Sustainable Urban Environment | Material Efficiency | Energy Efficiency

Kirsti Cura and Maarit Virtanen (eds.)

Lahti Cleantech Annual Review **1 / 2014**

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Lahti Cleantech Annual Review **1 / 2014**

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Lahti University of Applied Sciences

The publication series of Lahti University of Applied Sciences
A Research reports
B Study material
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Preface

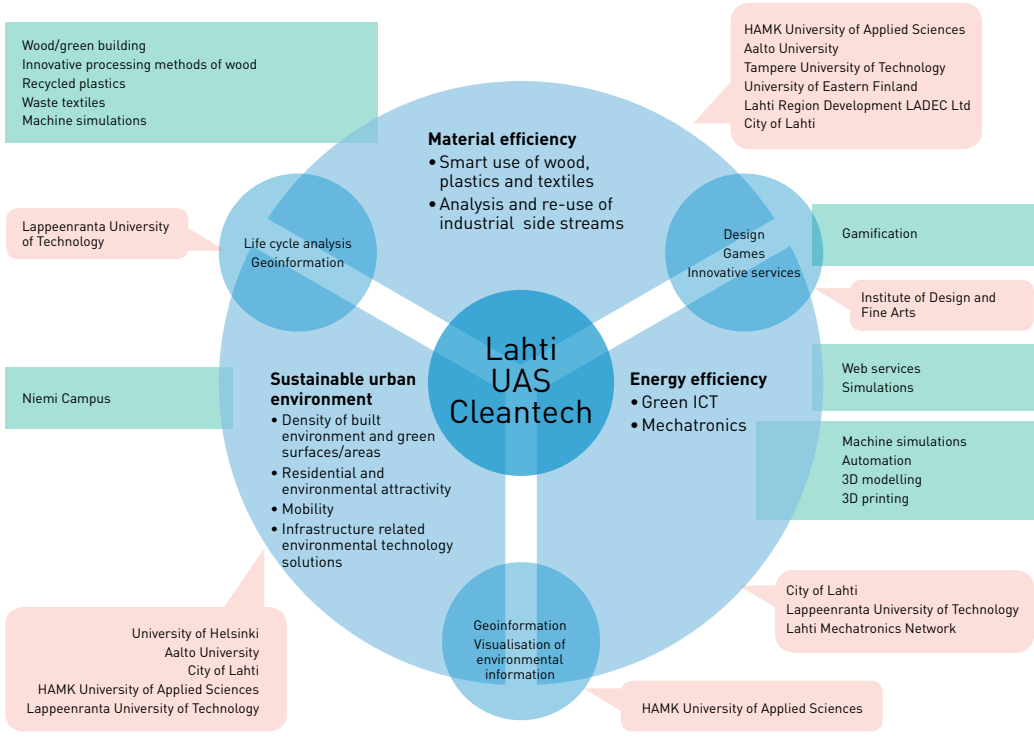
We have to learn to make things smarter, because otherwise our globe will not survive. In addition to scientific research and policies supporting this change, we need development work which aims at technological solutions using less energy and utilising materials more efficiently than the existing ones. These have to be based on the idea of closed circles, i.e. industrial symbiosis where somebody's waste is somebody else's raw material.

Clean technology refers to all products, processes, systems and services, which harm the environment less than their alternatives. Clean technology brings added value to the customer while at the same time, either directly or through the value chain, reduces the harmful environmental effects. Engineers are one of the key actors for designing clean technology solutions. In addition, more and more services are designed aiming at extending the life cycles of products.

According to the vision presented in the government's cleantech strategy "Finland is a global superpower in the cleantech business in 2020". The goal of the strategy is to accelerate growth in Finnish cleantech business and to renew traditional industry through innovations in clean technology. The combined turnover of Finnish cleantech companies was about EUR 25 billion in 2012, with 15% growth from the previous year. The special Finnish strengths in cleantech business activities include resource efficiency in industrial processes – i.e. energy, materials and water efficiency – as well as bioenergy and biobased products.

This Lahti Cleantech Annual Review is one of the outcomes of the development process which started five years ago in Lahti University of Applied Sciences (Lahti UAS). In October 2009, an idea for a "Cleantech Engineers" project was presented to the regional research and development funding authorities and to Lahti Region Development LADEC Ltd (previously known as Lahti Science and Business park Ltd). Luckily, the project idea was accepted for funding and the project started in May 2010.

One of the objectives of the Cleantech Engineers project was to find cleantech competences which should be included in the curricula of Degree Programmes in the Faculty of Technology at Lahti University of Applied Sciences. In addition, the main cleantech knowledge gaps were identified and necessary training was organised for teachers and other experts. The model which was developed was based on the project based or problem based learning pedagogy and the culture of carrying out co-operation with companies according to the CDIO framework (C = conceive, D = design, I = implement, O = operate).



LAMK Cleantech-osaajat / 8.4.2014

Figure 1. Schematic representation of Lahti UAS Cleantech (Lahti UAS Faculty of Technology 2014).

When the Cleantech Engineers project ended in 2013, a next step was to identify cleantech research and development (RD) themes in Lahti UAS. Financial support of the Elite2 project (LADEC Ltd) made it possible. The process was conducted during the autumn 2013 and spring 2014, and resulted in three main themes: material efficiency, energy efficiency and sustainable urban environment (Figure 1). In addition to interviews of Lahti UAS and stakeholder experts, relevant strategies and other documents were analysed. Schematic representation of Lahti UAS Cleantech includes the main themes, relevant core competences, technologies, initiatives and topics alongside the most important partners. Environment is one of the three focus areas of Lahti UAS. In FUAS, Federation of Lahti, HAMK and Laurea Universities of Applied Sciences, Lahti UAS is responsible for the development of the Environment and Energy Efficiency focus area.

This review consists of articles written by experts from the Faculty of Technology and Institute of Design, Lahti UAS. It is the first Lahti Cleantech Annual Review, but definitely not the last one. The purpose of this review is to annually present good examples of RD work and initiatives by Lahti UAS and its partners. The focus of the review is on the development activities in material efficiency, energy efficiency and sustainable urban environment themes. In this review, the material efficiency theme is presented by three articles, one of which focuses on 3D printing with biodegradable fibre reinforced plastics, second article introduces the recycling potential of textile materials, and third article presents woodchip product cards, designed for a company in a student project. In addition, design as a tool to produce zero waste, or to make products from waste, is described in one article in the context of education. Energy efficiency is the topic of three articles, first article of which is focusing on Green ICT in small and medium sized companies, second article tells about bioethanol concept of an innovative Finnish company and third article presents two local cases where renewable energy solutions were sought by students for interesting showcase locations with genuine needs. The sustainable urban environment theme is represented by an article on stormwater. This review presents only part of the development work in Lahti UAS and plenty of articles are published in Finnish in other journals. Some of the topics like development projects in mechatronics were left for a next volume.

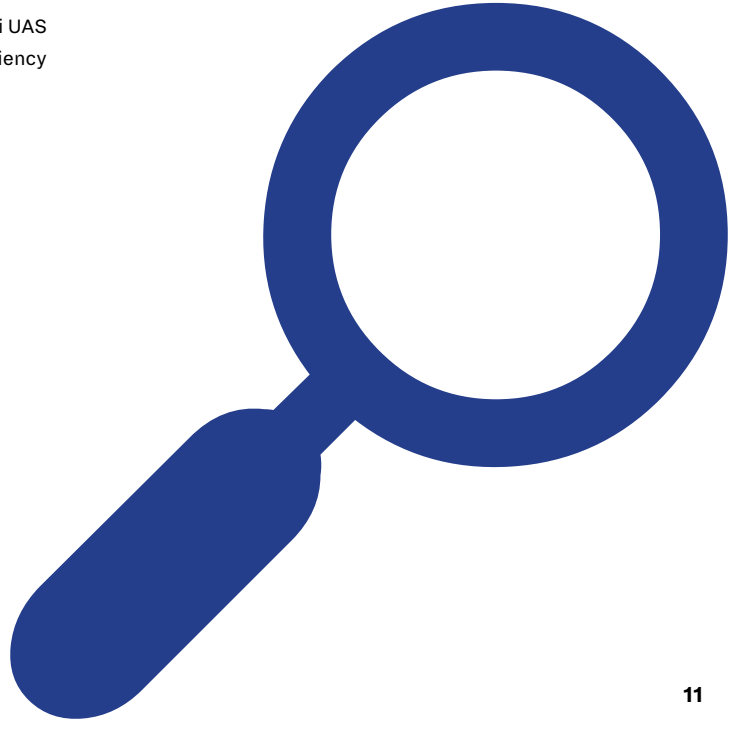
There is still a lot of learning and work left to be done. The schematic representation of Lahti UAS Cleantech and the Lahti Annual Cleantech Review help us both in communication with potential partner universities, companies and other stakeholders, and also in implementation of cleantech themes in the Lahti UAS RD and educational operations. Strategic partnership negotiations with companies have started and one agreement has already been signed. In volume, Lahti UAS is the most important higher education institution in the region, including the potential of over 5000 students and a lot of expertise. Our special focus is on small and medium sized companies (SMEs), but we are not excluding larger ones (!). SMEs do not necessarily have the resources to develop their cleantech business, which makes co-operation with universities valuable.

I am glad that the first Lahti Cleantech Annual Review is almost ready to be published. Thank you to editors Kirsti Cura and Maarit Virtanen for your effort and thank you to the

authors. Writing an article is an extra effort and you did a great job! We have plenty of ideas how to develop this review further, and for the next issue we challenge our colleagues from partner universities and from companies to write with us in the context of cleantech.

Lahti, 26th of October, 2014

Silja Kostia
Dean of the Faculty of Technology
Chair of the Environment Focus Group of Lahti UAS
Chair of the Environment and Energy Efficiency Focus Group of FUAS



Reijo Heikkinen

3D Printing with Biodegradable Fibre Reinforced Plastic

Figure 1. 3D printer (Felixprinter).

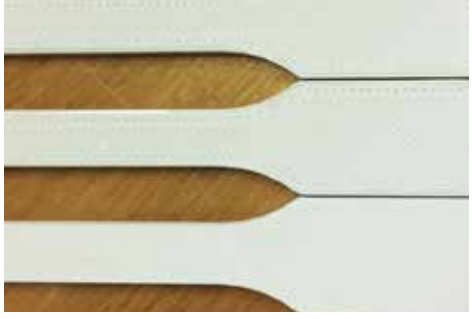


Figure 2. When printing larger areas or several parts, extruded filament does not melt very well to the previous layers. This is shown in this figure, where the lowest part is made individually, and the upper two have been made together (E. Hakala 2014).

3D printing has become accessible to everyone. The cheapest equipment costs less than a thousand euros and it is capable of printing with complex plastic and functional objects. In particular, the FDM (Fused Deposition Modelling), which is discussed in this article, is the fastest spreading printing technology (Figure 1). The system is based on the use of a simple extruder, where the wire-like filament material is melted and extruded through a small nozzle along the computer controlled path layer by layer. The method requires the use of a computer programme to make a digital 3D model.

Lahti University of Applied Sciences acquired their first FDM printer in the end of 2013. The laboratory of Plastic Technology purchased the printer in the beginning of 2014. The printer is particularly intended for research purposes, and it is used in projects by students. The printing filament is made by a laboratory extruder and with a suitable nozzle, which was originally used for welding filler manufacturing. In the spring 2014, a first thesis on printing and filament manufacturing, and strength properties of the printed parts was carried out by Emmi Hakala. In this thesis, the strength of the material made using FDM was compared to the same material made using injection moulding and printing.

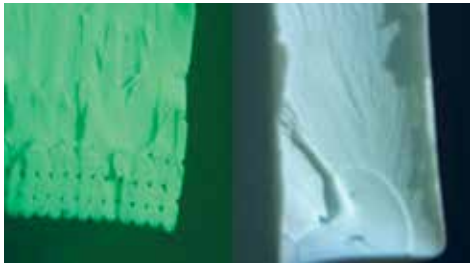


Figure 3. Injection moulded part is non-porous and isotropic compared to the printed part (E. Hakala 2014).

Figure 4. Raw cotton fabric was first cut into smaller pieces (R. Heikkinen 2014).

Figure 5. Ground fibre ready to be mixed with plastic (R. Heikkinen 2014).

Figure 3 shows how easily porosity remains in the printed part. The figure shows clearly the layered structure. A 100 % filling level is very difficult to achieve. If filling exceeds 100 %, the part easily fails. The strength of the parts is, however, surprisingly good. Compared to the injection moulded part, the strength is just as good in relation to the filling ratio in the direction of the layers. Because of the influence of bad melting through the layers the strength is a fraction in the cross section of the layers compared to the injection moulded piece, so the material is highly anisotropic.

At Lahti UAS a Bachelor's thesis by Katja Kauppinen was carried out in 2011 on mixing cotton fibres with plastic. Cotton rags were first ground and then mixed with polypropylene at various concentrations. The fibre reinforcing effect was significant and the test showed that the mixing of cotton was an effective way of using cotton together with the plastic.

An experiment was carried out for this article repeating the same procedure to make fibre-reinforced plastic material. However, the plastic used was changed from polypropylene to polystyrene, which is much better suited for printing. The fibre content was limited initially to 10 % by weight. Raw cotton fabric was first cut into smaller pieces, so that it was possible to be ground by a mill. The mill was originally designed for shredding plastic, but it was found to work excellently in grinding the fabric.

Figure 5 shows the ground cotton fibre. The matrix material can be starch-based biodegradable polysaccharide or polystyrene.

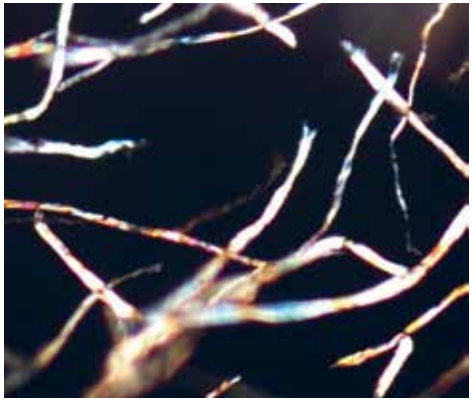


Figure 6. Microscope shows the structure of the cotton fibre. The length of the fibres is approximately 1 mm. Like typical polymer, the cotton reverses the polarisation direction and it is birefringent. (R. Heikkinen 2014).

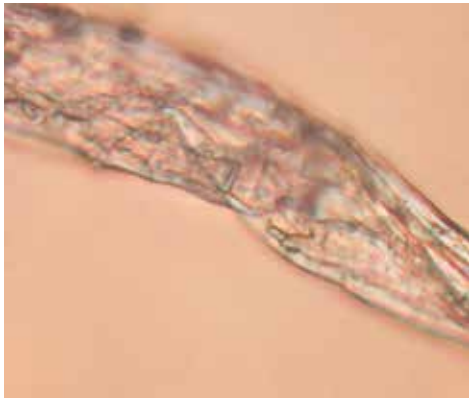


Figure 7. At high magnification it is clearly visible that the cotton fibre is flat (R. Heikkinen 2014).

The fibre is flat in cross-section. The dimension is usually between 10 and 30 µm. The strength of the fibres is 3-5 g / denier. The fibres and the plastic were mixed in 1 + 10 parts by weight. Mixing was done by an extruder, which was also intended to make the actual filament. Due to the low density of the ground fibre, it was not possible to make higher fibre content during one mixing. A mixer which could make blends of plastic and reinforcement with larger mixing ratios is planned for the laboratory in 2014-2015.

Normally, the printing filament is made by an oversized nozzle to meet the required filament diameter by pulling the filament thinner (Figure 8). This method is very accurate without complex calibration tools. However, this method is not suitable for fibre reinforced materials. If the drawing ratio becomes greater than 1:1.3, the filament gets broken. Unreinforced filaments can be pulled up to 1:3 at a draw ratio without problems. Nevertheless, all unreinforced materials cannot be pulled at high draw ratios.

The fibre must be dried thoroughly, as cotton may contain 6-8 % water. The melt mixing with high water content tends to cause evaporation, causing bubbles and foaming. Cotton must be dried for 12 hours at 60° C. After drying, the cotton still seemed to dissociate gases, which could be water coming from the plastic material. On the other hand, the mixing takes place at a temperature of 200° C, so the residual water and possibly the thermal decomposition of cotton easily causes the release of gases. However, the colour of the cottons did not become any darker, so decomposition is unlikely to have happened.

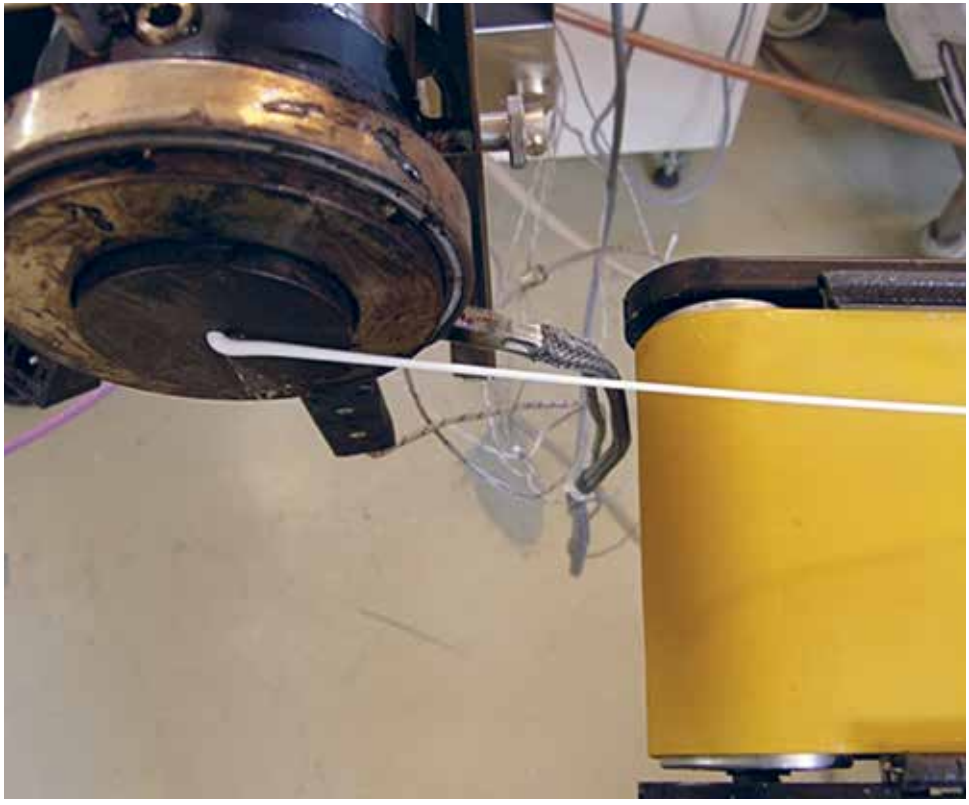


Figure 8. A variable speed conveyor belt pulls the unfilled plastics exactly to certain thickness. Just by pulling it was not possible to make the right diameter from fibre reinforced material. In addition, the filament contains lot of bubbles (R. Heikkinen 2014).

Since the extrudate cannot withstand the high draw ratio, the nozzle must be made to meet the desired filament size, especially when this type of die swell is very small. Cotton likely to contain water also caused bubbles in the filament. Water is surprisingly difficult to remove with sufficient precision to enable the successful melt processing of plastics. Drying is very difficult, particularly if the cotton achieves long-term equilibrium moisture content when mixed with plastic. In this case, a large amount of water is diffused through the plastic layer.

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Sakari Autio and Lea Heikinheimo

Recycling Potential of Textile Materials

The word “waste” could and should be already consigned to history. Used textiles are valuable raw materials or fuel. This text aims to bring to light some essential issues related to material recycling of textiles. The reuse of textiles, waste to energy strategies and development of textiles life cycle are also discussed, but to a lesser extent. Recycling is a small but important part of the concept of resource efficiency, where we so far have not reached a very advanced level.

About 70 000 tons of clothes and home textiles are used each year in Finland. Every Finn purchases over 13 kg of textiles yearly and the amount has been increasing. Most of textiles end up in waste, thus shortening the potential using phase of textiles. Finns produce 9 kg of waste textiles per person yearly. When compared to overall waste “production”, which is about 500 kg per inhabitant in the Lahti region, the amount of textile waste does not sound so significant. If you take wide negative environmental and sustainability impacts of the life cycle into consideration, the importance of reuse and recycling increases. Reuse and recycling of this valuable material reduces the impacts of dumping, while multiple improvements come via the reduction of negative environmental impacts of the production phase of textiles. The textile supply chain is one of the longest and most complicated supply chains of any industrial product. For example about 25 % of all pesticides used globally are needed to produce the cotton for our everyday T-shirts and other cotton fibre textiles. The reuse or recycling of 1 kg of cotton also saves about 7000 – 10 000 kg of irrigation water - and this saving occurs in countries suffering from a lack of fresh water.

Presently the textile waste reuse and material recycling rate in Finland lies at less than half (40 – 45 % approx.) of all textile waste. So far most of the used textile is landfilled, but in the Lahti region the textile waste is already being used for energy recovery through efficient gasification. From the beginning of 2016, organic waste such as textiles will not be allowed to be landfilled any more in EU countries. Energy recovery through waste incineration will probably then be a widely used method for disposing of this used raw material. How to get the valuable fibre raw material for better use before incineration is an interesting issue. Incineration as the first step does not follow the waste management principles of the EU. Waste prevention, reuse and recycling of (waste) materials are to be considered before incineration.

Figure 1. From the beginning of 2016 organic waste such as textiles can no longer be landfilled in EU countries (S. Tuomikoski).

There are several success stories with recycling different kinds of materials in the Lahti region. The story of metal recycling has been well known for decades. In recent years the value of organic waste (food waste/biowaste) has increased. An efficient sorting at source system makes it possible to produce biogas and fertile compost, useful for farming, in a profitable way. Now certain construction waste streams are also collected for material utilisation. All these improvements are realised through cooperation of public and private waste management and recycling companies, involving the inhabitants and enterprises of the region.

Normally, the textile raw material itself is reusable after the using phase. There are also a lot of opportunities for better utilisation of used textiles, but large scale industrial solutions are still in need of development. The driving forces for improvement are based on better knowledge of the textile waste and suitable logistical solutions. The development of legislation, technical and social innovations, as well as money are a part of the story. There are interesting textile waste projects going on in Finland and in other Nordic countries, such as Texwaste (Texjäte) - coordinated by the Finnish Environment Institute, which hopefully can find ways to improvements. Lahti University of Applied Sciences participates in a project called “Poistaripaja - Työpajamuotoisten poistotekstiilipankkien kehittäminen valtakunnalliseksi toimintamalliksi”, where a new model for a used textile material bank for Finnish regional and municipal use is developed. Lahti UAS’s task involves improved methods of textile recognition ranging from the use of the naked eye to a number of chemical-based ways.

The amount of textile waste generated in Lahti region can be estimated to be about 2500 tons per year. In Lahti region we have one of the most advanced sorting at source collection systems of municipal solid waste in Finland. Better textile separation alternatives would fit well into this sorting culture. Also, there has been on-going research concerning the content and utilisation of different waste streams. A natural step could be a research study on textile waste. The knowledge base on this aspect is not very strong in Finland. More information about the textile waste, material and fibre mixtures is essential when developing material recycling. An informative identification system for textile materials and fibres could be developed in a similar way to that involving plastics, which has been one key factor in the diverse utilisation of PET plastics. Studies on the identification of recycled materials have been carried out at Lahti UAS. One aim of this preliminary study was to analyse different types of natural and synthetic materials (textile fibres and fabrics) with SEM-EDS and FTIR spectroscopy, to validate the analytical methods for recycled materials studies.

The utilisation of textile materials can happen through different stages of the life cycle of textile materials, not only within the textile industry. In addition to regional and national forerunners, also efforts from the European Union are important. If textiles were included in the EU-wide Extended Producer Responsibility (EPR) procedure, it would solve the financing issue and the development of

Figure 2. Old bed sheets can be turned into rugs by crocheting (K. Sorola, 2014).

recycling industry of used textiles. For example, a one euro recycling fee in the price of a T-shirt would not be too much for an ordinary European consumer to pay. In fact, many would probably welcome it, knowing the huge employment and raw material potential of recycling.

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Noora Nylander

Zero Waste and Upcycling Waste into New Products – Sustainable Design Teaching in Institute of Design

Sustainable Design teaching in Lahti University of Applied Sciences Institute of Design consists of a combination of different teaching methods. Students are involved in discussions about environmental design from various viewpoints, as well as in the practical side of design by learning by doing, experimenting and testing. Even though sustainable design thinking involves many different levels, from green design to transformative design (Figure 1) and consists of many steps in a product life cycle, the practical side of a design brief and making a product concept is very often achieved by a material effective design task.

The following steps are included in the life-cycle thinking of a product from the designers' point of view:

- raw material selection and ethical sources of materials
- production, efficient use of materials and ethical manufacturing
- questions regarding sales and logistics of products
- user – usability in practice and social aspects of design as well as users involvement in sustainable products
- creating immaterial objects e.g. services instead of products
- end life - recycle, upcycle, re-use and lengthen – design for future

Material effectiveness as a design practice means using less material and creating no waste. Opposite to this, it also means using actions in which waste has become new raw material. When selecting materials a designer should choose non-toxic materials and use materials from ethical sources or new sustainable technologies. In his/her studies the designer learns where to find information and what things in specific materials might

Method - packaging, http://methodhome.com

TBS China – land air bus
http://inhabitat.com/land-airbus-straddling-bus-as-the-future-of-public-transportation-in-the-city/

http://www.treehugger.com/sustainable-product-design/design-with-waste-from-print-industry-by-onceneto-in-chile.html

CELLE-chair by Herman Miller

One laptop per child by FuseProject

GREEN DESIGN

ECO-DESIGN (DfE)

SUSTAINABLE PRODUCT DESIGN (SPD)

DESIGN FOR SUSTAINABILITY

TRANSFORMATIVE DESIGN

New envisioned scenarios

Focus moves beyond the product

Social aspects also considered

Entire product life-cycle optimised for eco-efficiency

Individual product aspects optimized for environmental performance

Figure 1. Defining Sustainable Design (B. Dusch 2014, adapted by N. Nylander 2014).

cause difficulties regarding sustainability. All the selections lead to design decisions – aimed towards creating something usable and meaningful for someone.

Zero Waste Fashion Design

A Zero waste project is an annual combination of several courses held by the Fashion Design department in the Institute of Design. The course has been running since 2011 and it combines the teaching content from courses in environmentally efficient design and pattern making. As a term, “zero waste fashion” means the new sustainable way of thinking in fashion design. In a “zero waste” process a designer plans the pattern marker on the fabric without creating any waste material. This way of thinking is very different from conventional fashion design. The complexity in pattern making lies in thinking how to make traditional curvy patterns with the effective usage of the square sheet of material.

Kia Koski, Lecturer of Fashion Design in the Institute of Design, describes the basics of the Zero waste project: “The starting point of the training was getting an insight into environmentally efficient and ethical thinking principles, as well as into what the meaning of sustainable product development is. The purpose was to explore how an environmentally efficient way of thinking can be included into a designing process. “

A typical zero waste design process contains restrictions and challenges for students. Normally the restrictions are presented naturally by the width of the fabric, but also by the chosen material and the amount of material. In the year 2014, the Zero waste project was made out of 1.5 meters of leftover cotton and 1.5 meters of roll-ends of bamboo jersey. Both fabrics had a width of approximately 1.5 meters. The material effectiveness is one key design decision of the Zero waste project. Even though the basis lies in the broader figure of environmental and ethical thinking, the material effectiveness is chosen as one point of view to start with. ”It is easier for a student to gain insight into their environmental thinking when there are not too many pieces in the puzzle to begin with”, explains Kia Koski. For example, Koski lets the students dye and use colours in their design without thinking of the toxicity aspects in these techniques. These are ruled out from the course task even though in the discussion, naturally, students are told that also these things matter from the environmental point of view.

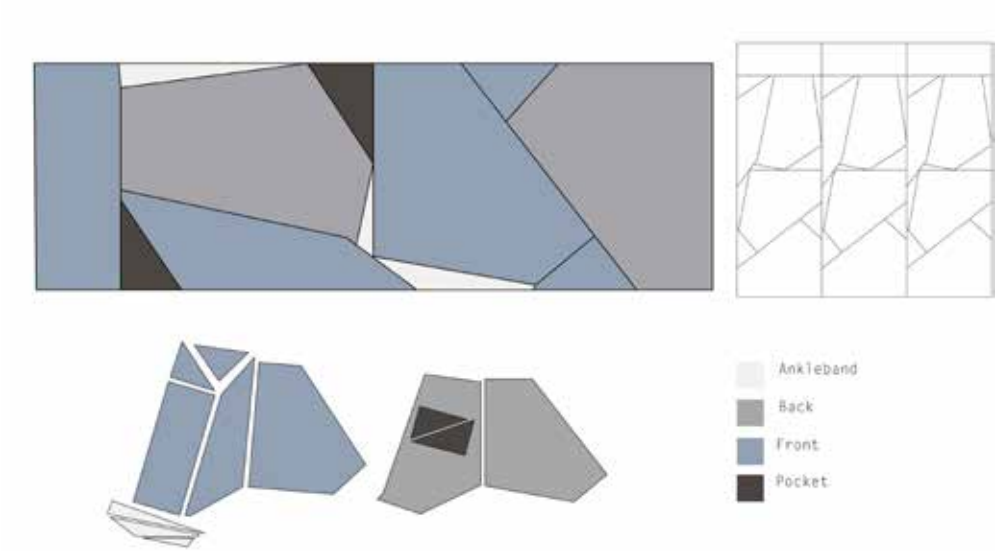

Figure 2. Pattern marker of the zero waste harem trousers (M. Jaakkola & P. Maas 2014).

Figure 3. Zero waste (M. Jaakkola & P. Maas 2014).

Figure 4. Making the Pitsi chair (M. Salmi 2014).

Upcycling Waste Products and Material – Case Specsavers

Upcycling as a design process means converting waste materials or surplus products into new materials or products of better quality. The design thinking is to increase the end life of material as an environmental design act. Sometimes the term trash design is also used in similar design situations. Trash design aims to make use of landfill materials and surplus products instead of using virgin raw materials as a product design solution. In addition, upcycling differs ideologically from recycling. While recycling downgrades the material, upcycling adds value to excess material.

Industrial design students of Lahti Institute of Design had a design brief from Specsavers Nordic. In the design brief, Specsavers asked students to design something new out of the surplus frames that otherwise would be thrown away. Specsavers' marketing point was to arrange a project with design students to raise awareness of responsible material usage and creating new value out of surplus materials. According to the brief, while considering material effectiveness, students named important definitions for their design. Among these were the following statements:

- to use all the material from given frames
- to use frames as a whole to gain savings in production
- to use also other waste material in the final design
- to use similar materials in the final design
- to make the designed object useful
- to make the designed object feasible and durable
- to lengthen the lifetime of excess material from brand value as well as material value points of view

The design process included material exploration by breaking products into parts and creating new surfaces and patterns out of the material pieces, as well as testing different joining methods. After that students produced a new product or prototype of the product out of the frames. Since frames as a raw material are quite difficult to make usable, other materials were allowed to be combined in the final design. In Salmi's Pitsi chair, for example, the web pattern that was designed from frames could be implemented into different products and objects, even though the example produced is the seating of the chair.

Meaningful and challenging enough

As an outcome, the Zero waste project opens up new ways of thinking fashion design as a practice. Parallel to that the upcycling product design addresses the question in student thinking – what is needed, what is meaningful. Can our design thinking create more sustainable products? The design brief needs to be meaningful, and at the same time challenging enough to a proper discussion on how to create sustainable design. Simultaneously, students need to tackle concrete problems of using materials and making ready products out of them to understand complexity of realisation of the design concept into real products. This helps them to understand relations of the design and material decision and production design and how these together create more sustainable life cycles for products. Experimental design process along with the co-operation with other students or companies and finishing the products throughout together creates positive learning experience for students.

Figure 5. Pitsi Chair (M. Salmi 2014).

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Päivi Kärnä

Developing Woodchip Product Cards for a Wood Procurement Company

Lahti University of Applied Science's environmental engineering students have been busy with different working life case projects during the years 2010-2014. Several case studies have been organised thanks to EcoMill project funded by European Social Fund (ESF), Lahti City and Lahti UAS. The goal of EcoMill project was to increase the environmental efficiency of Finnish SMEs by realising environmental efficiency case projects with the students of Lahti UAS. Altogether 27 working life projects were implemented with 18 different organisations. The case projects contributed significantly to developing the working life qualifications of the students and to promoting the environmental activity of companies.

The presented case project was carried out during the spring 2014. The goal was to prepare materials for advertising a wood procurement company's woodchip products. The results of the case were a product database and a set of photos for the company's product cards.

The company commissioning this case work was Koskitukki Ltd. They acquire annually 1.5 million cubic metres of wood, most of which is spruce, pine and birch logs. The company is a part of the Koskisen group which is an internationally acknowledged woodworking industry. The activities of Koskitukki include a sawmill, a plywood mill, wood acquisition, and the chipboard industry. The work provided a good cross-section of the products and activities of the company.

Figure 1. Koskitukki Ltd. is a company that operates in the woodworking industry.

Customer satisfaction is important to the company and it was also seen in setting this assignment. Product cards will serve both existing and new customers. Existing customers who have large boilers need more data about the products which they are using: they have the obligation to report the quality and contents of their residual deposit. The product cards will respond to the needs of the existing customers with the required data.

Also new customers with smaller boilers are interested in knowing more about the contents of Koskitukki products - smaller boiler users need more specific information on the woodchip used to optimise the burning process and the heat energy obtained. From this viewpoint the company was interested in developing product

Figure 2. Dry veneer woodchip is one of the woodchip products which Koskitukki offers to its customers (S. Himanka 2014).

cards to inform their customers on the features of different woodchip products.

The data for the product cards was collected for 18 different products, such as stump chippings, saw woodchip and cutter chips. The work was carried out over eight weeks. The active participants in the case were a company representative, a student and a staff member from EcoMill project.

The goal was to map out the different specifications to be stated in each card, to collect and modify the data into usable form and finally to make a suggestion about the layout. The implementation was carried out through three meetings, one sampling day, the collection of information, three photo shooting days at the university premises, and planning of the product card template with a layout programme.

Figure 3. Samples were collected for photo shooting of the products. Environmental engineering student Sanna Himanka is naming the sample bin for dry veneer woodchip (P. Kärnä 2014).

Figure 4. Saw woodchip at the sampling site (P. Kärnä 2014).

Figure 5. Sampling by the grinding dust (P. Kärnä 2014).

The specifications used in the product cards were:

- name and photo of the product
- classification data
- description
- technical information
- list of advantages
- proposed applications

The product cards are used as separate and combined printed versions, but also in electronic form.

The results of the case work were a worksheet of every product item including the material database and a set of figures from the photo shoot and the sampling day. Since the case was implemented, the company has used the results in completing their product cards. The first versions have already been printed and given out to customers. The product cards are planned to be inserted into the company's web site by the end of the year 2014.

The utilisation of the product cards and the data about product qualities will enable the effectiveness of material usage for the customers and buyers. Co-operating with Lahti UAS proved to be a successful choice for the company.

Figure 6. The photo shoot of samples was carried out in the Niemi campus of Lahti UAS (S. Himanka 2014).

Figure 7. Log ends waiting to be chipped (P. Kärnä 2014).

KOSKITUKKI

Minihake

Teollisuuden puutähteistä (rimat, tasauspätkät, levyteollisuuden viilut, vanerien syrjät yms.) tehty seulottu koivuhake, joka ei sisällä halogenoituja orgaanisia yhdisteitä, raskasmetalleja tai muoveja.

Tilastokeskuksen luokka:
3123 Puutähdehake tai -murske

Käyttökohteita ja etuja
Minihake on vaneriteollisuuden tuoreista hakkeista seulottu alite. Palakooltaan ja kosteudeltaan se on erittäin tasalaatuista ja soveltuu niin polttoainekäyttöön, lastulevytehtaan raaka-aineeksi kuin selluteollisuuden tarpeisiin.

MINIHAKE TEKNISET TIEDOT

Raaka-aineen laatuluokka: 1.2.1.3 Lehtipuu, kuoreton

OMINAISUUS	YKSIKKÖ	VAIHTELUVÄLI	LAATULUOKKA
Mitat	mm		
Kosteus, M	p-%	40 - 50	M 30
Tuhka, A	p-% kuiva-aineesta	0,4 - 1,0	A 0.7
Irtotiheys, BD	kg/m^3	150 - 300	BD 250
Tehollinen lämpöarvo, Q	MJ/kg	6,0 - 15,0	
Tehollinen lämpöarvo, vedetön	MJ/kg	18,5 - 20,0	
Energiatiheys saapumistilassa, E	MWh/irto-m^3	0,7 - 0,9	
Toimitettu energiamäärä saapumistilassa	MWh/t	1,5 - 2,5	

PEFC
PEFC/02-34-12

KOSKITUKKI OY, KOSKISEN PUUNHANKINTA
Mäntsäläntie 64, Järvelä
puh. 020 553 40, fax 020 553 4319
www.koskitukki.fi

Figure 8. An example of a finished product card. Mini woodchip is made of birch residue from industry. It is suitable to be used as fuel, as the raw material for chipboard, or in pulp industry (P. Kärnä 2014).

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Ilkka Tarvainen

Bioethanol from Waste and By-Products: A Finnish Energy Company That Challenges the Conventional

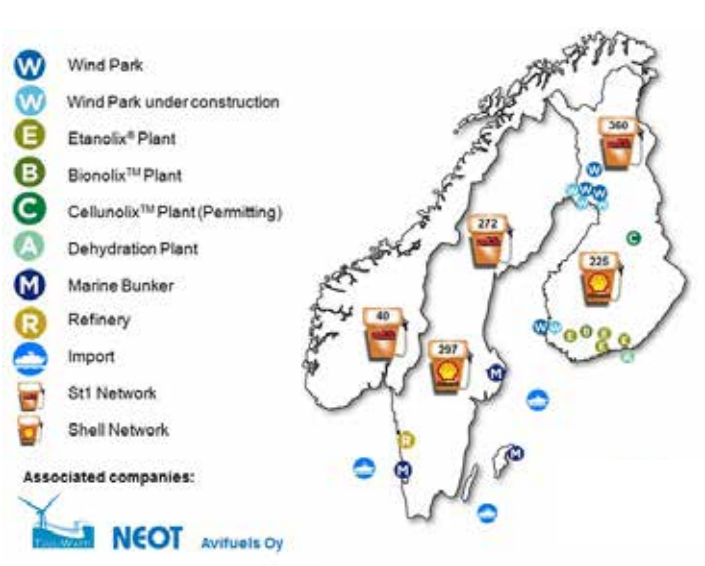

Figure 1. St1 map (St1 2014).

St1 is a Finnish energy company with a vision of being the leading producer and seller of CO2-aware energy. The basis of company is in traditional oil business and selling of liquid fuels for transport and heating, which enables investment for the future. St1 has already bioethanol plants and uses wind power to produce electricity. The company seeks solutions that are technically and economically feasible and ecologically sustainable.

St1 Biofuels Oy is a subsidiary of St1 concentrating on sustainable bioethanol production concept. St1 Biofuels was established in 2006 and has since built several bioethanol plants producing transportation fuel from waste and process residues. Using waste as feedstock for bioethanol offers a concrete way of replacing fossil fuels and reducing emissions from traffic, and also provides new methods for waste management. Bioethanol can be made from various fermentable waste and process residues coming from, for example, bakeries, retail shops, breweries, confectionery production and potato-based production.

St1 bioethanol plants are of two types depending on the feedstock: Etanolix® or Bionolix™. Etanolix® plants utilise various waste and process residues, while Bionolix™ plants use biowaste from households, institutional kitchens and shops. Third type of plant, Cellunolix™, is planned for the near future. In the Cellunolix™ plant, the main feedstock will be sawdust from sawmills.

The bioethanol produced in Finland is used in high blend ethanol fuels. St1 distributes high blend ethanol fuel containing 80-85 % waste-based bioethanol with the brand RE85. RED95 ethanol diesel can be used in ethanol diesel engine trucks and buses.

Cooperation between St1 and Lahti University of Applied Sciences

St1 Biofuel and Lahti University of Applied Sciences have cooperated on studies related to bioethanol for the past three years. The cooperation began with the request from St1 for basic project work with wood technology students. Lahti UAS has done until today five different basic studies, in which students have either surveyed the best raw material sources in saw industry or analysed the markets of sawdust in different countries. The surveys have mostly concentrated on analysing the sawdust resources available for bioethanol production. Students have focused on sawmills, which are big enough and logistically suitably located. Several markets have already been analysed in a basic level: Finland, Sweden, Germany and Austria.

The cooperation has also included a Bachelor's thesis written by Mikko Anttila on opportunities of producing bioethanol from the side streams of sawmills in Finland. The European Union has a new act, which aims to increase the use of renewable resources in energy generation. The target of the European Union is that 10 % of energy content of the fuel used in traffic is produced from renewable resources by 2020. Finland has adopted a stricter target: 20 % of energy content of fuel used in traffic will be produced from renewable resources.

The theoretical part of thesis concentrates on examining what kind of raw material wood is. The most utilised species in Finland are pine, spruce and birch. The thesis explains how the by-products of different sawmills may vary according to, for example, plant size and the production process. All the chosen sawmills were checked with absolute values and it was concluded whether there are necessary amounts of sawdust available. About 265 000 loose cubic meters of sawdust is needed to

Figure 2. Bioethanol raw materials (St1 2014).

produce 10 million litres of bioethanol. From all analysed sawmills three clusters were found. One cluster is able to produce enough raw material for one bioethanol plant.

The quantity, size, storage and current use of side streams data were collected from sawmills. The calculated results were compared to real-life results. Based on the results, it was analysed whether it would be profitable to set up a bioethanol unit. The end of the thesis deals with whether the establishment of a bioethanol plant is profitable in Sweden or elsewhere in Europe. Based on the results of this thesis, Lahti UAS has supported St1 Biofuels decision making on future investment. Lahti UAS wood technology is more than ready to continue this cooperation with St1.

From sawdust to biofuel

Figure 2 shows how St1 Biofuels can utilise different kinds of wood or fibre based raw materials in producing bioethanol. There is still a lot of research to be done to find the best ways of producing bioethanol from different raw material sources.

Traditionally all sawdust in Finland was used as raw material for particle boards or in energy plants. Today we have only one particle board producer in Finland. Many sawmills can still use their own by-products (including sawdust) in their energy plants. But in many cases this valuable by-product can be used by St1 with a totally new way of producing bioethanol.

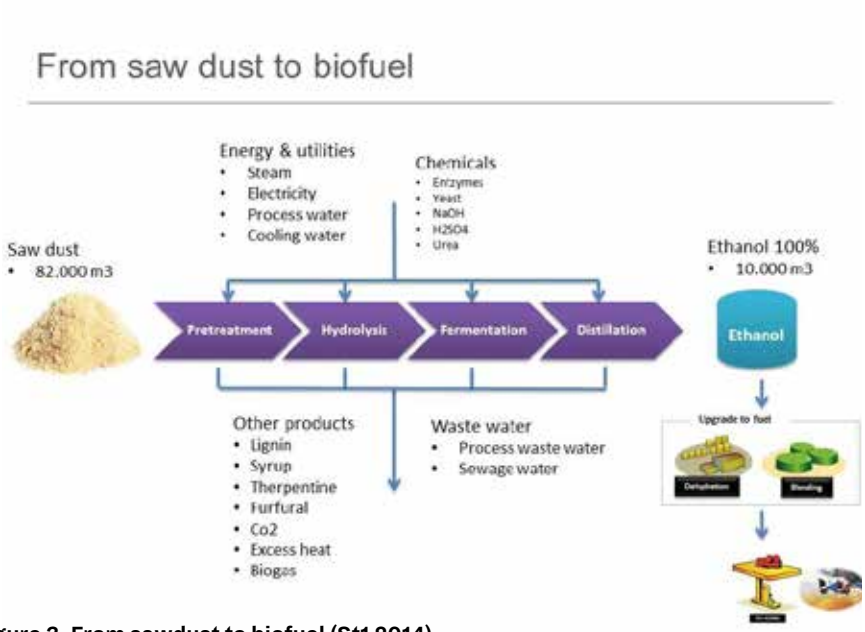

Figure 3. From sawdust to biofuel (St1 2014).

Figure 3 shows that in the sawdust to biofuel process, also some other valuable by-products are produced, i.e. lignin, syrup, turpentine and furfural. These products can be used in many ways, for instance, in the chemical industry. The remaining treated sawdust can be incinerated for energy.

North European Bio Tech Oy (NEB) has made an investment decision concerning the construction of a bioethanol plant on the Renforsin Ranta industrial estate in Kajaani. The raw material for the plant will be sawdust from local sources. The plant will be delivered by St1 Biofuels Oy, which is responsible for design, permits and coordination and will operate the plant once it is completed. Implementation planning is ongoing, and construction will be launched in summer 2015. The plant is projected to begin production in mid-2016. The production capacity of the plant, 10 million litres of bioethanol per year, will be leased to North European Oil Trade Oy (NEOT), which engages in oil and bio product wholesale trade.

For Lahti UAS and our wood technology students, cooperation with St1 Biofuel has been more than encouraging and a very motivating way to make student projects or even the thesis work. We have been happy also to give projects to our exchange students, who have analysed their domestic markets. We understand that St1 Biofuels is still in the beginning with this new Cellunolix™ technology, but we strongly believe, that St1 is the forerunner by processing sawdust to bioethanol. We really hope that Lahti UAS can continue cooperating with St1 in this new technology.

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Marianne Matilainen, Kirsti Cura, Jari Ilmaniemi, Juho Hietanen, Konsta Kaalikoski, Olli Metsähukala, Minni Aalto, Patrick Si, Jami Mononen, Toni Pekkola, Samuli Vainionpää, Joonas Komonen, Katja Kuitunen, Sami Kemppinen

Green ICT in Small and Medium Sized Companies

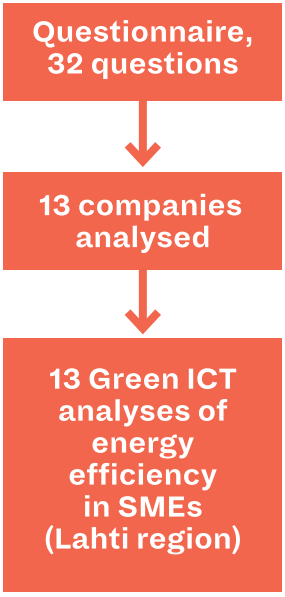

Figure 1. The process of the Green ICT in small and medium sized companies project (M. Matilainen 2014).

Energy efficiency has been a point of interest in companies for a long time now. However, both national and also regional focus has mainly been on energy efficiency improvement measures for properties and buildings. The "Green ICT in small and medium sized companies" project looks at energy efficiency from the information and communication technology (ICT) point of view. The targets of the activities are local small and medium sized enterprises (SME), regardless of their business type. Previous studies show that SMEs' know-how on energy efficiency is poor or even non-existent, even if there are plenty of good examples and working models from large industry sectors. In this project, analyses on the needs of participating SMEs for energy efficiency are carried out using a questionnaire, which was developed at the beginning of the project. The answers are analysed and participant SME-specific development plans are created based on the most important energy efficiency improvement needs. In addition, an analysis of the current state of Green ICT in our operating environment will be prepared, which will serve as background information for

funding applications for international projects. The overall target of this project is to increase the awareness and know-how of SMEs in energy efficiency and how to improve it.

This project has its origins in discussions with local SMEs, and all the actions are carried out through student work as a part of their studies. The process of the project is depicted in Figure 1.

The questionnaires analyse, for example, the level of virtualisation, printing options and electronic waste management in the targeted SMEs. Information technology students carry out 13 company surveys for SMEs in the Lahti region. In the spring of 2014, two companies were analysed as a pilot stage for this project and a few improvements were suggested for them. For instance, when the companies buy new computers, they do not pay attention to life cycle assessment and Greenpeace guidelines for acquiring computers. These two companies were also advised to inform their employees about energy efficiency, for example, in their printing habits.

The questionnaire was prepared as a student group work, and the questions were formulated based on the literature concerning the Green ICT. Students have also been involved in writing this article. The questionnaire consists of 32 questions that cover energy efficiency, ICT devices, hardware purchases, employees, recycling devices and the future. The beginning of the questionnaire is shown in Figure 2.

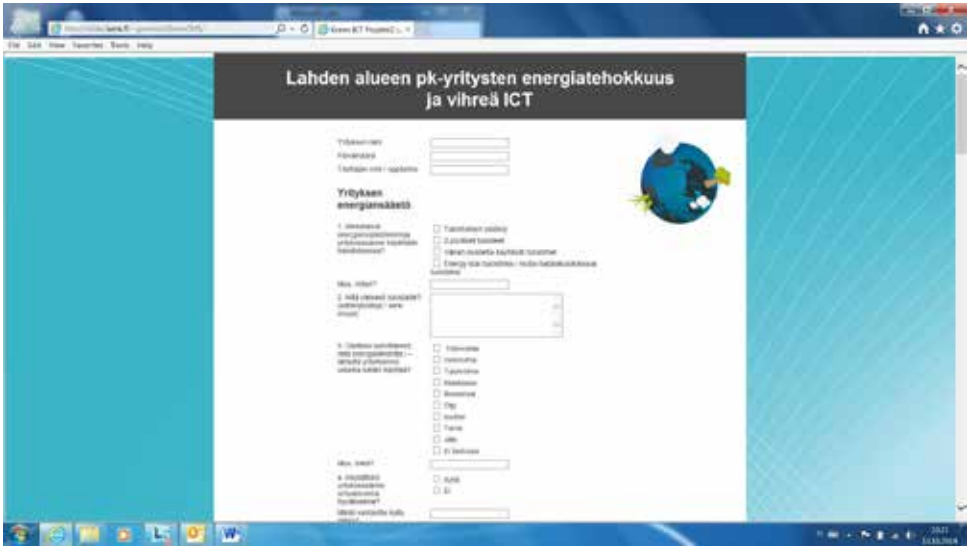

Figure 2. Beginning of the questionnaire (M. Matilainen 2014).

Overall energy efficiency

The purpose of the questionnaire is to find out how energy efficient a company is. Printing-related questions are used to find out how printers are used in SMEs, so that it can be analysed in the energy efficiency report. The questions reveal the use of two-sided printing, or if an SME employees print unnecessary documents, for example E-mails. It is also important to know what energy sources the company uses, because this affects the company's carbon footprint. The questionnaire includes all the energy sources commonly available for use in Finland, ranging from nuclear power to peat.

Many ICT companies have their own servers in their own property or in data centres. The company does not always know the efficiency of the data centres, so the questions should get employees to think and find out how much energy their servers really consume. The company is encouraged to think whether they should keep the servers at their property or if it would be better to relocate them in data centres.

Nowadays, very crucial data can be stored in digital form and there has to be certainty that it remains intact. The data can be stored, for example, in an employee's computer, but it should be stored somewhere else too (backup copying). One questionnaire question covers whether all files are stored in a safe and confidential place.

People often either do not think or do not know how much waste harms the environment, and hence landfills fill up with electronic waste. All kinds of electronic devices are taken to landfills, because people are often too busy to think about recycling options. Laws are constantly getting stricter, so companies need to be aware of forthcoming changes that will affect their operations.

Hardware purchases

Price is a very common criterion for choosing a device, yet the cheapest one might not last very long. This can cause more waste. The cheapest devices might also have the highest energy consumption. This is why the efficiency of devices should be included in purchasing criteria.

The IEEE 802.3az standard on energy efficient networks is quite new and unknown, so companies might not have heard about it. Companies are encouraged to start to follow this standard, after they have studied it further, and to be more energy efficient through using green networks.

Employees

The main goal of these questions is to raise awareness of Green ICT and energy efficiency in the workplace, and to bridge the gap between employees and employers in environmental matters. For example, the company can financially support employees who use public transport to travel to work, inform and educate them more about environmental issues, as well as sponsor employees who are interested in a degree concerning environmentally friendly ICT. Video conferences and remote working, instead of always meeting in person, reduce carbon footprint of employees.

Recycling devices

The target is to gain more knowledge for the companies on how to recycle. It is not often understood how important recycling is and what economic benefits can be obtained. For that reason the questions have clarifying options to broaden the thinking of employees. For example, one question explains how with proper care and maintenance the company can extend devices' lifetime and lower the amount of electronic waste. The questions also mention EU directives including the Restriction of Hazardous Substances Directive. It is possible that the companies have not heard about these directives and how they could implement them. Furthermore, it is not widely known that old small and medium-sized devices can be returned to a store without a fee.

Environmental standards can be seen as a hindrance to business growth and lowering regulations can provide a competitive advantage in product manufacturing. South Asia and Southeast Asia, where most of the world's electronic devices are manufactured, have a considerable amount of pollution sources in manufacturing. Regulations in those locations have been less strict than in Europe.

The origin of devices used is relevant to Green ICT, because of differences in environmental regulations, and thus different pollution levels. Economic and ecological thinking rarely meet, which is why the following question is presented: does the manufacturer support green values? Electronic waste causes huge environmental damage for air and water quality, and introduces hazardous materials to animal and human habitats.

Green ICT consists of many issues to consider, ranging from the equipment used to the energy efficiency of the facilities. Making the server facilities as energy efficient as possible using natural means for cooling and electricity rather than artificial means, and using the most energy efficient equipment that manufacturers have to offer, is the way forward.

The analysis of the current state of Green ICT is being carried out and it will help to plan further actions. This project is a small step and hopefully in the future the work will continue on an international level with international partner universities. The project is funded by the European Regional Development Fund.

Figure 3. Sorted electronic waste (M. Virtanen 2012).

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Paul Carroll

Two Feasibility Study Cases for the Integration of Renewable Energy Solutions in Sites in Lahti

Each autumn in Lahti University of Applied Sciences (Lahti UAS) a comprehensive course Environmental Project is offered to both international exchange students and Finnish environmental engineering students, who are at the later stages of their studies. The language of instruction is English. Within the course, which is of 10 ECTS units, sub-topics are offered from within the different areas of the study programme in question, namely from urban planning and different aspects of environmental technology. A central aspect of the latter is the energy field and specifically renewable energy sources (RES). This paper deals with two cases from this sub-topic of the environmental project course, one carried out in autumn 2013 and the

Figure 1. Carrot harvesting at ROK Food Cooperative (L. Heino 2014).

other under development at the time of writing in autumn 2014. Using personal connections and inquiry via stakeholders the cases for each year were identified, having in common interesting aspects of grassroots level activity.

A new food cooperative was set up in Lahti in early 2013 using greenhouse facilities and land belonging to a horticultural company. It is owned by a number of shareholders and runs on the principal of cooperation for the common good. It is known as ROK which comes from the Finnish, standing for food cooperative (Ruokaosuuskunta). The central approach is on producing organic and local food, with special emphasis being placed on biodynamic gardening practises. The cooperative employs a full time gardener during the growing season under a subsidised employment scheme and the members also help out with the work on certain evenings and for the harvest. It should be mentioned that in its very first year, ROK was granted the environmental action of the year award by Lahti Region Environmental Services.

Along the same lines ROK seeks to replace the existing fossil fuel based energy supply with any renewable sources that are viable. This may involve a range of different sources and/ or hybrid solutions. This is especially the case since ROK wants to extend the growing season, thereby involving the use of energy for heating and lighting during the colder and darker months of the year.

The aim of the project was to investigate all conceivable options for renewable energy sources that the cooperative could use for its fruit and vegetable growing operations. The study also included the integral aspect of scientific studies, that of the zero option as a possible solution, although this would lead to no real change in the present situation of the growing season being confined to the summer months, late spring and early autumn. Social and economic factors were also considered, in addition to environmental ones. A related issue investigated in this project was the conservation and thereby optimal use of energy, which in a greenhouse situation is based around insulation of the buildings used. The specific objective / central research question was to propose the most appropriate and cost effective sustainable energy solution to enable ROK to grow food outside of the summer season.

In order to explain the need for the agreed course tasks, and to explain the methodology necessary for its successful completion, an introductory class was held in early September 2013 attended by all involved. Representatives of the cooperative were present in the form of two shareholders and the gardener, who is himself a member of the cooperative.

Another element of the work of the students on this case was to provide estimates of the costs for feasible renewable energy solutions, which would then be used in applications for funding in order to receive grants aimed at getting started with installing them. In the end this grant from the Finnish Cultural Foundation was not approved, but the intention remained to apply again in the future.

Challenges

The food cooperative is located at the premises of Mrs Aaltonen's flower and garden centre from whom the ROK premises are rented. While the food cooperative cooperates well with the flower and garden centre, the overall solution for energy for the future still depends on what the owner agrees to and finds appropriate. The choice of energy sources then needs to suit the short term needs for keeping such things as the sales of flower products competitive. Nevertheless, in principal this cooperation required does not interfere with the process of speculating on suitable renewable energy sources.

Some interesting alternative results for Lahti renewable energy ROK food cooperative reported by students:

- insulation for greenhouses, using low-price material like bubble wrap plastic that passes sufficient light through
- geothermal or ground heat would mean a large initial investment
- hydroponics, the potential for growing plants in water with mineral nutrient solutions without soil would suit the ideology of the cooperative among other benefits
- biogas, produced on site in an anaerobic reactor could complement composting activities
- solar heat or power, including considering the best locations for collectors or panels
- biomass, whether in the form of logs, woodchips or similar could offer potential for members of the coop to source their own raw materials

Figure 2. Inside one of the ROK Food Cooperative greenhouses (L. Heino 2014).

Written feedback was requested from the students after this course, as with other courses in Lahti UAS. Course feedback was voluntary, while writing the diaries was a necessary task to prove active individual participation, encourage the reflective process and not least to assist the teacher in grading. The final presentation of results was attended by three members of ROK. While it was not possible to present a clear final solution for heating the cooperative greenhouses in a sustainable way that would also be affordable in price, there were a number of options listed and expanded on in detail, together with informed estimates of the relative costs.

The task for the second case

The theme for Environmental project course in 2014 is also related to renewable energy. There is really the need and intention to develop renewable energy solutions, while at the same time improving energy efficiency, at an old house called Yli-Marola. It is situated quite centrally in Lahti city and belongs to the municipality. It is an unusual location bordered on one side by the main railway line and then surrounded otherwise by a residential area.

Recently Lahti Region Environmental Services (henceforth LSYP from the Finnish acronym) had for budgetary reasons given up one property in the city centre that had served as a permanent environmental counselling and exhibition centre. At the same time a question mark hangs over the property that this case deals with, in that it needs to be extensively renovated. A survey study by Arkkitehtitoimisto Arkviiri Oy in 2013 showed this would cost a significant amount. This study was carried out under contract by an architectural office for the City of Lahti and funded through the European Regional Development Fund. An important conclusion of the resulting report was that rather than carrying out large-scale renovations of the house and other buildings on the site, a smaller scale incremental approach could be adopted, starting with the most essential repairs. It was then stated that the house could meanwhile serve both the purposes of the present occupant 4H and of LSYP.

This sentiment was confirmed by Päivi Sieppi, Head of Environmental Information for LSYP, who has been following the activity of Lahti UAS students. She emphasises that the matter is still open, but that there is good potential to have Yli-Marola serving as a showcase for sustainable energy and living solutions. Kari Porra, Director of Environmental Protection, in a separate conversation added that the other buildings besides the main house in Yli-Marola have good potential for serving as renewable energy sites and could accommodate such things as solar power and heat solutions. In practise the property in question is under the jurisdiction of the City of Lahti property division and decisions on its future are ultimately made by the municipality.

Figure 3. The exterior of Yli-Marola house (N. Diewald 2014).

4H is a non-profit organisation that is involved in environmental activities, combatting youth unemployment and providing activities for urban children. This organisation is the present occupant of the Yli-Marola house and pays rent to the City of Lahti for it. The organisation does not have the funds to keep the house very warm over the colder months, nor can it afford to insulate and otherwise renovate the house to a level that would make it more useable all year round.

Figure 4. The interior of Yli-Marola house (N. Diewald 2014).

Discussion and future prospects

The approach to Cleantech solutions involving real grassroots cases in urban areas has proven to be motivating to students through the study cases presented and the problem solving approaches adapted. At the same time, the involvement of students has been welcome by the different organisations and stakeholders involved in both the ROK cooperative and the Yli-Marola house. While the solutions proposed in both cases may or may not be implemented to various extents, the recommendations made and the background information included certainly serves to help in the long-term planning and decision-making process.

In 2013 a new strategy was approved for Lahti (City of Lahti Strategy 2025).There is much emphasis on making Lahti a pleasant and attractive living environment, with specific mention of making Lahti a child-friendly city and of greenness and proximity to nature. Achieving these goals would greatly be facilitated by the further development of such initiatives as the ROK food cooperative and the Yli-Marola house and domestic animal yard.

At the time of writing it was announced that Lahti has been accepted as one of the entrants for the European Green Capital Award for 2017 (a European Commission initiative). While the decision making committee for this award will no doubt pay a lot of attention to larger city strategy issues, town planning and sustainable municipal transportation solutions adopted, it is also bound to consider smaller scale local solutions where the citizens are involved in implementing sustainable living practises. Both cases presented here represent examples of this.

The first case stresses a sustainable method of producing local organic food and involving a strong participatory approach, while the second case deals with a showcase house aiming to demonstrate energy efficiency solutions to the general public. Both have a striving to implement the use of renewable and otherwise alternative energy sources in their respective properties and in both cases the funding and investment questions remain open. Nevertheless, where there is a strong enough will to do something there is usually a way found.

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Eeva Aarrevaara

Stormwater Management – Relevant Topic in Urban Planning

Stormwater research and management have gained more visibility during past years also in Finland. The need for new information and action models is based on impacts of climate change and urban heat island effect, which together change circumstances in densely built areas. Common challenge in cities is the amount of impervious surfaces which do not allow any infiltration of water into the ground.

Stormwater is traditionally lead into sewage system or separate stormwater pipes which increases the amount of water treated in waste water plants. Separate stormwater pipes usually lead into watercourses in which pollutants carried by stormwater decrease the water quality. Principles that should be adapted in stormwater treatment in urban areas include combinations of gathering, delaying and infiltrating stormwater, which should be considered and used as much as possible to diminish the amount of stormwater running straight into lakes, rivers or sewage systems. One reason for stormwater management is also increasing flooding in urban areas in cases of heavy rainfall.

Finnish Association of Municipalities gathered a multiprofessional group to prepare a new guidebook concerning stormwater issues that was published in 2012. Several changes in legislation have come into force on the 1st of September 2014. For example, a new chapter 13a in Land Use and Building Act defines the concept of stormwater and the goals of stormwater management. The act shows clearly that stormwater management must be considered as part of urban planning in the future and special stormwater plans are needed in planned areas. It also defines certain responsibilities to the municipalities and property owners.

At Lahti University of Applied Sciences, student projects, thesis works and research and development (RD) projects on stormwater issues have been carried out in environmental technology and planning during the past years. Lahti UAS was working as a partner in an RD project called Urban Laboratory of Sustainable Development, which dealt with stormwater monitoring, modelling and management. Project was managed by Aalto University which also provided several Master theses about stormwater modelling and GIS based user interface to illustrate monitoring data. University of Helsinki gathered new monitoring data of stormwater quality and quantity in Lahti from several monitoring stations. Lahti UAS was responsible for practical solutions and adaptations concerning stormwater management. Lecturer Paul Carroll realised

a project on land use inventories in Lahti shorelines together with first year students and Lahti Region Environmental Services. Shorelines have land use plans but the reality can differ a lot from the plan. The information is needed in urban and environmental planning. The information the students collected was found utilisable to the city.

Environmental planning student Jessica Huttunen worked in co-operation with Lahti Region Environmental Services on her Bachelor´s thesis concerning natural stormwater management in the new residential areas Karisto and Kytölä in Lahti. Measurements in existing stormwater delaying areas were carried out several times in both areas during 2013.

As a part of the thesis a questionnaire survey was carried out to the residents of Karisto in December 2013. The aim of the questionnaire was to record the experiences and opinions of residents at Karisto area on natural stormwater management methods. It was found out that most residents knew the main purpose of pools and ditches, and regarded natural stormwater management as a factor increasing the value and desirability of the area. On the negative side, some of the residents found the open systems dangerous for children and mentioned neglect of their maintenance, especially regarding cleanliness. Many respondents expressed a wish that the area should be changed to be more park-like and for the green area management category to be raised, and thereby the potential uses of the area to be maximised. One of thesis results was also an education material package to be utilised in Lahti UAS. Lecturer Paula Salomäki tutored Huttunen´s Bachelor's thesis.

Figure 1. Karisto residential area (E. Aarrevaara 2014).

One part of Urban Laboratory of Sustainable Development project was experimenting educational co-operation between two Master Programmes. University of Helsinki has been running MURE programme (Multidisciplinary Studies on Urban Environmental Issues) in Lahti since 2010, while Lahti UAS started a new Master programme in 2012 – Master in Sustainable Urban Planning and Climate Change. PhD Kirsi Kuoppamäki (HU) and DSc (Arch.) Eeva Aarrevaara (Lahti UAS) planned and implemented together two intensive week courses for both groups: Urban and interactive planning and Climate change and its environmental impacts, in which also lecturer Paul Carroll contributed. In Urban planning course the students participated in lectures, group work and excursion in Lahti. Planners from Lahti City Planning Department demonstrated the local master plan and the detailed planning process in Ranta-Kartano. Central theme of the course was resilience theory and its adaptation in urban areas. Resilient cities can be described as flexible and protean in changing situations, which means that they have to possess certain features or qualities which enable sustainability.

During the excursion, experimental green roofs in Jokimaa were introduced and also Karisto stormwater wetlands and arrangements were visited. In the group work the students got acquainted with Ranta-Kartano plans and especially the stormwater management plan. The task was to evaluate the adequacy of the plans to deal with stormwater and to establish a climate sensitive and attractive living environment. Interesting suggestions and views were shared in the closing seminar by intercultural student groups.

Figure 2. Student work (M. Keränen 2014).

The successful co-operation continued during Climate change course with lectures concerning Lahti City Climate Programme 2009-2015, emissions trading system, as well as carbon management. Common features of climate change research and forecasts were presented and discussed. In group works, the students searched for successful climate projects and tools in international and national level. Feedback from both courses was mainly positive and encouraging for this type of co-operation in the future. Although the backgrounds of students were quite different – in university programme scientific research orientated and in Lahti UAS programme working life and practical adaptation based orientated – still the issues were of common and shared interest.

The results of Urban Laboratory of Sustainable Development –project were presented in the publication Lahti as an Urban Laboratory of Sustainable Development. The publication was edited by Irma Mäkelä and Tarja Palvi, and it was published in June 2014. The publication consists of several articles by authors from Lahti UAS, Aalto University and University of Helsinki. On behalf of the project also a final seminar was arranged in spring 2014, in which research results were demonstrated. The seminar took place in Niemi campus where the Degree Programme of Environmental Technology moved in autumn 2013 into renovated premises. This new learning environment also supports co-operation with universities who already have their activities there. One part of the project was the planning and building of the decision theatre which has display equipment that enables the use of two screens as one panorama screen or two separate screens using different sources. This part of the project was included in Ari Vesikko's Master's thesis in Environmental Technology Programme. The equipment was used also in the presentation of doctoral student and researcher Jiri Kadlec who worked in the project with a web-based map application for capturing stormwater pollution sources in the changing city of Lahti. His research topics included the design of a web map client framework for sharing environmental observations, open GIS web services and spatial data infrastructure.

Figure 3. Urban Laboratory of Sustainable Development project's final seminar (P. Kärnä 2014).

Figure 4. Lahti UAS Niemi Campus (M. Aalto 2014).

Interest for stormwater issues has continued during autumn 2014. Lahti Regional Development Company Ladec Ltd arranged a stormwater management competition for local actors and stakeholders in autumn 2014. Representatives of Lahti Region Environmental Services have been active in competition planning process as well as the higher education institutions in Lahti. The competition was open to everybody and had two target areas, the centre of Lahti and Asko area along the main railway. The Asko area was part of Radanvarsi architectural competition which was arranged in autumn 2013. Companies with new product ideas and suggestions were also welcomed to join the competition. Stormwater management theme is taken as one target of Lahti UAS's environmental project course in which several exchange students participate yearly.

A new project called Future Campus Demonstrator concentrates on the development of new campus area in Niemi where Lahti UAS will locate all the faculties and other campus activities in the near future. The goal is to demonstrate new cleantech technologies and practices in the new campus area. Stormwater management is one example of possible cleantech themes to be tested in Niemi. Co-operation with companies, demonstrations and testing of new products could be done in this context.

Third course of Master students in Sustainable Urban Planning and Climate Change started their studies in autumn 2014. Several students are also interested in working with stormwater issues in their Master's dissertations. It can be expected that stormwater management will continue to keep its central position as a topic of applied research and development, and education during forthcoming years. The idea is supported also in the RESCUE project, an Erasmus Life-long Learning Programme funded project, which started in 2012 in co-operation with Glasgow Caledonian University (UK) and University of Salento (IT). The target of the project is to develop an international Master Programme which aims to combine research, planning and management in urban environments from the climate sensitive point of view.

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The first Lahti Cleantech Annual Review consists of eight articles written by Lahti University of Applied Science's experts from the Faculty of Technology and Institute of Design. The aim of the review is to present good examples of research and development activities of Lahti UAS and its partners. The focus of review is on work related to material efficiency, energy efficiency and sustainable urban environment, which are the main themes of cleantech activities at Lahti UAS.

Lahti Cleantech Annual Review supports communication with Lahti UAS's partner universities, companies and other stakeholders, and it is also a part of implementation of cleantech themes in the Lahti UAS RD and educational operations. The aim is to publish the review annually and also involve Lahti UAS's university and company partners in writing about joint projects and research. The first Lahti Cleantech Annual Review is published as a part of the Elite2 project funded by European Regional Development Fund.

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