Lahti Circular Economy
Annual Review 2018

Anni Orola (ed.)

The Publication Series of
Lahti University of Applied Sciences, part 40

Lahti Circular Economy Annual Review **2018**

LAMK
Lahden ammattikorkeakoulu
Lahti University of Applied Sciences

The Publication Series of Lahti University of Applied Sciences, part 40
Editor-in-chief: Miia Willman
Layout: Rebekka Lemmetty, Mainostoimisto SST Oy
Cover Design: Oona Rouhiainen
ISSN 2342-7507 (PDF)
ISSN 2342-7493 (print)
ISBN 978-951-827-289-5 (PDF)
ISBN 978-951-827-290-1 (print)
Printed by: Grano Oy, 2018

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Kati Manskinen

Foreword

The circular economy (CE) concept has gained an increasing interest among researchers, but also among practitioners (Kirchherr et al., 2017). It has been stated that it is one of the most attractive concepts to operationalize sustainable development for business (World Economic Forum 2014; EY 2015). However, the concept has been called too vague and theoretical (Kirchherr et al., 2017). To enhance the transition towards CE, Lahti University of Applied Sciences is developing practical CE solutions, which can be implemented to real-world systems. These solutions might be new technologies such as pilots for material recognition and recycling, as well as digital services like new demonstration platforms and cloud services. Moreover, the emphasis is on the resource efficiency and sustainable environment solutions, e.g. renewable energy, bio-based products and sharing economy concepts (see Figure 1). This review presents the latest significant 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.

In the first article of this review, Ms. Maarit Virtanen describes the implementation of regional CE road map. The CE road map for the Päijät-Häme region was developed as part of a project called Kiertoliike in 2017, and since then several concrete activities have been realized in practice. In her article, Ms. Maarit Virtanen also presents the launching of interesting pilots on collecting of plastic canisters and on repair services. The Päijät-Häme road map has been recognized by the Interreg Europe as a transferable good practice, which is presented in the article written by Ms. Katerina Medkova and Ms. Susanna Vanhamäki. Moreover, in their article, they describe the action plan of the Päijät-Häme region in the important field of bio-based circular economy.

By its very nature, the co-operation among individual stakeholders and across sectors is highlighted in CE. The article written by Dr. Kirsti Cura, Mr. Jaakko Zitting, and Ms. Piia Nurmi, describes the importance of co-working in the Finnish textile recycling ecosystem called Telaketju. Besides the research partners, VTT Technical Research Centre of Finland, Turku UAS and Lahti UAS, the Telaketju ecosystem includes over 30 public and private companies, which enables a holistic approach to create new businesses around textile recycling. Furthermore, the article of Dr. Eeva Aarrevaara and Ms. Mari Eronen presents how a network enables to create new farm-centered services and business activities in a rural area in Hollola.

The significance of collaboration is also pointed out in the article of Mr. Timo Permanto and Ms. Sirpa Keminen, who introduce the projects between our appreciated stakeholder, the City of Lahti, and Lahti UAS. Moreover, the article written by Dr. Markus Sihvonen continues presenting successful stakeholder projects launched together with the City of Lahti. In his article, he describes the development of a platform for personal carbon trading (PCT), which enables citizens to participate in the

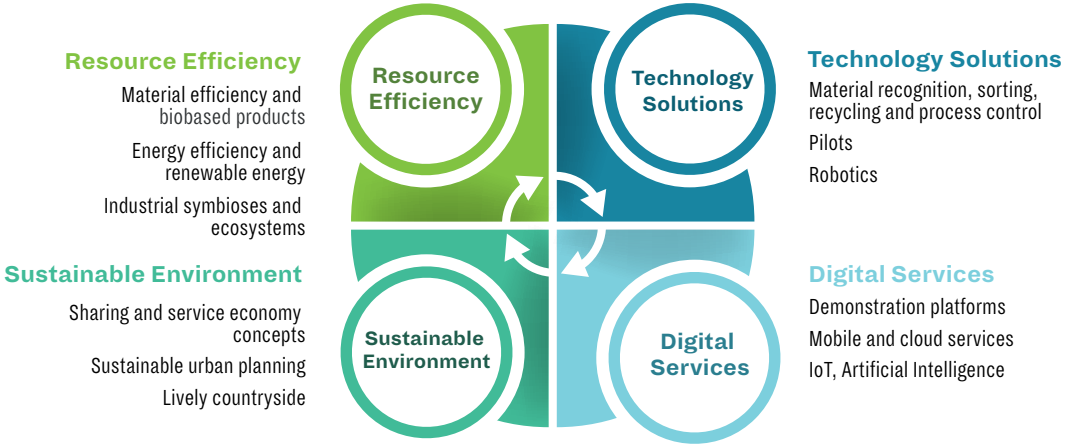

Figure 1. The fields of research, development and innovation activities of the circular economy at Lahti UAS. (Oona Rouhiainen 2018)

climate change mitigation. To fully support regional growth, the Lahti UAS co-operates actively with international partners too. The article written by our student, Ms. Sini Karvonen together with Ms. Katerina Medkova and Dr. Sami Luste describes the development of e-training material for the use of the wastewater operators in the Baltic Sea region.

New technologies have a lot to offer for CE. The article written by Mr. Reijo Heikkinen presents an interesting pilot-scale technology solution for plastics recycling and highlights that it is especially useful in developing countries where there is no transportation infrastructure. Developing countries may have huge challenges in urban planning. Our student, Ms. Ella Uotila, did her training in South Africa and she describes in her article, together with her co-authors Ms. Maarit Virtanen and Dr. Eeva Aarrevaara, some major challenges related to town planning and sustainability in South Africa.

I express my sincere thanks to all authors who published their latest interesting results in this review. I am very happy that many of you had a chance to share your professional expertise in this review and meanwhile, executed this publication once again. I express my gratitude to the editor of this review Ms. Anni Orola and to Ms. Maija Varala for correcting the English language of the articles. I wish that this review gives you some new ideas about promoting circular economy in everyday life.

Lahti, 23 October, 2018

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

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Maarit Virtanen

The Implementation of the Päijät-Häme Circular Economy Road Map

Finland published the world's first road map to a circular economy in 2016 (Sitra 2016). Päijät-Häme was one of the first regions that have drafted a regional circular economy road map to concretise and implement the national vision. The Päijät-Häme Road Map also acts the a circular economy strategy for the region supporting the Regional Development Strategy and Programme for the Päijät-Häme region for 2018–2021 (Päijät-Häme Regional Council 2017). The strategic vision for circular economy is "Päijät-Häme – the successful resource efficient region". (Päijät-Häme Circular Economy Road Map 2018).

The process of creating the road map included workshops, discussions and requests for comments from stakeholders including the Päijät-Häme Regional Council, other regional and municipal authorities, higher education institutions, a regional development corporation, as well as public and private companies. Lahti UAS coordinated the process as a part of the Kiertoliike project supported by the European Regional Development Fund (ERDF). The road map was published in October 2017, and the process continues with the implementation and updating of the road map. The road map includes five main themes and actions under each theme. The themes are:

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 by sustainable transport and energy solutions
4. New consumption models and business opportunities
5. Piloting and demonstrating innovative circular economy solutions

In the future, the Päijät-Häme Circular Economy Group will facilitate the updating of the road map. The first meeting was held in September 2018 to prioritise activities. As circular economy is one of the strategic spearheads for Päijät-Häme region, selected circular economy activities have been funded by the ERDF.

This article includes two examples on the implementation of road map through Lahti UAS's pilots on material streams and new consumption models. Examples on activities related to the other road map themes can be found in this

publication in articles about closing material loops (Co-working in a Finnish Textile Recycling Ecosystem), bio circular economy (Päijät-Häme Action Plan towards Bio-based Circular Economy), new consumption models (Promoting the Potential of Sharing Economy and Service Business in the Hollola Area) and pilots and demonstrations (Kiemura: Solutions for Recycled Plastics – a Machine that Separates the Wheat from the Chaff).

Closing the loops on plastics: piloting a deposit system for plastic packages

Plastics recycling and plastic waste have received a lot of attention lately. The tightening EU regulations and national circular economy goals mean that the current collection of plastic packaging needs to be expanded considerably. According to the new EU directive on packaging and packaging waste (European parliament 2018), 50 per cent of plastic packaging should be recycled by 2025, and 55 per cent by 2030. In Finland this means that the current plastic recycling of 26 000 tonnes should be increased into 64 000 tonnes (Soini 2018).

One way of increasing plastics collection and recycling could be expanding the deposit system for plastic packaging. The deposit system works efficiently for plastic bottles in Finland, but it might be also feasible for other packages. Lahti UAS and Muovipoli Ltd. decided to pilot the collection of canisters for car windshield washing liquid at a local service station, Hollolan Matkakeidas, together with Muoviyhdistys. The Finnish Plastics Recycling Ltd. is also involved in the cooperation.

In practice, the collection of plastic canisters is organised so that the customer buys a canister marked with a pilot sticker from Matkakeidas service station and returns the empty canister to the cashier. Then they receive a free coffee or tea as a reward. The canisters are recycled at a local factory for new plastic products. The pilot started at the beginning of October 2018 and lasts until the end of March 2019.

Figure 1. Plastics collection pilot. (photo by Maarit Virtanen, design Oona Rouhiainen)

Figure 2. Second hand textiles. (photo by Oona Rouhiainen)

New consumption models: piloting repair services

The lengthening of product lifetime is an important part of circular economy. However, many products are nowadays difficult or impossible to repair. The European Union has addressed the need to counter the alleged planned obsolescence process built into many products (European Parliament, 2017). The aim is also to make products and devices easier to repair and spare parts more affordable. In practice, repairing products is often very expensive and the available repair services are scattered and difficult to reach.

Two repair service pilots were done in the Kiertoliike project to test how a centralised repair service would work. The aim was to ease consumers' access to services and to collect information on their experiences of a centralised service. The pilots were implemented together with a local sewing shop and a shoe-repairer. The first pilot took place in Lahti, where the collection of repaired items was organised at the Lahti Service Point in the City Library. The customers both left and collected their items at the Service Point, and the project staff transported the items for repair. The service pilot lasted for three weeks with about fifty repaired products. The customer feedback on the service was very positive, over 90 % of users would recommend it to their friends.

The second repair service pilot was organised in Kalkkinen, Padasjoki and Artjärvi, which are neighbouring municipalities of Lahti. The collection of items was organised together with two local grocery shops and a restaurant. Unlike in Lahti, the service got only a few customers in the municipalities. The reason for this is unclear, because the service was advertised in local papers and notice boards, and the few customers gave a positive feedback.

In addition to the two pilots, the organisation of repair services was studied in the Kiertoliike project as a part of the Full-service Recycling Centre business model (Jänis et al. 2018). The idea in the Centre is to concentrate different kinds of product recycling, renting and repair services under one roof to ease the access to services and to reduce the costs related especially to transportation.

Pilots and experiments in circular economy

Pilots and experiments are one way of testing new types of services, engaging different actors and at the same time communicating about circular economy. One challenge in circular economy is that circular solutions are not widely known to consumers and, for example, recycling and repair activities tend to be very small-scale business. However, circular economy requires a broad systemic change with a major change in consumption habits. This means that engaging citizens is also an essential part of implementing the Päijät-Häme Circular Economy Road Map.

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Katerina Medkova, Susanna Vanhamäki

Päijät-Häme Action Plan towards Bio-based Circular Economy

Introduction

The circular economy is rapidly evolving. The circular economy aims at closing the material loops, as opposed to the currently prevailing linear economy. In these loops, the value of products, materials and resources is maintained in its highest utility for as long as possible (EC 2015). Cycles can be divided into biological and technical as defined in the Butterfly diagram of Ellen MacArthur Foundation (2015).

An economy relying on renewable biological resources (e.g. crops, forests and animals) and their conversion into food, feed, products, materials and energy, is called bioeconomy (Figure 1). Industries like agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of the chemical, biotechnological and energy industries, belong to bioeconomy. (EC 2012) Bioeconomy is, however, not always circular or sustainable. Therefore, when combining bioeconomy with the circular economy principles, a bio-based circular economy evolves and the full potential of the circular economy can be obtained. Bio-based circular economy or bio circular economy is the circular economy of bio-based materials, which are wholly or partly derived from materials of biological origin (EC 2018).

The Interreg Europe programme stimulates cooperation between different European regions through the exchange of experience and Good Practices (Interreg Europe 2018a). BIOREGIO is a five-year-long Interreg Europe project aiming to boost the bio-based circular economy. The partnership consists of eight partners from six countries. The main goal of BIOREGIO is to improve regional policies and programs related to the circular economy of biological streams by transferring knowledge and developing action plans. (Interreg Europe 2018b.) This article presents the action plan of the Päijät-Häme region in Finland.

From Good Practices towards an Action Plan

Good Practice can be related to technology, such as biogas production or biorefinery, or cooperation models, such as ecosystems and networks. All BIOREGIO partners and stakeholders carefully select successfully proven Good Practices in their regions based on the defined criteria. The full list of the criteria (n=8) of bio-based circular economy Good Practices, commonly identified by the BIOREGIO project consortium, is available on the project website (Interreg Europe 2018c). To name a few, resource efficiency, transferability and scalability in different European regions are listed.

Good Practices identified in BIOREGIO are available on the project website (Interreg Europe 2018d). Interreg Europe experts assess all practices. If a Good Practice is seen to have potential for being transferred in other regions, it is published at the Policy Learning Platform. The Policy Learning Platform is an online database launched by Interreg Europe, where expert-

Figure 1. Biological resources create the foundation for the bio-based circular economy. (photo by Oona Rouhiainen 2018)

validated Good Practices from European cities and regions are shared. By sharing knowledge, experiences and practices, everyone can benefit from already tried-and-tested solutions. (Interreg Europe 2018e)

As an outcome of Interreg Europe projects, an action plan on how to develop the use and focus of regional policy instruments (e.g. Structural funds like the European Regional Development Fund, ERDF) is set up (Interreg Europe 2018a). In terms of BIOREGIO, the action plan defines the goals of long and short-term regional development of the bio-based circular economy. The action plans set in BIOREGIO regions enhance the transfer of the Good Practices.

Towards a regional action plan in Päijät-Häme, Finland

As a part of the Regional Development Strategy and Programme for the Päijät-Häme region for 2018–2021, the Päijät-Häme road map towards a circular economy was launched in the autumn of 2017 as a part of the regional strategy and programme. The road map is described in detail in the article written by Virtanen in this publication.

The Päijät-Häme road map has been recognized by the Interreg Europe (2018f) as a transferable good practice. According to the Interreg Europe experts, the Päijät-Häme road map is a positive example of translating national priorities to a regional context by creating a joint regional strategy with a bottom-up approach. The experts see strong potential for transferring the road map example to other regions interested in a transition towards a circular economy.

One of the five goals of the road map is related to bio circular economy. As a part of updating the road map, as described by Virtanen, the bio circular economy or bio-based circular economy targets were specified. The action plan of the BIOREGIO project was set up based on the updated road map strategy.

Päijät-Häme regional council has chaired a regional bioeconomy working group since 2016. In 2018, the name and focus of the group were re-adjusted to become the Päijät-Häme circular economy group. Since the start of the BIOREGIO project, this group has also had the responsibility of being the regional BIOREGIO stakeholder group. The group consists of members from the administration, municipalities, business sector and academia.

The action plan was discussed in two meetings of the circular economy group/ BIOREGIO stakeholder group. In June 2018, the preliminary ideas were collected among the attendants. Based on the discussion, the regional council together with Lahti University of Applied Sciences formulated topics for further processing. At the meeting in September 2018, the focus of the action plan was clarified as a part of updating the circular economy road map targets. Additional comments were also asked from all municipalities in the region as well as from the members of the group who were unable to attend the meeting. The draft of the action plan was sent for final comments to the circular economy group and the plan was approved in October 2010. Figure 2 presents the connection between the Päijät-Häme regional strategy, the road map towards a circular economy and the BIOREGIO action plan.

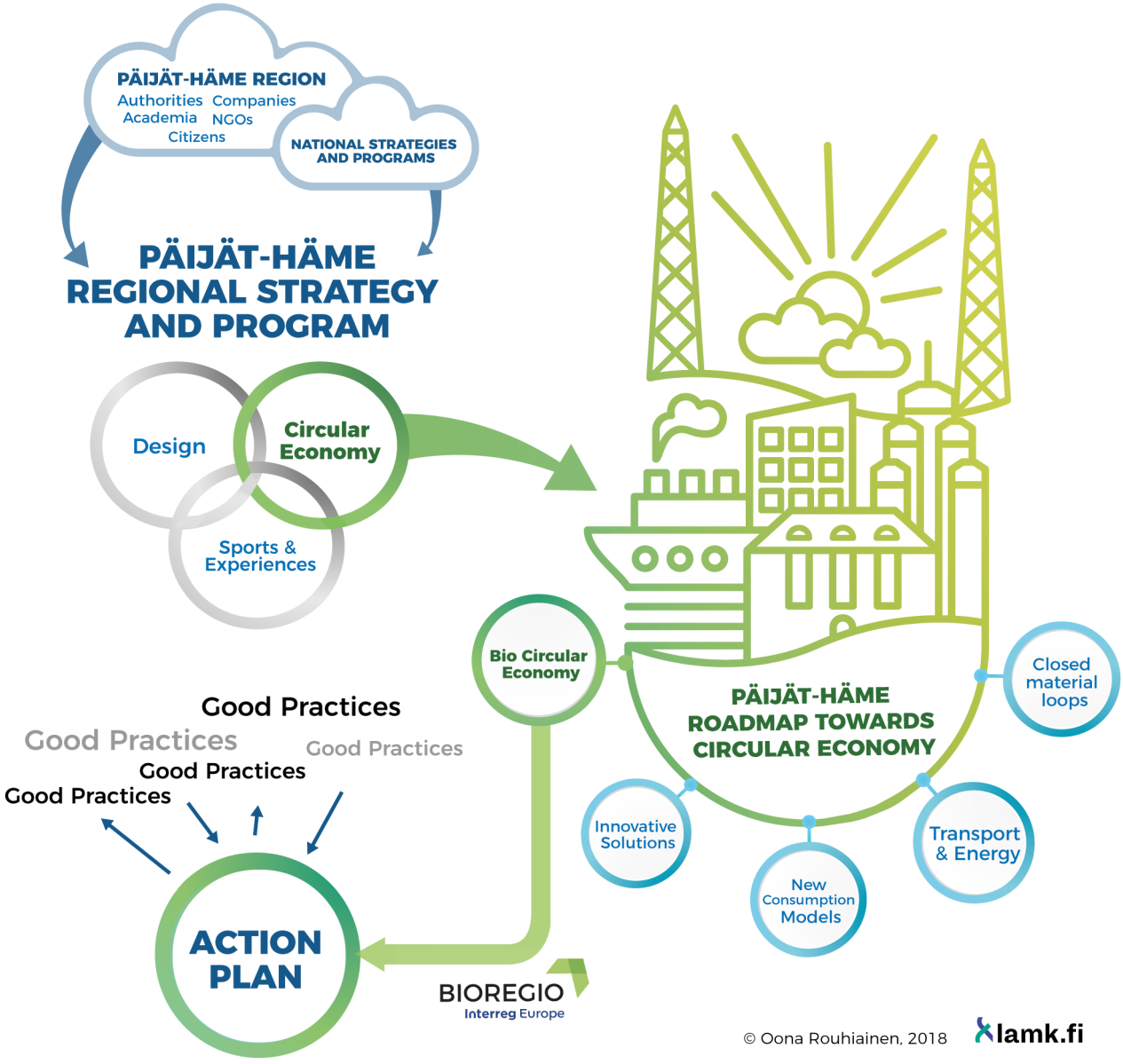

Figure 2. The link between the Päijät-Häme regional strategy, the road map towards a circular economy and the BIOREGIO action plan. (Oona Rouhiainen 2018)

Bio-based circular economy action plan of the Päijät-Häme region

The action plan is designed to include both short- and long-term targets to develop the bio-based circular economy in the region. The short-term targets are set up to be reached before the end of the current structural fund's programming period 2014–2020. The long-term targets express future goals related to the bio-based circular economy in the region and are also related to the coming programming period beginning in 2021. The actions are listed as follows:

1. Developing sustainable bio-based circular economy and enhancing the circulation of nutrients

   Timeframe: long-term goal

   - promoting utilization of bio-based materials and regional bio-based circular economy
   - aiming towards closing nutrient loops of nitrogen and phosphorus
   - developing sustainable business models in bio-based circular economy

2. New solutions in the collection and utilization of biowaste

   Timeframe: ERDF programming period 2014–2020

   - reducing the amount of biowaste and wasted food
   - user-oriented development
   - testing pilot solutions e.g. separate collection of biowaste, developing biowaste bins, composting pilots

3. Developing the utilisation of bio-products and bioenergy

   Timeframe: ERDF programming period 2014–2020

   - new possibilities of utilizing wastewater sludge
     - material utilization, developing and further processing by-products
     - utilizing by-products in small scale CHP production (related to a BIOREGIO Good Practice in Greece "Use of organic residues for energy production" (Interreg Europe 2018g)
   - developing the use of biogas-driven vehicles

4. Developing the Päijät-Häme regional circular economy strategy

   Timeframe: long-term goal

   - sharing the good practice of implementing a Smart Specialisation spearhead through a road map
   - involving sustainability in bioeconomy, developing holistic circular economy perspective
   - continuous updating in cooperation with the circular economy working group
   - new ways of involving companies in the process

Conclusion

Including sustainability and circularity in bioeconomy is a precondition for reaching a bio-based circular economy. As a result of the BIOREGIO project, six European regions will set up plans on how to develop and support a better use of bio-based resources in a more circular way.

The road map towards circular economy in Päijät-Häme, i.e. the regional circular economy strategy, lays the foundation for future development and will be updated continuously. At the same time, as a part of the road map, the achievements in bio-based circular economy clarified in the BIOREGIO action plan will be followed up. The road map, as well as the action plan, are both living documents, meant to be updated and changed according to regional, national and international challenges and needs. The broader view of the circular economy, which the holistic road map setting allows, forms the base for a comprehensive understanding of the full potential of the bio-based circular economy.

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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Kirsti Cura, Jaakko Zitting, Piia Nurmi

Co-working in a Finnish Textile Recycling Ecosystem

Abstract

One important innovation ecosystem in Finland at the moment is related to textile recycling. This ecosystem is called Telaketju. Lahti University of Applied Sciences has been a part of the Telaketju network since 2017, and Turku University of Applied Sciences even longer. This network is working to enable better utilisation of textile waste and other discarded textiles in Finland. This is important as separate collection of textile waste has to be organised in all EU member countries by 2025 and we need to create some ways to use this material – otherwise there is no real sense in collecting it separately.

In an ecosystem, actors from different backgrounds work closely together and benefit from each other's work. Cooperation and co-working are some of the most important aspects in well-functioning innovation and business ecosystems.

This article tells about the co-working needs and possibilities of an ecosystem – work that has been carried out in a consortium of three research institutes and about 20 companies. In Telaketju, a national ecosystem of knowledge is being developed, and the network also forms a platform for the creation of new and strong industry with multidisciplinary collaboration. The ecosystem develops the collection, sorting out and refining processes of end-of-life textiles. Moreover, it enables the development of business models related to circular economy. It is widely recognised as an important and well-functioning ecosystem.

Need for circulation of textile materials

Since the European Union's Circular Economy Package from late 2015, EU member countries have been required to take actions on all major waste streams. The ban on organic waste in landfills came into effect in the beginning of 2016, and separate collection of textile waste needs to be organised in all EU member countries by 2025. It is still not clear what the "separate collection of textile waste" requirement actually means in practice. In a sparsely populated country like Finland, it is unlikely that separate collection points will be placed in every municipality.

Scarcity of natural resources drives towards resource efficiency and circular economy. The textile and fibre industry is facing such issues as well. A report by the Ellen MacArthur Foundation from 2015 estimated that 73 % of the annual global fibre production for clothing either ends up in landfills or gets incinerated. About 12 % is recycled cascadingly and less than 1 % goes to closed-loop recycling. Global material flows of clothing are depicted in Figure 1. (Ellen MacArthur Foundation 2015)

In the past few years, there has been revealing news about some major brands burning their non-sold garments to protect their brand. Consumers and media have started to draw attention to this, and major brands have had to react. For example, the British luxury brand Burberry recently announced that they will stop burning unsold goods and using real fur. (BBC 2018) These are good observations about effects that can be achieved by raising consumers' awareness and that their actions really matter.

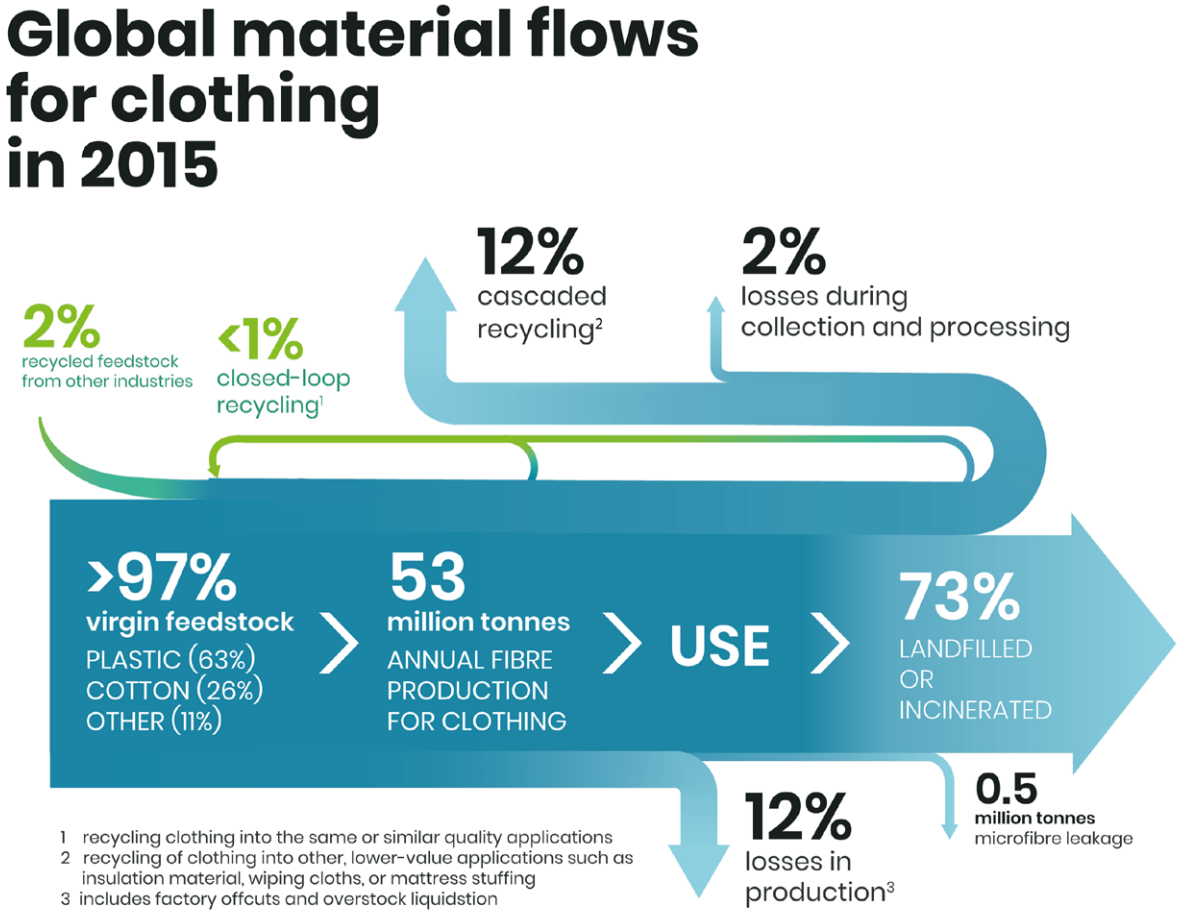

Figure 1. Global material flows for clothing in 2015.
(adapted from Ellen Macarthur Foundation 2015 by Oona Rouhiainen 2018)

”We really need to be consuming way less. We need to be loving and treating our clothes better.” Safia Minney, founder of sustainable clothing brand People Tree and managing director of ethical footwear brand PoZu. (BBC 2018)

Current status of textile recycling in Finland

In Finland, 72 000 tonnes of discarded textile waste is produced annually. This means about 13 kg per person a year. Only about 20 % of the textile waste is collected for reuse. (Dahlbo et al. 2015) Typical collectors are charity organisations and other NGOs (non-governmental organisations). Their work is valuable and brings along the social impact of sustainable development. However, in order to achieve cost effective business solutions, far greater textile waste volumes and new types of reuse are needed. The remaining 80 % currently ends up for energy recovery by incineration.

As in other EU countries, various actions towards closing the loops of textiles are also going on in Finland. The most relevant and multidisciplinary project on the national level is the Telaketju network (Telaketju 2017) where companies of various sectors (textile waste producers, waste collectors and handlers, reusers, technology developers, etc.) together with three research institutes work closely together. This is carried out by firstly understanding what is already in place and what is needed to get a working ecosystem of textile recycling in Finland; and secondly, after having identified the missing “gears”, again together finding solutions and new actors to complete the Telaketju chain (see Figure 2).

Co-working towards better textile recycling and new innovations

The Telaketju project aims for better utilisation of textile waste and other discarded textiles in Finland by launching simultaneous actions and R&D projects in textile collection and sorting as well as processing and product development. The research project focuses on development of processes, products and business operations in the participating companies. The research partners are VTT Technical Research Centre of Finland, Turku UAS and Lahti UAS. In addition to the research partners, the Telaketju network includes over 30 public and private companies. A great number of various actions have been carried out during 2017–2018. Practical demonstrations include for example making of non-woven textile mats out of recycled post-consumer cotton and/or polyester and further processing them to acoustic panels by Soften (see Figure 3). Pure Waste Textiles have used pre-consumer textiles in their jeans, T-shirts and knitwear products since 2013. They have recently trialled 20–40 % of post consumer cotton in polycotton blends on a small scale. Encouraged by these small tests, Pure Waste Textiles will proceed to increase the scale to 200–2000 kg. (Pesola 2018) Touchpoint has designed and produced well fitting workwear from recycled materials, such as PET bottles and textiles. After the first life cycle of workwear it can be used as raw material for composite products. (Saarimäki 2018)

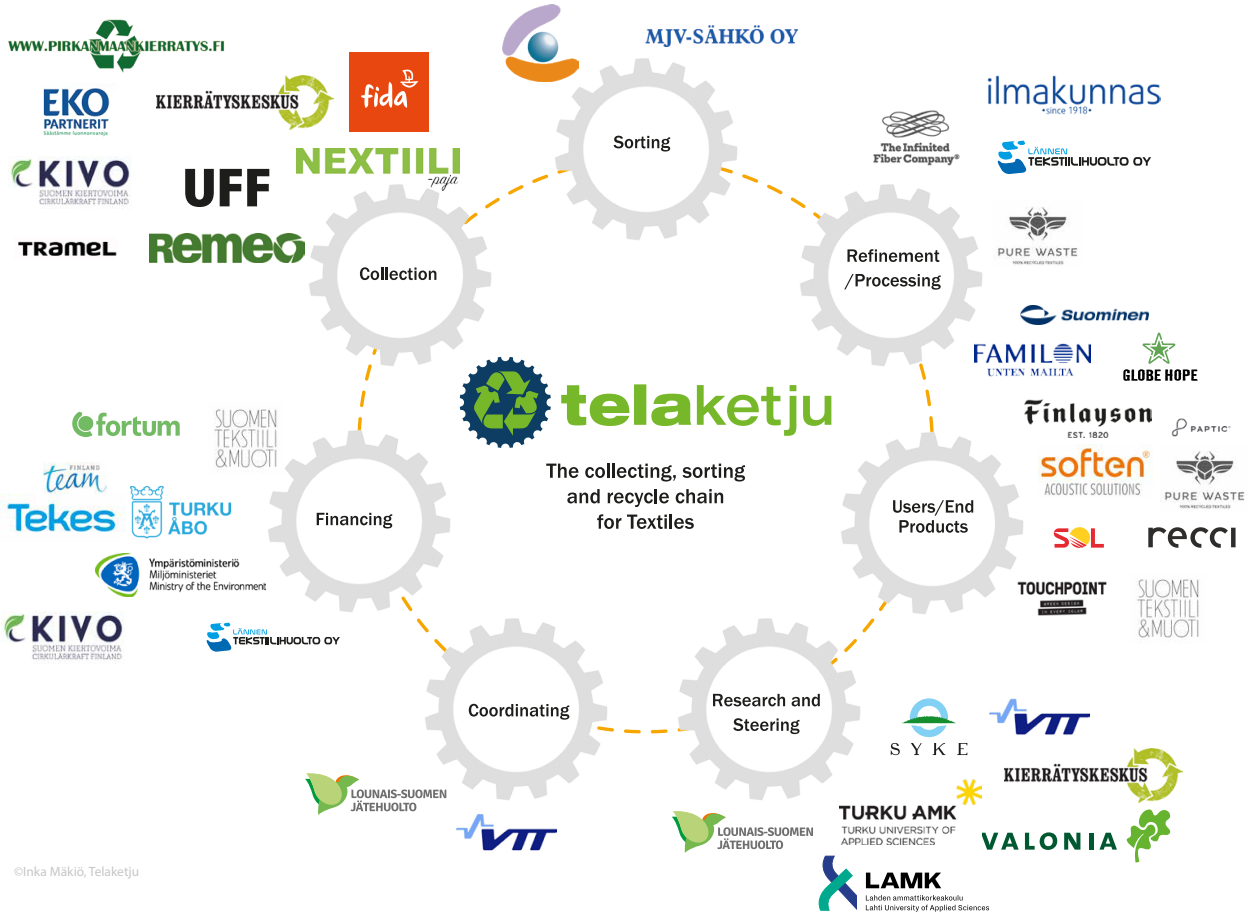

Figure 2. The collecting, sorting and recycling chain for textiles. (Telaketju 2017)

Figure 3. An acoustic panel made from recycled textiles. (photo by Marketta Virta)

> “A challenge in manual sorting of garments is that the washing, size and fibre material information labels may be unreadable or missing. This is a real problem especially with children’s clothes. In addition, sorting of discarded textiles requires trained staff. Knowhow and experience is also needed when sorting and pricing products.” (Eskelinen et al. 2018)

Work has been carried out simultaneously in R&D projects in textile collection and sorting as well as processing and product development. The overall target of the Telaketju network’s actions has been to build an ecosystem which consists of companies and other organisations that have the necessary knowledge and urge to enhance sustainability and textile recycling in Finland.

In addition to practical demonstrations, the Telaketju ecosystem has also focused a lot on communication. It has been recognised that consumers play a major role in order to achieve closed loops in textile recycling. Also, B2B communication is very important. Companies like to read and learn from other companies’ examples. The Telaketju network has very active web pages with blogs, webinars and reports. Also, it has active social media channels. In addition, great effort has been put into other publications and presentations in seminars and other events.

How to move forward?

Even if a lot has been done and achieved so far, a lot of issues remain to be studied and tested before a true ecosystem of textile recycling is fully in place. Here are some findings:

- it is essential to manage large volumes of textile waste in order to get profitable business in a sustainable way
- automated textile recognition is needed to get good quality recycled post consumer textiles and fibers especially for chemical recycling, but also for mechanical recycling
- logistics costs play a big role and different working models have been studied (Hinkka 2018)
- more and new applications for end products out of recycled textiles and fibres are needed
- innovative business models need to be applied even more to promote waste hierarchy; these include different service systems, hire & leasing, incentivised return, reuse and long life (WRAP 2018)

Lounais-Suomen Jätehuolto is currently investigating a possibility of having a textile waste refinery in Finland. This would offer a sustainable, Finnish solution for end-of-life textile collecting, sorting and refining for resusers of pre- and post-consumer textile waste. During 2018–2020, a first pilot will be built, including some equipment investments, and further actions will be planned. (Telaketju TEM 2018)

There are several cellulose-based sustainable bioeconomy research projects, such as Inifinited Fiber Company, Spinnova and Ioncell. They all concentrate on the development of textile fibre technology and do not take collection and reuse into consideration.

In the report “Innovation Ecosystems in a Sustainable Bioeconomy - A Finnish case study for OECD” from May 2018, the status of Finnish bioeconomy has been reviewed and rated. The target of this study was to give an insight into new application areas that use forest-based biomasses, one of them being cellulose-based textiles. The study applied the following phases in its analysis: predevelopment, development, take-off, acceleration and stabilization. The conclusion of the study was that cellulose-based textiles are in the end of the development phase and in the beginning of the take-off phase. (Business Finland 2018.) The strength of the Telaketju ecosystem is its holistic approach towards circular economy of textile recycling.

Co-working and co-creation in an ecosystem

The term ecosystem has become widely used in other than biological contexts where it originates. Nokia was probably one of the first users in the 2000’s. There is not one and only definition for it. (Hytti and Ruusunen 2016; Merkman 2012.) Ecosystem research often uses terms such as “innovation ecosystem” and “business ecosystem”. However, these concepts are quite often used rather loosely as umbrella concepts covering different thematic emphases and background assumptions.

To put it simply, in an ecosystem, actors from different backgrounds work closely together and benefit from each other’s work. There can also be competitors in the same ecosystem. The most

important outcome is that different actors find their role as a part of the system, identify the others' roles and interfaces, notice changes of the operating environment and act accordingly. At best, this way of working benefits from new practice-based innovations in a multidisciplinary way. (Melkas et al. 2018.) Furthermore, the end users – clients – should be a part of the ecosystems.

Co-working and a cooperative ecosystem are also important to the companies. Turku UAS interviewed the 13 companies participating in the Telaketju project to get an idea of their expectations regarding the project. The aim of the interviews was to find out what kind of circular economy work the participating companies are doing and their knowledge of textile recycling terminology and the handling of raw material. A desire to work together came up in every interview. Even though the companies come to the Telaketju project from different starting points, the end goal is the same for everybody: together they want to build a working textile sorting chain, which would utilise end-of-life textiles in a closed loop system.

Research, development and innovation (RDI) work at Finnish universities of applied sciences is often directed for local companies in the region, and hence has typically been funded by the European Union's structural and regional funds. These regional funding instruments are not the best tools for wider-scale development work as there is also a huge need for business ecosystem development. Telaketju has been funded mainly by Business Finland (formerly Tekes – the Finnish Funding Agency for Innovation) and that funding allows also ecosystem work. Actually, it does not only allow but also requires this kind of work. One important aspect to discuss would also be to think what other funding instruments support ecosystem work, as many complex business development issues and cooperations need ecosystems to really work.

Conclusions

This article discussed the co-working needs and possibilities of an ecosystem, more specifically of a textile recycling ecosystem. As this article shows, a lot has been done already. However, since a well-functioning business ecosystem is very hard to achieve, the situation is that even more needs to be done in the future. One part of the future work will be the new ecosystem projects planned after Telaketju. The Telaketju project funded by Business Finland is ending by the beginning of year 2019. However, the companies along with the research partners VTT and Turku UAS and Lahti UAS are now building Telaketju 2.

EU member countries are required to take actions on all major waste streams; for example separate collection of textile waste needs to be organised in all EU member countries by 2025. It is still not clear what this requirement actually means in practice but the need for the Telaketju ecosystem is obvious. Moreover, the whole value chain of textiles should be rethought and redesigned. We consume too much textile at the moment. For example textile as a service (product as a service) models could help us redesign the textile business ecosystem in a good way – meaning good for the environment as well as the economy. This kind of systemic changes in an ecosystem mean that many parts of the value chain need to change simultaneously. This means even stronger networking, cooperation and co-working in the future. In order to achieve that, there is an even bigger need for trust, transparency and dialogue than today.

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Eeva Aarrevaara, Mari Eronen

Promoting the Potential of Sharing Economy and Service Business in the Hollola Area

Global warming and depletion of nature's resources caused by constantly growing population and overconsumption are the most remarkable challenges of humankind. To solve these problems, we need to adopt more sustainable ways of consuming. Sharing economy is an economic model based on sharing, lending or renting goods and services. Common forms of sharing economy are for example car sharing, space rental and co-culture. New experiments are often concentrated on urban environments but also rural areas are able to benefit from these models.

Introduction

The Finnish countryside has great potential for sharing economy and service business. There are several examples around the world where the circular economy models are being developed in rural environments, such as Agrihood (short for agricultural neighborhoods) in the USA. Agrihood means planned community areas with a farm in the focus and services provided in cooperation. The available services are connected for example to green areas, cultivation and gardening to produce local food and common facilities for transport and other activities. The target group is often young families who appreciate healthy nutrition, outdoor environment, cooperation and shared services. (World Economic Forum 2018.)

A similar idea has been considered in the Hollola area in Päijät-Häme. The local farmers are looking for new opportunities to create a new network based on a farm centered services and business activities. Some farms have already ongoing businesses selling their own products and services. Further development will require larger regional cooperation between the residents and the entrepreneurs in the area. Moreover, the master plan of the region should enable the new circular economy business activity.

This was the basis for the project Promoting the potential of sharing economy and service business in Hollola area (PALJU). The aim of the project was to survey new possibilities for circular economy business in the Hollola area, focusing on sharing economy and service business. Moreover, the options for producing renewable energy in sparsely populated areas were contemplated. The project also aimed at building a cooperation network to create business activity, and at examining how the master plan would adapt to it.

The Farm Village

One of the project's goals was to explore opportunities for creating an environmentally friendly residential area that would offer a possibility for its residents to live near modern all-day services in the countryside. The main

Figure 1. Hälvälä area, where The Farm Village would be located. (photo by Mikko Niipala)

aspects in the development of "The Farm Village" are energy self-sufficiency, circular economy and nutrient recycling. The area would be located in Hälvälä, Hollola. This village actually belongs to a larger village area called Kankaantaka, which consists of altogether seven separate settlement areas. The initiative and activity of the local farmers encouraged the project staff and students in Lahti UAS to work in this multidimensional project during spring 2018.

First, a survey was conducted by interviewing the current and potential residents and entrepreneurs of Hälvälä. The result was a service concept description consisting of six models of sharing economy and service business: a café and a market hall, car sharing, a multi-functional schoolhouse, caretaker service, a service assortment, and the Farm Village

Figure 2. The final seminar of the project was arranged in May 2018. (photo by Mari Eronen)

application. Business students from Lahti UAS were examining the needs of possible future inhabitants and innovating new business models for the area. Another group was concentrating on brand creation and its elements. All the ideas were reported in the form of a website (Kankaantaka 2018).

The contents of the local strategic master plan were negotiated with the municipality (Hollolan kunta 2018). It was concluded that the development of these kinds of activities on a larger scale requires a detail plan for the area, which has to be developed with the municipality. Preliminary discussions with the planning authorities have been supportive to the idea. At the same time, the municipality is developing the surrounding residential area, which could also benefit from the new services in the neighborhood. Connected with these viewpoints, a group of urban planning students was examining the ideals for living in a farm village and also different options for the location of new built areas in the neighborhood of farms.

Three seminars were arranged in the village, with invited expert lectures and general discussions dealing with service design, farm networking and renewable energy production. The final seminar of the project was an activity day on one of the farms. The visitors could participate in a sightseeing tour of the village, enjoy local food products and give their opinions about the project to the staff members.

Renewable energy

The possibilities of producing local renewable energy were also observed in the PALJU project. A biogas plant proved to be the most interesting option among the local farmers. In the Hälvälä

area, there are several organic farms producing green mass, which could be used as feed in a biogas plant. Other potential feeds could be horse manure and other bio-based residues from the local farms.

Lahti UAS staff members made an interesting excursion to the Palopuro village in Hyvinkää in late 2017. The local farmers and entrepreneurs were about to start a project of biogas production with the support of the local energy company. Biogas production will be based on collection of manure and grass from the fields under organic farming.

In Hälvälä the biogas could be utilized in heating the residential area or refined to transport fuel. The farmers could use the digestion residue as a fertilizer, which would promote the nutrient recycling. However, there are still some economic issues to be resolved before the biogas plant can be established.

Conclusions

The residents and entrepreneurs of Hollola are clearly interested and excited about the new circular economy business models, which would also benefit the Hollola region in many ways. These new models need to be demonstrated and piloted. It is possible to start the piloting with the existing premises and resources but also a long-term plan needs to be prepared to achieve a larger volume of the new concept. Support and cooperation with the municipality will still be needed in order to achieve the ambitious goals of this rural development, which in the best case can really make a difference to contemporary living and housing concepts.

Considering funding, this was a small-scale project but it succeeded in integrating several different student groups to participate and bring their viewpoints to the project. Also, it succeeded in combining the perspectives of urban planning and circular economy – an achievement that new projects can be based on in the future.

Figure 3. Discussion in one of the workshops. (photo by Sami Tervo)

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Timo Permanto, Sirpa Keminen

Towards Climate Targets with Cooperation

How to win-win by intensifying collaboration

The City of Lahti has recently committed to circular economy. Already for decades, we have made plans, efforts and investments to reduce our CO_2 emissions and other impacts on the environment. Lahti was elected to the national network of ”resource-smart pioneer cities and municipalities” in 2016. The network has common objectives of a) zero emissions, b) zero waste and c) a sustainable level of overall consumption in the community. The aim is to meet the objectives by year 2050.

Lahti has also made shorter-term commitments connected to reuse of certain waste fractions. We should increase the material reuse level of household waste to 55 % and construction waste up to 70 % by 2023. (Lahden kaupunki 2018) These targets are common for another national network of cities. The network of eleven Finnish ”model cities of circular economy” started last year. The work is managed by the CircWaste project, which is coordinated by the Finnish Environment Institute. (Circwaste 2017)

We are well aware that although the city organization is a big local operator, it cannot manage the complicated challenges connected to these issues alone. Networking and collaboration are vital in aiming at these ambitious targets. For a long time we have found Lahti University of Applied Sciences (Lahti UAS) one of the best partners in this kind of local work.

Collaboration between Lahti City and Lahti University of Applied Sciences

Probably the earliest forms of collaboration with Lahti University of Applied Sciences (Lahti UAS) were students practicing in the city environmental and city planning departments and the city’s environmental experts giving lectures on some courses. Very soon we also got some useful thesis projects made by more advanced students of Lahti UAS. In many cases already, those projects have proved useful. Meetings of officials from city organizations, supervising teachers and students with fresh ideas and new angles have been instructive. This kind of partnership has continued beneficially until these days.

The role of different development projects in Lahti City and Lahti UAS collaboration has been growing rapidly in recent years. Many of these projects have been connected to circular economy that, as said in the beginning, is very topical also in Lahti City development efforts. Recent projects managed by Lahti UAS such as BIOREGIO, Kiertoliike, Developing Circular Economy Know-how at Päijät-Häme - LAMKgreen, and Telaketju have been in the very core of this development work.

One recent example was a seminar arranged by the Developing Circular Economy Know-how at Päijät-Häme - LAMKgreen project. In the Circular Economy in the Päijät-Häme Region interactive seminar, we heard some brilliant presentations by top experts in our region. In that seminar we

Figure 1. Circular Economy in the Päijät-Häme Region – interactive seminar. (photo by Sirpa Keminen)

participants could also take part in the discussion through the very interesting Mentimeter mobile application. The aim of the Developing Circular Economy Know-how at Päijät-Häme - LAMKgreen project is to organize training related with circular economy for employees in the Päijät-Häme region, and to test a variety of innovative learning methods. The project is funded by the European Social Fund (ESF).

Participating for example in the steering groups of projects and several workshops, lectures, excursions and other events arranged by some projects have been places for hopefully mutual learning and advancing in this field. For the city they have definitely opened new ways of networking. They have provided real help in preparing the ”Lahti City roadmap to more clever use of resources” and the ”Local Circular Economy Plan”.

Recently, the organization of both Lahti City and Lahti UAS have been in the process of transformation, and this seems to continue in the near future. In this change, we have to take care that our leaders or we ourselves do not lose interest in our fruitful collaboration or reduce resources to continue and even improve it. Successful work in promoting circular economy and climate protection is no less than a guarantee for the welfare of our children, grandchildren and future generations.

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Markus Sihvonen

Personal Carbon Trading Market Place: The ICT System for Sustainable Mobility in Lahti

1 The PCT system

The purpose of the PCT (Personal Carbon Trading) system is to measure personal mobility CO_2 emissions and provide means for the system user to trade CO_2 emission rights. To encourage users to decrease their personal CO_2 footprint, the PCT system supports different benefit schemes for the users that the system administrator can utilize. Figure 1 illustrates the PCT system architecture.

Any kind of IoT (Internet of Things) data or sensor data, in this case mobility-related, can be uploaded into the PCT platform. In the first PCT system prototype, mobility data is uploaded from cloud services provided by the following companies in Finland: Mattersoft, Moprim and Infotripla. Mattersoft has installed permanent sensors for buses that operate within the City of Lahti. Infotripla utilizes fixed sensors installed by third parties to the City of Lahti area. Moprim provides SDK (Software Development Kit) which is installed to the mobile phone of the PCT system user. It measures information on the user's mobility: means of transportation, length of a single trip, time used for a single trip, starting point coordinates and ending point coordinates. From the mobile phone, this data is uploaded first to the Moprim cloud service, where it is further processed and then forwarded to the PCT platform. IoT sensor data from AI (Artificial Intelligence) bike routes will later be added to the second prototype version.

Third party services are supported by the PCT system. Provisioning of these services are automated in order to achieve wider user acceptance and later profitability when the PCT system is in production use. This also enables basically any interested party to create new innovative services based on collected mobility data. Therefore, collected mobility data is available via public API (Application Programming Interface). The data is stored into a SQL (Structured Query Language) database in the platform. PCT market functionality resides in the platform and all the logical computation needed by the market place is done in the platform. Finally, there is a UI (user interface) available for Android and IoS smart phones. The UI has a dynamic list of available third party services for the system users. The PCT platform is implemented by utilizing the generic skeleton of the IoT platform provided by Good Sign Oy. That platform has very basic functionalities common to commercial IoT platforms in the cloud environment. We have added features and functionalities required by the PCT market place to this skeleton platform. This is described in detail in the Figure 2.

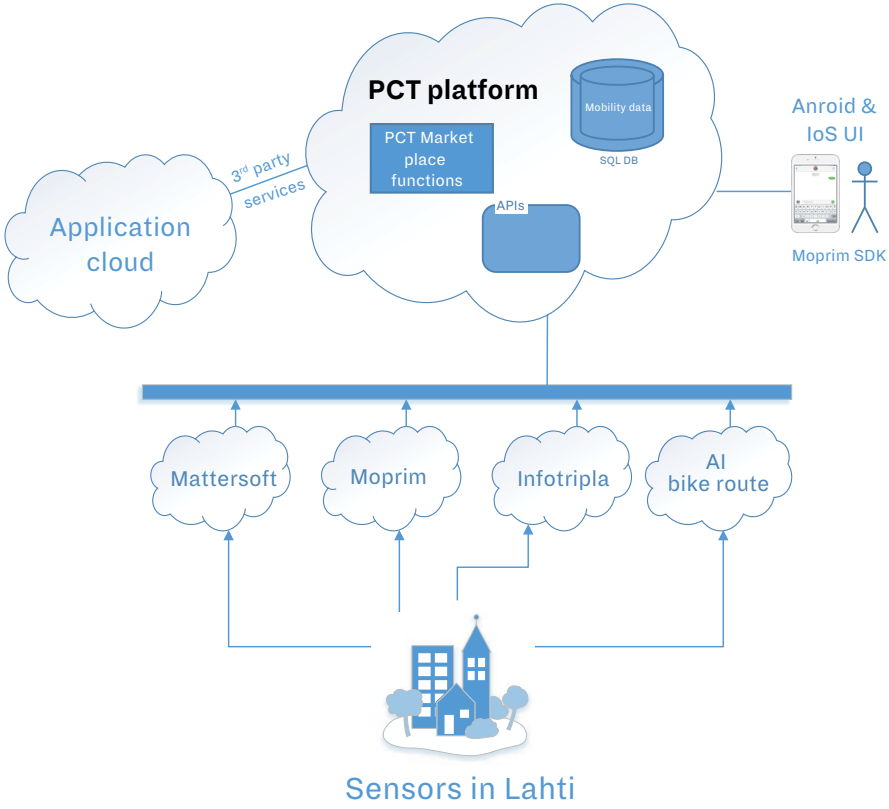

Figure 1: PCT system architecture.

All collected environment data that is still unprocessed is stored into the Ticket database. This raw data is never available for PCT market place users or third party service providers. The raw data is always further enriched by the Mediation Server. The application level communication protocol used to upload collected data to the platform is SFTP (Secure File Transfer Protocol).

User data of the system is stored into Objects in the platform. Achievements of a system user are collected from the entire user history. These achievements are set by the system operator and are intended to support the decreasing of CO_2 emissions. License plate numbers are collected from all vehicles used by a particular PCT system user. Detailed trip information from each individual trip by the system user is recorded.

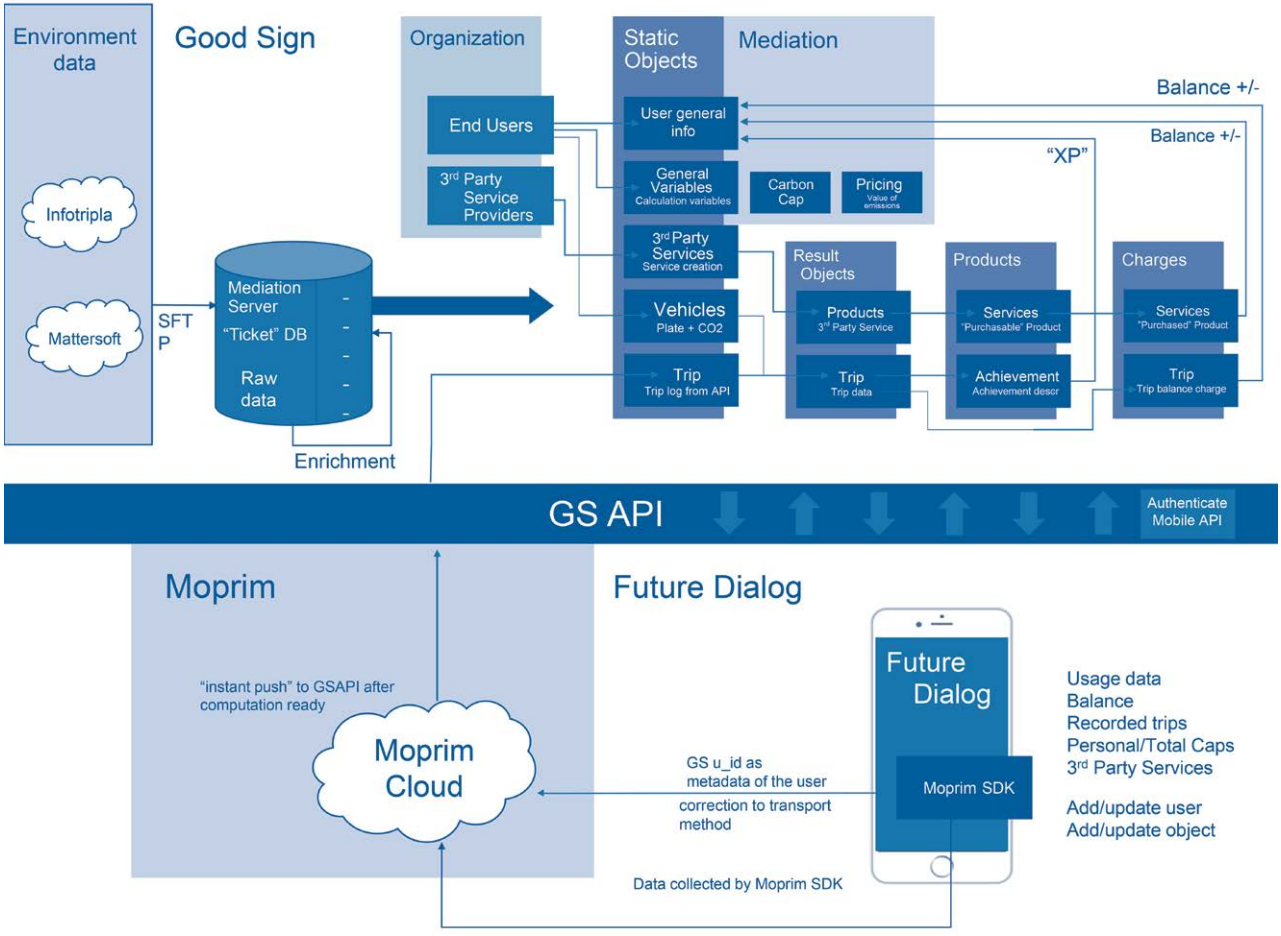

Figure 2: PCT platform.

Charges are rules created by the PCT system operators. These rules define how much CO_2 emissions a system user has produced per a measured trip. This information is stored in the user's Balance field. The information is also available for third party service providers to create services based on the CO_2 emission balance of the PCT system users.

The Mediation Server measures the total CO_2 emissions of all system users in real time. The target for the total amount of CO_2 emissions is automatically set by the Carbon Cap function and it is based on the historical emission data and set reduction target defined by the system operator. Then this overall target of reducing CO_2 emissions is transferred to personal CO_2 emission reduction targets of all users. There are many variables that are considered when personal CO_2 emissions reduction targets are set, due to different mobility needs and habits. Naturally e.g. availability of public transportation, physical condition, location of home and location of work must be considered when personal CO_2 emissions target are set for a given user. Most importantly the reduction target must be challenging enough but not a burden, and a reward must be available when the reduction target is met.

Finally, an important function of the Mediation Server is to put a price on CO_2 emissions. The system currency is virtual euro, which has no value in real life. It is used within the system to reward users. and third party services can utilize virtual euros within their services. The CO_2 emission value in virtual euros can be adjusted fully by the system operator. The purpose of using complementary currency (CC) with no value in real life is that it gives more freedom for third party service innovators and simplifies the technical solutions in the platform. The use of CC, in this case virtual euro, can be fully designed to support the desired behavior patterns as tool for exchanging CO_2 emissions (Seyfang 2007). In later PCT system development phase, a scheme for converting virtual euro to the real Euro currency can be designed if it supports the ultimate goal of the system to reduce personal mobility CO_2 emissions.

The system users can access the services offered by the PCT market system via a GUI (Graphical User Interface) in a smart phone. It can be uploaded from the Google Store when the pilot version of the PCT market place is ready. Once the GUI application is installed to a phone, a user account must be created. This can be done utilizing Facebook or the Google account of a user. If needed, a user account to the system can be made also by creating a particular user name and password for the PCT system. Once the user has access to the PCT platform, all available third party services appear on the user menu in the mobile phone.

From a third party service innovation point of view, it is important that the platform architecture enables collection of data directly from IoT sensors and sensor networks from multiple device manufacturers. For a service developer it should be easy to implement a new service as a part of the PCT market place service offering since it is easy to receive mobility data from the platform regardless of the origins of the data. Finally, to support and promote easy-to-use services, third party services are made automatically available for system users (Niemirepo et al. 2015).

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Sini Karvonen, Katerina Medkova, Sami Luste

E-Training Material for the Capacity Development of Wastewater Operators

When promoting international information sharing and knowledge exchange, digitality and e-form of learning should be in the "toolbox" (Aceto et al., 2010). Utilization of e-learning requires understanding and commitment to develop skills for the use of e-learning resources. Moreover, it needs good co-design, co-production of materials and a maintenance plan to reach the synergies in teaching and learning. This article describes the development of an e-training material package for the use of wastewater operators in the Baltic Sea Region.

The near-term and long-term planning decisions of the wastewater industry face many challenges, such as increasing energy costs, stricter emission regulations, climate change, urbanization and planetary boundaries. Tightening demands on energy efficiency and sludge utilization, evolving technology, changing the working environment, digitalization, ageing infrastructure and the ongoing generation change, just to name a few, pose serious questions to wastewater treatment plants. (Reardon et al. 2013)

The lack of training, awareness and international interactive information sharing have been identified as some of the major limitations regarding the energy- and resource-efficient management of the wastewater treatment processes in the Baltic Sea Region (e.g. PRESTO project 2011-2014, PURE project 2007-2013). Thus, the capacity development priority in the ongoing "Interactive water management" (IWAMA) project (Interreg Baltic Sea Region; 2016–2019) was to find the most suitable ways and methods to tackle these problems.

From the perspective of the wastewater treatment sector, treatment technologies will evolve to meet significant trends, such as energy conservation and production, nutrient removal and recovery, sustainability, and treatment for non-traditional contaminants, for example trace organic compounds, drug residues, microplastics and hormone-stimulating substances (Silfverberg 2017; Reardon et al. 2013). Among the main priorities for developing water supply (including wastewater treatment) are strengthening of resources for water supply facilities as well as strengthening research, development and innovation activities and know-how. It is also important to take into account the potential of water supply to be a part of the bio- and circular economy as well as the internationalization of the water supply sector (Silfverberg 2017).

According to the IWAMA surveys, the ageing of the infrastructure, as well as selection and implementation of the new technical solutions, are among the most urgent needs for the know-how development. In addition, there is a need for basic training development in the wastewater treatment sector as well. This is due to the ageing of the staff and difficulties to find new employees. For instance in Finland, a half of the personnel in the sector will retire by 2022 (Salminen et al. 2015). Moreover, the new employees come from different backgrounds and the duration of employment is usually short-term. Due to the heterogenic nature of the wastewater sector education cannot be taught in one class; specific information arises from students' individual needs.

Education and Learning

Today, a continuous self-development and education in the labour market have become a part of everyday life. This trend has also been seen in the water supply sector, where lifelong learning and continuing education are increasingly emphasized (Heponiemi 2016; Salminen et al. 2015).

Electronic learning or e-learning exists in many forms and can be formal- or non-formal. Examples of e-learning are, for instance, tutorials, videos, online discussion groups, and virtual tests. A good example of how to use electronic material is the method called "flipped learning", a method used in the implementation of lifelong learning studies implementation. In "flipped learning", basic electronic materials (e.g. videos, games, simulations) are combined with virtual tests, in which advanced interactivity with other students and a teacher is utilized. The basic know-how could be transferred through videos or animations, for instance, in an online training material package, where the virtuality and enhanced e-learning enable place-independent and advanced guiding/ teaching. Similar flexible methods that are utilizing digitalization and existing good practices should be developed in both formal and informal study structures.

Lahti University of Applied Sciences is leading the capacity development work package in the "Interactive water management" (IWAMA) project. One of the work package outcomes (i.e. capacity development tools) is an electronic training material package. The partly EU funded (Interreg Baltic Sea Region, 2016-2019) IWAMA project is a flagship project of the EU Strategy for the Baltic Sea Region.

Material and Methods

The aim is to examine the development, usability and maintenance of the virtual training material package (TMP) in relation to current needs and opportunities. TMP is an international Moodle-based platform that includes the following features: multilingualism, audio-visual learning materials, and virtual learning tests.

Capacity development in IWAMA: The capacity development has taken place during the workshops (n=6), webinars (n=5), several online meetings and dissemination events of the IWAMA project. Moreover, information change, surveys and co-development of lifelong learning tools (i.e., WWTP game, e-training material package with virtual tests) have been conducted in a separate capacity development work package. The surveys, the result of which are presented below, were mainly collected from the personnel of the wastewater treatment plants (WWTPs), but also from the organizations responsible for the training and information production, such as the water and wastewater associations and universities (referred to later as "training institutions"). Surveys were collected

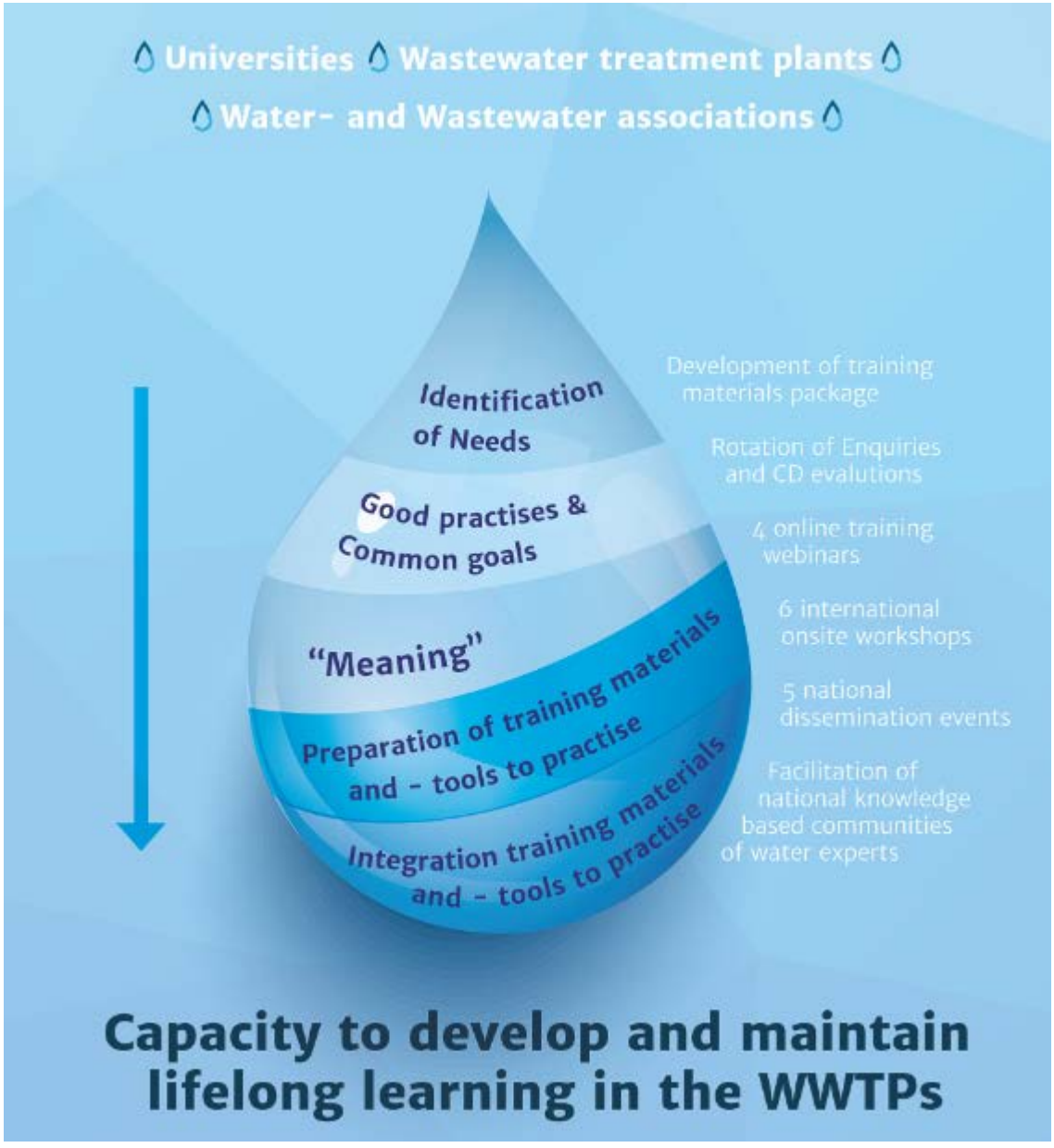

Figure 1. Capacity development steps during the IWAMA project. (Oona Rouhiainen 2018)

during the years 2017–2018. The core material of the electronic training material package consists of audio-visual presentations from the IWAMA workshops. The content of the workshops is based on the following capacity development steps as shown in Figure 1.

In the IWAMA surveys, made during 2017–2018 (answered by 78 WWTPs.), the "peer learning" and the e-learning material with the certification of competences are considered the most feasible learning tools in the future (Figure 2). This need rising from the "user interface" of the current development in education justified the birth of an electronic training material package.

Preparation of the Moodle-based training material package: TMP has been co-developed with the wastewater associations around the Baltic Sea Region in the capacity development workshops. The following main themes are included in the package:

- Wastewater Treatment Plants; Management; Maintenance; Case Studies
- Energy Production; Energy Efficiency
- Waste Water Sludge; Nutrient Recovery
- Capacity Development Tools; Educational Methods; Benchmarking

The English language folder is the main folder of the TMP. Some material has also been translated and located in the national folders: German, Estonian, Latvian, Lithuanian, Polish, Finnish, Swedish and Russian. Besides the study material, the TMP contains an automatic testing function with specific questions related to the topics studied (Figure 3).

The material in the TMP consists of audiovisual materials, reports, and other applications built for the capacity development purposes. The audiovisual material contains, for example, YouTube training videos with transcribed subtitles. These selected transcriptions are available in several languages.

Conclusions

The reliability of the currently most feasible training method, "peer learning", can be increased through the computer-aided training and evidence-based qualifications (i.e., quizzes or skills tests; Linturi and Kuusi 2018). The co-operation with the educational institutions and the WWTP sector is important for the maintenance and update of the e-learning materials as well as for identification of lacking competences. WWTPs play an important role in setting the competency standards in education. Learning from the "industry sector" is needed to better understand the skills, challenges and demands of the industry.

The training material package can be utilized as a part of the "flipped learning" method or for updating or enhancing the current knowledge. Similar flexible methods that are utilizing digitalization and existing good practices should be developed in the the formal and informal study structures, with the enhanced opportunities provided by social computing.

The training material package should be continuously developed and the national folders updated, to better reflect the national competence needs.

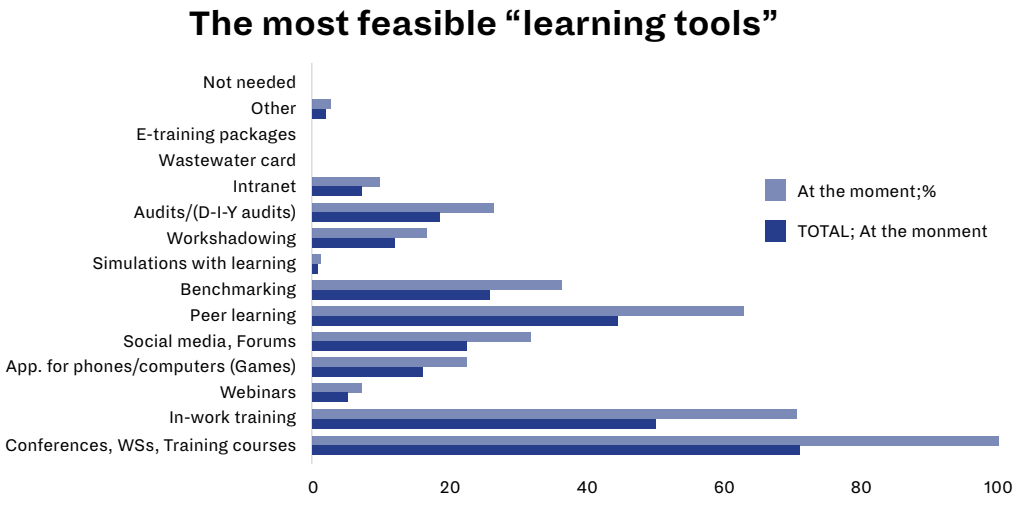

Figure 2. The most feasible learning “tools” for capacity development (n = 78).

1. Wastewater Treatment Plants; Management; Maintenance; Case-Studies	2. Energy Production; Energy Efficiency	3. Waste Water Sludge; Nutrient Recovery	4. Capacity Development Tools; Educational Methods
1.1 Treatment processes; Advanced technologies	2.1 Energy production in Wastewater Treatment Plants	3.1 Sludge Management	4.1 Life Long learning in the Wastewater Treatment Plants of the Baltic Sea
1.2 Maintenance of operations; Operational and structural changes	2.2 Energy efficiency of the Wastewater Treatment Plants	3.2 Nutrient Reduction; Nutrient Recovery	4.2 Wastewater Management Game; Visual materials
1.3 Case-Studies; Investments	2.3 Benchmarking data	3.3 Benchmarking data	4.3 Self-auditing of the Wastewater Treatment Plants
1.4 Material of students	2.4 Virtual learning tests	3.4 Virtual learning tests	4.4 Education and training material
1.5 Virtual learning tests			

Figure 3. The main themes and the structure of the training material package.

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Reijo Heikkinen

Kiemura: Solutions for Recycled Plastics – a Machine that Separates the Wheat from the Chaff

Introduction to a plastic problem

When a plastic product is used, it will end up as waste. How to deal with this waste depends largely on the practices and legislation of the countries where the waste is generated. In the European Union, plastics are not a big problem because we have advanced systems for waste recycling. Waste generated outside the EU is a much bigger problem. Primarily, the law requires minimizing of waste generation, but implementation of the law may not always be possible. (Leblanc 2018)

Plastic waste is typically packaging waste. This type of waste is usually polyolefin plastics such as polyethylene and polypropylene. The packaging may also contain a small amount of polyamides and other polymers used as gas barrier or bonding material between layers. These are needed to improve the properties of the plastic packaging. Agriculture and construction also produce plastic waste. These plastics are also generally polyolefins. The fourth major source of plastic waste is the electronics industry. These plastics are typically polystyrene plastics.

If these plastics are recovered clean, they are valuable material for reuse. The cleanliness of plastics is important because then there are no problems with remanufacturing and new products are clean. If it is not possible to get sufficiently clean plastic, it is only suitable for burning.

Introduction to the washing and pelletizing machine

A research project has started in Lahti University of Applied Sciences on September 1, 2018, which will develop a solution for processing and recycling various recycled plastic materials for reuse. As a result, a pilot size unit will be constructed to crush, wash, dry and pelletize the separated fractions of raw material for ready-to-use recycled raw material. It is especially useful in developing countries with no infrastructure for transporting and handling various types of plastic waste.

One goal is to build a machine that can fit into a shipping container. This allows it to be easy to move and compact in size, enabling transportation to different locations at sites where waste is generated. There are several similar devices in the world, but they are normally large-scale factories. The washing and separating principles are the same, but the idea with this device is that it is very easy to move.

Construction of the machine

The container can be an open-side type, which is structurally open on the sides. For this reason, the container will be easy to equip because the hardware can be installed from the sides. Constructing the machine from just one opening would be much more difficult. At the bottom of the container's one end, there is the opening for

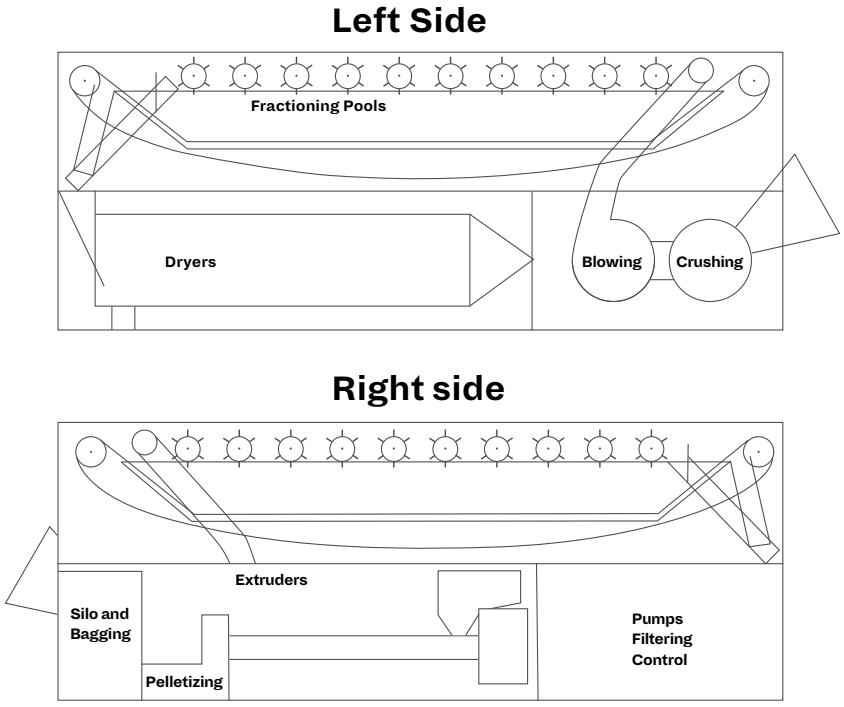

Figure 1. The layout of the machine.

a mill that crushes the plastic waste that is being sorted and processed. The mill reduces the size of the plastic particles to 5–10 mm. After that, the ground plastic is blown to a water tank at the top of the unit. There is approximately 100–300 mm of water in the pool. There are special rotating rolls on the surface of the pool to move and mix the plastic crush under water. As the plastic moves forward by the rollers, the air bubbles are removed from the plastic and the heavier plastic particles sink to the bottom of the pool, where there is a conveyor system that carries heavier particles towards the other end of the pool.

Near the pool´s end, it deepens gradually to a depth of 300 mm and a special weir system prevents the floating particles from moving forward. At this point, the floating particles are drained into the dryer below the pool. The paddle conveyor running on the bottom of the pool draws heavier particles up to the end of the pool, from where the particles are drained into another dryer.

The dryers work by blowing hot air in counter-current direction to the plastic. The air can be heated with the waste heat of the extruder and the pelletizer. Polyolefins do not absorb much water, so the removal of moisture

in the surface is enough to dry the plastic. The extruder can also be provided with a degassing zone if moisture is a major problem.

After drying, the plastic crush is fed to the extruder. The extruder can be a twin screw or single screw model. A single screw extruder is much cheaper and simpler in structure. The single screw extruder works very well for melting and extruding polyolefins into pellets. In the supply of the extruder, either volumetric or gravimetric feed can be used to supply additives. The screw can also be provided with a mixing element to ensure better mixing. (Giles 2005)

By using a twin screw extruder, a greater variety of plastic materials can be produced. The twin screw extruder is not so sensitive to the viscosity variation due to the uneven rheological properties of the plastic to be fed. The addition of various additives to the plastic is more secure with a twin screw extruder. Such an extruder is, however, more expensive and heavier. Immediately after the extruder, there is a pelletizer. This device makes pellets of about 3 to 4 mm in size, which are the actual product of the machine. If required, the pelletizer can be equipped with a silo that can accommodate a short-term yield of material.

The machine can also be equipped with another pool, filled for example with salt water. In this case, the heavier fraction from the first pool is sent to the salt water pool, where further fractioning can be made. In this case, the machine can, if necessary, separate polyolefins and styrene plastics from heavier fractions. If there is only one pool, it can for example isolate polyolefins from other plastics, or simply wash them, whereby the soil and other heavier debris sink to the bottom of the pool. PET bottles and caps can also be easily separated by using plain water.

Two dryers are needed when separating two beneficial fractions. For two fractions, there should also be two extruders. This increases the cost of the device and the energy consumption considerably.

Challenges of the machine

There will be some challenges in designing, manufacturing and using the machine. One major challenge is to have the washing and separating line sufficiently long to achieve the required degree of cleansing and separation. When using a TEU container (Twenty-foot Equivalent Unit), i.e. a 20 ' long shipping container, the maximum length of the washing line is 5.5 m. When using an FEU container (Forty-foot Equivalent Unit), the length of the line will be about 11 m. This longer option is likely to be sufficient, but it has an effect on the transportation costs. (MoverDB 2018).

Another major challenge will be the supply of the energy needed by the extruder. If you want to limit the connection of the device to 3X64 A, you will not get a very efficient extruder. In this case, the amount of plastic produced by the extruder would be only about 200 kg/h, so the extruder would be a bottleneck.

The third possible problem is the drying of the plastic after the separation. Drying should also take place on the shorter possible 5.5 m long route. The drying time depends on the thickness of the material flow and the speed of the line. The drying capacity should be the same as that of the extruder. Depending on the extruder, most twin screw extruders must be fed with the starve-feeding method (Giles 2005). Starve-feed is more suitable if intermediate storage is not possible.

If the device separates two useful fractions, there may be a difference between the lines in

the production speed. For example, if the input feed contains the same amount of the two wanted fractions, both dryers and extruders have to be of the same power and about half the capacity of the wash separator line, i.e. 100 kg/h. If the device separates for example electronic waste containing 70 % of styrene plastic, 20 % of waste material and 10 % of polyolefins, there will be a significant imbalance in drying and extrusion. In this case, the drying and extrusion of styrene plastics will be at the rate of 140 kg/h, whereas with polyolefin the rate is only 20 kg/h.

The fourth challenge is the water handled by the machine. If there is only one pool filled with water, the problem is not large if there is reasonably clean water available. The machine can be equipped with a water purification system that filters out contaminants from the washing water. The water that dries out and evaporates directly from the pool must also be replaced. In hot and dry climates, water evaporation can be several tens of liters per hour. When two pools with different liquids are used, the liquid in the former pool also contaminates the liquid in the latter pool. If the salt water pool comes after the clean water pool, the problem is small because dilution of salt water is easily compensated by the addition of salt. The pools should not be used in reverse order. Sea water is a good option for making denser salt water. Since the density of sea water is not enough, it cannot be used as such (The Physics Factbook 2018).

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Ella Uotila, Maarit Virtanen, Eeva Aarrevaara

The Hard Way to Sustainability in Rustenburg, South Africa

Rustenburg Local Municipality, Lahti UAS and the City of Lahti are working together to co-create initiatives for more climate resilient and socially inclusive townships in five pilot areas in South Africa. The pilot townships are Boitekong, Meriting, Monnakato, Karlienpark and Phatsima. The co-creation process includes a baseline study on the five townships, three co-creation workshops on site, an intensive training in Lahti and drafting of piloting plans. This article describes some of the challenges related to town planning and sustainability in South Africa and Rustenburg.

Challenges of land policy in South Africa

During the apartheid era in South Africa, different groups of non-white people were evicted from "white only" designated properties into their own sections of land called townships. Townships are still often underdeveloped areas, struggling with a lack of basic infrastructure such as sanitation and electricity. Most people living in and moving into townships do not own the land, so the housing is informal and unregulated. Rapid population growth and immigration from neighbouring countries contribute to the problems of illegal housing, overpopulation and poor living conditions. (Cousins 2018)

South Africa's land policy is based on three main points, which are restitution, redistribution and tenure reform. Restitution involves people claiming back the land taken away from them after 1913, or compensation for their loss. Land redistribution involves acquiring and transferring land from white farmers to black farmers. The tenure reform aims to secure the land rights of those whose rights are unclear as a result of past discrimination (Cousins 2018). The land reform has been slow and it continues to cause a lot of political tension and protests. Securing the rights of people living in informal settlements should be taken into account as well.

The constitution of South Africa states that everyone has the right to have access to adequate housing (Republic of South Africa 1996). The Prevention of Illegal Eviction Act (Republic of South Africa 1998) protects the rights of tenants and people occupying vacant land, reflecting past experiences with random evictions. A landowner needs a court order to evict a non-paying tenant or a person squatting on their land.

Town planning is challenging with the uncontrolled growth of townships. The situation is further complicated by illegal immigrants living in the townships, because they do not have the same legal rights as citizens. Officially, there is no apartheid anymore, but the population of informal settlements and poor townships is mainly black and the upmarket suburbs white.

Government housing programmes support the poorest

In all of the studied townships, except for Karlienpark, the Government provides subsidy

Figure 1. Housing in Rustenburg. (Photo by Maarit Virtanen)

housing known as RDP houses (Reconstruction and Development Programme). The government builds RDP houses and donates them to low income families. The applicant needs to fulfil several criteria to qualify for an RDP house: South African citizen, over 21 and competent to sign a contract, married or living with a partner, or single and having dependants, earn less than R3,500 (about 207 euros) per month per household, be a first time government subsidy recipient and a first time home owner. The owner can sell the RDP house after living there for eight years but cannot rent the house. (Chaskalson 2017)

The process for receiving an RDP house can take many years from leaving the application until the houses are built. The waiting can make people impatient and cause violent solutions. Also in Rustenburg, there were protests demanding low cost housing in May and June 2018. Sometimes it also happens that people who are not the future RDP house owners invade the houses under construction, leaving the real applicants without a home.

The government also has a Community Residential Units and Housing Programme (CRU). The CRU housing units are for rent and the residents do not own them. To qualify for CRU housing, you must be a South African citizen, married or living with a partner or be a single person with dependents, over the age of eighteen and have a monthly household income between R800 to R3,500. There are also some government projects for those who earn more than R3,500 but less than R15,000 per month. R15,000 is the minimum monthly income to qualify for a housing loan from a bank. (Chaskalson 2017)

Figure 2. Government housing. (photo by Maarit Virtanen)

Figure 3. Street view from Monnakato. (photo by Maarit Virtanen)

Town planning challenges in Rustenburg Local Municipality

Local town planners consider sustainability a very challenging issue in Rustenburg. People in townships live in poverty and their education level is low. Town planning concentrates on the official processes of acceptance of building permits according to the land use plan. Town planning is also very political and has little flexibility. In Rustenburg, townships are usually located close to the mines, relatively far away from the town centre. The mining industry dominates the economy and land ownership in the area. The municipality owns little land, which makes the planning complicated. If municipal land is taken over by squatters, politicians often prevent their eviction since there is no alternative land to offer. However, stopping the eviction stops other development plans for the property as well.

According to Rustenburg officials, town planning with green spaces, walking lanes and recycling facilities is not possible in the townships as a part of land use planning. The municipality faces difficulties in providing services for townships and illegal settlements, because the poorest cannot afford to pay for them. For example, the low education level and language barriers of immigrants complicate environmental education on waste management. Wealthier residents of the complexes have started their own recycling projects and hired private waste management companies. There are also plans to promote urban agriculture. However, financial help is needed from the municipality to implement sustainable initiatives and to educate people on the benefits of recycling, food production and a clean environment.

Characteristics of pilot townships

The five pilot townships are situated 5 to 40 kilometres from central Rustenburg and the population varies between 7,000 and 80,000. The residents are relatively poor and not very educated. The township population is predominately young, with most of the residents aged between 20 to 30 years. Youth unemployment rate in South Africa is very high, currently about 38 percent in age group 15–34 (Statistics South Africa 2018).

According to the Statistics South Africa 2108, most of the people in the baseline study townships have access to electricity and a flush toilet connected to the sewerage system. However, the statistics do not always reflect the real situation with constant population influx. The government houses have been criticised for their small size, which compels families to build shacks for more space. Some families also lease the poorly constructed shacks. During visits in townships, it seemed that most of the households do not have a toilet, and even some of the RDP houses did not have an indoor toilet. The municipality provides water and electricity to the government housing, but there are a lot of illegal electricity lines connected to the grid. Waste management is working poorly, and dumping of waste is common.

In terms of the quality of housing and living, the differences both within the townships and between the townships are considerable. The most striking example of inequality is in Karlienpark, where tin shacks have been constructed next to the high walls of upmarket houses. The informal settlement has caused the neighbourhood to lose its value and has created tension and even violence between the different social groups. The informal settlement

of Karlienpark has no services like electricity or water but the squatters cannot be evicted. High unemployment rates increase crime and general insecurity.

There are some projects aiming at sustainable development in townships, like a non-profit project in Phatsima taking care of disabled youth, and some urban agriculture experiments. However, some of the planned projects have been cancelled because of spreading informal settlement. These include an urban agriculture project in Karlienpark and launching of a driving school in Zinniaville. The social inequality makes project planning and implementation difficult. Many township residents do not trust the administration and municipal officials are reluctant to visit the most insecure townships. An example of the absence of administration is the empty police station in Monnakato. The nearest police station is tens of kilometres away.

Discussion

Sustainable town planning seems to be a privilege of suburbs and wealthy areas in South Africa. In townships, town planning mostly concentrates on trying to control the spreading of informal settlement. In these conditions, even the provision of basic services of housing, sanitation, water, electricity and waste management is very challenging. Solving these problems would already be a step towards more sustainable townships and might enable a more future-oriented planning and dialogue with townships residents. Another question is what kind of level of sustainability should be the development goal. Would it be better to state that the primary need is to take small steps towards more sustainable townships?

Even though the challenges of town planning are huge, there are also good examples of community engagement in townships in South Africa. The North-West University has implemented a number of participatory projects with a focus on, for example, construction of a public park and children's playing area, restoring the sense of place and raising awareness of recycling and environmental protection. These kinds of projects would also be needed in Rustenburg to create trust between the authorities and the township's residents and to enable sustainable development.

It can be also concluded that in the development of the sustainability of the townships, new kinds of activities and actors are needed. Town planning plays an official role in the public sector, and community development requires stakeholders who are willing to start co-operation with local residents on the grass root level. As our colleagues from the North-West University stated, the first challenge is to create a mutual trust and positive attitude to the development of townships. Listening to local people´s voices and their opinions can create a basis for community engagement and enable small actions for the common environment. (Puren 2018)

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The theme of this publication is circular economy solutions, which is one of the four focus areas at Lahti University of Applied Sciences. This publication contains nine articles written by experts and students from Lahti University of Applied Sciences, Turku University of Applied Sciences and the City of Lahti. The aim of this review is to present the latest interesting research and development projects in the field of circular economy.

The Lahti Circular Economy Annual Review series supports communication with Lahti UAS's partner universities, companies and other stakeholders, and it is a part of circular economy related actions in the R&D, educational and company partnership operations of Lahti UAS. This Lahti Circular Economy Annual Review is published as a part of the Kiertoliike - Päijät-Häme Region Circular Economy Model and New Business Opportunities project (2016-2018), which is funded by the European Regional Development Fund.

The Publication Series of Lahti University of Applied Sciences, part 40
ISSN 2342-7507 (PDF)
ISSN 2342-7493 (print)
ISBN 978-951-827-289-5 (PDF)
ISBN 978-951-827-290-1 (print)

LAMK
Lahden ammattikorkeakoulu
Lahti University of Applied Sciences

Leverage from the EU 2014–2020

EUROPEAN UNION
European Regional Development Fund

THE REGIONAL COUNCIL OF PÄIJÄT-HÄME