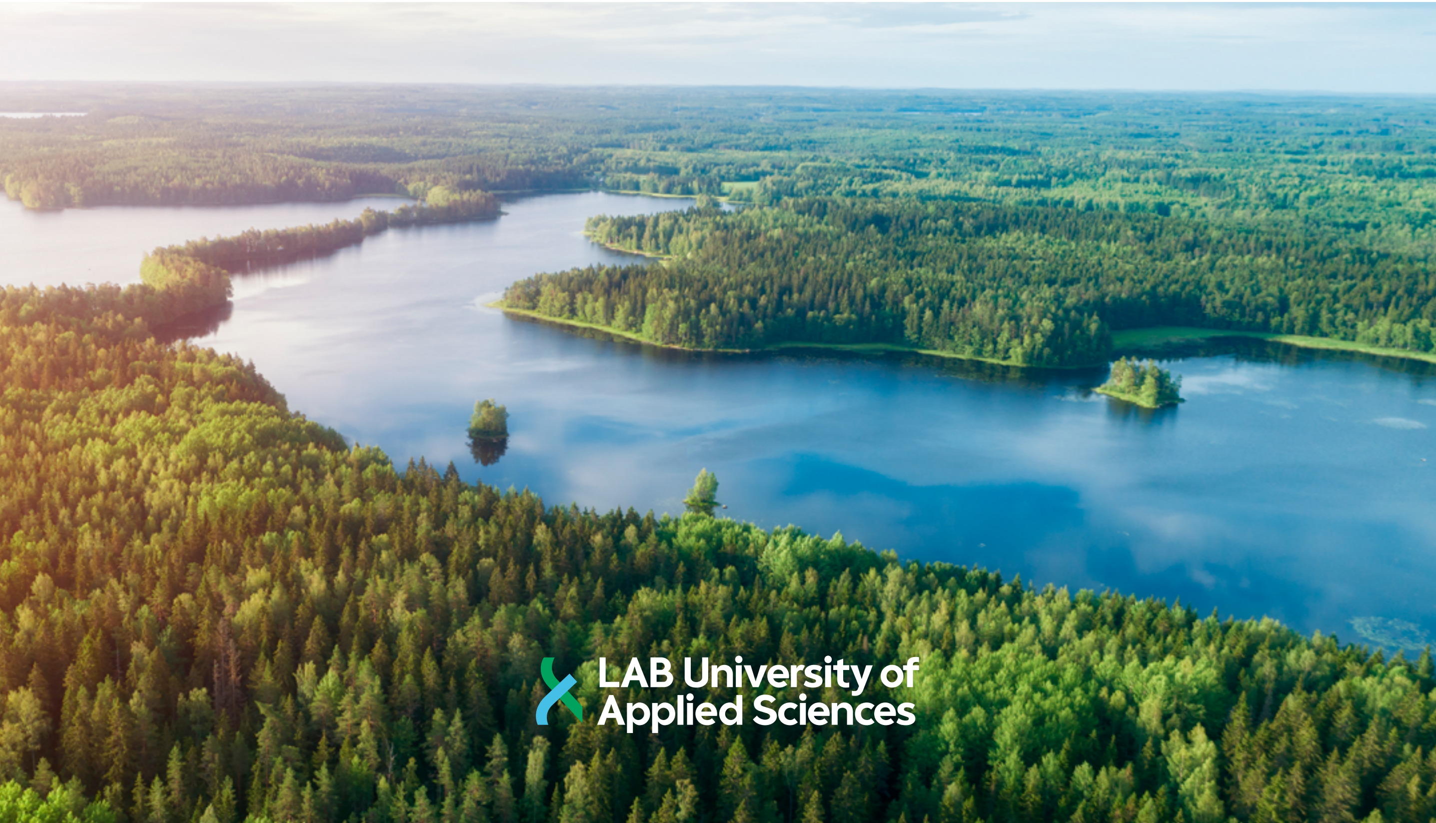
Ria Gynther (Ed.)

LAB Circular Economy Annual Review 2022

The Publication Series of LAB University of Applied Sciences, part 56



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LAB University of Applied Sciences

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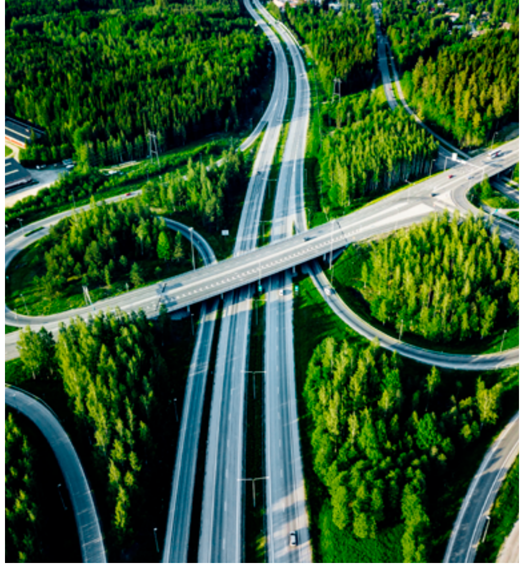

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Susanna Vanhamäki, Ph.D. (Sustainability Science), works as a chief specialist and a project manager at LAB University of Applied Sciences, Faculty of Technology. Her interests include sustainability, circular economy solutions and regional development. She has 15 years' experience in regional and international RDI projects.

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Susanna Vanhamäki

Foreword:

Developing a Circular Economy through University-Industry-Community Collaboration

This review presents the latest research, development and innovation activities in the context of the circular economy and sustainability at LAB University of Applied Sciences (LAB). The articles are written by experts in our staff and in collaboration with stakeholders. The aim of LAB is to promote the transition towards a sustainable circular economy together with our stakeholders. We actively participate in the development of new technologies and digital solutions to support resource efficiency and enable sustainable material cycles, as well as to develop sustainability in the society (LAB 2022).

The European Green Deal is Europe's agenda for sustainable growth. In 2020 the European Commission adopted a new circular economy action plan as one of the main building blocks to support the Green Deal (European Commission 2020). Since then, the Commission has implemented a number of actions to achieve these objectives, and several initiatives are under way, such as those related to the European Union strategy for sustainable textiles and strengthening the role of consumers in the green transition (European Commission 2022). In this review, you will find LAB's solutions and actions to support the green transition.

At LAB, the research, development and innovation activities in circular economy since the beginning of 2022 are organised through four growth platforms:

- Biobased cycles
- Technical cycles
- Carbon-neutral built environment
- Sustainable societies

The review will present an overview of each growth platform as well as case presentations of activities or projects under each topic.

The first article in this review presents the context of the ‘Biobased cycles’ platform and is written by Dr. Annakaisa Elo and Dr. Sami Luste. It highlights the central role of a sustainable bioeconomy as a base for the circular economy. The case studies concretizing the activities of this platform begin with the article by Mr. Petja Rinne describing the circular economy laboratory at LAB’s Lahti campus. The new laboratory provides excellent opportunities for developing and deepening cooperation with regional industries. The laboratory supports the research and development activities of both biobased and technical cycles platforms. The article written by Mr. Kimmo Heponiemi further explains regional collaboration in the field of the grain industry related to laboratory development.

The comprehensive regional cooperation in Päijät-Häme in the field of biobased cycles is explained in the article by Dr. Merja Kontro, Ms. Lei Liu, Dr. Sami Luste, Dr. Ossi Martikka, Ms. Mari Sarvaala and Mr. Vesa Taitto. They present a pilot on the separate collection of biowaste, microbial polyhydroxyalkanoate production from sludge, and the efforts to create a regional ecosystem for carbon dioxide producers and consumers. Moreover, the article written by Ms. Eliisa Punttila tackles the possibilities of establishing a supply network for straw as the base for a biorefinery.

The ‘Technical cycles’ platform is presented in the article written by Dr. Anna Keskisaari. The platform focuses on developing the circularity of three materials: plastics, textiles and construction and demolition waste. The case article, written by Ms. Mia Johansson and Dr. Ossi Martikka, presents an example of how plastic waste is recycled into new products. Following that, Mr. Qaisar Munir and Mr. Ville Puhakka explain the activities and results of a regional project related to a pre-treatment approach to construction and demolition waste.

The third growth platform gathers LAB's activities in the field of the 'Carbon-neutral built environment'. In their article, Mr. Juha Poskela and Ms. Kirsi Taivalantti define the context of this platform and LAB's history in the field, especially in the region of South Karelia. The case articles explain our recent activities in research and development projects. Mr. Mauri Huttunen gives an interesting overview on the possibilities of building information modelling. Furthermore, digital solutions, for example, digital twins, are a central way of developing the built environment, as Mr. Kusti Alasalmi explains in his article.

Finally, 'Sustainable societies' wraps up the context of the circular economy focus area. Together with Ms. Riika Kivelä, we explain the role of the circular economy supporting the sustainability transition. The platform combines circular economy thinking with a social science perspective in a multidisciplinary manner to support forming sustainable societies. The case article, written by Ms. Katerina Medkova and Ms. Marjut Villanen, explains how citizen involvement in the circular economy has been boosted in Päijät-Häme through an interregional project. Furthermore, Dr. Aarrevaara and Ms. Maksheeva present how an international master's degree program supports students in developing expertise on climate change and expanding their view of sustainability.

I would like to warmly thank all authors for their valuable contributions to this publication. I would also like to express my gratitude to the editor of the review, Ms. Ria Gynther, and to Ms. Oona Rouhiainen for the layout. I hope that this review gives you inspiring ideas and perhaps opens up possibilities for future cooperation within the fields of circular economy and sustainability.

Lahti, 27 October 2022
Dr. Susanna Vanhamäki
Chief Specialist,
Circular economy

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01
Biobased Cycles

Annakaisa Elo & Sami Luste

Biobased Cycles Growth Platform

The bioeconomy uses renewable resources to produce food, energy, nutrients, products, and services, connecting various fields crossing traditional boundaries. The material flows generated in product manufacturing processes are utilised in other products, which minimises the loss of raw materials and energy. The bioeconomy can help mitigate climate change by reducing dependence on fossil fuels and at the same time enabling green growth and the development of new businesses and jobs. In 2019 the European Commission announced the European Green Deal to address climate change and various environmental challenges aimed at making Europe the first climate-neutral continent by 2050 (European Commission 2019, 4). The Green Deal is Europe's new growth strategy that aims to transform the EU into a modern, resource-efficient, and competitive economy. It is estimated that the bioeconomy can create 400,000 new green jobs by 2035 in rural and coastal areas if supported and deployed by regional and national strategies (Bio-based Industries Consortium 2017, 13).

At the national level, concerns about climate change, biodiversity loss, the COVID-19 pandemic, and circularity requirements for materials and energy call for new and more sustainable solutions for the biobased sector (Arasto et al. 2021, 2). The objective of the Finnish Bioeconomy Strategy is to generate new economic growth and new jobs from an increase in the bioeconomy business and from high added-value products and services while securing the operating conditions for nature's ecosystems

(Biotalous.fi. 2014, 3). The strategy is being updated during 2021–2022. One of the four strategic goals of the strategy states:

"The bioeconomy competence base will be upgraded by developing education, training and research"

thus also emphasizing the important role of applied universities (Biotalous.fi. 2014, 19).

Based on the views by Business Finland, raw materials from Finnish agricultural and forestry have the potential to provide the global bioeconomy product market with products of significantly higher value and superior quality that serve emerging needs. In the '***Sustainable growth from the bio-economy***' -program, Business Finland emphasises the roles of the different regions in the bioeconomy. Finland's 2025 vision is that sustainable solutions will form the basis of the country's future welfare state and competitiveness, and at the moment, bioeconomy services is one of the fastest-growing sectors (Arasto et al. 2021, 30).

The Biobased cycles growth platform at LAB University of Applied Sciences focuses on building on the opportunities of the circular bioeconomy. Regionally, the platform answers the goals set, e.g., by ***Päijät-Häme Region Circular Economy Road Map***, ***Smart Specialization Strategy in Päijät-Häme***, and circular economy strategies and programs, such as ***Greenreality***, in the South Karelia region.

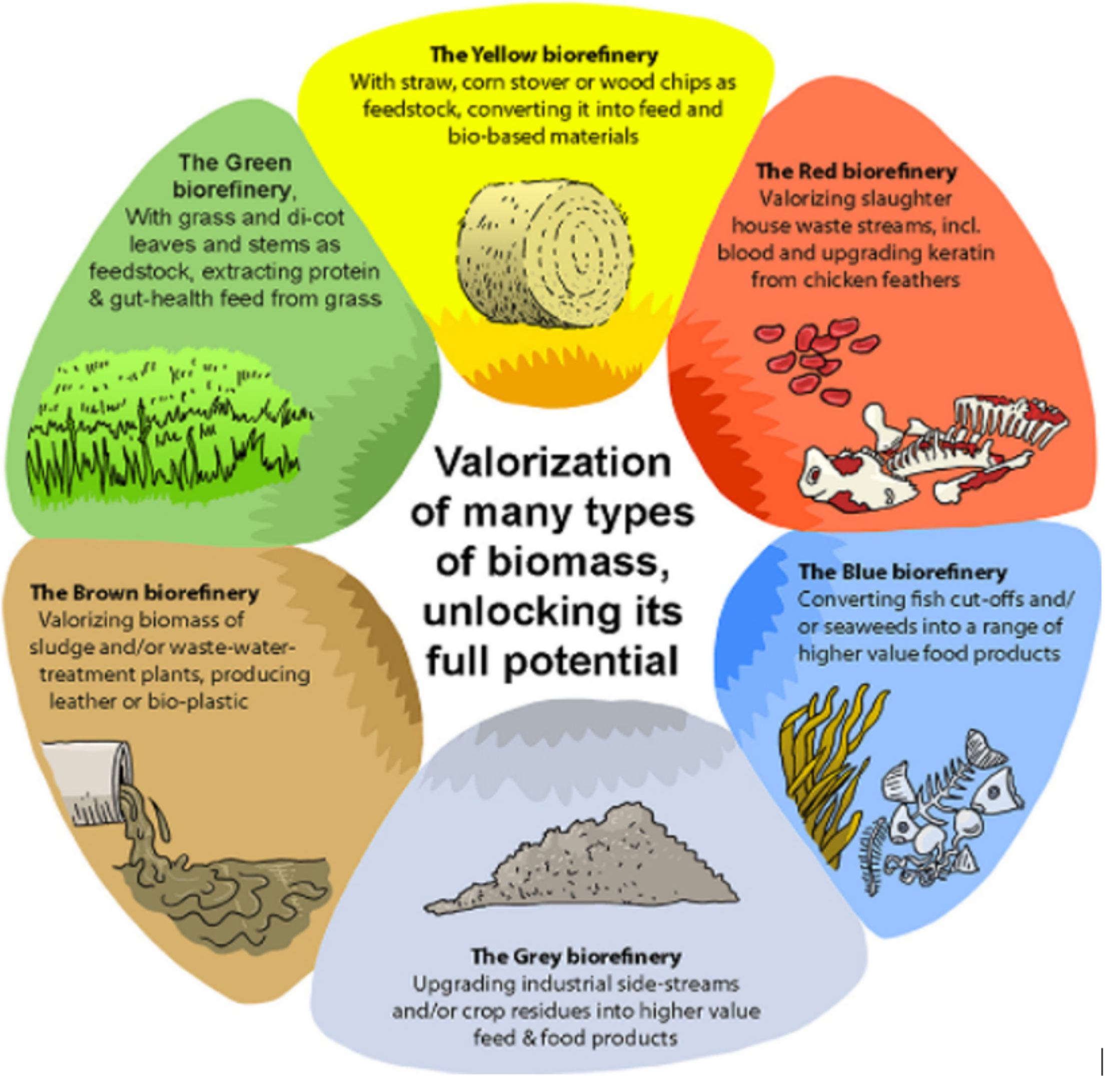


Image 1. High-value conversion examples from the six basic types of biomass (Lange 2022)

Thematic and development areas of LAB's Biobased cycles platform

Agroforestry-based biomass is in a key role in the transfer out of the fossil-based economy. Biomass is an abundant yet limited resource for which unequal distribution and variation in amounts, sources, quality, and availability are typical. Investing in new, resource-efficient processes in the whole biomass value chain holds significant potential in increasing both the overall production and the value of the existing resource use. The biobased cycles are based either on biomass originating directly from primary production, such as forest or field residues, biomass-based industry (typically forest, food or energy sectors), or biobased side and waste streams coming, e.g., from industry or municipalities. The aim is to transfer the industry from volume-based, low-value products towards value-added and innovative biobased industry and biorefineries. The sustainable use of raw materials will require the cascade principle in the use of biomass and should avoid mechanisms that favour the use of biomass in energy (Bio-based Industries Consortium 2017). This aim needs efficient and focused investments both in research and in education and know-how.

As thematic subject, the Biobased cycles platform is multidisciplinary and has several intersections with the Technical cycles platform and key competences, especially Innovations. The Biobased cycles platform focuses on four development areas which are described below.

Primary production, solutions and supply chains

The bioeconomy is based on value chains originating from primary production, mainly from the agroforestry sector. The value chains are mainly based on field- and forest biomass and animal husbandry (manure), but also horticulture, aquaculture, and fishery. The agroforestry sector produces large volumes of under- or unutilised biomass as a side stream, which is typically left on fields or forests, causing CO^2 emissions. Forest biomass often ends up either in high-volume and low-value products or in the energy sector, which doesn't support strategies aimed towards a low-carbon economy. The sustainable use of biomass involves innovative technological and logistic solutions to efficiently set up new value chains based on bio-waste by making the best possible use of cascading and circular approaches. The main problems to be tackled rose from the northern climate, long distances, small volumes (both farms and materials) and varying quality of the raw material. Thus, national, and regional solutions are emphatically needed. LAB University of Applied Sciences' strength lies in the interface between primary production and the processing industry – identifying opportunities and solutions. A good example of this kind of project is '***Green Growth Bio-village***' (presented in detail in another article in this publication), where a supply chain for the 100,000 tons of straw was built together with farmers and the refining industry.

Systematic utilisation of material properties

Materials in this area include, for example, bio-waste and by-products from various processes (i.e., sewage sludge, animal slurries, by-products from therefining industry, etc.). For example, the ongoing project ***BIOSYKLI*** (presented in detail in another article in this publication) tackles the challenge of utilising sewage sludge and closing CO^2 cycles. The development of the LAB Sustainable Materials Laboratory facilities is strongly connected to this area. The deep knowledge of both material properties and using them in a process as catalyst, raw material or manipulation enhances the circular economy and the symbiosis between the various businesses and actors. This underlines the systemic perspective regarding the local supply and specific quality demands coming from various industry sectors. Typically, on bioprocesses the raw materials do not have to be completely purified, but they have to meet the specific requirements of each recovery purpose. These kinds of tailor-made solutions and symbiosis between the industry sectors enhance the techno-economic viability of biobased solutions.

Systematic development of bio-processes and technologies

The focus of this development area is to support local businesses to build product demonstrations or a piloting environment and create references that accelerate the implementation of regional bio- and circular economies and enabling expansion and export opportunities. The development of sustainable materials laboratories as well as RDI development in the regional clusters is related to this theme. Delivering the bio-circular economy at a practical level and creating value chain benefits require systemic understanding, identification of synergy interfaces and matching of process boundaries with material properties. LAB's strengths are especially in the interface of bioenergy production and higher-level material utilisation: biochar (pyrolysis products) and refining products and end products of biogas process (CH^4, CO^2, digestate), but also process intermediates. The interfaces with the Technical cycles platform will be evaluated to determine the best solution (BAT) as well as symbiotic elements to generate economical profitability via new business opportunities. This developmental theme is strongly connected to the technical material applications in the fields of bioplastics, composites and textile fibres.

Smart biobased material cycles

The rapid development of automation and data management in manufacturing technologies could significantly benefit the biobased sector, e.g., by making the production and management of bio-resources more efficient (Bio-based Industries Consortium 2017, 19). ICT technologies could also improve information exchange along the material value chain, leading to more efficient logistics and more efficient biomass mobilisation, as well as improving the predictability of the actions and verifiability of the impacts. Advanced monitoring and control paradigms at the plant level will increase productivity and resource and energy efficiency. LAB's strengths are related, for example, to (environmental) data mining, upgrading and machine-learning processes.

The mainstays of the Biobased cycles platform

The RDI, educational and service-related needs arising from the biobased themes mentioned above are resolved with the four 'tools' of the platform:

1. systematic development of regional ecosystems and symbioses;
2. research team;
3. integration of RDI and education;
4. development and efficient utilisation (LAB Sustainable Materials Laboratory – SUMA).

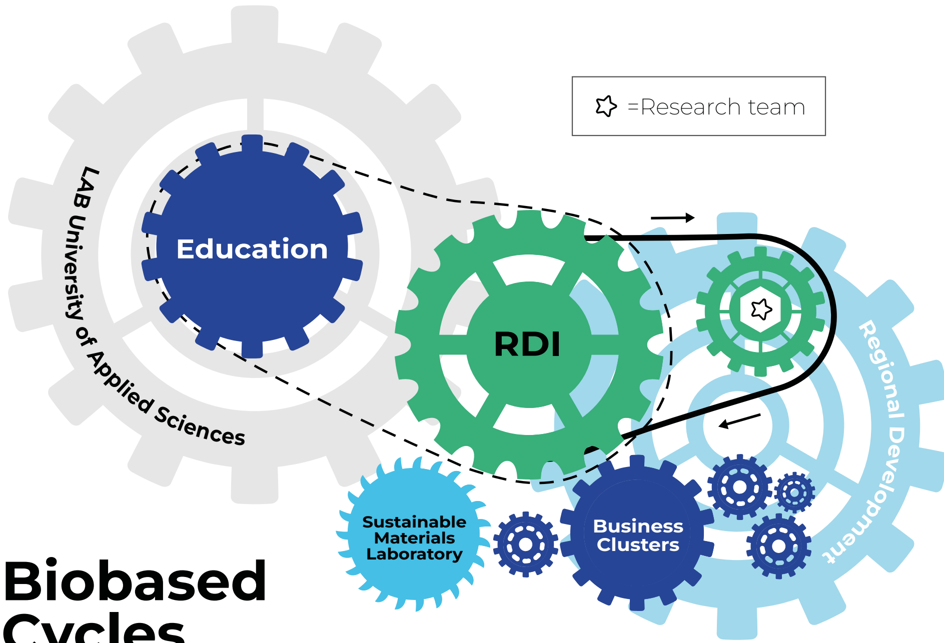
Systematic development of regional ecosystems and symbioses are, for example, the ongoing Grain Cluster pilot plant cooperation and the Heinola city Biohub cooperation. The building of the local example of a biochar cluster under the regional Ecosystem Agreements has also begun. In addition, there are several cooperation entities that will be shaped as a project and sent to the funders during the period of 2022–2023.

The nutrient cycle and carbon sequestration technologies research team is aiming to take the regional level to international visibility. The research team is implementing leading research

regarding biobased materials, focusing on peer-reviewed publications and empirical research, for example, in the fields of biochar and biogas applications.

Integration of RDI and Education: The shortage of employees is one of the main bottlenecks limiting the growth of companies in the Päijät-Häme region (Nieminen et al. 2021, 147). The importance of education and training is highlighted in the Finnish Bioeconomy Strategy to achieve set goals for the bioeconomy and the predicted number of jobs it could create. When there aren't suitable competences available, the lack of specific know-how could be tailored and implemented e.g., by continuous and supplementary education and training, organised in the collaboration by RDI and education and their networks. This would involve the synergic development and cross-talk between RDI and related education within the platform.

Development and efficient utilisation of LAB Sustainable Materials – SUMA laboratory is at the crossroads of empirical research activities and services for companies and businesses as well as teaching and education. The development of laboratory facilities and services is also crucial to identifying the techno-economic synergies between the separate LAB laboratories, as well as



Biobased Cycles

- » Primary production: solutions and supply chains
- » Systematic utilization of material properties
- » Systematic development of bioprocesses and technologies
- » Smart biobased material cycles

Actors:
Chief specialist, researchers, developers and teachers

Research team:
Nutrient Cycle and Carbon Sequestration Technologies

Image 2. Biobased material cycles growth platform illustrated (Image: Oona Rouhiainen)

with LUT laboratories, to fulfil the needs of businesses and avoid the wasteful situation of overlapping facilities. The current development of the laboratory services is related to biochar, pyrolysis, biogas, quality of biomaterials and nutrients. The second phase of laboratory development includes the piloting and analysis of food and brewery products and raw materials by the Grain Cluster pilot plant cooperation.

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SuMa Laboratory

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15210 Lahti
Finland

Petja Rinne

Sustainable Materials Laboratory

The Sustainable Materials Laboratory (SuMa), a new research and development facility, began operating in December 2021 at LAB University of Applied Sciences. The laboratory is in the city of Lahti at the Mukkulankatu 19 campus and consists of about 300 m^2 of new floor space for research. The construction of the SuMa laboratory originates from the '***Energy and circular economy operating environments***' (EKI) project that was launched on September 1st, 2019, and funded by the European Regional Development Fund (ERDF). The aim of the EKI project was to create a new research and development environment that could obtain more resources and expertise to provide new energy and circular economy services to companies, including piloting, testing, product development and demonstration facilities. (LAB 2022) The SuMa laboratory in LAB represents the successful conclusion of the EKI project.

New services and operating model

The SuMa laboratory's operations include research and education in the field of environmental technology and circular economy as well as technology development and testing services for companies. However, these operations not only take place in the new laboratory environment; the SuMa laboratory works closely with all the other LAB laboratories, which include laboratories for wood technology, furniture, metalworking and machines, digital products, and construction technology. This new operating model will distribute circular economy know-how and projects for all the LAB laboratories. The idea is that LAB can generate more added value in technology and business development projects for companies in topics based on sustainable materials from different

technological approaches. For example, the laboratories have capabilities to research the effect of using sustainable and recycled materials in various end products and applications. In addition, combining traditional manufacturing methods with new sustainable materials or developing completely new materials for traditional industries can be studied as well, without forgetting digitalisation of manufacturing processes and material data control.

The new SuMa laboratory consists of six different departments that each focus on a specific research area. In addition to the analytical laboratory, there are departments of pyrolysis, anaerobic digestion, plastic handling, textiles, and construction demolition waste. Next, the capabilities of these departments are described in more detail.

Analytical laboratory

The analytical laboratory was originally located in another LAB campus building in Lahti, Niemenkatu 73. The purpose of the laboratory was solely to serve as a learning environment for students. The laboratory was moved in fall 2021 to the Mukkulankatu campus to more easily integrate its operations to the new SuMa laboratory under construction in the same building. The analytical laboratory will continue as not only a learning environment: the new premises, together with the new equipment acquired within the EKI project, allow the laboratory to be used more for research and development projects and to provide analysis services for external organisations. The laboratory is also being used in research projects of the LUT University and will provide more opportunities for collaboration and joint projects between LAB and LUT.

The following tests and analysis can be performed in the analytical laboratory:

Gas chromatography–mass spectro- metry (GS-MS) analysis for solid and liquid organic samples for analysing:

- Volatile organic compounds (VOCs)
- Polycyclic aromatic hydro-carbons (PAHs)
  - PCBs
  - Brominated flame retardants
- Chlorophenols
- Volatile fatty acids
- Odour nuisance compounds

Other analyses provided are:

- Flue gas measurement (field measurements)
- Material recognition with near infrared spectro-scopy (NIR) and Fourier-transform infrared spectroscopy (FTIR)
- Recognition of elementals from solid and liquid samples with X-ray fluorescence (XRF)
- Sieve analysis with various sieve sizes (20μ, 100μ, 300μ, 500μ, 1 mm and 5 mm)
- Testing of concrete

In addition, the laboratory can provide services also for analysis of water and soil samples:

- Soil moisture and nitrogen content analysis with NIR
- Water pH measuring
- Water iron content with photometric measurement
- Sulphide content analysis in natural waters
- Chemical oxygen demand (COD) measurement
- Turbidity analysis
- Precipitation and flocculation studies of wastewater samples
- Chromate analysis of wastewater
- Analysis of ash and minerals from sludge and sediments

Image 1. Pyrolysis reactor of LAB University of Applied Sciences (Henttonen 2021)

Pyrolysis department

The pyrolysis department is equipped with a batch-type pyrolysis system that can be used for laboratory-scale gasification of biomaterials and biochar modification. The equipment in LAB's Sustainable Materials Laboratory can process various materials. The effective volume of the pyrolysis reactor is about 300 l, and it can be used to pyrolyse biomass, plastics, rubber and textiles. In addition to the reactor, the pyrolysis system consists of condensation columns and a gas burner.

The equipment can be used for testing the process with various materials to study the productivity of biocarb and pyrolysis oil as well as to study their properties. In addition to this, finding optimal process parameters with various materials can be offered as a service for companies that are planning to invest in pyrolysis equipment.

The maximum operating temperature of the LAB's pyrolysis equipment is 700 °C, and the process itself takes place in anoxic conditions in a vacuum. The optimal temperature for generating biochar is in the range of 500–700 °C. (Ruokamo 2022)

Pyrolysis is an excellent alternative for burning material side streams that are generated in industrial processes such as mechanical wood processing. With normal combustion, the benefit is the energy production, but the cost is the released CO^2 in the atmosphere. With the help of pyrolysis, about 30%–50% biochar can be received from the process, and this carbon can be bound for millennia. (Ruokamo 2022.) Biochar can be used as a soil improvement material to enhance the growth of trees and forests, which in turn binds even more carbon dioxide from the atmosphere.

The pyrolysis oil that is achieved from the process can replace both light and heavy fuel oils. In addition, bio-oil can be used to manufacture high-added-value products such as cosmetics and medical products. (Ruokamo 2022)

Department of anaerobic digestion

The department of anaerobic digestion is equipped with a reactor for studying and optimizing the digestion processes of various biobased materials. Sample handling and storing also have important roles in this laboratory area. With the help of the reactor, process parameters of digestion can be adjusted, and optimised processes can be found for optimal biogas production. Methane generation potential is being explored with the AMPTS II analyser. Research projects can be offered as a service for companies and agricultural entrepreneurs who possess and generate larger volumes of biomass as a result of their primary operation. The research projects can study how much biogas can be generated from the available biomass, and the results can be the basis in investment planning for an anaerobic digestion system.

The generated biogases and their characteristics can be investigated in the analytical laboratory of LAB.

Image 2. The double-screw extruder of the SuMa laboratory (Image: Joni Alhonen)

Department of plastic handling

The department of plastic handling specialises in processing recycled plastic materials and finding new ways and applications to use them. In this area of the SuMa laboratory, mixed plastic refuse from various material streams can be treated and processed. The initial treatment usually consists of crushing, washing and separation. The separation of various plastic types uses equipment designed and built by LAB's laboratory personnel. The separation method is based on hydrocyclone to separate light plastic particles from heavy particles. Material recognition and sorting can also be done manually. In this work LAB students can participate in the recognition and separation process. The work will teach the students to recognise various plastic material types and also help them to gain credits and work experience. FTIR (Fourier-transform infrared spectroscopy) analyser can be utilised together with visual recognition to ensure correct sorting of materials. (Määttä et al. 2020)

The sorted materials can then be processed in a double-screw compounder to create granulates that can be used as raw material for new proto-products or test parts. The compounding process can also be used to study new material recipes and create new mixed materials, such as biocomposites. The newly developed materials that are derived from recycled plastic can be used to produce filament for 3D printing or manufacturing proto- and test parts and products with injection moulding.

3D-printed and injection-moulded materials and parts can be tested with various methods to research their strength and durability, among other properties, to find suitable applications for the developed new materials and proto-parts.

Plastic particles after washing and sorting can be utilised alternatively in a 3D-printing robot developed by LAB. The robot uses a single-screw extruder to melt the plastic material so that it can be printed through the nozzle that the robot is moving according to a set printing program. Unlike with typical 3D-printing robots, the LAB's printing robot is not holding the extruder itself but only a smaller cartridge that is filled with molten plastic. This will give more flexibility for the robot to print very challenging shapes and forms at various angles. While the robot is printing a product or test part, the single-screw extruder next to it is filling the next cartridge with plastic, and the robot can change the cartridge when the previous one becomes empty. The effective printing area for the robot is currently ca. 2000 x 500 x 1000(h) mm. Smaller parts can be produced with 3D printers that use filament as a base material. To develop 3D-printed products with reinforced structures, a printer combining plastic filament and carbon fibre can be utilised. In addition to 3D printing, compounding, filament production, and injection moulding, recycled plastic materials can also be used for creating and studying membrane material with a membrane film blowing machine. Various material test methods can be performed for developed film to find out its characteristics and possible applications.

Image 3. SuMa laboratory's 6-axis ABB 3D-printing robot with injection unit developed by LAB. (Image: Oona Rouhiainen)

The textile department

The textile department is the new home of LAB's textile identifying and sorting unit, REISKAtex®. The unit was funded by the ERDF and designed and built by the experts of LAB together with the help of students. REISKAtex® is utilised to identify various textile materials with help of NIR sensor technology. The unit is integrated with an automatic sorting line that stores the recognised textiles to separate containers. (Cura et al. 2021)

The textile department also includes standard washing machines that can compare characteristics of recycled textiles with regular textiles, like colour fastness and washing resistance.

For standard-method testing of wear resistance and resistance to pilling, Martindale test equipment is available at the laboratory.

Department of construction demolition waste

The department for studying the circular economy and new product applications from construction demolition waste on a laboratory scale is currently under construction. This is also described in the article written by Qaisar Munir and Ville Puhakka in this publication. The laboratory room was completed in late 2021. The next step is the procurement, installation and start-up of the laboratory equipment which will include a crusher, magnetic separator and pelletizing device, among other tools. On the Lappeenranta campus, a significant investment in the research and development of concrete will be made in 2022. This investment will also support operations of the SuMa laboratory to develop new construction materials with the help of recycled demolition waste.

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Kimmo Heponiemi

Case: Päijät-Häme Grain Cluster Pilot Plant

The Päijät-Häme Grain Cluster was founded in 2003. Today it is a major regional player: the total turnover of the companies belonging to it exceeds €600 M,€ and it is Finland's most extensive and diverse grain- processing network. (Päijät-Hämeen Viljaklusteri 2022.).

The Grain Cluster can be divided into the bread chain and the beverage chain. The bread chain includes about 700 rye, oat and wheat farmers providing employment to almost 1700 people. The biggest bread chain companies are Fazer, Sinuhe and Viipurilainen Kotileipomo. The beverage chain consists of approximately 500 barley farmers and 1300 employees. The biggest beverage chain companies are Hartwall, Viking Malt and Teerenpeli. (Päijät-Hämeen Viljaklusteri 2022.).

The Päijät-Häme Grain Cluster cooperation model has been identified as a circular economy good practice at the European level (Medkova 2019).

The bio- circular economy is defined as one of Päijät-Häme's strengths and a focus areas of the regional circular economy roadmap (Regional Council of Päijät-Häme 2021). The roadmap has been further defined in a bio-based circular economy action plan, which embodies the regional interest in further developing the expertise in the area. Furthermore, in the recently approved ***Päijät-Häme smart specialisation strategy 2022–-2025***, "***Food and beverage***" has been named as one of the three smart specialisation spearheads. The Grain Cluster pilot plant project supports the regional aims of strengthening this area of expertise.

LAB University of Applied Sciences' role in regional development

Food and beverage have been named as one of three key segments of regional smart specialisation in the Päijät-Häme region (Regional Council of Päijät-Häme 2022, 10). This implements the action plan for the biological circular economy, which embodies the regional willingness to promote the biological circular economy. The Grain Cluster pilot plant project is a good practical example of how it is put into practice.

Background of the project

The COVID-19 crisis affected companies in the Grain Cluster. Sales declined and companies have been unable to perform their full complement of laboratory tests due the assembly restrictions and remote work requirements caused by the pandemic.

The pandemic has also increased retailers' willingness to introduce new products to their assortment. They have asked Grain Cluster companies to develop and prepare new types of modern product launches, especially of vegan products. Due to these challenges, a regional project was developed in cooperation with the Grain Cluster and LAB University of Applied Sciences.

Aims of project

The main goal of the project is to build a development platform for the products and business. The development platform allows for a quick response to a declined sale caused by the pandemic and makes it possible to develop new products in line with retailers' expectations. The revenue growth potential for new products from the international market is significant. The project will therefore have a major impact on the appeal and vigour of the Päijät-Häme area. Later, the development platform will also provide services to companies outside the region.

Design of the pilot plant

The project's activities focus on the design and construction of the development platform, the mapping and acquisition of equipment, and the ramp-up of processes. All this takes place in close cooperation between the companies of the Grain Cluster and LAB, and the needs of the companies are the guiding parameters of the space and equipment design.

The pilot plant is designed to fulfil the demands of both the bread chain and the beverage chain. The equipment makes it possible to carry out product development and manufacture of small test batches for customer testing. A small-scale brewery and distillery, bottling and carbonizing devices, and small-scale extruders and packaging devices are included in development platform's devices.

The connection of a microbiological laboratory to the development platform has also been discussed because companies have expressed a need for diverse microbiological analyses. The development platform should be fully operational in 2024.

Enhancing research and development cooperation

When the laboratory plat is built, the companies have access to an agile and tested product development process for new green growth products from idea to market, increasing R&D opportunities and thus business prospects for the Grain Cluster companies and widening the R&D work in the field.

Results of the project will enhance the use of production by-products, which will have a direct impact on the more sustainable use of natural resources. The project strengthens business conditions for the plant-based food industry. Refining the use of plant-based foods reduces the carbon footprint of the entire food chain.

In this project, the process towards a second phase, the full-scale platform, is started. On a tight schedule, new processes are piloted, markets for new products explored and the development a process in cooperation with companies and LAB strengthened.

The project also creates good conditions for providing continuing education to companies. Long-term influence includes the strengthening of the grain industry, increase of national-level know-how of the industry, and as a result, increased attraction to the Päijät-Häme region.

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Merja Kontro, Lei Liu, Sami Luste, Ossi Martikka,
Mari Sarvaala & Vesa Taitto

Case BIOSYKLI - Enhancing Bio-circular Economy in Päijät-Häme Region

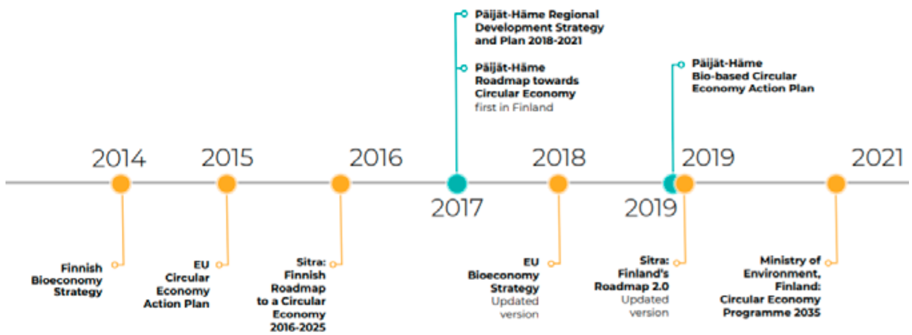

Image 1. Timeline for Circular Economy. (Regional Council of Päijät-Häme 2021)

The Päijät-Häme region has a long history of promoting clean tech and the circular economy. The region was the first in Finland to publish a regional roadmap towards a circular economy in 2017. In Päijät-Häme, the roadmap was part of a regional smart specialisation strategy, and the circular economy was the former spearhead from 2017 to 2021. Nowadays the circular economy or, commonly, sustainability is a cross-cutting principle in smart specialisation strategy. (Regional Council of Päijät-Häme 2022)

The roadmap was supplemented in 2019 with the Päijät-Häme Bio-Based Circular Economy Action Plan (Interreg Europe 2022a). The action plan is part of the European-wide BIOREGIO project that will improve regional knowledge on bio-based circular economy through policy instruments and collaboration (Interreg Europe 2022b).

The main objective of the BIOSYKLI is to promote the bio-based circular economy through developing low-carbon solutions and new sustainable business in the Päijät-Häme region.

The project focuses on four topics:

1) a pilot on separate collection of biowaste,

2) utilising organic waste as a raw material for bioplastics,

3) promoting the use of biobased plastics, and

4) utilising biogenic carbon dioxide (CO^2).

(LAB 2022)

Image 2. Small biowaste bin and accessories for an individual household. (Photo: Salpakierto Ltd)

Separate collection of biowaste

According to national waste law, separate collection of biowaste will become mandatory in 2024 for all properties in built-up areas of more than 10,000 inhabitants, including detached houses (Ministry of the Environment 2022).

Considering this, in 2020–21 the regional waste management company Salpakierto Ltd tested a comprehensive biowaste collection service called Bioneer in Lahti.

Bioneer has two types of customers involved. The average household needs only a 35- or 50-liter biowaste bin and a smaller vehicle (van) can be used for gathering the biowaste instead of a large waste truck. A small proportion of customers have a larger 240-liter biowaste bin (Biolink) in their yard.

The van empties biowastes from the smaller bins and places them in the Biolink. On average, biowaste from seven households can be collected in one Biolink. The waste truck is only responsible for emptying the Biolinks. Thus, the truck does not need to drive through the residential area which makes the concept safe, cost-effective, and environmentally friendly.

Customer satisfaction was high throughout the testing period. Three compositional studies of mixed and energy waste showed that the share of biowaste in mixed waste decreased from 61% to 14%.

Promoting bioplastics - Use of organic waste as material for plastics

The recycling of plastic products and the development of new biodegradable plastics have developed rapidly since the publication of the European Strategy for Plastics in a Circular Economy in 2018 (European Commission 2018). Bioplastics are produced completely or partially from renewable biomass. Certain bioplastics are biodegradable; some are even compostable when placed under the right conditions (Ashter 2016, 179–209).

In the huge plastic markets, the share of non-fossil plastics is still very small. Global plastics production totalled 367 million tonnes in 2020 (PlasticsEurope 2022), while bioplastic production reached 2.09 million tonnes (European Bioplastics 2021a). The biggest markets for bioplastics are in packaging applications (54%), both inflexible and rigid, followed by consumer goods (11%) and textiles (10%) (European Bioplastics 2021b).

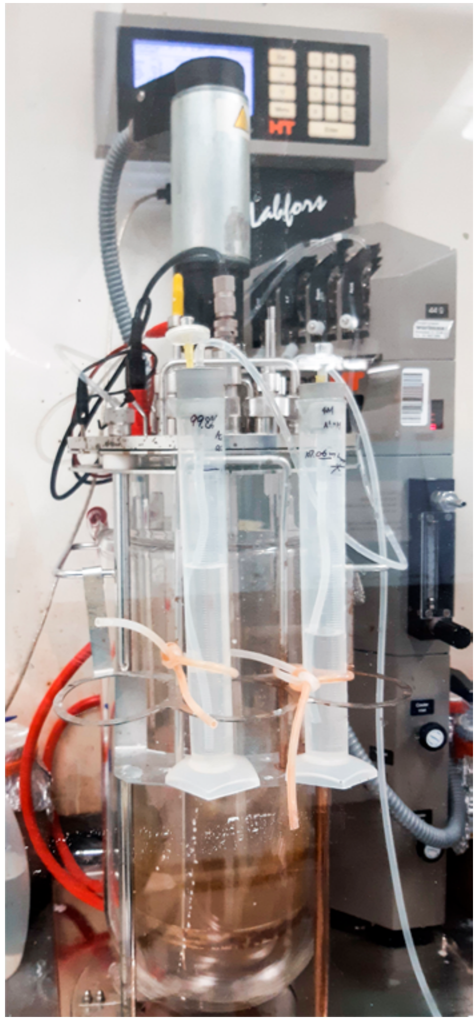

Image 3. PHA accumulation fermentor in a laboratory scale. (Photo: Merja Kontro)

One new intensively developed raw material for plastic is polyhydroxyalkanoate (PHA), a bacterial storage lipid. Bacteria can transform the carbon of various waste materials first into volatile fatty acids, and then into PHA in a second bioreactor. The BIOSYKLI focuses especially on sewage sludge as a carbon source for PHA production. The PHA accumulation in a mixed microbial culture is achieved by stressing the bacteria between the nutritional conditions of feast (rich in nutrients) and famine (starvation), and they can accumulate PHAs more than half of the cell biomass.

PHAs recycle waste carbon to plastics, replace fossil carbon sources, and make plastics carbon sinks, mitigating climate change. The production of PHA-based plastics would complement the plastic production chain in the Päijät-Häme region. Based on the life cycle assessment, the production of PHA is economically feasible.

Based on interviews and discussions conducted within the Finnish plastics industry stakeholders and companies during the project implementation, we can see the circular economy as an opportunity. However, there are technical and legislative constraints which prevent using recycled content. In bioplastics, high price and poor availability are seen as obstacles.

Biogenic CO^2 - From emission to multi-beneficial raw material

There are ongoing great efforts to reduce carbon dioxide (CO^2) emissions and introduce carbon neutrality. At the same time, fossil-based CO^2 (FB-CO^2) is produced as a raw material for various processes and applications.

In BIOSYKLI the aim is to create a regional ecosystem in which the local CO^2 producers and consumers can create a new circular economy business from the local CO^2 emissions. However, this requires that the quality of the gas is suitable for the specific intended use and that the price is lower when compared to the FB-CO^2. The current market price for FB-CO^2 is about 130 €/t, thus, to turn biogenic CO^2 into a business, its maximum price is estimated to settle around 100 €/t. CO^2 does not have to be completely pure in all applications, which increases the economic viability of biogenic CO^2.

The regional CO^2 producers are companies from the energy (e.g., biogas purification, wood-based combustion) and refining industries (e.g., brewing industry). In turn, CO^2 is utilised in greenhouses, energy production (e.g., synthetic methane production), packaging, protection, flow, and pressurisation gas in various industrial applications. There are quality criteria for CO^2 in some cases (e.g., food and drink industry) (Ringo 2000), but in most cases, this requires case-specific study.

Conclusions

As a result of the BIOSYKLI, the expertise of SMEs in the Päijät-Häme region and the region's role as a strong contributor to the future circular economy and bio-based circular economy solutions will be strengthened. As presented above, all project activities involve tight cooperation with companies and other stakeholders.

BIOSYKLI
Päijät-Hämeen
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BIOSYKLI – Circular Bioeconomy in Päijät-Häme Region

Coordinator: LAB University of Applied Sciences

Partners: University of Helsinki, LUT University, Lahti Region Development LADEC, Salpakierto Ltd (former Päijät-Häme Waste Management Ltd), Finnish Plastic Association

Timetable: 9/2019-8/2022

Funding: ERDF 2014-2020, 998 000 €

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Eliisa Punttila

Supply Potential of Straw for Bio-refinement Defined in the Päijät-Häme Region

Straw is one of the most remarkable side streams from fields, but it is currently not commonly utilised in Finland. Usually it is chopped and ploughed into the soil. In bio-refinement the straw could be separated into valuable fractions and utilised as a renewable raw material in industrial production. However, the main question in Finland has been how the supply chain could be organised so that the availability and security of supply would be ensured.

The Vihreän kasvun biokylä project (Green Growth Biovillage; 2019–2021) aimed to establish a supply network for straw in the Päijät-Häme region, in Southern Finland, to identify the main challenges and to find solutions. It was implemented by the City of Heinola, LAB University of Applied Sciences and LUT University and funded by the European Agricultural Fund for Rural Development.

The results of the Biovillage project were originally reported in Punttila et al. (2021), which the following is based on.

Image 1. Straw is a remarkable side stream of fields (Colin 2016)

Supply potential in the Päijät-Häme region

The Biovillage project conducted a survey among entrepreneurs in Päijät-Häme. The aim was to reveal the supply potential of straw in the region – the interest towards selling the straw if a biorefinery were buying it. The survey was conducted via phone interviews and an electronic questionnaire between November 2019 and August 2021. (Punttila et al. 2021, 10.)

The project contacted a total of 1229 entrepreneurs, of whom 713 entrepreneurs (58%) expressed their interest in selling straw or participating in the supply chain in other ways. The entrepreneurs were also asked to mention the field area from which they would likely sell straw or other baleable biomasses annually. The combined field area was 27,500 ha for straw and 7,700 ha for other biomass, which was mainly hay. This supply potential would denote 102,000 tons of biomass annually. (Punttila et al. 2021, 12.)

Supply Potential of Straw and Other Biomasses by Municipality

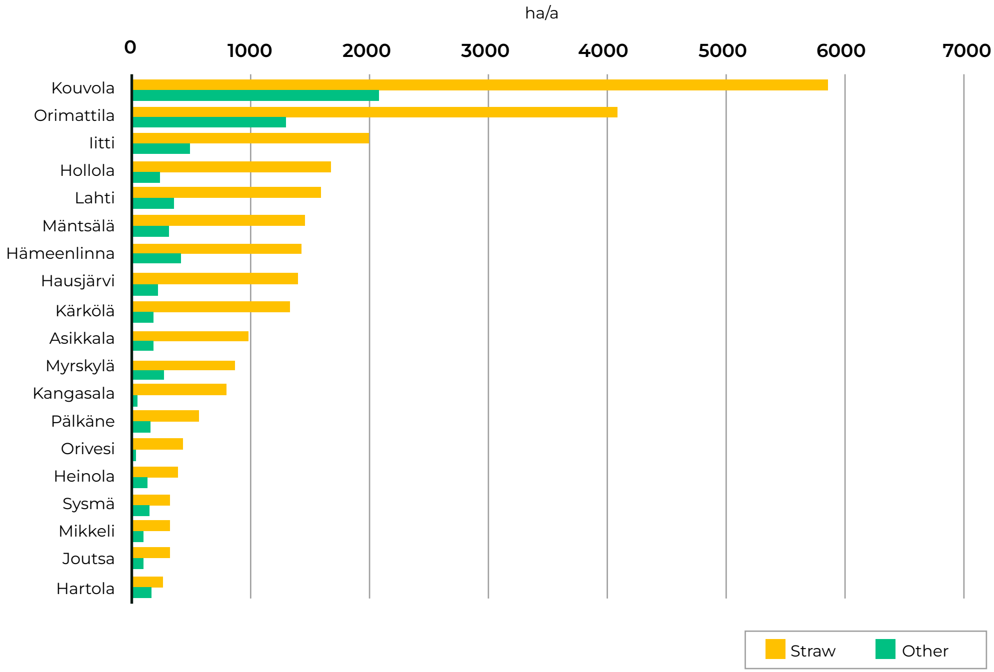

Image 2. Supply potential of straw and other biomasses according to the survey results in those ten municipalities where the supply potential was highest. (Modified from Punttila 2021.)

In the beginning of the project, it was thought that the plant would need 100,000 tons of biomass annually. Thus, it seems that the supply potential in the region would be sufficient for the plant and may be even higher. The estimated straw biomass potential in the municipalities where the respondents were from is almost 400,000 ha/a, so the achieved amount is approximately 17%. However, in sustainability terms the straw would not be harvested every year, so the achieved amount can be regarded as remarkable. (Punttila et al. 2021, 18.)

Two options for supply chain

Approximately half of the respondents preferred to sell straw in bales, but half would need a contractor to collect the straw from the field after the harvest. In total 289 entrepreneurs had were able to bale the straw with their existing machinery, and 172 expressed their interest to work as contractors. (Punttila et al. 2021, 13.) When considering the total annual need of straw biomass, approximately 250 farmers could bale the straw by themselves, and the rest of the straw would be baled by 100–150 contractors. The existing capacity may seem sufficient, but many who were interested in working as contractors would need to invest first to new, efficient machinery. (Punttila et al. 2021, 34.)

The biorefinery should be ready for two supply chain models. In the first one, the farmer sells only the straw left to field in the harvest, and the contractor, hired by the biorefinery, will bale and collect the straw. In the second, the farmer sells ready-made bales. The bales can be stored either in the field, in regional storage or in the main storage close to the plant. The farmer and the biorefinery would make a contract in the beginning to define the amount of straw and how it will be supplied. (Punttila et al. 2021, 9-10.) The contract should consider the responsibilities in the supply chain and ownership of the straw, as well as the quality criteria (Punttila et al. 2021, 44-45).

Main conditions for operation

Entrepreneurs were also asked for their conditions for selling the straw. The concerns were quite similar between the respondents who were interested and those who were not interested in participating in the supply network. The most common comment was related to the weather risks and logistical bottlenecks. Respondents were worried about the possible damage to their fields if contractors with heavy machines went there despite the weather and concerned for their harvest plans if the bales were not collected from fields as agreed. (Punttila et al. 2021, 16-17.) These issues can be taken into account by the contract and good pre-planning of overall logistics. Also, the biorefinery should have the capacity to substitute straw with other biomasses if straw yield remains low in some years. (Punttila et al. 2021, 45-46.)

Another common concern was the price. An example price given in the survey was regarded as sufficient by some respondents but as many thought that it should be higher. The price should include the lost value of straw for farming, since it fertilises and improves the structure of soil when left in the field. It also should include the value of work; overall, selling the straw should be profitable for the farmer. (Punttila et al. 2021, 16 & 37.) From the biorefinery point of view, the production would be profitable only if the value of the end results exceeded the total costs from supply chain, storage, administration and the harvest process. In the project it was estimated that the unit cost for straw would be around 90–137 euros per ton, including the supply chain from field to gate, except for storage and administrative costs. (Punttila et al. 2021, 43.)

As mentioned above, the straw is valuable for the soil. Many respondents were also worried that collecting the straw would decrease the quality of the soil (Punttila et al. 2021, 16). How the removal of straw biomass would influence the soil was reviewed in the project but the outcome was that it is not clear and would require soil monitoring information (Kasurinen et al 2021, 20).

The Biovillage project gathered a potential supply network of straw biomass for bio-refinement in the Päijät-Häme region and practical information to support an investment decision. After the project, the City of Heinola will manage the supply network and continue negotiations with potential investors. (Tuominen 2022.)

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02
Technical Cycles

Anna Keskisaari

Technical Cycles Growth Platform

LAB University of Applied Sciences (LAB) technical cycles platform focusses on technical materials and their circulation. This platform has three main material streams where actions are focused: construction and demolition waste (C & D), plastics, and textiles and their circular economy.

Background

One of the key drivers of the platform is based strongly on the tightening and tightened legislation on different waste fractions and the will of the European Union (EU). All three key material streams in the platform have mentioned the EU's circular economy action plan presented in March 2020 (European Commission 2020). Clearly, materials focused on through this platform are topical now and will continue to be so. The role of the circular economy in EU policy and the requirements arising from it in connection with, e.g., obligations to use recycled materials play a very important role in shaping the operating environments of the future. Companies in LAB's area of operation must take this into account in their operations because these requirements significantly determine the requirements for future development funding for the regions.

Legislation related to waste recycling has tightened both nationally and internationally. Construction and demolition waste are controlled due the EU directive (Directive 2008/98/EC) that 70% of construction and demolition waste should be recycled by 2020. This directive puts enormous pressure on the member countries to deal their C & D waste properly. This platform is interested in different material streams from the C & D industry and better ways to utilise them.

The textile sector also has relevant legislation regulated by Directive (EU) 2018/851. Due to this directive, all textile waste must be collected separately in the future. This directive makes lots of recycled materials available. There are several options on how to process this material stream, and this platform participates in this development.

Plastic waste is one of the most well-known problems globally. The EU is also keen on this material, and plastic strategy is part of the circular economy action plan. There are several actions regarding plastic wastes, and one of them is directive concerning packaging (Directive (EU) 2018/852), which requires 50% of plastic packaging to be recycled by 2025 and 55% by 2030. In Finland there are obligations planned for the domestic plastic industry to use recycled plastics in their product manufacturing (Valtioneuvoston kanslia 2021). Tightening legislation of used materials and disposal of materials offers many future opportunities to be developed around these topics. LAB has interest as well as expertise in this field.

Current state

Activity of this platform is steady and strong due the former and current projects, and RDI-action has strong traditions. One example of a strong research background is a research group that has already been in operation for some time. The research group for textile and plastic material cycles has conducted research and projects in this area. The group consists of people from different backgrounds with different competences. Common RDI projects with the industry have been done, and several peer-reviewed scientific publications published.

Connection to the other platforms

The Technical cycles platform is closely connected to some of the other platforms. One close connection is to Biological cycles, due to the materials used and that both platforms are also closely connected to the laboratories involved. The Biological cycles platform is based on the biomass of both primary and biomass-based industries (biorefineries, especially the forest industry; bioenergy; food industry) as well as bio-based waste and by-products. The Carbon-neutral built environment platform is connected to the Technical cycles platform from the construction point of view. Both platforms are concerned with the construction industry, and the Material cycles platform can offer its knowledge concerning C & D waste. The Design for sustainable business platform already has strong connection to Technical cycles; they are already cooperating on common projects and also with the research group. Design for sustainable business is the platform of LAB's design unit and is focused on designing sustainable products, services, and environments.

Ongoing projects

At the moment, this platform has several projects going on these previously presented themes. To keep up with good speed, new projects from the needs of business had to developed and new projects as a continuation to existing ones to proceed around the selected topics. Regarding plastics, four different projects are going on at this moment. The projects concern the plastic industry on a wide scale. For example, in the ***RAMPO project***, plastics from the construction industry are an object of interest. In ***Muovin tarina***, waste plastic from the community were developed into new products. ***WOW!*** searches business opportunities for raw materials from wastewater capitalisation, and a regional project in the field of circular economy (***Kiertotaloudesta kestävää kasvua Päijät-Hämeeseen***) is searching for new opportunities for the plastic industry in the Päijät-Häme area.

Textile area has several projects going on at this moment. Five different kinds of projects are currently running. For example, ***FINIX*** is focusing on co-development of a resource-wise global textile business in Finland. Business

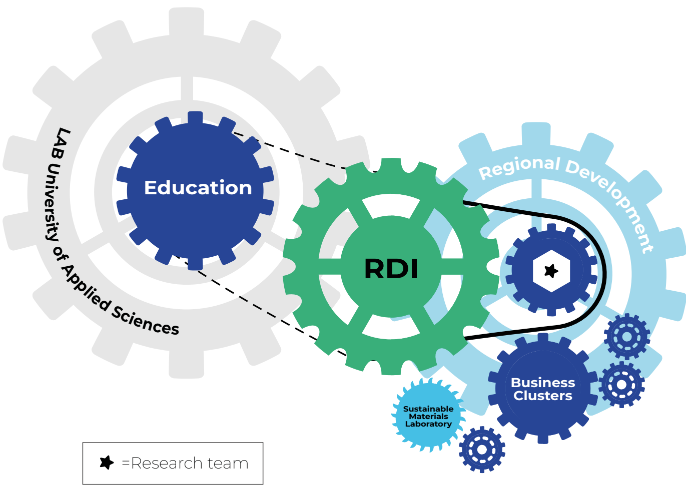
Finland funded **TELAVALUE - Value Chains for Sustainable Production**, **Use and Cycles of Textiles** and a regional project from the textile circular economy (***Tekstiilit kiertoon Päijät-Hämeessä***) is preparing action on separate collection of textile waste in the Päijät-Häme -area. In the C & D sector the ***RAPA project*** is developing new processing methods to increase the value chains of the construction and demolition waste facility and to manufacture new products.

Future

The platform aims to strengthen regional vitality by developing expertise in the circular economy of the platform's materials, with the aim of becoming one of the nationally significant experts in the circular economy in the future. All platform materials have existing projects, but to keep up with the progress, work had to be done to recognise the needs of society. Technical cycles have strong background, which can be seen from the project in which we are participating. In the future, the focus will be to solve more demanding challenges, and secure more funding, from sources like Horizon and Business Finland.

Development contents of the platform can be divided in four different sections. Material treatment and increasing the utilisation rate of by-products and waste streams are one major content area to be developed. Development of new recycling technologies and processes, like identification technologies, is important. This leads to preservation and enhancement of value added and comprehensive utilisation of material properties. One of the developments of the content is systematic understanding of the value cycle and supply chains by material.

While this platform has plans to operate in the future more internationally, local actions are still the significant ones. To develop internationally requires strong work made locally. RDI-action made locally and nationally helps both business life and us. The platform will help companies in the region to identify and promote measures to make them more sustainable, in line with EU objectives. Educational expertise provided by the growth platform produces experts with up-to-date information for the needs of the region's work and business life. Cooperation between two campuses is vitally important. LAB is operating in two provinces, and it is important to transfer know-how and improve cooperation in both areas. Establishing service sales, competence identification and productisation helps this platform to compete.



Technical Cycles

» Material treatment and increasing the utilization rate of by-products and waste streams
» Development of new recycling technologiesand processes
» Preservation and enhancement of value added and comprehensive utilization of material properties

Actors:
Chief specialist, researchers, developers and teachers

Research team:
Textile and plastic material cycles

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Page 61: Gray, M. recycled felt rug pad seamless background. Adobe Stock. Cited 9 Dec 2022. Available at https://stock.adobe.com/fi/images/recycled-felt-rug-pad-seamless-background/320342545

Ossi Martikka & Mia Johansson

The Story of How Plastic Waste Becomes a New Product

With the Story of Plastic project, the concept of how plastic waste can be recycled into new products is demonstrated. The challenge of reusing mixed plastic waste especially will be tackled by utilising both novel technical processing methods and product design that is heavily based on the material properties and processing methods. In addition, citizen and consumer awareness of the need and reason for sorting waste and recycling plastics are raised by creating the Story of Plastic exhibitions.

Current state of plastics recycling

The quantity of plastics produced continues to increase globally, reaching 368 million tonnes in 2020. Even though the amount of post-consumer waste plastics sent to recycling in Europe has doubled between the years 2006 and 2018, still only 32.5% of the total amount was recycled; 42.6% was incinerated, and 25% was still being landfilled (PlasticsEurope 2020). Meanwhile, in the EU, the requirement to recycle wastes, including plastics, continues to face challenge to current procedures and creates the need for novel solutions. The EU legislation demands that 55% of all municipal waste be recycled and prepared for reuse by the year 2025 (Directive (EU) 2018/851) , and landfilling of materials containing more than 10% by weight of organic matter was banned in Finland in 2020 (Valtioneuvoston asetus kaatopaikoista 331/2013)To meet both the Finnish national and European material recycling demand, novel solutions must be invented and applied. Even the lower-grade mixed waste plastics must be recycled as material in order to fulfil both the current and upcoming legislative demands.

The collection of plastic waste in Finland is no longer the major challenge, as plastic separation and reuse have become the most notable issues. Many common plastic types are recycled quite efficiently, especially polyolefins (i.e. polyethylenes and polypropylene), but the growing issues are less common plastics and, e.g., mixtures of polyethylenes, commonly used in transparent packaging films as multilayered structures. The reason for the growing use of multilayered materials in food packaging is that they possess good barrier properties while having low film thickness yet providing improved shelf life and stability of food items (Cinelli et al. 2016, 2). Also, the film material has to be suitable for modern day high-speed production processes, adding further demands for the material, such as good heat resistance and rigidity, in order to produce reliable and fault-fee packaging (Soares et al. 2022, 2).

For recycling of plastic waste, mechanical recycling is the most commonly used process, which typically consists of material collection, shredding/grinding, washing, clean extrusion, filtering, or pelletizing (Al-Salem et al. 2009, 2; Villanueva & Eder 2014, 54). The sorting typically utilises optical methods such as spectroscopic identification and the use of high-frequency cameras (Villanueva, A. & Eder. P. 2014, 50). Unfortunately, there are no such efficient recycling methods for mixed waste plastics containing multilayered materials. It also appears that no viable recycling method for such materials will be available within the next decade (Soares et al. 2022, 6–7). Therefore, novel and sustainable low-cost approaches have to be considered and investigated. The approaches are developed and tested in the Story of Plastic - From Waste to Product project, funded by the Finnish Ministry of Environment, where the City of Espoo is the lead partner and LAB University of Applied Sciences the project partner. One of the main goals is to develop novel processes and methods to upcycle plastics that involve minimal processing.

Concrete examples of recycling plastics

During the Story of Plastic project, plastic waste is collected from schools in Espoo and checked to ensure the quality of the material. This is done mainly by students but also by other related personnel after receiving sufficient instructions and information.

The plastics collected are then processed at the LAB University of Applied Sciences, including material safety and property analysis. The processing includes grinding, washing, drying, and granulating the waste plastic prior turning it into demo products. The transformation of the material is illustrated in Image 1. The demo products to be made of the reclaimed plastics are designed in cooperation with students/trainees at the LAB Institute of Design and Fine Arts, who are also involved in the handling and processing of the waste plastics in order to gain a deeper understanding of the material at hand. The demo products are produced using the novel 3D-robot printing equipment developed at the LAB University of Applied Science. Examples of the designs are shown in Image 2 along with the robot 3D-printer. The recycled material will be transformed into new demo products for public outdoor spaces and placed for experimental use in the Keran Hallit area of Espoo to show residents and other people the possibilities of sorting and reusing plastic waste.

The entire chain from a single piece of plastic waste to a novel product available to the public will be shown in the Story of Plastic online exhibition, which will be available to both the schools and consumers. Another major outcome of the project will be the Story of Plastic ecosystem that connects residents, community, waste management, industries, and research. The ecosystem is organised during the project and ensures the continuation of cooperation between all the parties involved with the project as well as new participants.

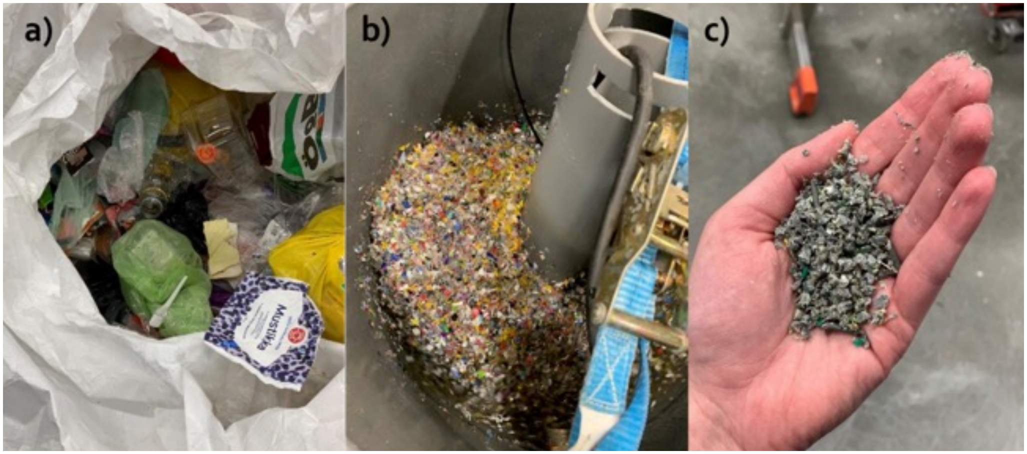

Image 1. a) Plastic waste, b) ground plastic being washed, and c) granulated waste plastic (right) (Images: Netta Kandelin)

Image 2. a) 3D-robot printer (Image: Reijo Heikkinen), b) vertical planter (Image: Heidi Ahola), and c) plant vessels (Image: Netta Kandelin)

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Qaisar Munir & Ville Puhakka

Pre-treatment approach for construction and demolition waste

Construction and demolition (C&D) waste, consisting of inert (rock, wood, concrete sand, brick, etc.) and non-inert (wood, plaster, cardboard, plastic, etc.) materials, is waste generated by construction, maintenance, and demolition activities, contributing close to 35% of all waste generated in the European Union (Menegaki & Damigos 2018, 8; Tilastokeskus 2019). Construction (16%), renovation (27%) and demolition (57%) all develop C&D waste with different properties and compositions (Meinander & Mroueh et al. 2021, 27). Statistics demonstrate that over 80% of C&D waste consists of ceramics, concrete and masonry (Gálvez-Martos et al. 2018, 166). The main units of C&D waste, such as wood, metals, bricks, concrete, and ceramics, have a substantial potential for material reuse. Therefore, the European Union has set a notable material recovery target (70% of C&D waste generated) for the recycling, recovery or reuse of such waste as a construction material (Liikanen et al. 2019, 717). The target was set at the beginning of 2020 and is currently only met via low-grade recycling such as backfilling or not at all (European environmental agency 2020).

The C&D waste is generally used as green material in road construction and building materials. The mixture of 30% recycled aggregate and brick dust waste can replace 15% of the cement used in construction without significantly reducing the final material strength properties as compared to a control concrete (Letelier et al. 2018, 2). However, the percentage of recycled material in these industries is still inadequate. A prominent reason for this is the cost

of recycled materials, which is normally greater than virgin materials.

The mobile and stationary plants for C&D waste treatment have screens, one or two crushers, and some kind of separator, such as a magnetic separator. The mobile plants are operated on site; they are suitable for large demolition sites and can easily be transported from one site to another. However, the quality of the end products is limited by the noise generation and the absence of cleaning facilities (Kumbhar et al. 2013, 87). Similarly, stationary plants contain cleaning equipment, separation machines, and primary and secondary crushers to limit the production of inadequate products. In addition, stationary plants are more productive related to mobile plants because they offer the possibility to produce different recycled products with different sorting grades.

C&D waste as a filler material in geopolymer formulation

Construction waste contains high concentrations of aluminum and silica, making recycled construction waste a potential source of sustainable building materials. Concrete is the most widely used building material in the world. The main component of concrete is ordinary Portland cement (OPC), which is considered a high energy consuming material (Munir & Kärki 2021, 2). In 2018, the cement industry was responsible for about 8% of carbon dioxide emissions and up to 20% of global industrial emissions (Mäkikouri & Vehmas 2020). Geopolymers, which are considered green building materials, have significant acid resistance and are economical and environmentally friendly alternatives OPC (Munir & Kärki 2021, 3). These green building materials are produced by polymerisation of aluminosilicate materials activated with an alkaline solution. The C&D waste can be used as filler for the production of geopolymers. For the recycling of C&D waste, different treatment processes must be applied to make them useful for the formulation of sustainable building materials. LAB University of Applied Sciences (LAB) and LUT University (LUT) are tackling this challenge in the ERDF-funded ***RAPA project*** (low-carbon products of construction and demolition waste reject). The RAPA project develops the pre-treatment approach for C&D waste screening reject, one of the biggest non-utilised waste fractions from the construction industry. During the RAPA project, LUT and LAB also developed recipes for lighter moulded concrete objects, such as roadblocks and construction Legos, using screening reject as one of the raw materials.

Pre-treatment approach for construction wastes

The pre-treatment procedures for detaching and separating various materials in C&D waste depend on the target application. The C&D waste used for the formulation of geopolymer synthesis is the underflow of the screen. The crushing process is carried out to make the material size homogeneous and to simplify the material for the treatment processes. Crushing waste streams produces uniform particles with low to high hardness and facilitates separation of materials. There are two types of crushers: compression crushers, which break the material by employing significant pressure on the material surface, and impact crushers, which break the material by accelerating the material feed. Pressure crushers include cone, jaw, roller and gyratory crushers, and impact crushers include impact mills and hammer mills. The desired final size cannot be achieved immediately with one crushing operation, so screening and a secondary crushing operation must be performed.

The screening process is performed to separate materials sized from 300 mm to 40 µm. Screening usually has a lattice with many holes of the same size. There are two types of screening: dry screening, which is used to separate materials having a minimum size of 5 mm, and wet

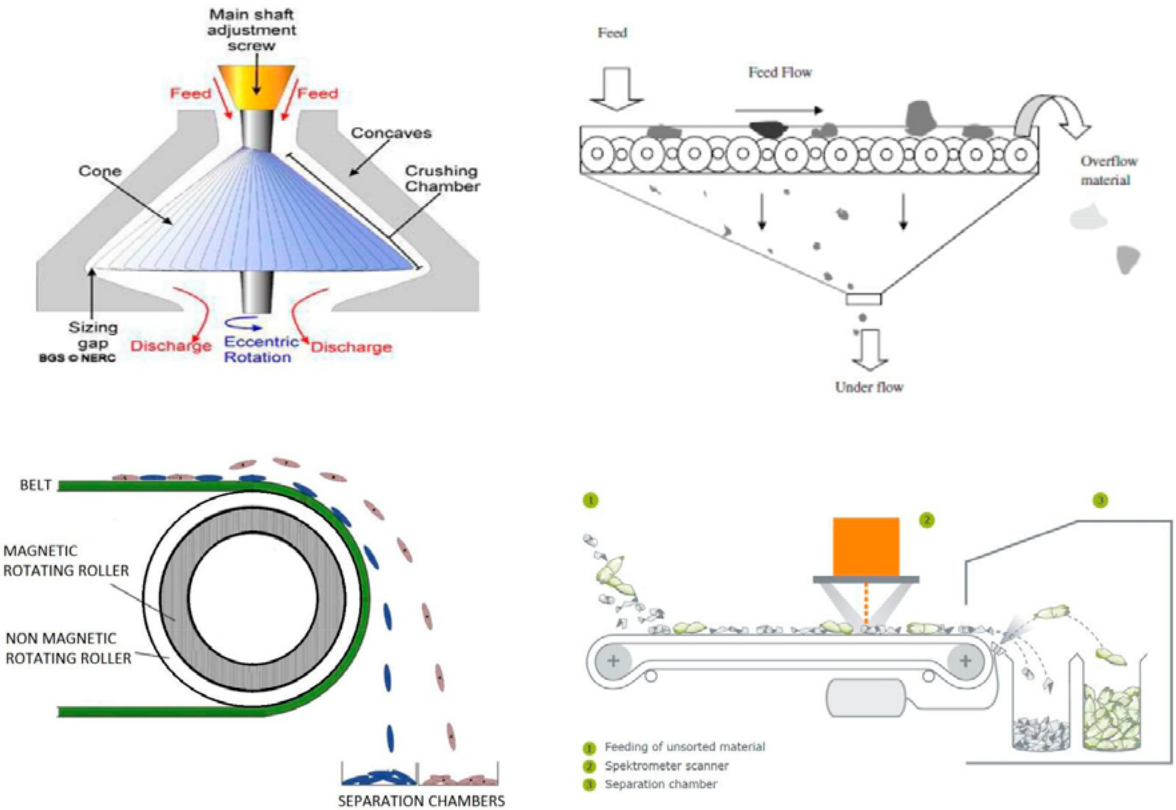

Image 1. Machines for the pre-treatment of construction and demolition waste.
a) Cone crusher (Metso 2011, 24).
[Alt Text: Homogenous size reduction and shaping of materials for uniform separation.]
b) Eddy current separator (Li, Jiang & Xu 2017, 1318).
[Alt Text: Particle of non-ferrous materials separated from ferrous materials with high productivity.]
c) Disc screen (Chandrappa & Das 2012, 91).
[Alt Text: Screen allows separation of materials through uniform size opening.]
d) Optical sorting using near-infrared (NIR) separators (Vegas et al. 2015, 123).
[Alt Text: Materials separated based on magnetic susceptibility, density, and electrical conductivity.]

screening, which can separate particles with a size of 250 μm. For the separation of tiny materials, a large screening surface is required.

To separate magnetic materials from non-magnetic materials, the technique of magnetic separation is used for the treatment of screening residues. Magnetic separation can be applied on materials in dry or wet conditions. Similarly, the eddy current separator (ECS) is used to separate non-ferrous metals such as aluminium. LAB's laboratory of circular economy has a brand-new pilot scale metal separator, combining magnetic separation and ECS for research, testing and process development purposes. Materials with different density, size or shape are separated by an air classifier. Higher separation efficiency is achieved when the particles are in rotation due to centrifugal force. Optical sorting is used to separate different glasses with different colours and to separate glass from ceramics.

Conclusion

The construction industry generates a significant share of waste in a variety of categories that are challenging to recycle. LAB and LUT collaborated in the RAPA project to study pre-treatment methods for C&D waste required for recycling in additive manufacturing. Using recycled C&D waste as raw material would reduce CO^2 emissions as well as minimise material waste and reduce labour requirements. Three-dimensional printing requires finer C&D waste screening compared to current processes.

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03

Carbon-neutral Built Environment

Mauri Huttunen, Juha Poskela & Kirsi Taivalantti

Carbon-neutral Built Environment in LAB University of Applied Sciences: Presenting the previous path

Awareness has risen. Climate change affects societies, communities, and their infrastructure. No city or community is left out. The challenges facing civilisation include increased rainfall and wetness, temperature drops, the heat island effect (HIT), flooding, and drought. Effects vary, depending on the geolocation and the geological and climate conditions of the area. Carbon dioxide (CO_2) plays a major role in human-caused greenhouse emissions. Therefore, the EU chose CO_2 as the main indicator in evaluating the actions taken toward climate change prevention. (Euroopan ympäristökeskus 2020, Intergovernmental Panel on Climate Change 2018)

The LAB University of Applied Sciences has established a growth platform for built environment development projects. This means a focused group of experts in the field. The platform is focusing on carbon neutrality in the whole value chain of the built environment. Key expertise in this field is information modelling, adding value, and using data in design and planning of sustainable communities. One aim is to develop an information model-based approach to estimate and evaluate the CO_2 balance of a built environment. The next individual project aims to launch a regional platform and network (Päijät-Häme and Etelä-Karjala) for construction businesses and municipalities called Data Management in the Construction Value Chain.

The objectives of this project are:

- » Developing systematic information management as part of the Lahti Urban Carbon Neutral Development Center and the innovation ecosystem
- » Establishing follow-up project blanks for the construction information management development entity
- » Establishing a development network to pilot and implement the utilisation and coordination of information models, information systems and new technologies
- » Strengthening the understanding of the information model
- » Assessing climate impact through data models as part of the area´s carbon neutrality target for 2025.

New development projects are built on strong knowledge and practice gained under the guidance of BIM pioneer Timo Lehtoviita, using experiences from previous work in the fields of construction, civil engineering, and urban planning. During the past decade, LAB UAS has been carrying on projects in the areas of building information modelling (BIM), AI, IoT and digital twins, in South Karelia as well as nationally. LAB also coordinated a network for local construction businesses, municipalities, and authorities to help apply BIM throughout their operations. From the completed and ongoing projects, LAB has developed strong know-how and educational RDI base for BIM use, BIM-based development for construction and property management.

In this article, we wish to present the practical path and base for further development of LAB. The following are examples of completed and ongoing projects.

Years of development work for digitalisation of the built environment

TOKA – Implementations of basic BIM know-how for construction sector

(2012-06-01 to 2014-12-31, €206,740)

The project focused on building information modelling know-how in the house-building sector with 17 construction companies involved. An essential part of the project was to train and coach participants to become BIM professionals. The project developed readiness to work in BIM-based projects. (Lehtoviita et al, 2015, 3; 5)

DORF II – Business potential of activity-based information models in the smart built environment

(2015-03-01 to 2017-04-30, €330,000)

In this project the possibility was studied to develop an operational information model, similar to a building information model. The model would combine static information, dynamic operational information, and a time dimension. As a result, understanding of the benefits of digital continuity, data and information models in various use cases was achieved. (Kokko 2017, 10-11; 46)

Digi-Infra – digitality for the infra-structure sector in South Karelia

(2016-03-01 to 2018-10-30, €299,981)

and

Digi-Kone – digitality for machine control in South Karelia

(2016-05-02 to 2018-05-31, €171,428)

In the project, infrastructure operators in South Karelia were explored, and training and knowledge for Common InfraBIM Requirements YIV, information modelling and 3D machine control were provided. Also, a reference network was created for local operators. The trainings also included familiarisation with various design, construction, and maintenance sites, as well as different pilot projects in which skills learned were put into practice. The equipment needed for training was acquired within the framework of the Digi-Kone project. (Mertanen & Saikko 2018, 3; 5-6)

Enhancing building safety using information models

(2018-05-15 to 2019-02-28):

The focus of the project was to find ways and tools that enable utilising building information models in the everyday life of the rescue authority. Development was carried out with the Rescue Department of South Karelia and the City of Lappeenranta. As one of the outcomes, a new set of information model requirements related to fire safety was developed for possible use in updating the Common BIM Requirements 2012 guidelines. The project showed that building information models have potential in ensuring the fire safety of buildings in relation to rescue operations. (Lehtoviita et al. 2019, 2)

UIR – Urban Infra Revolution

(2017-11-01 to 2020-12-31, €4.2 m)

In cooperation with LAB and several other organisations, the city of Lappeenranta carried out a development project, 'Urban Infra Revolution', funded by the Urban Innovative Actions programme of the European Union. One of the products developed in the project was a comprehensive and highly visual virtual city model of the Lappeenranta city centre. The model works as a platform to test new urban structures. These are 3D-printed from a new novel material produced in this same project. The virtual city model can be viewed in multiple ways such as CAVE and VR systems. (Jantunen et al. 2021 18; Huttunen & Taivalantti 2019)

BIM-ICE – BIM Integration in Higher and Continuing Education

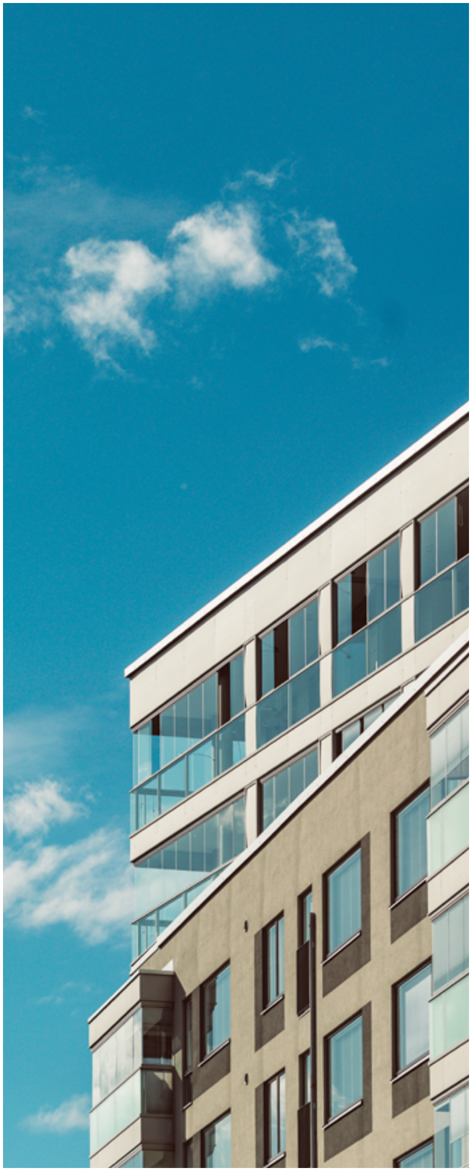
(2020-04-01 to 2022-11-31, €599,950)

The main goal of the project is to increase building information modelling expertise and the use of building information models in the construction sector. The project will also develop the knowledge base in both higher education and in companies. The measures secure the availability of skilled labour and increase the quality and productivity of the construction sector. (BIM-ICE 2020)

RYHTI – Productive built environment by digital solutions

(2021-09-01 to 2023-08-31, €336,000)

The aims of this project are the development of building automation and low-carbon construction processes; the application of artificial intelligence; and the prerequisites for new service businesses for the entire life cycle of buildings, from the point of view of maintenance and operation (https://lab.fi/fi/EKKIRA). For example, two dynamic digital twins will be developed, the network for the region will be strengthened, and the development of extended reality and artificial intelligence solutions for companies in the region will be enabled by providing a testing environment. (LAB 2022)



Conclusions

By showing these examples, we wish to demonstrate the variety of the development work done during past 10 years. This work creates not only a solid and wide-ranging fund of know-how in LAB UAS and our experts but also a comprehensive network of companies, cities, and other organisations. This is our foundation to set new and more ambitious goals for national and international targets in developing a carbon-neutral built environment. Specifically, we focus on developing digital tools and processes for new-generation cities and areas, for the safety and security of people, now and in the future.

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Kusti Alasalmi

Bringing Digital Solutions into Practice in a Built Environment

A technology development isn't a technology developing by itself: it is individual humans taking actions to bring tools into a real and beneficial use. That is the case with a productive built environment brought about by a digital solutions project too. These digital solutions and the hype around them have been around for a long while. There are plenty of places where these solutions could be utilised – and that's the problem. Imagination is not limiting any glamorous presentations, while beneficial business cases would be looking much duller. In the past, digital twin projects failed when they wanted to get straight into these complex, full-scale digital twin models (Dooley 2021). As an outcome, professionals have largely stayed with their well-known building information models (BIMs) and continued with business as usual.

Our project concentrates on the South-Karelia province. The project is financed by EAKR/React EU, which means the purpose is to fix the local slump caused by COVID-19. The project helps to strengthen resource productivity and cost effectiveness. Its subsequent effectiveness is to decrease carbon footprint both in the investing phase (construction) and during the life cycle of the building, thus promoting sustainability and the circular economy. Our aim is to bring digital tools and solutions (digital twins, AI, XR-technology) into concrete actions.

Image 1. LOAS Teatteri pilot 1 construction in the centre of Lappeenranta. (Image: Kusti Alasalmi).

We have two physical pilots, the first in Lappeenranta-LOAS Teatteri and the second in Imatra-Mioni Kampus, where we are demonstrating the real cases. The impulse to these digital twins is market pull. During this project we'll demo these cases to our network. The stakeholders involved are property owners, real estate professionals, users, and people involved in building services, the construction industry, software and security. After the project, the aim is to have an established ecosystem in the South Karelia province in which digital solutions are an everyday tool in a built environment.

Digital twins

How should digital twins in a built environment to be understood? First, think about the BIM of an individual building. Most everything grows around it. Then data are taken, for example, from sensors which are physically located in that building. A data pipe is built from that sensor data in which necessary conversions have been done to put it in the correct form for analysis and presentations (Welin & Similä 2021, 14-16). The analysis sometimes utilises artificial Intelligence (AI), but it is not necessary in most cases. When that physical sensor, data, and presentation have been combined in a user interface, we'll have a working digital twin.

There can be many optional levels of digital twin (Dooley & Camposano 2020, 12). The most complex one is a as-built digital twin. It uses the whole BIM of the massive building and can include virtually everything imagined (and that may cause the complexity problem). With a careful design and a smart restriction this as-built digital twin could give a holistic view of that building. In both pilots, a twin is chosen where an operator can see every apartment's/room's temperature and moisture combined with a central heating line. When an automated alert arrives, the operator can see whether there is a problem with a single apartment or the heating line itself. With this model, the operator can analyse whether there are differences on the north, west, south, or east sides of the building. Problems could be a result of major wind direction or differences between insulation factors.

A slightly more modest version is a building services digital twin. There, the aim is not to present a holistic view. This twin is limited to handling building service devices, like HVAC systems, either together with a simplified BIM model or as part of a larger BIM model. Our pilots are going to have a case with route view where a certain coded key is allowed to enter. In that visualisation it is easy to see whether one person has rights that are too limited or too broad compared to their entrance needs.

An even simpler version is an interactive floorplan. It is not necessarily related to any BIM. A starting point could be a 2D drawing of a building that includes only an interior. But keep in mind, it is very important to ensure that this drawing is updated if the actual building is old, and not all modifications are updated in original drawings. It is always better to have an as-built BIM as a starting point. From this point on, the logic of the interactive floorplan digital twin is the same. Sensors are located (for named devices) and info presented in a user interface. This version is very suitable for interior design aid or marketing purposes. A final aim also sets the goal to the tool needed. If users need only 2D information, it could be better to stay in a 2D user interface and not confuse them with a 3D interface, which can be more complex to learn, adapt to, and follow.

The business intelligence platform digital twin is possible to implement without showing any actual building. This digital twin is primarily a dashboard with relevant information provided through graphs, bars and hard numbers. This version is also called a digital twin although it isn't literally one. There isn't a replica of a building involved. But there can be a link to open the BIM and show the locations of apartments and other issues related to the dashboard data.

Where to start? When choosing a digital twin, the most important initial information is the actual business need. How will a solution save labour, costs, time, or other resources and decrease carbon footprint? Do we solve one single problem or could we offer a solution to combine data from separate buildings and yield information which serves bigger decisions? Starting with a simple version and building it step by step over time is recommended (Dooley et al. 2020, 16). In development, all the decisions and programming code documentations should be made bearing in mind that a simple digital twin could later be scalable. Everything should be developed leaving the possibility to have a complex full-scale digital twin in the following years.

All digital twins have one thing in common: if a user interface is not well designed, all previous work is depreciated. Hire good UX managers and designers for a project to ensure a world-class user experience. That way, users have the full benefit and potential of their precious tool. The LAB UX Center will participate in our project implementing usability testing for Mioni's digital twins.

Artificial intelligence (AI) is not always included in digital twins. In fact, AI in a built environment doesn't even necessarily need a digital twin. AI can be developed and used without a digital twin. A good example of AI in a built environment is one in which AI is used to detect whether a construction worker uses a safety helmet or not (Reaktor Education 2021). This addition could be a very significant improvement in occupational health, liberating supervisors from the time needed to detect these helmetless employees.

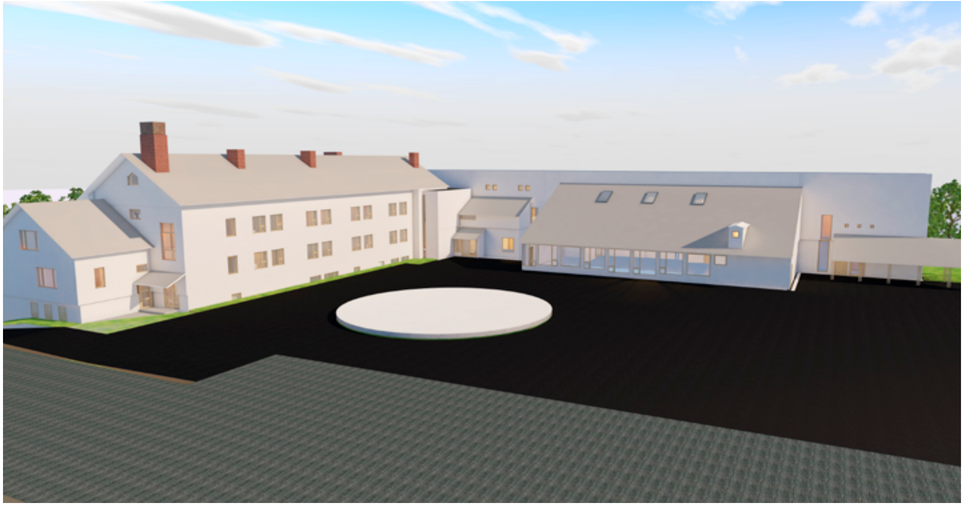

Image 2. Screenshot of pilot 2 BIM model of Mioni Campus in Imatra. (Image: Topi Huhtanen)

Mixed reality XR

What is XR's role in this all? Virtual reality and augmented reality are also well-known tools around basically every area of industry. To not narrow the scope, it is better to use the term XR, meaning mixed reality. XR is independent from a digital twin. It uses BIM but doesn't need a twin. In our project we are concentrating our efforts into these topics: the sketching phase of a construction site, supervision of a construction process and a schedule follow-up, assembling building service devices, safety, and planning a reconstruction project. First of all, a BIM-model must be precise, as-built. We are standing on sand if the actual building differs from the BIM, which can be easily the case with the new building-in-process. Not all modifications done on-site are getting back into this BIM or vice versa: not all details have actually been built.

Our network: future ecosystem of stakeholders

What is needed from them? Time. What do we give them? A show of demonstration steps from an empty white paper towards concrete digital solutions. They also get a stronger network of South Karelia developers and customers in the built environment.

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Mauri Huttunen, Eliisa Punttila & Timo Lehtoviita

Building information modeling (BIM) enables ways to lower emissions

The shift towards carbon neutral construction requires implementing new technology and new ways of information management. Because buildings have long lifespans, everything should be initially planned as well as can be. Implementation of BIM will improve the quality and efficiency of building processes. It is also an essential step to take for reaching carbon neutrality in construction.

In order to utilise the possibilities of BIM, learning new skills and increasing knowledge are required. The 2020–2022 ***BIM-Integration in Higher and Continuing Education (BIM-ICE)*** project is all about accelerating use and utilisation of BIM in multiple different ways to pursue a smaller carbon footprint in the building industry.

What is BIM?

BIM originally stood for building information model. This model is a three-dimensional digital model with geometry and information on building objects such as walls, windows, beams and ventilation systems. Every design discipline makes their own model, and all of these can be combined into one building information model. Nowadays BIM means building information modelling. BIM is the use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions (SFS-EN ISO 19650-1:2019). So the scope is now much wider, and the main point is how building information models and other digital sources can be used in different ways.

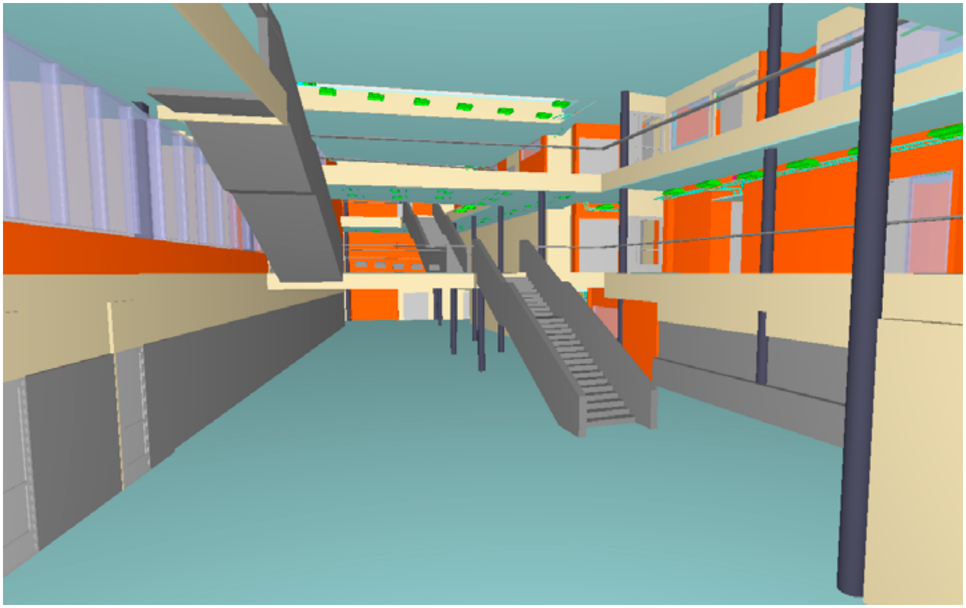


Image 1. BIM combination model from LAB Lappeenranta campus. (Screenshot from the model: Jarno Rautiainen)

OpenBIM extends the benefits of BIM by improving the accessibility, usability, management and sustainability of digital data in the built asset industry (BuildingSMART 2022). In the OpenBIM workflow, all needed information exchange between each role in the project shall be handled with the help of international standards, such as IFC-standard. This workflow needs to be implemented among civil engineering professionals. LAB has organised many development projects with designers, contractors, clients, officials and the building industry to help them in this work. One of the recent projects in this field is the BIM-ICE project.

BIM-ICE aims to increase BIM competence
The BIM-ICE project aims to integrate BIM into education and increase BIM-competence to ensure a skilled workforce in the future. The project is led by the LAB University of Applied Sciences and co-funded by the European Union (BIM-ICE 2022).

The BIM-ICE project has both gathered information on the current state of BIM development and tested and piloted new training models together with university students, company collaborators and academic staff. The project has also increased understanding of the international BIM standards and different use-cases. A special aspect of all activities has been OpenBIM, which as a working process enables the main benefits of BIM.

There are perhaps an unlimited number of ways in which BIM could be utilised in reaching a carbon-neutral society. The project can provide some examples. Two use-cases of BIM have been defined in greater detail in the project: using BIM in energy analysis and in carbon calculation. Also, the project organised a course on inventory modelling, which can be used in refurbishing buildings, lengthening their life span, or in waste management in deconstruction of buildings. From the perspective of new ways to utilise BIM models, extended reality (XR) is a notable opportunity.

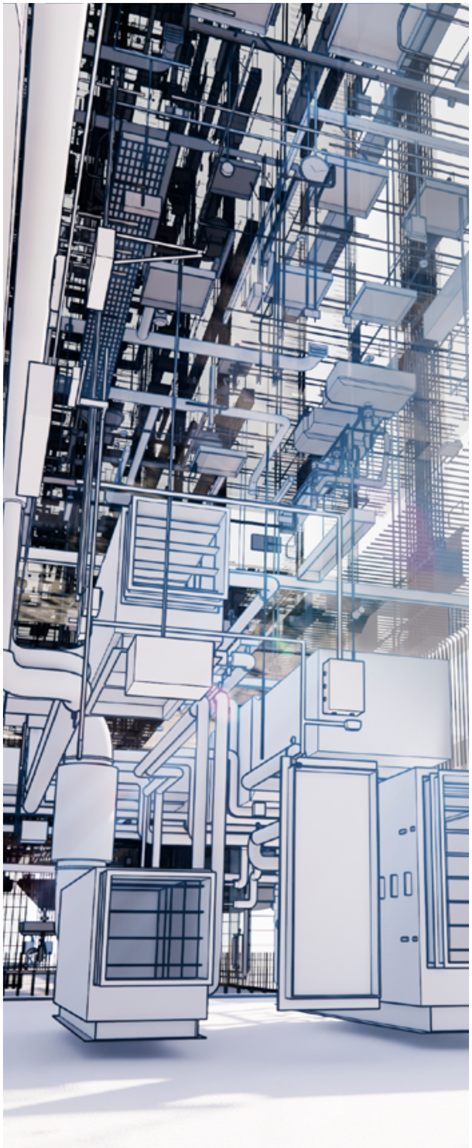
Extended reality as an enabler

Using an immersive virtual reality solution to view BIM models can drastically improve the ability to spot design errors compared to viewing the same models only via a computer screen. Design errors are more often spotted using this technology, especially among industry novices (under three years of industry experience) but also among industry experts. (Construction Industry Institute 2019.)

Results should not come as a surprise to those who have been able to use a BIM in some kind of an XR use case. With today's available XR technology (including virtual reality, augmented reality and mixed reality) and related software, it is possible to develop holistic use cases quite easily around BIM to help all involved parties and stakeholders to do their parts more efficiently and hopefully with less modification work and redesign required.

In the BIM-ICE project multiple different XR use cases were piloted with our project partners, infrastructure construction company GRK Infra Oyj and property management and construction client company Lappeenrannan Toimitilat Oy LATO. With an augmented reality (AR) device, Trimble SiteVision, and its integrated GNSS antenna the BIM can be placed automatically in its real environment with accuracy within centimetres. The second XR device, the Microsoft Hololens 2 mixed reality headset, was used with Trimble Connect software to glue a BIM onto real-life structures. These XR technologies could, for example, enable more efficient quality control in the construction site and even reduce installing errors.

Image 2. Project engineer Jani Paappanen from Lappeenrannan Toimitilat Oy LATO seeing the design model in its real location. (Photo: Jarno Rautiainen)



On the road to carbon-neutral construction, BIM will be the most critical tool with its ever-evolving new use cases. It is important to make the most of BIM not only when planning and building but throughout the whole lifecycle. The power of BIM can be used in many ways to lower emissions of the built environment. To achieve this goal, every participant in different kinds of civil engineering projects must understand the main advantages of BIM: useful information and good visualisation for multiple different use cases.

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04
Sustainable Societies

Susanna Vanhamäki & Riika Kivelä

Sustainable Societies Growth Platform: Circular Economy Supporting the Sustainability Transition

The sustainability crisis has shown that economic growth and welfare can no longer be generated by consuming natural resources and producing and owning new goods (Sitra 2021). The circular economy is an economic model in which consumption changes in a more sustainable direction. The circular economy involves a systemic change in the society. Achieving long-term transformation requires a consensus on how to move towards sustainability at all levels of government: international, national, regional and local (European Commission 2020). The international and national levels are leading the way, while more concrete actions are being planned and implemented at regional and local levels. This fundamental change requires cooperation and close dialogue between stakeholders at all levels. Regional policies and strategies have a key role to play in supporting systemic change in practice.

LAB University of Applied Sciences' '***Sustainable Societies***' growth platform operates as part of the Circular Economy focus area. The growth platform supports the transition to a circular economy in accordance with the principles of sustainable development. It combines circular economy thinking with a social science perspective in a multidisciplinary manner through utilising cross-cutting expertise from LAB's other focus areas.

Image 1. Sustainable and lively local communities are at the core of the sustainability transition. (Image: Adobe Stock)

Sustainable Societies promotes strategic cooperation, laying the foundation for a sustainable transition to a circular economy, as well as concrete actions to accelerate the transition. The growth platform is built around four key themes.

1) systemic and sustainable change towards a circular economy,
2) regional and social conditions and impacts of the circular economy,
3) circular economy operating models and sustainable service solutions, and
4) sustainable and vital local communities.

The aim is to accelerate research and development-related growth in the Päijät-Häme and South Karelia regions through regional cooperation on these themes.

The Sustainable Societies platform's perspective on sustainability is closely linked with LAB's goals of promoting the United Nations Sustainable Development Goals (SDG; LAB 2021a). SDG 11 '***Sustainable Cities and Communities***' particularly highlights the importance of urban planning in the pursuit of sustainability. Social sustainability is seen as a key measure in building sustainable communities.

Synergies from interregional and regional projects

In the past programming period, 2014–2020, there has been close cooperation in the Päijät-Häme region between the Regional Council and LAB University of Applied Sciences in research and development of the circular economy at a strategic level. The cooperation, especially in interregional projects, has been seen as an effective way to support regional circular economy strategy development. Developing a circular economy from a broad perspective has been a strategic goal of the Päijät-Häme region as defined in the Päijät-Häme regional strategy 2018–2021 as well as the regional smart specialisation strategy (Päijät-Hämeen liitto 2017). The strategic cooperation began with setting up a regional roadmap towards a circular economy in 2017 (Vanhamäki et al. 2020). Through interregional projects funded by the Interreg Europe program (BIOREGIO, CECI), the roadmap has been linked to project goals which further defined the actions for two of the circular economy priority areas: 'bio circular economy' and 'new consumption models'. The linkages between the regional strategy and the bio circular economy action plan are described in detail in publications

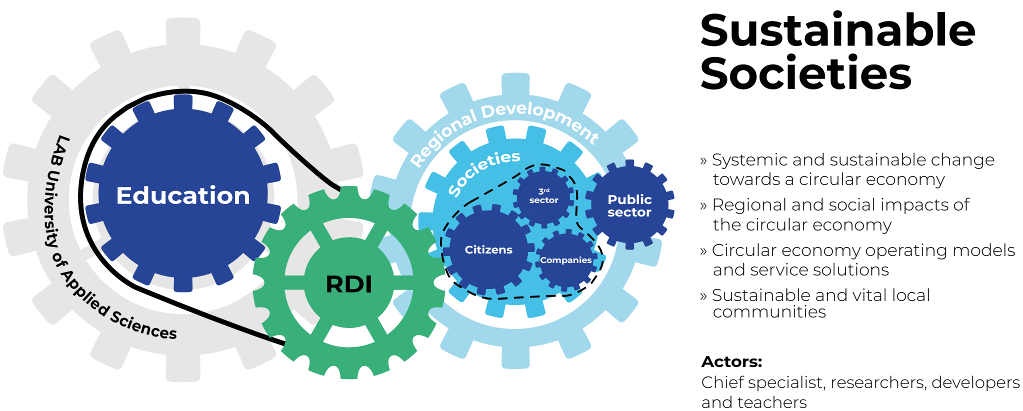

Image 2. Sustainable societies growth platform illustrated (Image: Oona Rouhiainen)

written by Medkova and Vanhamäki (2018) and Medkova, Vanhamäki and Snell (2019). In addition, Medkova, Snell and Villanen (2020) have written about new consumption models from the perspective of citizen involvement in the circular economy.

As the implementation of the Interreg Europe-funded projects includes supporting regional spinoff activities, new projects linked to the practical implementation of circular economy solutions have been prepared and implemented in the Päijät-Häme region. For example, as a result of the ***Citizen involvement in Circular Economy Implementation (CECI) project***, a regional project, ***Co-developing Services for Sustainable Living (ASKEL)***, was funded from the European Regional Development Fund. The ASKEL project facilitated development of three eco-efficient services with a citizen community and a housing cooperative in Lahti (LAB 2021b). The project improved SME´s capabilities to produce circular- and sharing economy-based services to help consumers move towards low-carbon housing and consumption.

Interreg Baltic Sea Region funded projects have also been central in the Päijät-Häme region. The Regional Council of Päijät-Häme has promoted sustainable smart specialisation and green transition with the ***GRETA project***. It aimed to develop policy tools for sustainable smart specialisation innovation strategies in the Baltic Sea region, supporting green transformation in ways aligned with the EU Green Deal (Mariussen 2021, 3.). Furthermore, LAB is a partner in the ***Baltic Sea Region S3 Ecosystem Platform project***, which shares and disseminates transnational smart specialisation cooperation concepts developed around the Baltic Sea (Leino & Hunter 2020, 5).

Towards holistic and systemic crosscutting sustainability

The new regional strategy of Päijät-Häme 2022–2025 and the shaping of smart specialisation present a change in the role of the circular economy (Päijät-Hämeen liitto 2022, 8). In the updated smart specialisation strategy, the former spearheads circular economy and design are seen as founding the cross-cutting principal 'sustainability' (Päijät-Hämeen liitto 2022, 8; 13). The new spearheads are, thus, more specifically related to industrial sectors: sports, food and beverages, and manufacturing. The opportunities in Päijät-Häme are seen to be at the intersections of the spearheads and principles.

In addition to the selected spearheads being provincial strengths, they also meet the European Commission's other requirements for smart specialisation. The region has enough companies, education, RDI activities and internationalisation potential in the leading industries (Päijät-Hämeen liitto 2022, 8-9). These have the potential to rise to the next level and respond to the structural change caused by low-carbon targets and digitalisation. The new perspective is very welcome to bring on the systemic change towards sustainability.

Expanding the cooperation

The experiences of the results and cooperation in Päijät-Häme serve as a good example on how funding from, for example, Interreg programs is suitable for boosting strategic regional research and development activities. Through the collaboration between the Regional Council and the University of Applied Sciences, as well as other regional stakeholders, valuable synergies for regional development have been found.

In LAB's other operating region, South Karelia, the focus areas of the new regional strategy 2022–2025 are based on the four aspects of sustainable development: social, economic, environmental and cultural sustainability (Etelä-Karjalan liitto 2022, 17). The strategic spearheads of smart specialisation are attached to each focus of the regional strategy, forming an RDI entity related to their theme. For example, related to entrepreneurship, the strategy aims to support industrial renewal and thematic, broader entities across provincial borders. New openings in the bio- and circular economy as well as industrial digitalisation are planned to be realised by companies and diverse project consortia. Attention is paid to the development of knowledge-based entrepreneurship and to supporting new spinoff and start-up companies.

To move towards sustainability is a shared aim in Europe. Likewise, how to actually achieve concrete results is a joint challenge. Smart utilisation of interregional and regional development funding can give advantages. Tight and successful regional cooperation between central stakeholders; for example, clusters of companies, higher education institutions, and regional development authorities, provides the advantages for regions to support the sustainability transition.

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Katerina Medkova & Marjut Villanen

Supporting Sustainable Community in Päijät-Häme, Finland

The Citizen Involvement in Circular Economy Implementation (CECI) project aims to improve related regional policies. The Interreg Europe co-funded project connects eight partners from six countries: Finland, France, Spain, the Czech Republic, Bulgaria, and Belgium. Two partners from Finland participate in the project, LAB University of Applied Sciences, which acts as a lead partner, and the Regional Council of Päijät-Häme as the project partner representing public authority (Interreg Europe 2022a).

Through interregional cooperation, CECI collects and shares already-tested good practices to inspire other regions to implement them to boost the circular economy and emphasise the role of citizens in its implementation. These successful practices, knowledge exchange and site visits, serve as a base for designing action plans in all partner regions (Interreg Europe 2022a). Currently, 64 good practices have been identified in CECI and are displayed on the project website, out of which 25 are from the Päijät-Häme region, Finland (Interreg Europe 2022b).

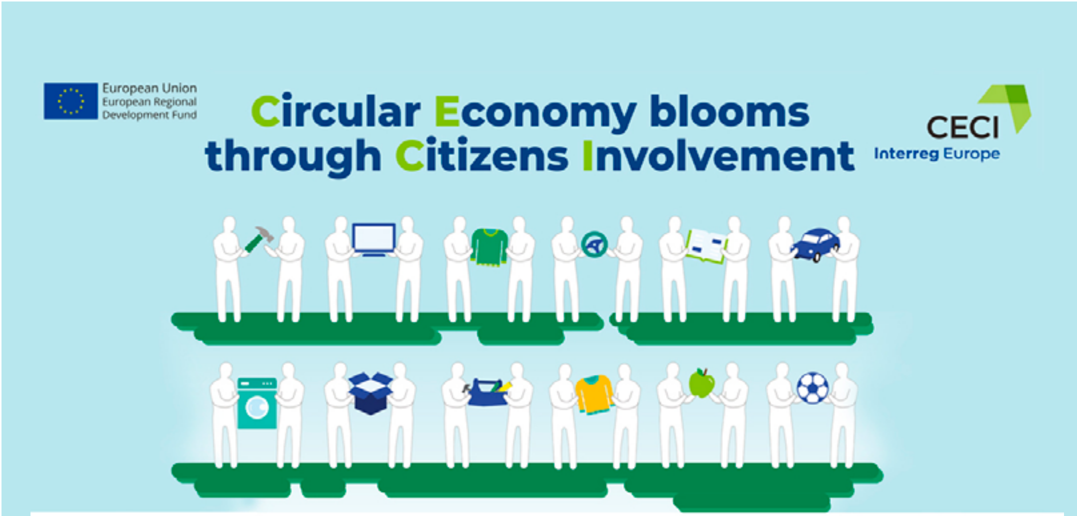

Image 1. CECI – Circular economy blooms through citizens involvement. (Rouhiainen 2020)

The following four CECI good practices from Päijät-Häme, Finland, have been selected based on their unique approach in addressing various ways to engage citizens in the circular economy.

Bioneer – improving the collection of biowaste from detached houses

Bioneer is a biowaste collection experiment that began in 2020 as an ERDF-funded project in Lahti, Finland. The Bioneer service is targeted to detached houses in built-up areas, and it is organised by the local waste management company Salpakierto Ltd. When the experiment started, only houses with over 10 apartments were obligated to separate their biowaste (Päijät-Hämeen jätelautakunta 2021, 13). Detached houses were exempt. The regulations are changing, and in 2024, all detached houses in larger towns must separate their biowaste from mixed waste (Ympäristöministeriö 2021).

The Bioneer experiment was used to collect customer feedback on a cost-effective and environmentally friendly method of biowaste collection. What makes the Bioneer concept sustainable is that the biowaste bins are emptied by a van instead of a bigger waste truck. By recycling their biowaste, the households have the potential to decrease their costs for waste collection by extending the interval between their mixed waste bins being emptied. According to the results collected during the experiment, most participants (66%) used that opportunity. Customers who participated have been very happy with Bioneer service, and the feedback has been positive during the whole experiment. This experiment also had a positive effect on overall interest in recycling (Interreg Europe 2022c).

Local rubbish to raw materials

One easy way for citizens to participate in climate action and the circular economy is by separating and recycling their waste correctly. In March 2021, the municipal rental housing company Lahden Talot installed sensors in the mixed waste bins of 10 apartment buildings in Lahti, Finland. With these sensors, the variation and volume of mixed waste were measured. During this three-month long campaign, the residents of those 10 apartment buildings got information about how their recycled waste could be utilised. The experiment challenged the residents to rethink their waste as a valuable raw material. The installed sensors monitored the volume of waste in real-time. During the campaign, recycling

Image 2. The Bioneer (in Finnish Bioneeri) project experiments with a more sustainable and efficient collection of biowaste from detached houses in Lahti. (Photo: Marjut Villanen)

Image 3. Sensors installed in the mixed waste bins in Lahti, Finland, helped to decrease the volume of mixed waste. (Image: Anna Svartström)

was improved and the volume of mixed waste was reduced. In one case, the reduction achieved was 17.2%.

Since mixed waste is the most expensive type of waste, there are also economic benefits to recycling. The main reasons not to separate waste correctly are lack of information, lack of effort and lack of space. The experiment showed that when residents were better informed and encouraged to recycle more efficiently, they were more willing to do so. At the same time, the waste management costs were reduced, which can act as an additional inducement (Interreg Europe 2022d).

Hair waste as a part of the circular economy

The Hiukka project utilises hair waste to produce hair fibre mats for environmental use. These mats are tested around stormwater wells to filter out impurities. They are also used for soil improvement as hair contains nutrients for plants and binds moisture. The next experiment is to test the mats for oil control in the port of Lahti. More possible ways to use the mats are being tested in the local Kymijärvi power station. The local energy company is investigating whether and how the hair fibre mats are suitable for iron filtration.

Hair waste is currently disposed of as mixed waste. Although the exact volume of hair waste is not known, the amount of unutilised hair waste can be expected to be enormous. Citizens can join the project as 'hair fairies'. In total, 22 hairdressers are already involved in the Hiukka project. Animal hair from horses and dogs, as well as wool, is also used for the mats. Three animal trimming companies are already participating in the project (Interreg Europe 2022e).

Monitoring service for properties

The smart property monitoring service Reiot allows citizens to measure the air quality, water and energy consumption of their household and understand better the household's carbon footprint. When service users see the correlation between adjusting their habits and the change in water and energy

Image 4. Human or animal hair is an organic fibre with unused potential. (Akyurt 2019)

consumption, it motivates them to reduce consumption.

Reiot is a part of the environmentally conscious services offered by Lahti Energia, a local energy company. Because households account for a significant proportion (about 66%) of Finland's consumption-based emissions, and housing is one of the biggest carbon footprint contributors, it is important to understand the impact of different lifestyles. Monitoring and tracking motivate and help citizens to minimise their carbon footprints (Interreg Europe 2022f).

Summary

Some sustainable solutions already exist in the neighbourhood, some in other regions or even in other countries. Citizens, communities, and policymakers are still unaware of these possibilities. It is important to share and promote the knowledge of these good practices to make better use of them and to develop a more sustainable society.

Some of the CECI good practices have already inspired other project partners to implement similar actions in their regions, which will then be implemented in their regional action plans. Some of the good practices from Finland have already inspired all the project partners. For instance, the Reiot example has been referenced in the French action plan.

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Eeva Aarrevaara & Alexandra Maksheeva

Master Program Students Collaborating with Finnish Working Life

Multidisciplinary master-level education, the ***Master in Urban Climate and Sustainability (MUrCS) programme***, has been integrated with LAB since spring 2019. During their stay in Finland, international students have experienced working life briefly via the internships in the Päijät-Häme region. This article discusses the MUrCS programme story as well the student experiences and internships in different organisations and also the challenges to integrate into Finnish working life.

How it all started

The awareness of emerging climate change and the need to enhance multidisciplinary master-level education for professionals with different backgrounds were the drivers of the consortium striving for a new kind of master education by the beginning of the 2010s (Emmanuel et al. 2020, 6-7). In the Erasmus+ project 'Rescue', several higher education institutes were proving understanding of the current education opportunities and justifying a new kind of programme. Lahti University of Applied Sciences was the coordinator in the project. (Aarrevaara et al. 2013, 1-2)

After a couple of years of preparation, the new consortium succeeded in getting the funding for the programme to start the first application period in 2017, with the first intake in 2018. The consortium formed a managing group from representatives of each partner university to govern the application process, which includes basically two steps. First, the applications are evaluated and graded by different staff members based on the education and work life background of the applicants. In the second stage, online interviews are arranged with the highest-graded applicants, and they are given a separate evaluation based on those.

International Master students learning about urban climate and sustainability have spent half a year in Lahti since spring 2019. The first group of students started their studies in September 2018 at Glasgow Caledonian University, which is acting as the coordinator of the Erasmus Mundus joint master's degree, MUrCS (Aarrevaara & Horn 2019). LAB University of Applied Sciences and the University of Huelva have been the partners in the programme. Since the planning phases, one firm requirement has been to require the applicants at least two years of work experience after their Bachelor degree (Image 1).

The first MUrCS programme contained three intakes. In 2019 a new funding period was granted to a modified programme MUrCS1.5 which includes a new partner, HTW Dresden in Germany, and updates the study programme. Through the new partner university, the roles of nature-based solutions and urban ecosystems are strengthened in the programme. Based on this funding period, four more intakes are possible, with the first of them starting in autumn 2021 in Glasgow.

Image 1. The third MUrCS student group visiting the Karisto area in Lahti (Image: Alexandra Maksheeva)

Enhancing connections with work life

The requirement of work experience for the eligible applicants was first experienced as a challenging issue among some partners because in universities it is always possible to continue straight from Bachelor-level to Master-level studies. However, this requirement has appeared to be very interesting and even crucial in the application process. Based on their work experience, the applicants could prove their qualifications for the multidisciplinary programme. The new students have also been very interested to get real work life experiences through internships and work life-based projects during their stay in a partner country.

The internship is considered in the MUrCS context as a student placement in a public or private organization from one to four months, where the working tasks are related to the topics of urban planning, climate change, sustainability, waste management and circular economy. A maximum group of four students has been supported by a single organization. The students can sometimes work part-time in the office or just have meetings with a client. (MUrCS Consortium 2021)

Internship tasks for international students

The MUrCS programme has institutional and industrial partners in every partner country. In Finland institutional partners are the Päijät-Häme Regional Council and the city of Lahti, while the industrial partner is Ramboll Finland Ltd. (Urban Climate and Sustainability 2021.) In 2019 some of the students were involved with different projects in Ramboll and also rewarded for their successful input. The internships in 2020 included groundwater data visualization and a report for Helsinki Environment Services (HSY), preparation of an interactive sustainability map for the city of Lahti and assessment of business in the environmental and sustainability sector of organisations like the World Bank.

In 2020 the Päijät-Häme Regional Council provided an internship for two students to work on identifying the major climate-related risks for the region and making recommendations for risk mitigation in the form of a climate change adaptation plan. Two other students evaluated regional circular economy policies and strategies to identify existing gaps and opportunities. The regional council also supported contacts with municipalities, and as a result one student completed the noise-level measurement in the centre of Hollola to identify quiet places using a decibel meter and provided a noise map based on the fieldwork. Another student worked on identifying stormwater discharge points in the surrounding urban areas of local lake systems.

Also in the same year, one student worked on producing climate-sensitive street design for the municipal centre of Orimattila. Her fellow student worked to identify the biophysical attributes of the local landscape and to enhance a green infrastructure master plan to support sustainable city development (Image 1).

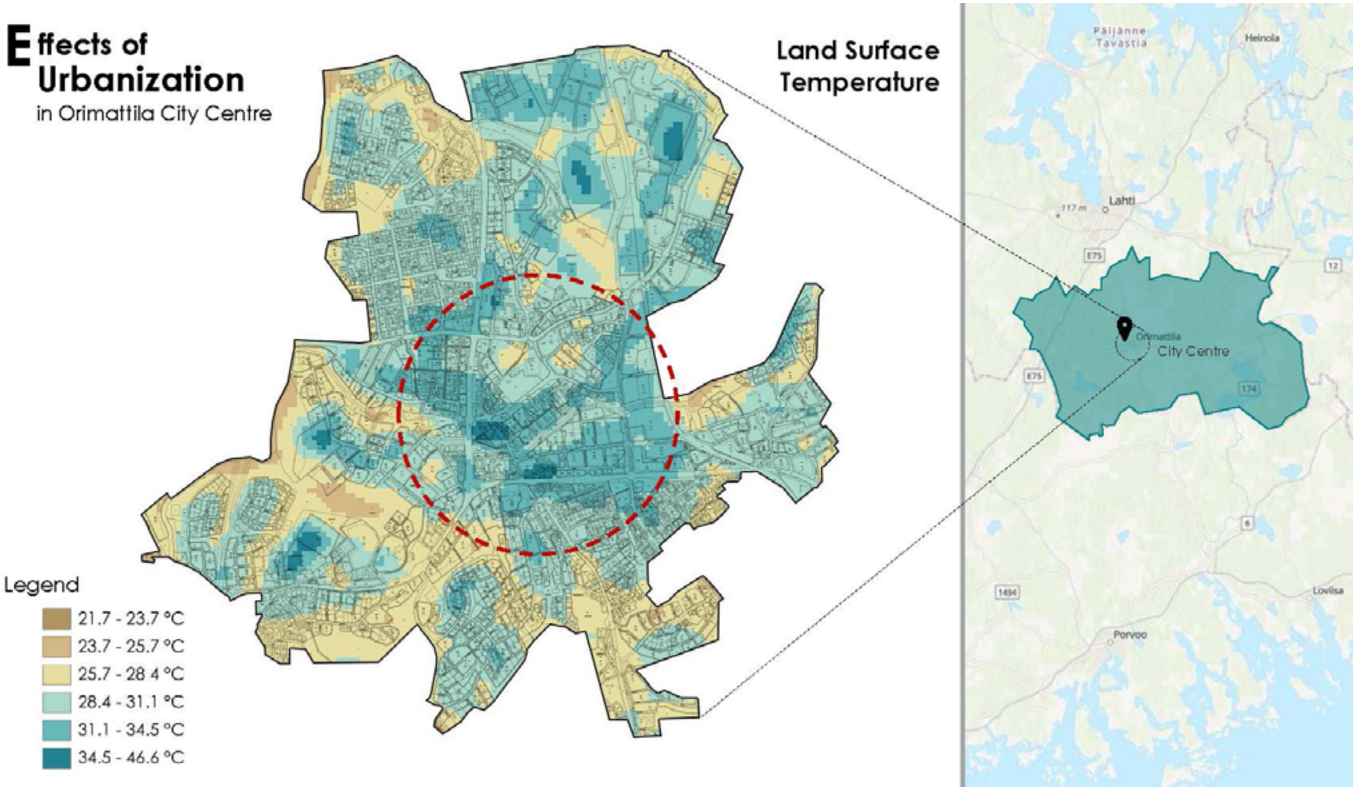

Image 1. Land surface temperature in Orimattila city centre (Valdez 2020)

The year 2021 caused more challenges than earlier years due to the later start for the third MUrCS intake. A couple of them arrived in Lahti in July and were able to work for the city of Lahti in a development project in the Nastola church village. An environmental analysis and development proposals were prepared for the area, and some of the illustrations were presented in a local resident meeting during autumn 2021.

MUrCS students have also participated LAB RDI projects like **HYPE (Wellbeing and clean environment – Japan-Finland cooperation platform for Asian markets)** as well as **Collaborative Mukkula (citizen-based developing experiments and collection of multilayered knowledge in Mukkula 2020-2022)**. In both projects the students have been collecting research information and making literature reviews as well as developing possible solutions for environmental development. (Popal 2021, 22-31.)

How to support internships in practice

The role of the staff in LAB has been to actively contact public and private organisations for internship opportunities, in this case both institutional and industry partners. The students have felt they lacked guidance in the workplaces, and they hope for more interaction with the clients. They would also like to learn more about the Finnish work culture. Although these challenges have been identified with all stakeholders, the results of the internships have been, in all cases, abundant and useful for the client.

The summary of internships and their detailed contents is based on the email responses of MUrCS students collecting the information required.

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The theme of this publication is circular economy, which is one of the four focus areas at LAB University of Applied Sciences (LAB). This publication contains 14 articles written by experts from LAB and its stakeholders. This review presents the latest interesting research, development and innovation activities in the context of sustainable circular economy. This publication supports communication with LAB's partner universities, companies and other stakeholders, and it is a part of sustainability and circular economy related actions in the R&D, educational and company partnership operations of LAB.

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