumers remove washing instruction labels from their garments. As a result, if identifying is done only using washing instructions, many textiles cannot be identified/guessed at all. According to the Telaketju project's experience from sorting pilots, 1/3 of the garments do not have a washing instruction label (Engström & Mäkiö 2017).

Lahti UAS is involved in developing identifying analytics for different textile fibres. The Faculty of Technology has recently acquired a textile identifying and sorting unit. Identification of textile fibres is based on NIR (near infrared) spectroscopy.

As the spectrometer and software itself does not contain information for textile fibre identification, libraries of different textile fibre samples need to be built, using known textile fibre samples with different knit and weave structures.

In addition to textile fibres, samples of harmful and hazardous chemicals are being collected to find out if such chemicals can be detected using NIR. Companies that plan to use discarded textiles have raised concern about which chemicals can and may be present in which amounts. Legislation requires recycled fibres to meet the same requirements for chemical contents as it is required for products made from virgin fibres. This means that it is extremely important to get more information about the concentration of chemicals in products made of recycled fibres, in order to bring recycled textile products to the market. Pre-consumer textile waste is regarded as easier to reuse because for example the composition and possible chemical treatments of production waste is known by the factory where the waste comes from. Post-consumer waste is a great challenge as it is not known what chemicals and harmful substances discarded textiles contain. This problem can partly be solved through appropriate sorting, which needs to be well instructed for consumers. For example, T-shirts with thick rubbery prints, which can contain PVC with plastic softeners, can be separated. This ensures that PVC with softeners does not end up in recycled products but it is removed from recycling loops.

Global and local perspectives

The Circular Fibres Initiative by the Ellen MacArthur Foundation (Ellen MacArthur Foundation 2017) was launched in November 2017. It claims to bring industry together in order to create a circular economy for textiles. The first focus is clothing, and it tries to tackle significant drawbacks caused by the current "take-make-dispose" consumption model in the textile industry. The targets are to create growth that benefits consumers and businesses, at the same time phasing out waste and pollution issues. Dr. Cura is among the official contributors interviewed for this initiative.

At the same time, Lahti UAS has launched the Päijät-Häme Circular Economy Road Map for the region (Lahti University of Applied Sciences 2017). As a part of this road map, regional textile waste streams have been estimated. Despite the fact that some studies and enquiries have been carried out during the REISKA-project, the only way to describe regional textile waste streams is to use a study conducted by SYKE in their TEXJÄTE project (Dahlbo 2015). It is estimated that the amount of textile waste produced annually in Päijät-Häme is 3 370 tonnes (Lahden ammattikorkeakoulu 2017). The national number is 70 000 tonnes, so the impact of this regional textile waste stream is very small. However, as has been noticed in the Telaketju project, Finland needs a national ecosystem for textile recycling

Figure 5. Textile identifying and sorting unit at Lahti UAS. (photo by Oona Rouhiainen)

in order to get enough textile material streams for cost-effective exploitation. The quantities of regional streams help to understand how logistics need to be organised, where and what the greatest bottlenecks are, et cetera. In addition, the qualitative issues of post-consumer waste has been recognised, regarding fibre purity and harmful chemicals. Lahti UAS has an important role when identifying and developing both qualitative and also quantitative methods for analysing harmful, toxic and hazardous chemicals in discarded textiles.

Acknowledgements

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Sami Luste and Juho Hilden

A possibility to increase recycling volumes and business around plastic waste

Introduction

The present crosscutting description is based on the current volumes and solutions of plastic recycling, and the possibilities opened by the development of sophisticated energy systems by Nocart Ltd. The aim based on the circular economy is to introduce flexible method(s) that would enhance the recycling of the "difficult plastic fractions".

Targets and current status of plastics recycling in the EU and Finland

In the EU, a third of our plastic waste still goes straight to landfill (EC 2017). That is a waste of resources, both of material and energy. The general recycling target for household waste, such as plastics, is determined in the Framework Directive on Waste (2008/98/EC). Plastic waste must already be collected separately and, according to the Directive on Packaging Waste (94/62/EC), about 23% of the plastic material should be recycled back to plastic manufacture. The EU's Circular Economy Action Package (2015) proposes raising the recycling target for plastic packaging to 55% and reducing landfilling to less than 10% by 2030.

In 2013, the global production volume of plastic was 300 million tons, out of which 57 million tons was produced in Europe. The volume of plastic annually imported to Europe is anticipated to increase to 67 million tons by 2020 (EC 2011). This would mean an increase of almost 20 %, when compared with year 2013 (56 million tons). The most commonly used plastics include polypropylene PP and various polyethylenes, such as PE-LD, PE-LLD, PE-HD and PE-MD (Eskelinen et al. 2016). Waste generation in Finland is monitored by collecting and analysing statistical data of plastic released into the market (Figure 1).

The volumes of plastic waste generation in Finland vary depending on the chosen calculation method. For example in 2014, 117 000 tons of plastic-based packaging waste was generated in Finland (ELY 2016). However, the calculations do not include waste that is generated by companies with turnovers under 1 million €, or by e-commerce (Eskelinen et al. 2016). In 2012, 36 000 tons of community plastic waste was separately collected, out of which 32 000 tons was utilised in energy production (Tilastokeskus 2013). According to the Finnish Environment Institute's estimate, around 50 000 to 110 000 tons of plastic ended up as municipal solid waste between 2010 and 2012 (Eskelinen et al. 2016).

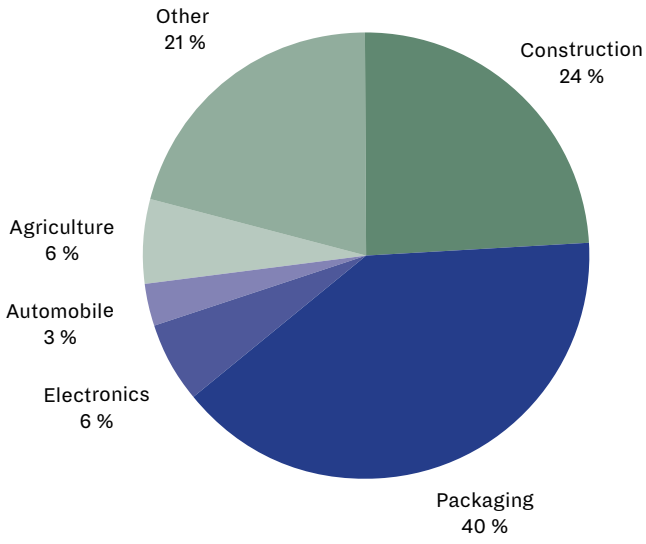

Figure 1. Plastic uses by product types in Finland.

Recycling of plastics

A very small amount of plastic is recycled in Finland. In 2013, the amount of the recycled plastic in Finland was less than 1% from total plastic consumption (Salmenperä et al. 2015). Also, 30 000 tons per year of plastics are exported to be further processed. Finland's plastic recycling rate (57%) is notably lower than the EU-28 average (66%). In 2014, the EU generated about 25 million tons of post-consumer plastic waste, of which only 30% was recycled (Table 1). Landfilling (31%) and incineration (39%) rates are very high and, while landfilling has decreased over the past 10 years, incineration has been growing, with big disparities among the member states, linked to various states of implementation of existing legislation. In Finland, energy utilisation of plastics is not considered to be recycling.

Table 1. Target distribution of the recycled plastic in the EU. (Aaltonen 2014; Eskelinen et al. 2016)

Recycling targets	Examples	Relative share (%)
Distribution products	Bags, film	40
Building materials	Pipes, profiles, insulation	30
Household products	Garden furniture, composters	20
Other products	Landscaping, textiles	10

The recycling methods of plastics can be classified as follows (Eskelinen et al. 2016):

- Primary recycling methods aims to reuse the waste as such or for its original purpose without the loss of value. Primary and secondary methods are represented by the recycling of PET bottles, in which the material attributes of recycled PET plastic remain equal to virgin plastic.
- Secondary recycling stands for methods that utilise plastic waste as a raw material for new products. Normally, the plastic material attributes suffer during processing. For example, canisters made from PE-HD plastic are recycled in an open-loop manner into raw material for plastic fences.
- Tertiary methods recycle plastic chemically back into raw plastic material.
- Quaternary methods utilise plastic in energy production.

One of the recycling methods for plastics is a thermochemical treatment that aims to separate side streams that can be utilised, from the various waste fractions. The thermochemical treatment could, depending on the material and specific technology, combine the opportunities of secondary, tertiary and quaternary recycling methods mentioned above. Most of these solutions, used around the world, fractionate the process intermediates typically up to a few different end products, but most often only solid and liquid fractions. The flexibility of the technology is highly important, when different kinds of plastics are recycled for both energy and material cycle captures. Both options complement each other and exploit the full potential of plastics wastes.

The process, which is under development at Nocart Ltd., would treat raw material in a continuous-type reactor, where the raw material is thermally processed into gases and various side products. The process gas and side products could be refined into multiple end products, such as fuel gases, fuel oil, carbon black, and other solid fractions. The process could be designed to be thermally self-sustaining, and to produce heat, such as electricity.

Bottlenecks and possibilities regarding enhanced plastic recycling

In Finland, the thermochemical decomposition of plastic is interpreted as waste incineration, if the end-products of the process are utilised only as energy within the facility and no chemicals or other products are harvested from the process as materials. The thermochemical treatment process which aims to produce recycled materials could increase the overall rate of plastic recycling in Finland, reducing the use of virgin raw materials. However, this would need the updating of the national legislation.

One of the greatest problems associated with recycling plastics is the natural incompatibility of some of the material properties of different plastics (Eskelinen 2016). Multi-layer plastics, often found in municipal and packaging waste, have proven to be especially difficult to recycle. These plastic waste streams are also dirty, which increases investment costs in the form of the required washing or cleaning. There are also market-relating challenges, and thus the demand for recycled plastic products is rather low, while the cost-efficiency of recycling processes requires large volumes. The low demand can partially be explained by limited applications for recycled plastics. The applications are limited by the weaker material properties of recycled plastics, when compared with their virgin counterparts (Järvelä & Järvelä 2015).

Besides the currently increasing amount of plastic flows in the EU, there are high volumes of plastic waste in the "reserve" of the EU landfills. The interest towards landfill mining has increased due to the nowadays critical raw materials (dumped to landfills). It could be estimated that since 1995 (when the Eurostat started to summarise the national waste data), 450-1400 million tons of material suitable for incineration have been dumped to the EU-28 landfills. The estimated share of plastic waste would be 180-540 million tons (Eurostat 2015). The actual amounts of plastic waste are notably higher, when the potential of the 70's and 80's landfills are taken into consideration (Franke et al. 2013).

In Russia, there are rapidly growing amounts of plastic waste material available, with an increasing need for managing it in a sustainable and decentralised way. Russia produces about 7000 million tons of waste per year, of which 80% is disposed of in landfills. The main part of the recycled waste comes from the industry sector and the main problem is related to the increasing amount of municipal solid waste (MSW). The amount of the produced municipal waste is about 8-10% of the total amount of the waste (about 700 million tons per year; Rosprirodnadzor 2012). Almost the entire amount of the municipal solid waste (MSW) produced in Russia is disposed of in landfills, both authorised and illegal dumps. However, in the St. Petersburg area the majority of the existing landfills are outdated and unable to meet the future challenges of the growing amount of waste (IFC 2012). Moreover, there are no incineration plants in the Leningrad region and the logistical connections are long and usually in a bad condition. The treatment and disposal of plastic waste is calculated to be about 8 times more expensive than with industrial waste, and almost three times more expensive than the treatment and disposal of the waste collected from the municipalities (Cleandex 2010).

The amount of the plastic waste in Russia in 2009 was about 3.3 million tons, of which

only about 0.4 million tons was reused (material from industrial processes). The amount of plastic in the total amount of the solid waste is estimated to be 4-5%, which is about 35 million tons (IFC 2012). The mixed MSW produced in the rural areas is mainly plastic packaging waste. According to the estimates generated in the LugaBalt project (2012-2014; South-East Finland - Russia ENPI CBC Programme 2007-2013), about 60-80% of the waste in the illegal dumps was plastic packaging waste. The volume of plastic waste in Russia is expected to be more than 7 million tons by 2025 (DRG 2013). The expected deficit of polymers as a raw material increases the need to develop flexible recycling technologies (i.e., both raw material and energy; Abercade 2010). This offers possibilities for Finnish technology suppliers, but also the raw material based business, for more efficient recycling of the challenging plastic waste. A flexible technological solution would offer an interesting tool to tackle the problem. Such development, on the interface between the material- and energy cycles, would also contribute to decentralised energy production and energy ecosystems implementing the circular economy into practice.

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Jussi Kuusela and Erika Korpijaakko

Energy connects companies in Nastola

In 2014, EU countries agreed on a Framework for climate and energy for the period 2020-2030, with new targets. These targets are to reduce greenhouse gas emissions at least 40 % compared with 1990 levels, to reach a 27 % share of renewable energy sources of total consumption and to improve energy efficiency by 27 %. (European Commission 2014) To achieve the EU's targets, the Finnish Government has conducted a report on the National Energy and Climate Strategy for 2030 (Ministry of Economic Affairs and Employment 2017). In this strategy, one policy to increase the use of renewable energy and raise the degree of self-sufficiency of energy consumption is to promote decentralised electricity and heat production that is based on renewable energy.

In the ERDF-funded project (2016-2018) "The industrial symbiosis and energy ecosystem in Nastola – NETS", Lahti University of Applied Sciences, Nastola's Energy Foundation (Nastolan Energiasäätiö) and seven companies from various industrial sectors in Nastola have explored opportunities for energy efficiency cooperation. The aim of the project is to promote energy and material efficiency and the use of renewable energy sources. The companies have joined the project to achieve economic benefits through energy solutions based on renewable energy and a common energy ecosystem. They also want to improve their self-sufficiency in energy production and to utilise surplus energy from production. (Lahti UAS 2017)

Cooperation between industrial companies

When designing new industrial areas, industrial symbiosis of the material and energy sectors and cooperation between companies can be taken into account. In old industrial areas, cooperation may be more difficult because the area's infrastructure has not been planned for that. This can pose challenges for example for co-generation of energy. Also from a financial point of view, there might be problems with cooperation because of competition. Trust between companies is the key to start cooperation.

It is exceptional that many different companies strive for joint renewable energy production and look for solutions together for example in groundwater and solar energy. In the NETS project, cooperation has been easier because all participating companies are from different fields and hence there is no competition between them. The companies have been transparent about sharing their energy consumption data and energy efficient practices, thanks to their good dialogical connection. It must also be mentioned that there is strong cooperation of companies through the Nastola Energy Foundation and the Industry Group of Nastola (Nastolan Teollisuusryhmä).

Groundwater has great energy potential

The NETS companies are located in the Salpausselkä end moraine formation, which led to the idea to exploit the aquifer for energy source. The NETS project provided the companies with a preliminary study of the suitability of groundwater as a source of energy. This study was done by the Geological Survey of Finland (GTK). For example, groundwater temperatures were measured in several observation wells (Figure 1).

Groundwater energy utilisation (GEU) can be divided into two main techniques: 1) GWHP (Ground Water Heat Pump) system and 2) ATES (Aquifer Thermal Energy Storage) system. In both of these systems, groundwater is pumped from an abstraction well and returned to the subsurface via an injection well. There is an energy-transfer system between these two wells, which can simply be a heat exchanger, or it can also contain a heat pump. Heat pumps are used when higher temperatures are needed, for example when producing heating power for buildings. (Arola 2015)

In the ATES system, groundwater is pumped in two directions depending on whether groundwater is used for heating or cooling. In the heating season (winter), warmer groundwater is pumped from the abstraction well and returned to the injection well at a lower temperature. In the cooling season (summer), this reserved and colder groundwater is pumped from the injection well (which now works as an abstraction well) and returned to the other well at a higher temperature. The groundwater is not in contact with the heating or cooling distribution system and only the temperature of the groundwater changes between the abstraction and the injection well. (Arola 2015)

Groundwater is particularly widespread in areas with extensive deposits of permeable sands and gravels. In Finland, there are around 6 000 classified aquifers. Groundwater plays an important role as the source of water supply management, for which reason classification and mapping are done relatively accurately. (Britschgi & Gustafsson 1996) The water supply management can restrict the utilisation of groundwater energy.

Aquifers are not widely recognised as an option for renewable energy source (RES) in Finland even though aquifers are commonly used as an energy source in other European countries. In Sweden, groundwater aquifers have been used for energy source for decades, and about 160 ATES plants represent about 300 MW capacity (Gehlin & Andersson 2016). The Netherlands is the world's leading country in the utilisation of groundwater energy and in year 2015 there were already about 2000 ATES systems in use (Bakema & Schoof 2016).

Arola and his colleagues (Arola et al. 2014) estimated that out of the 6 000 classified Finnish aquifers, 801 are under urban and industrial land, covering approximately 565 km^2. These aquifers are relatively easily exploitable as aquifer energy reservoirs and altogether 60 MW of heat load could be utilised. In the NETS project, groundwater energy potential was mapped for the companies that are involved in the project. The main result was that it is possible to cover a significant part of the base load of heating and cooling by the groundwater in the area (Kuusela et al., submitted).

Figure 1. Temperatures were measured from groundwater wells by the GTK. (photo by Joonas Kouvo)

Solar power

Solar energy is problematic because of the inconsistent availability and relatively high cost. In Finland, the seasons also set their own challenges, and the changeable weather conditions also cause that the predictability of production is weak. These reasons have prevented solar power from becoming a more widely utilised energy source. However, the cost of solar panels has reduced significantly in the past few years (European Photovoltaic Industry Association EPIA 2014). The solar panels (PV systems) have indeed become more and more interesting, especially in the economic sense, but a restricting factor is quite a low return expectation of the capital. The repayment period in most cases is much more than ten years, which is too long for most companies. If there is overproduction, it means a longer repayment period even though the electricity company pays for the production that is fed to the electric power distribution grid. That is why the system should be designed so that all production is spent at the same time.

A hypothetical situation of average electricity production by PV panels and electricity consumption in the same one-week period is shown in Figure 2 (Monday to Sunday). The consumption is partly based on real data. The blue dots combined with a blue line indicate electricity consumption per hour and the green dots combined with a green line indicate electricity production per hour. The PV production has been divided in two parts where the green area indicates production that can be utilised (recoverable production) and the red area indicates overproduction. In this case, during a one-week period total consumption is 1 193 kWh and electricity production is 1 170 kWh. The recoverable production covers about 60% of the total consumption and overproduction is about 28% of the total PV production. In reality, local weather conditions affect PV production, which is most probably smaller than in the ideal case.

An energy ecosystem between companies can be a solution for the challenge of overproduction. If companies have a local distribution grid, overproduction can be used by other companies in that grid. Then electricity does not need to be recycled via the central network, in which case the companies would have to pay taxes and the normal price to power grid companies.

Challenges of energy ecosystems

When designing energy ecosystems, many kinds of challenges can be faced. Cogeneration of energy is challenging because the Finnish legislation does not identify communities that produce energy with a common system (Jalas 2015; Electricity Market Act 588/2013).

Storage of energy from renewable sources might also be challenging. Because of this, the production of companies could be designed so that consumption peaks will even out. This requires closer cooperation between the companies because they must know each other's energy requirements and consumption peaks, which must be taken into account when examining different energy ecosystem solutions.

Cooperation with local energy companies is needed in order that energy ecosystems are possible. To reach this, there is a need to develop new business models that encourage companies to switch to renewable energy sources and raise the level of equity ratio of energy. Additionally, challenges may be caused

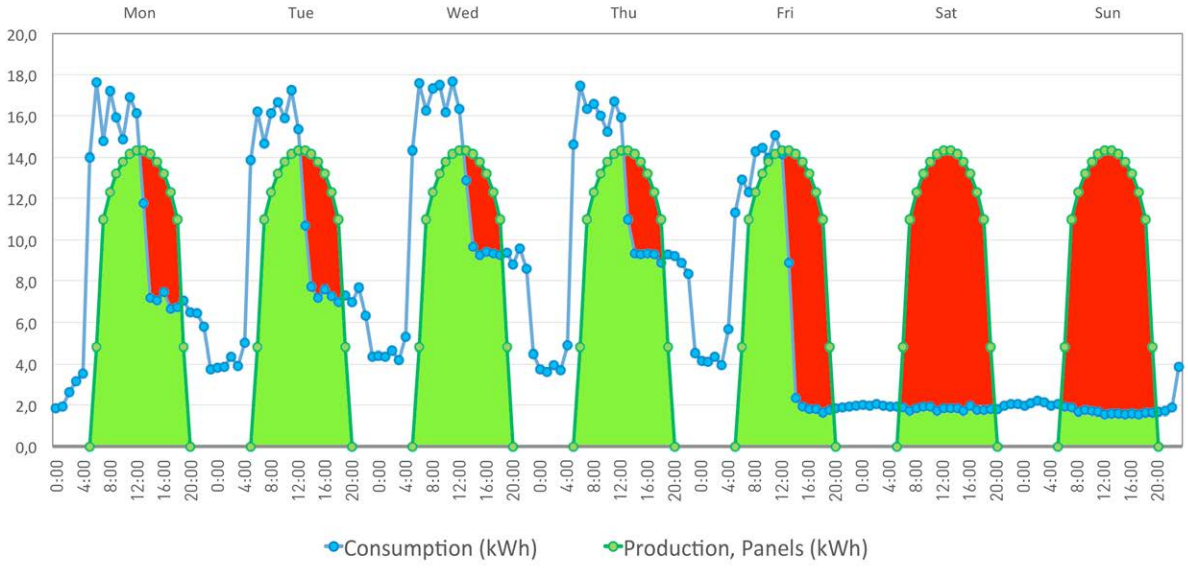

Figure 2. Example of electricity consumption versus solar PV generation during one week (Monday to Sunday).

by the tax assessment, interpretation of the legislation, division of the production, and how to manage the electricity consumption of the companies involved.

New models and ideas are needed

Usually companies have to make decisions based on costs. Switching to the renewable energy production is challenging when comparing only repayment periods of investments. In order that increasing of cogeneration is possible, the participation of local energy companies and development of their business models are vitally important. It is not common that companies together start to contemplate cooperation in an energy ecosystem. However, this requires synergistic cooperation of the companies. There are not yet any national “ground rules” and/or references how such an energy ecosystem of different industries should be built.

It has been noticed that applied research is needed. The next step is technical and functional planning of the distribution of electric energy. It is also important to define the responsibilities, duties and business models of the companies involved, in order to make it possible to create genuine energy ecosystems. Development of the legislation is also important so that cost-efficient local renewable energy production will be possible.

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Marika Vainio and Sami Luste

Auditing concept to improve the energy efficiency of wastewater treatment plants in the Baltic Sea region

Wastewater treatment (WWT) is highly resource and energy intensive. By improving energy efficiency and paying attention to energy production, wastewater treatment plants (WWTPs) can save in their operational costs and contribute to the implementation of the circular economy and low-carbon processes. In the "Interactive water management" (IWAMA) project (Interreg Baltic Sea Region; 2016-2019), an audit concept is being developed for a smart management of sludge and energy. The concept is being built together with the WWTPs, researchers and technology students.

Water utilities usually account for 30-40% of total energy consumption in municipalities (Motiva 2014). Consumption of electricity constitutes a major part of the operating costs of the WWTPs. This does not only affect the management costs, but also the carbon footprint of WWTPs. A significant proportion of greenhouse gases (CO_2eq.) from WWTPs is formed indirectly through energy consumption. A study by Pöyry, Approximately 84% of CO_2eq produced by the WWTPs was from the purchased electricity and 13% from the purchased heat. Also, part of the emissions was originated from their own electricity generation (Pöyry Environment Oy 2009). Energy auditing is an important tool when the carbon footprint, management costs and environmental impacts are minimised (Pöyry Environment Oy 2009; Barjenbruch 2016).

Energy consumption depends, among other things, on the size of the plant, on the requirements of the effluent quality, on the type of the treatment process and on the age of the plant and the equipment (Bodík & Kubaská 2013). However, the energy consumption varies in different sections of a WWTP and the most consuming stages are often the same in all WWTPs (Figure 1).

In the first in-depth study of 23 WWTPs in the EU, it was observed that the power consumption could be reduced by 20-80%, average being 67% (Müller 1999). Moreover, these reductions were achieved even if the WWTPs were recently built or they had a modest power consumption and utilised combined heat and power (CHP) production. In all cases, the achievable savings exceeded the required investment and operating costs (Huber 2017). At a general level, it is estimated that up to 30-40% energy savings could be achieved if WWTPs were optimally operated. So, energy efficiency improvements are almost always economical (DHI 2017).

Energy efficiency can be enhanced by identifying the most consuming parts of processes. Suitable tools for this would be energy auditing, benchmarking and energy

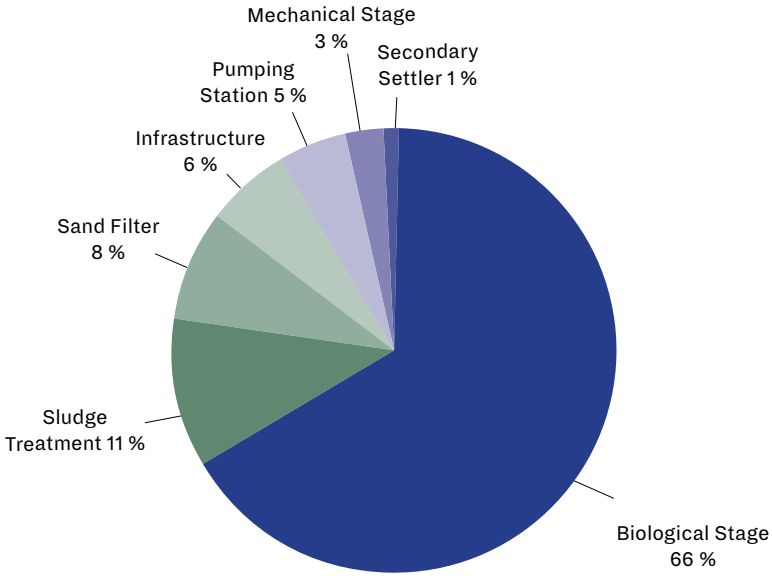

Figure 1. Distribution of electricity consumption at a 100 000 PE (population equivalent) WWTP.

analysis. In energy audits, the energy data from the WWTP is gathered to tables, which also enables benchmarking. However, some WWTPs are missing adequate monitoring, such as flow meters. Monitoring, management and factory optimisation depend on reliable data that you cannot have without measurements. During energy analysis, the energy consumption is calculated separately at every stage of the process, and the energy losses and energy efficiency are compared with the other WWTPs. Then the information in the benchmark tables can be compared, to find the parts where there are best opportunities for development (Fitzsimons et al. 2014).

At the moment, there are already many WWTP audition and benchmarking concepts, for example that of VVY in Finland (VVY 2017). However, the concept presented here, developed in the IWAMA project, has been planned so that it can be implemented by the WWTPs themselves or in co-operation with universities and future experts – the environmental technology students. This is expected to lower the threshold and costs for energy audits, which ultimately leads to enhanced low-carbon WWT processes.

Development of the energy auditing concept – first-round examples

An international group of students from Lahti University of Applied Sciences (Lahti UAS), Technical University of Berlin (TUB), University of Tartu (TU) and Linnaeus University (LU) performed energy audits at nine WWTPs around the Baltic Sea region with the help of supervisors from their universities. Marika Vainio, an auditing team member and IWAMA project trainee, conducted a closer study of the Zdroje WWTP in Poland, which is used as an example case later in the paper. The auditing concept is being developed during the IWAMA project (2016-2019) and the case discussion below is based on the situation after the first round during spring 2017 (Table 1).

The first step of the energy audit was to perform an energy review, where each process stage was analysed. The energy review was performed with the help of a specific Energy Analysis Tool (EAT), based on the German standard DWA-A 216. The standard includes instructions on energy review and analysis of WWTPs. The first round of the audits (8 February 2017 - 6 June 2017) was for the development of the EAT, and the concept will be further developed and tested during the IWAMA project.

The information collected from the WWTPs to the EAT includes: the number of devices, specific information from the nameplates of aggregates, motors, pumps and other devices (e.g. nominal voltage, U; power factor, cos φ; installed power, P; electric current, I), friction losses, amount of inflow and outflow, concentration of nutrients and biological/chemical oxygen demands at the various stages of the treatment processes, among other information. In addition, online energy meters were installed to some of the plants to get information on real-time energy consumption. The approach used in the energy review process and the number of devices in Zdroje was divided to the stages presented in Table 2.

Electricity consumption in the Zdroje WWTP in year 2016 was 2 800 MWh (~0.54 kWh/m^3 of wastewater). The electricity consumption of the various stages in the Zdroje WWTP is shown in Figure 2.

Table 1. Audits from February to June 2017.

Energy audits	Size of WWTP	Type of the process
Poland, Szczecin, Pomorzany WWTP; 8.2.2017	418 000 PE	Activated sludge process + biological/chemical phosphorus removal
Poland, Szczecin, Zdroje WWTP; 9.2.2017	177 000 PE	Activated sludge process + biological phosphorus removal
Lithuania, Kaunas, Kaunas WWTP; 13.3.2017	387 400 PE	Activated sludge process + biological/chemical phosphorus removal
Latvia, Daugavpils, Daugavpils WWTP; 14.3.2017	120 000 PE	BioDenitro process (Krüger)
Poland, Gdansk, Wschod WWTP; 25.4.2017	860 000 PE	Activated sludge process + biological phosphorus removal
Latvia, Jurmala, Jurmala WWTP; 9.5.2017	35 400 PE	Activated sludge process + biological phosphorus removal
Estonia, Tarto, Tarto WWTP; 10.5.2017	100 000 PE	Activated sludge process + biological/chemical phosphorus removal; tertiary treatment with membrane filter for suspended solids
Estonia, Türi, Türi WWTP; 11.5.2017	5000 PE	Activated sludge process + biological/chemical phosphorus removal
Germany, Grevesmühlen, Grevesmühlen WWTP; 6.6.2017	65 000 PE	Activated sludge process + biological/chemical phosphorus removal; in addition deammonification for sludge reject water

*PE= Population equivalent

Table 2. Number of devices in Zdroje WWTP.

Observed process stages	Number of devices	Examples
Feed pump station	4	Feed pumps
Mechanical cleaning stage	37	Motor of screens and conveyors, grit and grease removal pumps, motors of grit chamber scrapers and blowers
Biological treatment stage	19	Pumps to return the activated sludge, blowers for aeration, mixers and motors
Secondary clarifier	10	Motor of scrapers, pumps for excess sludge
Sludge treatment	27	Pumps and motors for sludge thickening and digestion and other aggregates
Sludge dewatering	12	Mixers, pumps and motors for polymer dosage station
Other	1	Blower for biogas
Total	**110**	

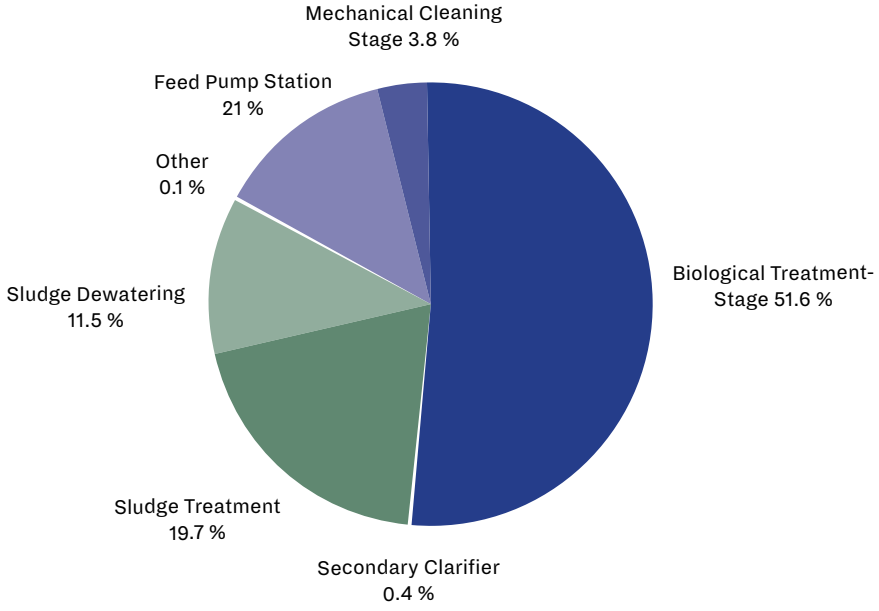

Figure 2. Distribution of electricity consumption in the Zdroje WWTP.

Possibilities to improve energy efficiency – Case Zdroje

The energy consumption among the WWTPs may vary a lot, depending on the processing methods and techniques. However, the Zdroje plant's energy consumption per influent (0.54 kWh/m^3 of wastewater) is comparable to 20% of the WWTPs that answered to the questionnaire in the beginning of the IWAMA project. For the other 20% of the WWTPs, the consumption was >0.6 kWh/m^3 and around 50% of the WWTPs did not know their consumption. This example outlines the importance of the tools for energy efficiency – such as audits.

The proportion of aeration in the energy consumption of the biological treatment is 40-80% and almost half of the total energy consumption of the WWTPs (Tukiainen 2009). That was also the case in the Zdroje plant (52% from the total consumption). Possible ways to enhance the energy efficiency in the Zdroje plant is, for example, the implementation of more advanced control systems for the aeration tanks (e.g., dissolved oxygen (DO) and ammonium nitrogen (NH_4-N) concentrations). DO control is reported to reduce 10-30% of energy consumption, and the NH_4-N based control system can reduce it by 15-20% (Mikola 2016).

Higher than optimized DO concentration (1.5 to 2mg DO/l) may still improve nitrification (Au et al. 2013). However, there is an optimal level above which the costs of aeration only rise. For example, 18% reduction of airflow is reported to bring approximately € 55 000 of savings

Figure 3. International student audit team in Poland in February 2017. (photo by Mariia Andreeva)

per year (Thunberg et al. 2009). Moreover, the bubble size reduction of aerators via ultra-fine diffusers may provide 10-25% energy savings. Regular maintenance and cleaning of aerators could improve energy efficiency by 15% (Antoni & Longo 2016).

Sludge treatment, including for example sludge pumping, dewatering and drying, accounts for the second biggest share in energy consumption. (In the Zdroje plant, 20% from the total energy consumption). These processes together are usually the second highest energy consumers after aeration (Tukiainen 2009). It is estimated that the drying and digestion of sludge will consume 10-20 % of the electricity and 80-90% of the heat required by the WWTP (Tukiainen 2009). Pumping can be responsible for high energy losses, which can be neutralised by new equipment or more efficient controlling. In this way, up to 30-50% of the energy consumed by pump systems can be reduced (Tukiainen 2009; EERE 2001). Energy efficient motors are estimated to improve the energy efficiency by 2-6%, and the variable-speed drives in such motors may be reduced the energy efficiency by 20% and also contribute the energy consumption for example the pumps, that the engines use (Au et al. 2013). Similar estimation relating to the efficiency of the new blowers is around 35%, when compared with conventional blowers (Antoni & Longo 2016).

Trainee´s perspective - once in a lifetime experience

Developing an auditing concept was one way to integrate R&D activities and education. Moreover, the auditing concept includes the idea that in the future it hopefully lowers the threshold for WWTPs to do energy audits. Being a part of an international audit student team was an amazing experience (Figure 3). This experience taught a lot about wastewater treatment, wastewater treatment processes and different kinds of WWTPs. It also provided new knowledge about energy efficiency, use of energy and methods how to save energy at a WWTP. The experience was challenging and taught how to work in an international team in different kinds of situations with different kinds of people. I got to know amazing people, travelled more than ever and got to know a great number of WWTPs, which would not have been possible without this experience.

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Katerina Medkova, Susanna Vanhamäki and Riika Kivelä

Bio-based Circular Economy Good Practices in Päijät-Häme

Bioeconomy means an economy that relies on renewable biological resources (e.g. crops, forests and animals) and their conversion into food, feed, products, materials and energy. Bioeconomy includes agriculture, forestry, fisheries, food, and pulp and paper production, as well as parts of chemical, biotechnological and energy industries. (EC 2012) Bio-based products are products that are wholly or partly derived from materials of biological origin (EC 2017a). Circular economy means closing the currently linear economy in a loop where the value of products, materials and resources is maintained in the economy for as long as possible (EC 2015). Bio-based circular economy is the circular economy of bio-based materials, i.e. biological resources are managed and used in a way that the value of the materials is maintained at the highest level of utility in the economy for as long as possible.

Bio-based circular economy is in the core of the interregional project BIOREGIO (Figure 1). The project boosts bio-based circular economy through transfer of expertise about the best available technologies and cooperation models in six European countries. The project will improve regional policies and programs related to circular economy of biological streams. (Interreg Europe 2017a)

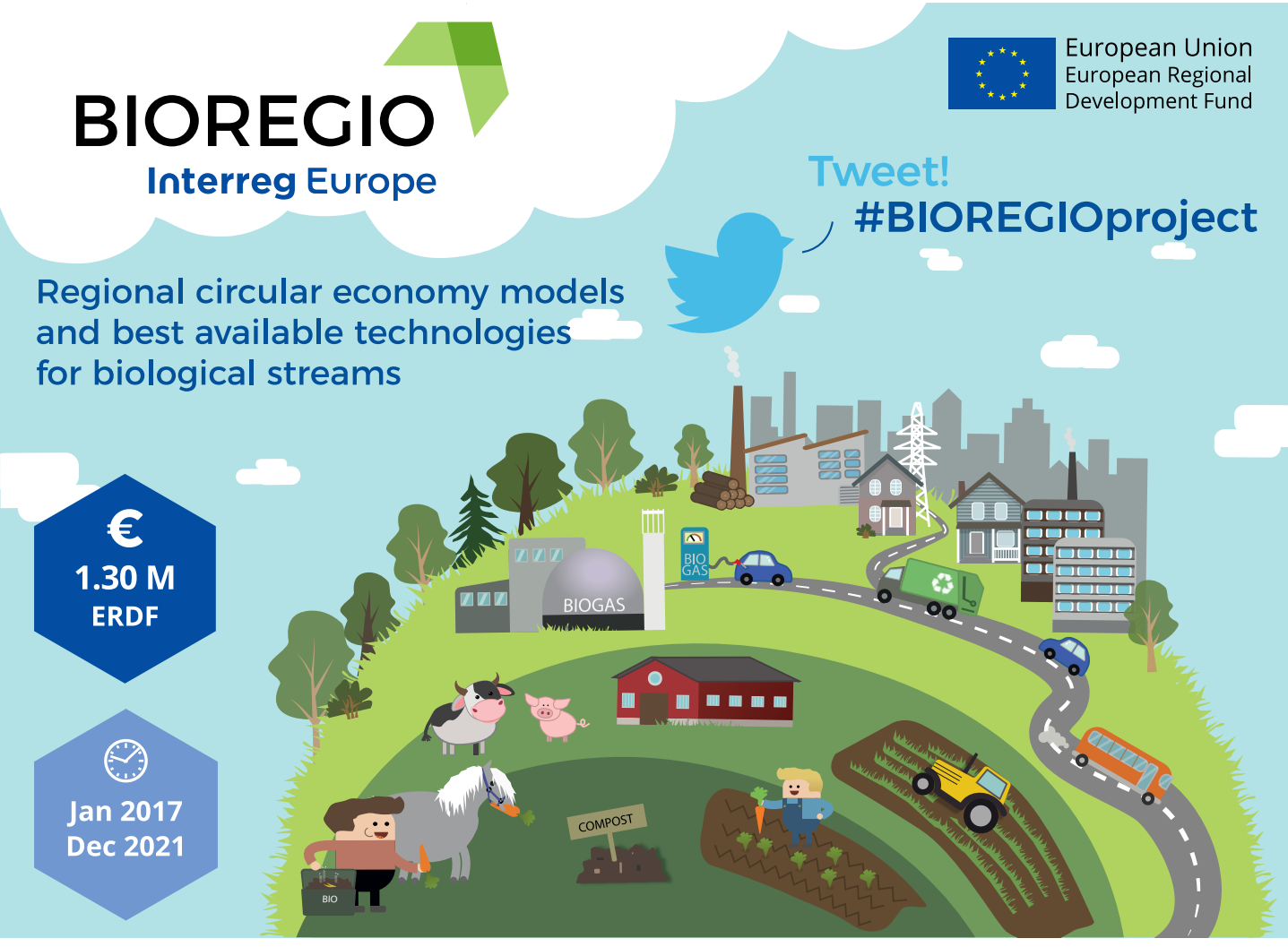


Figure 1. BIOREGIO aims to share good practices in bio-based circular economy. (made by Oona Rouhiainen 2017)

Definition of Good Practices

The BIOREGIO project consortium together with stakeholders has defined criteria of bio-based circular economy Good Practices for cooperation models or technologies. One of the key aims of the BIOREGIO project is to identify and collect these bio-based circular economy Good Practices from the six partner regions and share them on the Interreg Europe (2017b) Policy Learning Platform to be available for other regions in the EU.

BIOREGIO Good Practices have been proven successful in practice and fulfill the following criteria:

1. Promote circular economy - It has been shown that the traditional linear economic model of "take, make, dispose" needs to be revised. A restorative and regenerative circular economy (CE) provides the solution (Ellen MacArthur Foundation 2017; EC 2015).
2. Are related to biological materials i.e. bio-based materials - Bio-based materials are products consisting of substances originally derived from compounds existing in nature (EC 2017a).
3. Promote social and environmental sustainability, as well as economic growth - All three main aspects should be supported to reach sustainability: social, environmental and economical (EC 2017b).
4. Are resource efficient and economically feasible – The development towards a circular economy requires resource efficient but economically competitive solutions (EC 2015).
5. Minimise waste directly or indirectly according to the waste hierarchy - The waste hierarchy aims at getting maximum benefits from products and, at the same time, generating a minimum amount of waste. The preferred option is waste prevention, followed by reuse, recycling, recovery including energy recovery and as the last option, safe disposal (EC 2016).
6. Encourage closing the loops and emphasising longer cycles/cascades - In a circular economy, products and materials circulate at the highest level of utility (Ellen MacArthur Foundation 2017).
7. Preferably include joint actions (discussions/cooperation/business) among different stakeholders, e.g. RDI, government, companies and consumers – Cooperation is the key for functional circular economy (Ellen MacArthur Foundation 2014).
8. Are likely to be transferable and scalable in different European regions – Sharing knowledge and expertise about good practices is one of the aims of the Interreg Europe program (Interreg Europe 2017b).

Päijät-Häme Good Practices

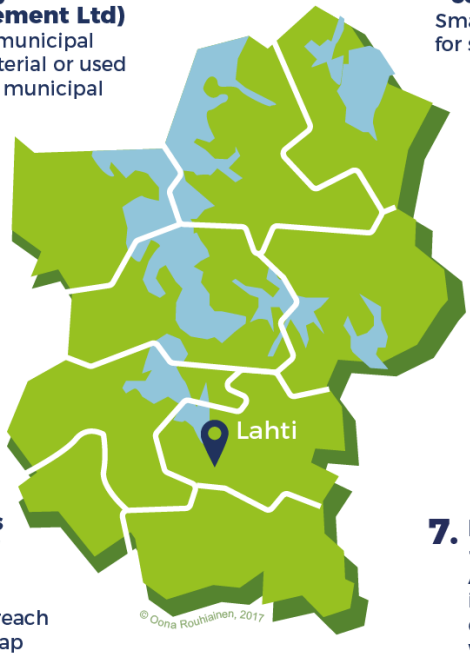
Based on the definitions of the BIOREGIO Good Practices, good examples of circular economy solutions with bio-based streams in focus will be discovered in all project regions. These Good Practices include new technologies and solutions, cooperation models, networks and ecosystems. The regional stakeholder group in Päijät-Häme has detected seven Good Practices (Figure 2):

Bio-based Circular Economy Good Practices in Päijät-Häme, Finland

1. Effective municipal waste separation and collection - industrial symbiosis (Päijät-Häme Waste Management Ltd)
After appropriate processing, the municipal waste is recovered as recycled material or used in energy production, the share of municipal waste landfilled was 3 % in 2016

2. Utilisation of biowaste streams - bio-based industrial symbiosis (LABIO Ltd)
Biogas and fertilizer production from municipal biowaste, waste from food industry and sludge from wastewater treatment plants

3. Regional road map towards circular economy - strategy (ERDF project Kiertoliike)
Visualized state of art of regional material streams, cooperation to reach a regional joint vision and road map towards circular economy



4. New possibilities in sorting waste - conveyor solutions (Ferroplan Ltd)
Smart conveyor solutions and systems for sorting waste

5. Grain Cluster - cooperation model
An active network for the grain producers and related industry in the region aiming at e.g. utilisation of bio-byproducts

6. Personal responsibility in saving resources - campaign and calculator (City of Lahti)
An ongoing challenge to stimulate the debate about resources and promote people's awareness to reduce their consumption of natural resources

7. Rescuing food from being wasted - mobile application (ResQ)
An application where left over food is announced on a webpage and citizens can "rescue" food from being wasted for half of the normal price

Figure 2. Päijät-Häme Good Practices (BIOREGIO 2017). (made by Oona Rouhiainen)

1. Effective municipal waste separation and collection - industrial symbiosis

The Päijät-Häme Waste Management company (PHJ), located in the Kujala Waste Treatment Centre, is the core of the Kujala industrial symbioses. Due to a sophisticated at-source sorting system, in 2016, only 3% of the total waste generated in the region was landfilled. PHJ's landfill gas is captured for energy use via the regional energy company and distributed directly from the landfill to PHJ's premises and to a nearby beverage producer. (PHJ 2017a; Vehviläinen 2017)

PHJ also collects energy waste, which is processed into a solid recovered fuel consisting of wood waste and household waste, for the nearby gasification power plant, to produce district heat and electricity for the Lahti region. The biowaste and sewage sludge are treated in the biogas and composting facility, LABIO. Biogas and digestate are further processed by companies in the area. (PHJ 2017a; Vehviläinen 2017)

Metal scrap is separated and forwarded for recycling and the gypsum plasterboard waste is sent for new plasterboard production. In the Kujala area, there are also companies which for example manufacture earthwork products from concrete waste and process roofing felt waste to raw material for asphalt production. (FISS 2015; PHJ 2017a)

2. Utilisation of biowaste streams - bio-based industrial symbiosis

The bio-based part of the Kujala industrial symbiosis is particularly interesting from the BIOREGIO point of view. The LABIO plant produces biogas and fertilizer from municipal biowaste, waste from the food industry, sludge from wastewater treatment plants and biodegradable material from farming, forestry, fisheries etc. This plant is the largest biogas production and refining plant in Finland. (LABIO 2017; Savolainen 2017)

Biogas generated in the dry digesters is transported through the pipes to the nearby operator for upgrading and distribution in the gas network. The digestate is processed with other biowaste in the composting facility to produce compost, soil and other growing solutions. (FISS 2015; Savolainen 2017) The compost is further used in agriculture, cultivation and gardening.

3. Regional road map towards circular economy - strategy

The Päijät-Häme region has created a regional road map towards a circular economy, i.e. a regional circular economy strategy. The road map presents regional goals and actions to achieve the vision: "Päijät-Häme – the successful resource efficient region" by year 2030. The goals are related to material flows, bio circular economy, energy, new services and to the role of Päijät-Häme as a forerunner. (LAMK 2017)

The vision and the road map have been developed in a regional ERDF project through intense cooperation between stakeholders, e.g. the regional council, universities, municipalities and companies. The road map will be updated regularly. (LAMK 2017)

4. New possibilities in sorting waste - conveyor solutions

Conveyor solutions play a central role in promoting circular economy and developing the waste separation system of the Kujala Waste Treatment Center. The LATE sorting plant enables recycling of waste that has earlier been used for energy recovery. (PHJ 2017b) Ferroplan (2017), the supplier of the conveyor solution,

provided over half a kilometer of conveyors for the plant.

The sorting plant, built in 2016 with an annual capacity of 65 000 tons, supplements the sorting of waste when it is not possible at the source, e.g. when handling construction and mixed waste as well as waste generated by industry. The plant separates fibers, plastics and various metals that can be recycled or further processed to achieve an effective material-recycling rate. (PHJ 2017b)

5.Grain Cluster - cooperation model

The Päijät-Häme Grain Cluster (2017) is a cooperation network of the local grain value chain. It brings together all actors in the region, from grain producers to industry and retail, from large international companies to small craft companies, e.g. oat mills, breweries, a malt producer and over 1000 farms. The cooperation model was created in 2003 and it is exceptional on an international scale. The activities are coordinated by LADEC, Lahti Region Development Company. (Päijät-Häme Grain Cluster 2017, Kivelä 2017) Funding of the cooperation is covered by the member companies but also partly from the ERDF project financing. (Kivelä 2017)

The cluster companies look for synergies, product development and circular economy solutions. Since 2010 bioethanol has been produced from the side streams of cluster companies like bakeries, breweries and mills (St1 2009). According to Kivelä, currently new possibilities in carbon dioxide recovery from bakery and mash processes, as well as more effective possibilities in using biowaste through e.g. logistics are developed in an ERDF project. The cluster collaboration has also succeeded in developing new innovative food products. (Kivelä 2017)

6. Personal responsibility in saving resources - campaign and calculator

The “Tonnilähti” material footprint calculator is an online-based tool for consumers to calculate their material footprints. It has been developed in cooperation with several companies and public organisations in the Päijät-Häme region. (Tonnilähti 2017)

The material footprint expresses the total amount of natural resources used during the life cycle of an observed product, service or other unit. The respondent answers questions about issues such as housing, consumption, food, free time, holidays and transportation. The short test shows the person’s material footprint compared with the sustainable level, the average Finnish footprint and the target values set for 2030 and 2050. The respondent can also commit to reducing his/her footprint. (Järvelä 2017)

7. Rescuing food from being wasted - mobile application

In food services, a huge amount of food ends up as biowaste. Thus, the environmental impact of food production is significant. (Kosseva 2013) The ResQ service saves food from turning into waste, helps local businesses get better results and supports the environment. In the application (ResQ 2017), restaurants announce their leftover food and citizens can “rescue” food from being wasted for half of the normal price. The user interface shows the doses available depending on location and diet settings. Almost 500 restaurants have registered for the service in Finland. In 2016, around 10 000 portions/month were sold, and in 2017, the number increased to 30 000 portions/month. The service also operates across Europe. (Evinen 2017)

Figure 3. The Päijät-Häme Grain Cluster - BIOREGIO Good Practice of local grain value chain including the farmers. (photo by Oona Rouhiainen)

Discussion

The Good Practices found in the Päijät-Häme region reflect the definitions of the BIOREGIO Good Practices in versatile ways. They promote bio-based circular economy and all of them include joint actions and cooperation between different stakeholders. They are transferable to other regions and can serve as examples. However, one of the challenges in the region is to minimize waste according to the waste hierarchy. Even if only 3% of the waste is landfilled, there is more to be done in developing the reuse of products and recycling of them as material prior to energy recovery.

Experts of the Interreg Europe Program will evaluate the recognised BIOREGIO Good Practices of the Päijät-Häme region. After the evaluation, the accepted practices will be available in the freely accessible online Policy Learning Platform database (Interreg Europe 2017b).

This article reflects the authors' views; the Interreg Europe programme authorities are not liable for any use that may be made of the information contained therein.

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Consumers' perspectives on sustainable food purchase and consumption

Food sustainability and consumers' perspective

Due to increasing global population, it has become imperative to produce more food for human consumption today and in the near future (Nelleman et al. 2009; Simons 2015). Intensification of food production, however, leads to different kinds of environmental sustainability challenges such as climate change, land system change, biodiversity loss and impacts on biochemical nutrient flows (Simons, 2015). Many of these challenges have been reported to exceed the safe operational zone (or boundary) for humanity (Rockström et al. 2009; Steffen et al. 2015). Therefore, food production sustainability has become the agenda of governments, food producers, and industries in many societies as highlighted in the media and in various social movements. This has also led to the search for and innovation of new food products and alternative protein sources, which have become popular among consumers. This has created a pressure or an opportunity for agricultural and food sectors to improve their production and business to meet sustainability expectations of consumers.

Consumers are an essential part of the food systems. Consumers' purchase decision and consumption trends have direct impacts on food production. In this regard, it is a common argument nowadays that the sustainability of our food and its whole production system is an important factor for many consumers (Salonen et al. 2014; Van Doorn and Verhoef 2015). However, there are multiple sustainability perspectives and yet only a little information on which sustainability perspectives are important for consumers in their purchase and consumption decisions. Hence, the lack of this kind of knowledge makes it difficult for food industries to develop their products and include sustainability aspects in their production processes and, more so, in their marketing activities. Based on this premise, this research was conducted to answer the following questions:

- What factors impact consumers' food purchase and consumption decisions?
- How important are sustainability perspectives in consumers' food purchase and consumption decisions?
- What are the important sustainability aspects that consumers are looking at in the food they buy?
- How should food industry actors focus their development and marketing, to provide interesting information for consumers?

Survey of consumers in the Päijät-Häme region

In order to get answers to the research questions, a survey was conducted among consumers in the Päijät-Häme Region, Finland. The survey was conducted from May to August 2017 using the following approaches:

a) Questionnaire sent to three different lunch restaurants (for the customers)

b) Through social media groups (e.g. Facebook) using the Webropol questionnaire tool

There were slight differences in the surveys because of the restaurant specific data. In addition, the survey carried out in the restaurants was mainly related to the sustainability of lunch food, and the social media survey was focused on food consumption in general. Out of the three restaurants, one is serving only organic food mainly produced in the nearby region. In addition, they are employing people who otherwise have challenges in getting employed. It can be assumed that the customers (consumers) in the said restaurant are greener than the general consumers. Hence, based on this assumption the consumers were categorized in two main groups, as general consumers and green consumers.

The survey questionnaire was designed to obtain information on: a) the consumers' basic personal background and food purchase and consumption habits; b) aspects that have an impact on the consumers' food purchase and consumption decisions in general; c) various sustainability perspectives and their impacts, e.g. climate change, eutrophication, use of pesticides and social sustainability aspects; d) environmental labels and categories such as organic food and on information sources related to food sustainability. There were also questions about how to make sustainable food choices easier. Data was collected anonymously and answers were encoded and analysed using the IBM SPSS statistics software.

Results and discussion

The survey yielded a total of 214 answered questionnaires. These were divided to two main categories so that 81 respondents were from the organic lunch restaurant representing green consumers, while 130 respondents were from the social media Webropol survey representing general consumers. Figure 1 presents background information related to the two main groups.

As can be seen in the figure, more answers were received from females than males. In addition, the web survey reached younger people, and green consumers were on average older.

Figure 2 presents how consumers rated the roles of different aspects such as price, taste, domestic content, health and purity, environmental friendliness, and ethical issues in their food purchase and consumption decisions. These aspects were ranked by the consumers in order of importance (from the most important to the least important), with number one as the most important aspect and number six the least important aspect.

Price and taste were considered the most important factors affecting the food purchase and consumption of the surveyed consumers (Figure 2). This is indicative that sustainable food choices have to be able to compete in price and taste. Domestic production, health and purity issues were also relatively important

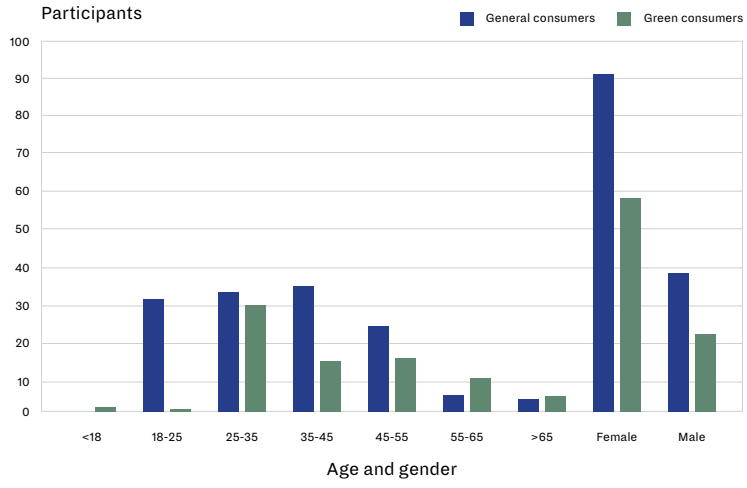

Figure 1. Background information on the two main consumer groups.

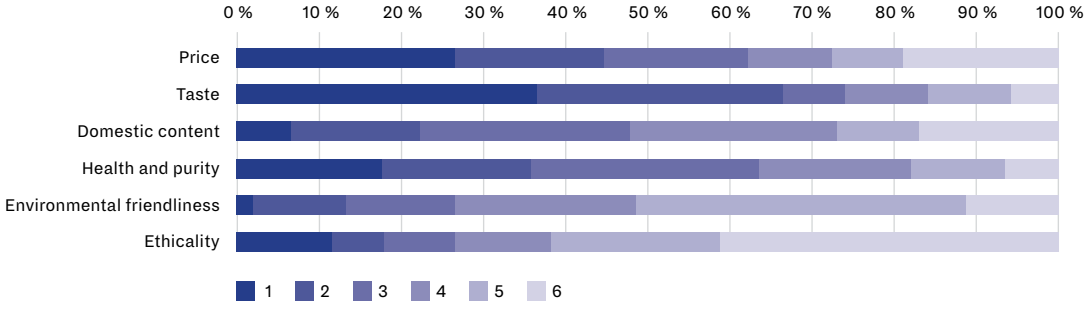

Figure 2. Important aspects that affect consumers' food purchase and consumption decisions. (1=the most important factor, 6=the least important factor)

for consumers. This can be partly explained by the fact that many answers were received from an organic restaurant, which focuses on purity in food and on domestic production sources. Ethical and environmental issues were not highly rated compared to other factors. However, these issues may be important for consumers but not as important as the rest.

Figure 3 presents how different sustainability indicators impact consumer choices. The rating is the same as in Figure 2. It can be seen in the figure that pesticides and use of chemicals was rated as the most important factor affecting consumers' purchase decision. The second most important indicators were climate change and social sustainability. The differences between general consumers and green consumers were surprisingly small.

Figure 4 shows how different sustainability labels affect the consumers' food purchase and consumption decisions. As can be seen in the figure, organic product, fair trade, local product and Nordic Swan labels are recognised by a high share of consumers. Such recognition and the information and marketing campaigns behind those labels are assumably affecting consumers' behaviour. Whether or not the consumers support all these sustainability labels, it is indicative of their awareness about the sustainability issues and indicators studied in this research. However, the carbon footprint label is rarely used maybe simply because of the relatively small number of products that actually have a carbon footprint label.

These results imply that consumers in the the Päijät-Häme region are still very much focused on the economic arguments and incentives when making purchases and decisions when it comes to food. Although there is a growing build-up of awareness, recognition of sustainability issues, and labels in the food markets, many of the decisions can still be based on the consumers' own economic circumstances and purchasing power. However, it is noteworthy that domestic production and healthy products are highly valued and considered important by the consumers. This can be seen as a signal for more local production, which could lead to a lower price yet sustainable production of local foods.

Conclusion

Based on the results, the most important factors in food purchase and consumption decisions of consumers in the Päijät-Häme region are price and taste. Sustainability perspectives are not as important for consumers in food-related decisions. The most important sustainability aspects for consumers are health, purity of food, social sustainability issues and climate change impacts. However, consumers only rarely include carbon footprint of products in their decision making. Consumers are more familiar with organic food, fair trade, and local food labelled with Nordic Swan. This also shows that consumers prefer to buy locally produced organic food, which can be regarded as environmentally and socially sustainable.

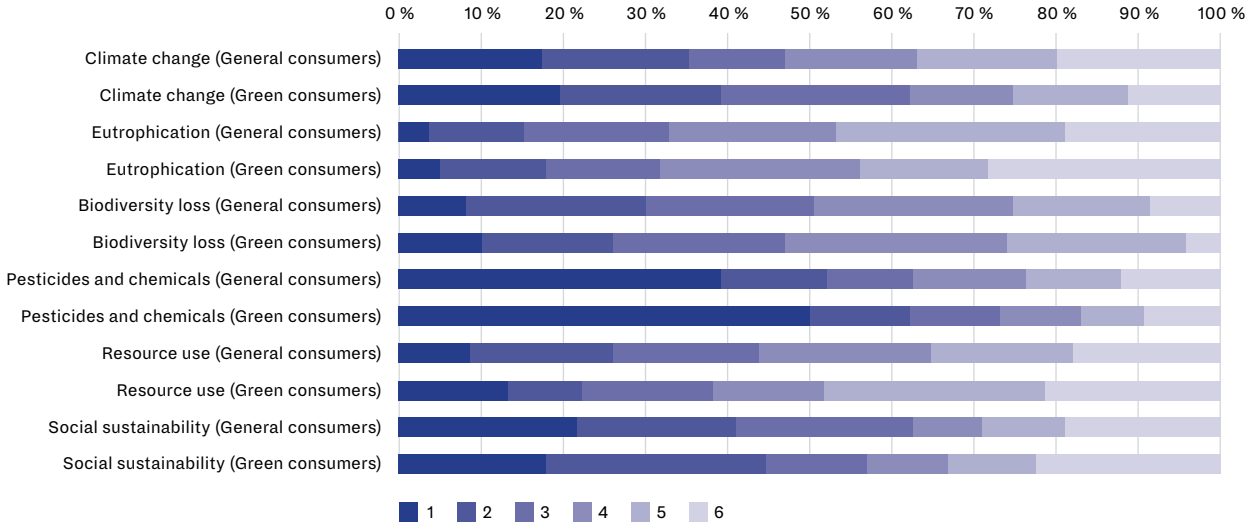

Figure 3. Important sustainability aspects that affect consumers' food purchase and consumption decisions.

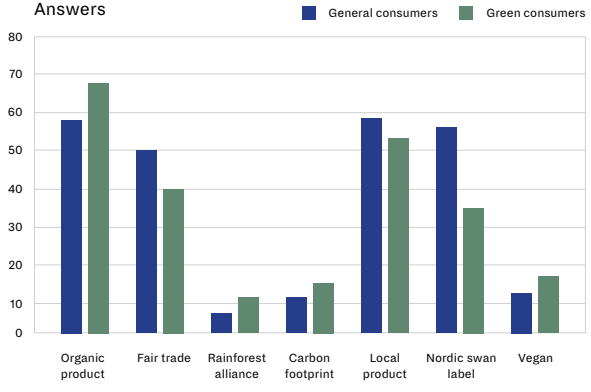

Figure 4. The impact of sustainability labels on consumers' food purchase and consumption decisions.

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Mirja Kälviäinen and Vivi Koivisto

Consumers' hidden resources of goods and materials suitable for reuse

Abstract

In circular economy the consumer choice, use and disposal stages should include product service systems to support consumers with product flows covering prolonged, shared and multiple circles. The solutions for tackling underuse and waste depend heavily on real user interactions. This paper presents a consumer research meta-analysis and empirical interview results about the barriers and interests the consumers have for tackling underuse and recycling of products. Furthermore, empirical user studies in 42 homes in the Lahti region have been conducted to review accumulation of things in people's homes and how and what some selected homeowners would be willing and interested to do around circular material consumption. The user research reveals product areas where recycling and sharing types of activities are already taking place or could be activated further. It also emphasizes the requirements for understandable, accessible, convenient and socially normal product service solutions.

Introduction

"In an ordinary middle-class Finnish home there might well be 100 000 products. It is a huge amount. And most of these things are for nothing: they are never used, not even remembered."

Elina Järvinen, Suomen Kuvalehti 19/2016

In circular economy the already existing material products, their choice, use and disposal stages should be managed to create product flows that are prolonged, shared and cover multiple circles. There are possibilities for product service systems that could support consumers in collaborating and interacting for the sake of these multiple circles. Since the solutions tackling underuse and waste depend heavily on the real users' behavior, this paper presents a consumer research meta-analysis and empirical interview results about the barriers and interests the consumers have with the prolonged and shared product flows covering multiple circles. Furthermore, the paper describes the results of home interviews conducted in the Lahti region to review possessions in people's homes and selected homeowners' activities around circular material consumption. The aim of the user research is to identify product areas where recycling and sharing types of activities are already taking place or could be activated even more.

Performance-based growth with multicycle product use

From the consumer products' point of view, circular economy solutions are not achieved solely by designing and producing environmentally sensible and resource- saving products aligned with circular economy. There

is important potential for multiple circles and efficient use in the consumer choice, use and disposal stages: using the already produced goods in different ways. The Oslo Declaration on Sustainable Consumption in 2006 already stated that the social mechanisms and cultural viewpoints of consumption need to be studied in order to fulfil human needs. (Tukker et al. 2006, 11). In the case of prolonged, shared and efficient multiple-cycle-covering product use, this requires research on consumer attitudes and activities around product flows.

The United Nations Environment Programme defined a product-service system (PSS) in 2009 as a system of products and services that are together able to fulfil a particular customer demand. In this satisfaction-based economic model the need is fulfilled but together with products, services and stakeholder interaction. (Vezzoli 2013, 276-277) The possibilities for efficient operation of products, upgrading and availability as a shared resource can diminish the amount of material resources required. Sometimes a material product can be completely replaced by a service and the route towards dematerialisation is open. (Ryan 2013, 410-411). Design for circular economy develops system-based approaches to the use phase with non-wasteful use, long-life attachment, product durability, standardization, ease of maintenance and repair, upgradability and adaptability, disassembly and reassembly. It uses different means to dematerialize the products with design as a service or performance as a service solution. (Bocken et al. 2016, 308-320). Spangenberg et al. (2010, 1488-1489) present the "term satisfier efficiency" of offerings for lifestyle change implementation. Lifestyles are shaped by context and habit and require personal motivation and information, need to function in the restrictions of the social context connected to acceptance, image, peer group identity and are provided by the availability of alternatives at competitive resources.

For Lacy and Rutqvist (2015), one target in circular economy is to tackle the underutilisation of products that have short, unused working lives and are disposed of even when still usable. Wasted capability or embedded value can be extracted from existing underused products, components, and materials. As the idea in circular economy is to move from resource-based growth to performance-based growth, the concept of waste as potential value also includes those resources that exist within the already produced products. The circular economy business should help the customers to make the most out of the products; facilitate trade between users; service to put not-in-use goods to use; offer buy-back solutions; and sell performance services instead of products. Recovery and recycling in different ways, product life extension with repairs, upgrades and remanufacturing, and sharing platforms and products as service solutions are means to achieve this. The resources on the markets, rather than production, should be managed.

Lacy and Rutqvist (2015, 24-26) point out how the customers' role and activities during and after the product use are the main business driver in circular economy. A deep understanding of demand is vital, with emphasis on customer behaviors regarding recycling, community engagement, buying sustainable products and reducing waste. A large body of consumer research has explored the motivation for sustainable consumption and the barriers and hindrances that people

encounter in their effort to live sustainably. Kälviäinen's meta-analysis (Kälviäinen 2014) on recent sustainable consumption studies, especially green consumption in western countries, revealed that the bulk of consumers have in-between attitudes between indifferent and dedicated environmentalist consumers. The situation of green consumption can be summed up by the gap between positively green attitudes and not so sustainable behaviour as attitude surveys show that the majority of the western consumers are concerned about the environment but are incapable of changing their consumption practices. (e.g. Gleim et al. 2013, 45-46; Partidario et al. 2010, 2850; Power & Mont 2010, 2574; Bemporad et al. 2012; Young et al. 2010). Consumption is framed by social norms, habits and cultural traditions. Identity and lifestyle get to be built within the socially acceptable consumer culture and the related variety of offerings. (Gleim et al. 2013, 46,49; Heiskanen 2011, 49; Power and Mont 2010, 2574-2577; Skill and Gyberg 2010:1878) In the middle of everyday practical activities, consumption decisions get defined by the consumption culture and short-term values. (Gleim et al. 2013, 46-48; Id and Laaksonen 2012, 44-49; Krantz et al. 2011, 14). Green consumption tends to be associated with strenuous efforts suitable only for the truly devoted and excluding ordinary and busy consumers (Skill and Gyberg 2010, 1871, 1874-1882; Tan and Johnstone 2011, 3). Health, capabilities, family bonds, social networks, trust, cultural values and identity are important, rather than ecologically sustainable choices (Gilg et al. 2005: 502; Partidario et al. 2010, 2864). The lack of time and knowledge, complex and disturbing knowledge, expensive prices and pressures from the various non-green criteria prevent green choices. (Gleim et al. 2013: 46-48, 58; Partidario et al. 2010, 2856; Young et al. 2010, 22,25).

On product end-of-life decisions Kapitan et al. (2014, 56) draw up the spectrum of consumer activities: reuse, sharing, refurbishing, donation, recycling, leasing and postponement of purchasing. Specific consumer groups can be identified that are especially inclined to second-cycle product activities such as groups of thrift-store shoppers, vintage lovers and voluntary downshifters showing examples of valuing the ownership of second-hand goods. There are, however, specific hindrances in these activities. As loss aversion is a very strong and evolution-based human feeling, people might suffer and decline to part from their excess of unused goods. Some products also carry strong positive meanings although they would not be in practical use. Parting from the unused products might happen for free but in a selling process the goods need to be converted into commodities by possibly difficult cleaning and price setting. (Kapitan et al. 2014, 60-63). As to purchasing a used object, Kapitan et al. (2014, 64-66) point to the fact that the consumers might also experience feelings of contamination through fear for dirt and touch of an unknown person. Positive contamination can, on the other hand, occur through admiration of the earlier owners, e.g. a valued celebrity.

Some findings of consumer activities around product flows

On the basis of Kälviäinen's meta-analysis, she also conducted user research in Finland for the purpose of finding user interests and barriers in the minds of Finnish consumers, and then solutions to cross these barriers. The qualitative

interviews based on visual stimuli included 76 participants from 20 to 63 years of age in the Helsinki and Joensuu regions. (Kälviäinen 2015). The general respondent comments around green consumption were fragmented and focused on small, concrete issues. The perception of wider, holistic systems of production and consumption with resource use, emissions, pollution and waste was rare. The hindrances of green consumption choices were similar to the findings of earlier research: not enough time, effort and money to care for sustainable green consumption. Respondents did not have the necessary resilience or knowledge for finding solutions that would be eco-efficient. Many respondents used the adjective "lazy" stating that green solutions are too difficult and complicated to find, compare or purchase. They suggested that the solutions should be in the ordinary shops, easy to find, look and feel normal, and be affordable. The following analysis accounts the specific findings considering the acquiring, use and disposal of goods that could offer circular economy business ideas for service solutions based on owning, sharing, repairing, recycling and reusing.

The respondents described difficulties of acting against the heavy product consumption tide. "More stuff and advertisements for stuff, is there any sense in this anymore and I have not done anything for adjusting this insanity." There were also comments about huge consumption amounts globally and the respondents suspected if there was any meaning in their small reduction efforts. The phenomenon of us consuming too much stuff was seen to impact on climate change, distinction of species and other nature-destroying problems. Promoted by a picture of an African boy in front of a garbage pile, the respondents discussed how the waste we throw away causes harm in some other parts of the world. Especially electronic waste and the health issues it causes when handled in poor conditions was a major concern. This reflected the fact that we do not pay the price for the products we ought to, considering the harm they cause. There is a fundamental respect for materials and products demonstrated by the disapproval of unnecessary product purchasing and of the disposable, throwaway culture, which the waste dumps make visible. It related to material and energy resources used in reckless ways and producing huge amounts of landfill, electronic waste, or plastics in the sea. It also reminds that things should not end up in the general waste dump but be recycled.

The outcome of these worries is, however, that people might keep the excess of stuff in their homes or store it. The amount of storage business has been growing together with the increasing amount of possessions people have. Struggling with too many products in the home was discussed and some admitted that they did not manage it. Others tried to manage the amounts by recycling their stuff using different means. The cleaning operations were even described as clarifying the whole life pointing to trendy Marie Kondo type of life organising advice: how to transform your cluttered home into a space of serenity and inspiration (Kondo 2014). People ponder on the possibilities of using their free time for something better than for product consumption: enjoying food, travelling, trekking in nature, doing crafts and socializing with other people in different ways. Slow lifestyle, nostalgia, freedom of stress, taking care of possessions was a positive opposite to the busy city life with lots of consumption and a quick circle of throwaway products.

The respondents had intentions of shopping for long-term purposes, even ”not always getting the cheapest”. An expensive price seemed to guarantee durable, long-lasting qualities. The Finnish saying “if you are poor, you cannot afford to buy cheap things” was brought up. Even thinking about easy recycling possibilities was mentioned as a buying criterion. It restricted people from buying a lot when they considered that you should actually have the stamina to check and find out about the product background and working conditions during production. However, it was argued that it is hard to get transparent production information about the materials, energy sources and water consumption. The respondents seemed to be more interested in the social human conditions than the resourcing from nature or about the environmental consequences of the product. This ethical approach was, however connected to an ecological approach: if people are treated badly, then the producers also pay no attention to environmental issues.

The respondents did not describe their own repairing activities much. There were some mentions about renovating houses with old elements. Many of the respondents did not associate crafts as a part of green consumption. The contact with handicrafts seemed broken with many and the picture of hand knitting did not raise discussions about the possibilities of repairing things. For some respondents craft delivered the message of ecological consumption with ideas of nostalgia and time for hand skills and repairing as a value-increasing means. There were even findings of the ideal of the self-sufficiency culture in such hobbies as growing your own vegetables or making logs for the fireplace but not so much in repairing or altering the already owned products.

Recycling was seen as a means to do at least something, a kind of citizens’ civil duty. The concrete nature of recycling makes it rewarding. The fact that yearly the global use of raw materials has exceeded nature’s capacity earlier and earlier was mentioned and worries how the raw materials would last for the next generations was expressed. This was a reason to recycle. Different approaches with recycling included sorting the garbage appropriately. This garbage sorting was even described as ”skill-based activity”. People in the suburbs and sparsely populated areas complained that the recycling possibilities were not easily accessible. Some of the respondents expressed doubts that the consumer-sorted material may be dumped together to the basic landfill at the end of the collecting process. The visibility and credibility of the reuse process is important.

In the case of unnecessary but usable products, the respondents frequently took them to the recycle points or flea markets. Some people complained that there were not enough suitable places to take the items still usable for someone. Some residential areas had organised special recycling events or points and Facebook type of swap possibilities for unnecessary stuff. It was hoped that if the product is not reused as such it would at least be used as material for lower status products. Not many respondents mentioned trying to sell the products. Instead, it was more typical to give items such as too small children’s sports equipment to friends. Other people were reproached for not recycling properly. People admitted that they were searching through garbage bins to find usable things or moved other people’s garbage into the right bin. From the negative perspective, recycling was also seen as expensive, hard and

producing some disgusting experiences such as smell. The point was that it should be made easy, comfortable and cheap for the consumers.

At least cars, clothes or books were seen as items that could be purchased as used ones. The balance between new and old stuff was also a dilemma. ”It might make you feel good to buy a new energy efficient lamp or then you use the old one till the end.” Many of the respondents mentioned flea markets as shopping places. Baby’s clothes and toys could be acquired from the flea markets or received from friends as their use time would be so short. People commented that you would like to reach the flea markets by walking and how it is a shame that you need a car since they are often situated on the outskirts of cities. It was also commented that the flea markets and e-shopping possibilities of used items could be advertised more efficiently. One older lady explained that she buys things at flea markets for her grandchildren but does not tell this since she did not think the teenagers would accept it. Another mother, however, said that her 11-year-old shopping addicted child accepted even flea market shopping. The popularity of flea markets related to the fact that respondents thought that you could find good products there.

In the negative sense, respondents mentioned some contamination type of thoughts with recycled products and materials, such as nasty smell or dirt. This was also connected to new products made from recycled materials. The products with recycled material origin should be as fashionable and normal and feel as clean as products made of newly sourced materials. Cleanliness is a quality that is sought for although there are no guarantees about the chemicals or processes used for new products to achieve this feel.

Statements like ”not everyone has to own everything themselves” relate to business opportunities of performance value rather than products. Such values as transportation for cars and health issues for bicycling were mentioned. Joint owning or the product-as-a-service solution are imaginable in the consumers’ minds when the use value, not the product, is important. People even disapproved of what others own, such as big cars. Joint and communal, collaborative and shared activities were frequently described as desirable. Community spirit was a positive feeling that sharing type of activities provided. It was especially mentioned with renewable energy production. People also mentioned that they borrow things such as cars from relatives. Jointly or regionally owned things appeared possible in the minds of people.

Findings from Lahti homes and Lahti homeowners

The Lahti region is committed to promoting the move to circular economy so even the everyday shopping, owning and recycling of consumer products in the region is of interest. The Kiertoliike project, led by Lahti UAS, had a work package dedicated to the user-driven circular economy. As part of the package, the design and media students from the Lahti Institute of Design did some 42 home visit observations and interviews to investigate local consumer needs, challenges and opportunities of recycling and reusing the excess products and materials. Of the respondents, 14 were 20-29 years old, 8 were 35-45 years old, 10 were 46-59 years old, and 10 were 60-85 years old. There were 32 female and 10 male respondents. The study concerned

the products people store in their homes unused or prolonging their service life. The connected interview included homeowners' willingness and ideas about reusing, recycling and sharing goods. The services that people would need for making the recycling easy were also discussed. In addition, students on the the user-centred photography course documented interesting used possessions that people kept in their homes. These studies on the material culture in consumer homes aimed at searching for new services required for promoting the multicycle and intensified product use in the Lahti region.

The first interview question was about the portion of the products (furniture, clothes and others) people thought were, in one way or another, recycled (inherited, borrowed, bought as used) in their homes. As a rough estimation, 21 of the respondents said that it was only around 10-30%, but 6 people thought the amount was as high as 75-90%, and 7 people estimated it at 65-70%. This was followed by the question: when you need something, is your first thought to purchase it as used or as new? From the respondents 18 said they would think of buying everything as new, 15 as used and 12 did not know as they thought it depends on the product.

The respondents, however, mentioned some products that they would not want as pre-owned. These were especially products where hygienic issues were of concern, such as swimming suits and underwear or bedlinen and towels. Practical utensils fared well in the question of what people would buy as pre-owned.

Figure 1. Many people value old and pre-owned products in their homes even for practical everyday use. (photos by Ninni Lahti)

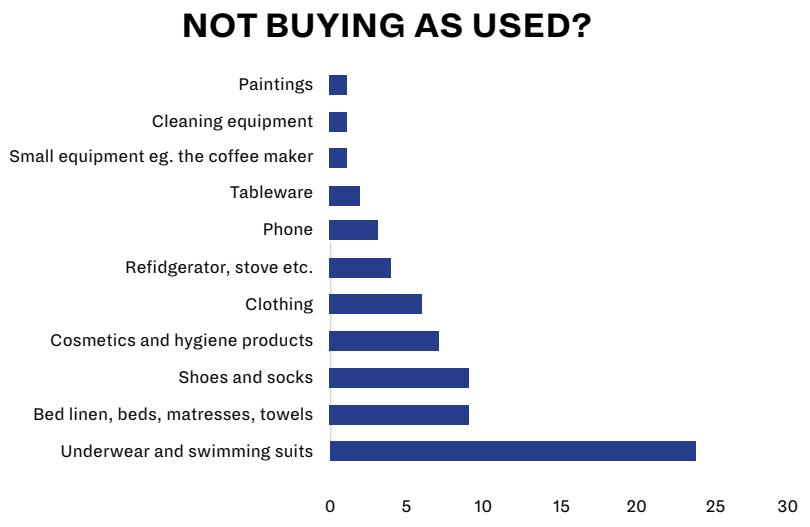

Figure 2. The products that 42 homeowners stated that they would not want as used ones.

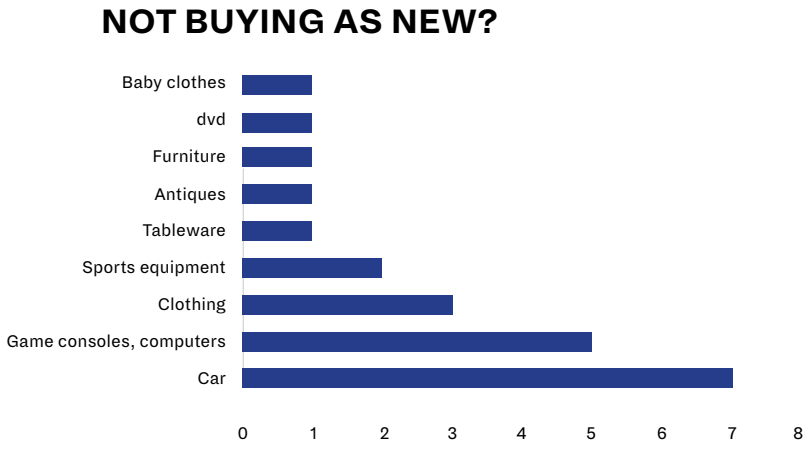

Figure 3. The products that 42 respondents said they would not want as new ones.

Figure 4. Typical items that people save in their homes for emotional reasons are some toys from the different generations of the family history. (photos by Karoliina Redsven)

When asked if there were some things that they would not give up, even if they did not have any use for them, the respondents had different items and reasons for keeping things. A total of 38 respondents referred to an emotional value: inherited items, souvenirs from trips, things relating to their childhood or something they had received as a gift.

An interesting point is that when observed, people have a lot more unused objects in their homes than these kinds of emotionally valuable things. When asked what kind of unused products or materials they have at home the respondents listed especially clothes and shoes and then books, tableware and interior design items. Most of the respondents were female and they listed items inside the living areas of the house. In the user research by photographic documentation, also the garages and outdoors of the houses were inspected, revealing unused storages of cars, car parts and other technical items.

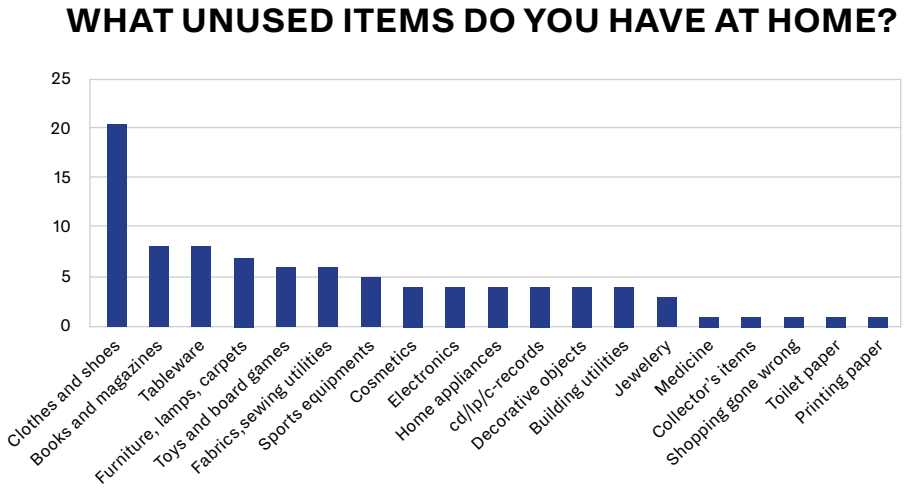

Figure 5. Various unused items that the respondents admitted keeping in their house.

With lots of excess items in the respondents' homes it was interesting to scan what they knew about the possibilities of taking the unused products to possible further use. For the question about the places that they know in the Lahti region where you can take those products and utensils that you want to give up the respondents stated a myriad of different recycle charities and businesses. As preferable places they mentioned Patina, the Finnish Red Cross, UFF and the Salvation Army recycle organizations. The best-known of them was Patina, a flea market organised by the City of Lahti. Even though popular, UFF was on the other hand also boycotted because of not being trustworthy as a transparent actor. The Kujala waste station was also counted as a typical place to take your stuff.

In the garage and backyard documentation of car-related items the owners admitted that they might have thought that they would sell their possibly interesting old vehicles. For the love of these items or for not getting it done, these vehicles had, however, stayed in the backyards for years.

In order to improve the recycle services, the respondents were also asked what they hoped from the recycling businesses and organisations. The most asked for service was transportation. Among the respondents, 32% wanted this and a further 10% especially pointed out that this transportation should be free of charge. Also, 7%

Figure 6. A picture from a garage storage with old car-related technical items. (photo by Sampsa Laine)

Figure 7. The cherished old cars have been left to the backyard for years. (photo by Sampsa Laine)

of the respondents argued that the information, advertising and communication on the services was poor. Some needed help for setting the prices for their old things when selling them. The wishes covered varied issues: the profiling of the recycle and further selling places, selling platforms for special goods, mending services, exchange markets, services for photographing the products, clearing out services, web-based catalogues for products, and specialized containers for different recycle purposes. The respondents also expressed hopes about the nature of the service and their places: they should be easy to go to, clean, with good location and pleasant display for items, and have good customer service and even coffee facilities.

When asked what motivates them to recycle, 62% of the respondents listed ecological reasons as the most important. Economic reasons were also important with 18% of the respondents mentioning them. Further reasons were that a good product gets a new owner-user, some respondents enjoyed findings things to buy in recycle shops and some even felt they were better people or could help others when recycling the material stuff they had.

For the question how to make the multicycles of the material things easy for the consumers to handle, the respondents gave several suggestions: transportation services, clear web services and pages, recycle points for suburbs, special campaigns, 24/7 multipurpose recycle places, more recycle boxes with better guidance for sorting and easier sorting for special materials. As a benchmark service they mentioned the “gold for money”, where you get a parcel at home where you send the item to the collector and you get the money to your bank account.

The final questions dealt with the sharing economy. The respondents had rented cars, gardening equipment, tools, trailers, household appliances, sports equipment, suitcases and small vehicles. In joint use they had had similar things: cars, gardening equipment household appliances, tools, sports equipment and small vehicles. The respondents had a positive attitude towards renting or sharing some seldom-used products. The things they thought they do not necessarily need to own, which they could borrow or rent, included different sorts of cars, household and garden equipment, tools and such bigger possessions as a cottage. The respondents had a good comprehension of the things you can already rent. They mentioned cars, tools, cottages, flats, art, sports equipment, tableware, movies and building equipment. Items relating to spending your free time were mentioned, such as games, instruments and gym cards. Some respondents listed things that you need only for short periods in life, such as baby care items. One group of things to rent was related to luxury, such as the red carpet, security service or your own ice hockey VIP box.

Conclusion: suggestions for multiple cycle solutions

The service systems that involve sharing, renting, leasing, repairing, donating, recycling, reusing and repurposing promote multiple use circles, and prolonged and efficient product use. The consumer points of view presented earlier in the text can serve as user-driven information for these use and disposal relating solutions. In general, the solutions should take into consideration everyday urgencies, social norms, habits, identity-based lifestyles and cultural traditions.

People are asking for long-term product use possibilities that could be served with modular and repairable products that can be upgraded. Buying long-term products and taking care of products is a mark of respectful slow life that seemed to be desirable for many respondents. Repair and upgrades are not well understood operations and these kinds of services should include showing or even teaching how to repair. Since there is an interest in social aspects, the repair services could also include social learning and repairing together. It could feel especially worthwhile to put emotional-value items back to use by repair and repurposing.

Not all the needed products, indeed, require to be owned by individual consumers. Practical products that are used rarely and for performance purposes are the easiest to rent or share since people do not build their identity by possessing these objects. At the other end, even products for short-term, rare or special luxury occasions provide possibilities for renting businesses or peer-to-peer sharing.

People can be inspired to put their non-used products for others to use by their desire for a simple life and time for more important things than physical objects: social interactions, self-improvement or health. Some new products are already marketed with buy-back services. Sharing platforms and web-based systems for sharing seldom-used products, and easy ways of swapping or donating should also be constructed and promoted using people's urge to help others. For selling pre-used products, pricing and photographing help could be useful.

To really know where to put your things for recycling is still a problem. Confusing, difficult and scattered information should be replaced by clear, visible, understandable and transparent explanations of where the product or material goes and why. Easy pickups should be organised from where the consumer has the items. The system should be showing that nothing is wasted and it will do good, not harm.

It is also vital to make people take or buy pre-used items instead of new alternatives. The western expectations of pure products and a transparent production chain concern even the recycled products and materials. Flea markets and vintage shops already attract certain consumer groups but they should do so for many others. A good shopping experience requires easy-to-reach locations, nice displays and coffee with the possibility of findings. The feel of contamination could be avoided by user stories even glorifying the previous use.

It can be claimed that the most sustainable product is the one never made. It can be added that at least products should be made less often. To promote the consumers' activities and habits to change towards multiple and non-wasteful use circles, it is important in all of the described solutions to have an easy customer service path that is based on service design. People are busy but also at the same time lazy so there should be marketing and easily accessible, transparent information available. The locations should be accessible and easy to find or there should be transportation services. The services should look and feel normal and affordable. First and foremost, the solutions should be offered to the consumers so that they are easy to notice and find and the benefits are understandable. In addition to merely being easy to use, they should also be desirable to take in use.

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Maarit Virtanen

Co-creating Circular Economy Solutions with Ho and Rustenburg

The benefits of circular economy are recognised especially in Europe, but a few studies have been done on the opportunities it offers for developing countries. As many countries are experiencing economic growth, rapid urbanisation and expanding population growth, circular economy can provide an opportunity to avoid and solve problems related to the linear economic model. (Ellen McArthur Foundation 2016, 10)

Circular economy cooperation with Ho, Ghana and Rustenburg, South Africa

The City of Lahti, the Ho municipality in Ghana and the Rustenburg municipality in South Africa have a long experience of municipal cooperation. Lahti University of Applied Sciences coordinates the current phase of cooperation funded by the Ministry for Foreign Affairs for 2017 - 2018. The main focus of cooperation is on co-creating circular economy solutions. In Ghana, also the work on sustainable sanitation continues (Aalto & Virtanen 2017).

Co-creation is carried out in a process of three workshops in both Ho and Rustenburg, complemented with research and development activities. The workshops bring together stakeholders from the local government, private sector, communities and NGOs (non-governmental organisations), as well as Finnish experts and companies. The first workshops took place in spring 2017. The project also provided a two-week circular economy intensive training for project partners in Finland, including expert lectures, company site visits and a company workshop. The opportunities recognised in the co-creation process until now are summarised below.

Figure 1. Workshop in Ho, Ghana. (photo by Petteri Launonen)

Circular economy opportunities in Ho

The Ho municipality is dependent on agriculture and has no large-scale industry. There is an interest to develop the waste sector, as the problems related to the lack of services are visible and new income opportunities are needed. The first official landfill site was constructed in 2017 and is expected to start operations by the end of the year. The expected life span of the landfill is five years, unless waste separation is done. Through the cooperation, the local municipality has acknowledged that landfills are not the solution but waste can provide value through circular thinking.

Waste is collected from households and from centralised collection points located, for example, at market places. The greatest waste stream is organic waste consisting of different food and garden waste, and plastics. Other waste streams include paper, cardboard, metal (aluminium cans), glass, textiles, electronic waste, tires, hospital waste, hazardous waste, and sludge from septic tanks. There is very little separation of waste and no treatment facilities in Ho. A waste management company, Zoomlion Ltd, buys a small amount of plastic waste for processing in Accra. There is also some informal recycling of glass and metals cans.

Plastics and organic waste have been identified as the most promising fractions for piloting improved collection and utilisation. Plastic waste is generated for example at homes, schools, market places, social centres, restaurants, hotels and lorry parks. Some plastics (water sachets) are collected separately, but the collection could be considerably widened. The motivation for plastic collection at households and companies would mainly come from a discount in waste service charges and the possibility to generate income. Plastics could be collected through buyback centres and stored at a transfer station before selling them for recycling in bigger batches. The collection could be widened from water sachets to at least water bottles. Some processing of plastics might also be possible in Ho, but electricity supply is a challenge. If plastic collection were organised, it could also include glass and metals for which there is an existing market.

Organic waste including food and agricultural waste comes from markets, farms, industries (cassava etc.), restaurants and households. There is no separate collection for it. However, collection points could be established at main locations and organic waste could be processed in a centralized composting station for use in agriculture and gardening.

A potential place for piloting organic waste collection, and also the collection of plastics, is the new Ho market area, which is expected to open in 2017. Ho Technical University is also interested in cooperation with the municipality and Finnish partners to pilot waste separation and recycling. The student hostels and campus area would provide a good piloting opportunity with around 5 000 students, teaching staff and student restaurants.

Circular economy opportunities in Rustenburg

The Rustenburg area is dependent on mining and there is a need to diversify the economy. The waste sector would provide opportunities for this, but there are currently no processing facilities in Rustenburg and waste sorting is done mainly by the informal sector. Waste collection organised by the municipality is in operation in most parts of Rustenburg. The first engineered landfill site,

Figure 2. View of Ho. (photo by Maarit Virtanen)

Waterval, is in operation, but the planned waste separation is not functioning.

Some materials, like plastics, metals, glass, paper, cardboard and car tyres are collected separately for sale and processing outside the area. The collection is mostly done by individuals and co-operatives, and it is not formalised. There is a need to formalise the collection to provide better income and working conditions for collectors. Waterval could be one of the places providing facilities for formalised recycling activities. Work is currently underway to list all waste recyclers and the amounts and types of waste they handle.

The local municipality has plans for opening a composting facility, and has already reserved a space for it. Pilots on the separate collection of biowaste have been done in the area. The facility would assist in diverting especially garden waste away from the landfill. The facility could also provide other services supporting the formalisation of recycling activities. There is also a small-scale pilot on biogas production.

The Rustenburg municipality cooperates with German GIZ on developing the Waterval landfill site and collecting landfill gas from a closed site. However, there are many cooperation opportunities related to both technology and the organisation of waste separation. There is a special interest in manual waste separation, composting and electronic waste recycling. Furthermore, there is an interest to develop other circular economy services related to, for example, repairing and renting, besides the handling of material streams.

Next steps

The co-creation process continues with workshops in November 2017 and March 2018. The aim is to invite also Finnish companies to the Rustenburg workshop in March. The final results of the process will be Circular Economy Roadmaps for Ho and Rustenburg, and pilot project plans. The financing of the pilots will also be specified during the existing project.

Figure 3. Recycling co-operative in Rustenburg. (photo by Maarit Virtanen)

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Figure 1. Opencast uranium mine in Namibia. (photo by Albert Mäkelä)

Albert Mäkelä and Pia Haapea

Towards circular economy in South Africa, Botswana and Namibia - Environmental engineering student's perspective

Introduction

Africa is estimated to have the highest economic growth potential in the near future. One concern is the environmental threats related to the population and economic growth. A big question is whether growth can take place in a sustainable way, taking into consideration the new economic model, based on Circular Economy. One aim of this article is to give a view of the business potential related to circular economy in southern Africa. The article is based on empirical analysis, a literature review and interviews conducted by Albert Mäkelä, an energy and engineering student, during his internship period in Namibia. The study was carried out for Honkajoki Oy and it concentrated on the opportunities and challenges of circular economy in the Republic of South Africa (RSA), Namibia and Botswana. This article summarizes the literature review and SWOT analysis done by Clay Meadow Consulting Pty, as well as empirical experiences collected during Albert Mäkelä's internship in 9/2016-2/2017.

Africa: only poverty and misery?

People commonly think that Africa is full of poverty, misery and primitive environments. Those were also Mäkelä's thoughts before his student exchange and internship period in southern Africa, Namibia. However, the reality was completely different, and most of the prejudices were broken. Namibians were roaming on paved streets with smartphones in their hands and flushing toilets with drinkable water. But at this point the similarity with Scandinavia starts to vanish. In Finland you are used to how well everything is organised and punctuality is emphasized, but in Africa it is not so. Everybody is taking their time and it is not offensive to arrive late for a meeting. This makes Namibia a challenging and interesting environment to work. Yet almost everything works and things get done one way or another, although not the most efficient way. It is not a lack of enthusiasm at work, it is just a more relaxed mentality. The fact is that at the moment African economy is growing rapidly, although the change has been slow after the colonialism. Hence, people are doing something right.

Republic of South Africa (RSA), Namibia and Botswana

SADC (Southern African Development Community) consists of 14 countries including Namibia, RSA (Republic of South Africa), Botswana, Zambia and Zimbabwe. South Africa´s dominance in the economy is strong: nearly 66% of the GDP distribution in SADC is by South Africa. The RSA´s superiority has made the surrounding countries very dependent on the RSA. Hardly anything is manufactured in Namibia or Botswana. Therefore, Namibia and Botswana are very vulnerable if there are problems in the RSA. Besides, Namibia is expensive and price rating is not under the country's control. The biggest export product of Namibia is uranium and for Botswana it is diamonds and other minerals. The recent decline in diamond and mineral markets has slowed economic growth in these countries, and the RSA's poor economic situation has affected as well. (African Development Bank 2013)

Many of the countries are totally led by the government, and that is why bribery, nepotism and corruption are not rare. Fortunately, corruption was not so bad in Namibia and Botswana compared to many other countries. In addition, southern African countries are struggling with the climate. Draughts are very common and there is sometimes scarcity of water resources. Draught peaks especially affect agriculture because Namibia's self-sufficiency is at a low level. Thus, a poor harvest or failed grazing brings problems to the citizens. A positive side of the problems is that it opens possibilities for new technology and actually forces to take immediate actions. When there is no problem, there is no innovation. A good example of this is from the interview that Mäkelä made in Zambia. Usually Zambia has owned big resources of water but now they are struggling with the draught, so Zambia has not been prepared for a situation like that. Now they are forced to act and solve the problem in one way or another.

Everyone wants to have a share, but it is not that easy

Competition is hard almost everywhere in Africa. European and Chinese companies are trying to sell their ideas and new technology to the growing and forward pushing countries. There are many projects going on and everybody wants to get involved. New technologies are needed in developing countries, so Namibia, for example, offers a lot of opportunities for companies. A good example is Namibia´s energy policy: 90% of the energy is produced by coal, which is imported from South Africa. When Mäkelä entered Namibia, he saw a big sign at the airport that said: ”0.3% of Namibia´s solar energy potential could provide energy for the whole Europe”. But still the installed capacity of solar power is ridiculously small in Namibia. However, it might just be a matter of time when a breakthrough happens, especially in the sector of renewable energy.

If an international company wants to succeed in SADC, it is almost mandatory to have connections and a committed consultant in the country. Companies must have composure and a long-term plan if they are willing to make an impact in SADC. In the last decade, growth and wealth have also made SADC countries more proud because of the feeling that ”we have developed now and we do not need help from Europeans anymore”, which is partly true. However, technology is still needed, but the issue with technology is that automation is not necessary in Africa; manual labour is used instead of automation. Regulations and laws force companies to employ people, so for instance a biogas plant cannot be run by only 5 people like it is possible in Europe. Assembly lines should be replaced by manual labour. Workers are expected to shovel the whole day at the same spot to earn money. That is the way in highly populated Africa to employ poor people.

Figure 2. Typical sanitary building in a slum area in Namibia. (photo by Albert Mäkelä)

Circular Economy

In a nutshell, Circular Economy abandons classic linear consumption, the ”take, make and dispose” model, and replaces it by restorative and regenerative design. Creating loops where the amount of waste is minimised or waste has a new purpose, someone´s waste is someone´s resource for example. The whole process starts from designing and includes sustainable services as well, not only products. In addition, one main principle is to rely on renewable energy. (Ellen MacArthur Foundation 2017.) Generally, renewable energy has a lot of potential in Africa so it offers a good base for Circular Economy. More information about Circular Economy and the study results can be found in Mäkelä’s thesis (Mäkelä 2017).

Figure 3. Waste management of an informal settlement in Namibia. (photo by Albert Mäkelä)

There is not only one Africa

In conclusion, it must be remembered that Africa has 54 countries and it is three times bigger than Europe in square kilometers. Thus, there are many different cultures, tribes, habits, economies and infrastructures. This article discussed SADC and mostly the RSA, Namibia and Botswana. When it comes to business, Finnish companies should take more risks and try to be part of the breakthrough in technology in African countries. For some reason, activity by Finnish companies is very small, even though Africa is growing and developing fast. One of the biggest features required is patience.

This article, as well as Mäkelä's thesis and internship period, is an excellent example of the possibilities that Lahti UAS's student have if they take the chance. Lahti UAS has almost two hundred partner universities for student exchange. Besides that, there are many international projects going on which students can participate in. Students can also do their internship abroad with the help of the financial support of, for example, Erasmus. Teachers always encourage students to go abroad; they will learn and expand their knowledge in a way that will never happen when staying only in Finland. At least they will learn that they have sufficient language skills and knowledge to manage and solve different kinds of problems. However, what matters the most is the attitude.

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The theme of this publication is circular economy solutions. It contains nine articles written by experts and students from Lahti University of Applied Sciences, from its Faculty of Technology and Institute of Design, and from Lappeenranta University of Technology, Lahti UAS's partner and future consortium member. The aim of this review is to present the latest interesting research and development projects in the field of circular economy. The publication has been renamed Lahti Circular Economy Annual Review to better represent Lahti UAS's focus area of circular economy solutions.

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