EEVA AARREVAARA & ANNIINA HARJAPÄÄ (EDS.)

Smart Cities in Smart Regions 2018

Conference Proceedings

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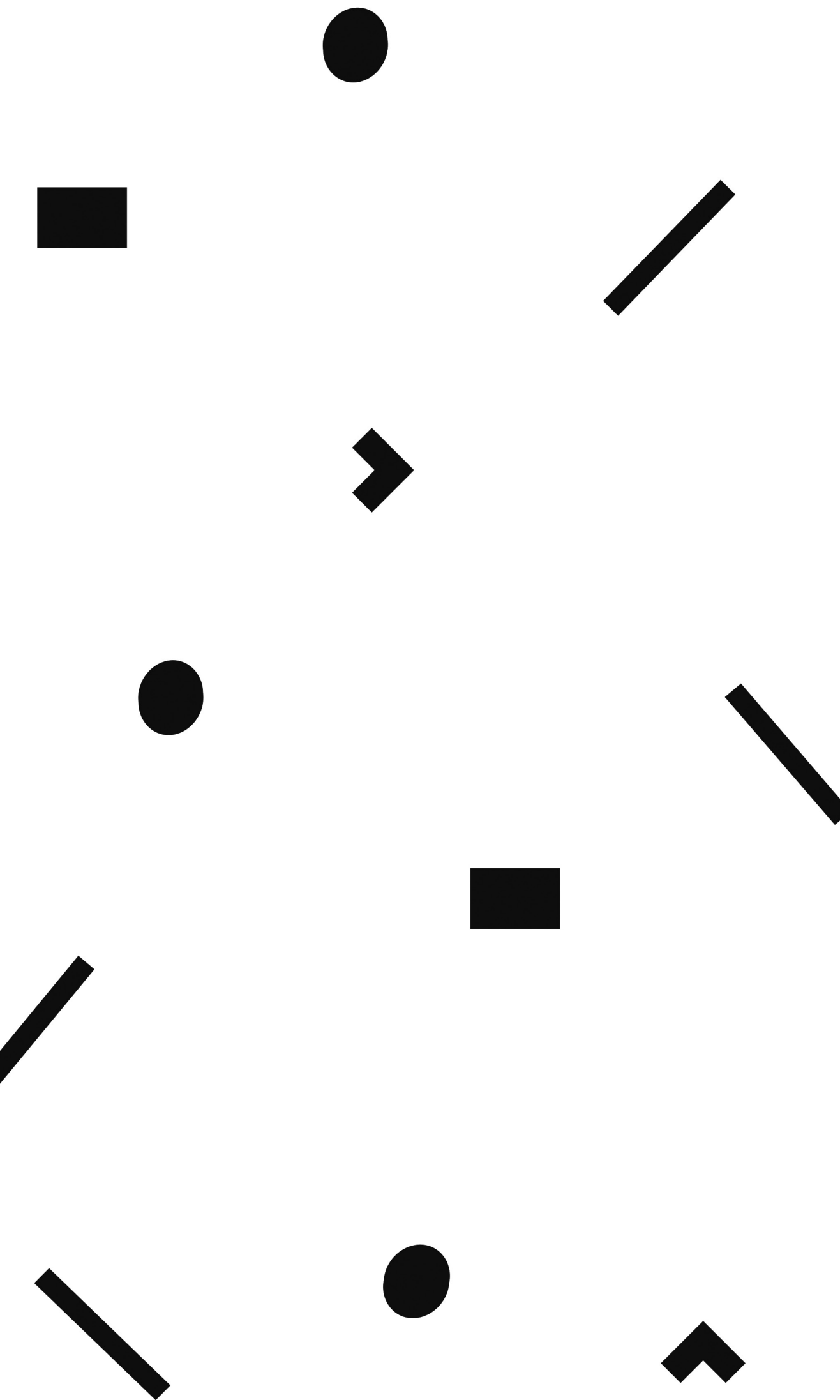
THE PUBLICATION SERIES OF LAHTI UNIVERSITY OF APPLIED SCIENCES PART 39

LAMK Lahden ammattikorkeakoulu
Lahti University of Applied Sciences



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Foreword

In Finland, May and July 2018 were warmer than any other previous one in the measurement history. Extremely warm summer was a wake-up call: although global warming is a global phenomenon, its' consequences, like floods, storms, and droughts, have a local impact. Current public debate focus on the risks warming can cause to for example domestic agriculture, forestry, infrastructure, housing, energy production and health, and how well we are prepared to those risks.

Lahti is an excellent place to organize a conference aiming at to help cities and regions to overcome global challenges in a smart way, which also generates new business opportunities and well-being. Lahti has implemented several ambitious environmental projects together with local university partners University of Helsinki, Lappeenranta University of Technology and Lahti University of Applied Sciences. Circular economy roadmap towards 2030, Industrial symbiosis of Kujala Waste Center and several pioneer companies improve material and energy efficiency of the city and region in practice. Still, there is work to do!.

Higher education institutions are key players to generate new research based information and expertise and to educate professionals to apply it. Conferences like Smart Cities in Smart Regions are important platforms for researchers, developers, innovators, educators as well as policy makers to share knowledge, adapt new ideas and even co-create innovative initiatives in a multidisciplinary context.

For us organizing Smart Cities in Smart Regions conference twice has been a learning process. Based on feedback and experience two years back, we have made changes both to the content and to the practicalities. I am especially proud of this proceedings publication– a fine collection of academic papers and case studies and best practices. Thank you for all the authors, for Scientific Board members Eeva, Rohinton, Johan and Tuuli for reviewing so many papers, and for our assistants Anniina and Jutta who were doing hard work when we were enjoying the summer.

Lahti 26th of August, 2018

Silja Kostia, Chair of Steering Group

Dean, Faculty of Technology

Lahti University of Applied Sciences

Content

Introduction

The second Smart Cities in Smart Regions conference was designed to call papers under three different themes:

- Green Infrastucture and Well-being (A)
- Design, Technology and Digitalisation (B) and
- Circular economy and Entrepreneurship (C)

The suggested papers went through the peer-review evaluation process by the scientific board and the chosen papers were classified into three different categories: research articles, review articles and best practices and case studies. The definitions of the paper categories are follows:

Research Article: Thorough experimental or analytical studies performed in a relevant thematic field, using consistent methods and present results based on empirical data.

Review Article: A review article provides significant insight into a specific topic deemed to be of high relevance and critical a analysis of the related literature. The quality of the references and their assessment is critical for this type of publication.

Best Practises and Case Studies: a best practice and a case study is a well-documented study or report of a practical, implemented technological innovation or development project. This type of full paper provides an analysis of a specific problem, description of an implemented solution and evaluation of outcomes and impact.

In the proceedings the articles are grouped according the main themes A, B and C, and presented in the previously mentioned order by different types. The contents of each subtheme are described in the starting page of each theme along with a short summary of the published articles and case studies. The combination of research articles and case studies demonstrates that the Smart City concept is not only a theoretical framework, but rather promotes useful and smart experiments which stand out as smart practices in many cities and regions nationally and internationally. The scientific board of the conference hopes that the readers will enjoy this combination of published articles and case studies as well as the oral and poster presentations in the conference in Lahti in 2018.

Theme A: Green Infrastructure and Well-being

Attention to the green environment has been growing over the past decades. Its role in urban planning is better recognised, but still needs strong argumentation in decision making concerning growing cities and regions. The need for resilient urban areas brings forth the necessity for wider understanding of the functions of green infrastructure. In urban planning processes the consideration of ecosystem services makes a big difference to physical solutions for the city structure, compared to the situation where these services are neglected. Planning processes also need support from leadership and management to realise the ideas presented in the plans.

Flooding, storm surges and overheating are becoming significant challenges in urban areas. The impacts of densification in urban areas need to be evaluated also in terms of the quantity and quality of green infrastructure. Provisioning, regulating, supporting and cultural services provide a variety of functions which are enabled by green areas and elements in cities and their surroundings. It is possible to utilise Nature based solutions (NBS) in climate change mitigation and adaptation. Flooding, storm surges and overheating are becoming significant challenges in urban areas, where the management of heat stress and stormwater need to be considered. Research in these areas can bring important scientific knowledge to be utilised in the evaluation of urbanization processes. The development of nature connected services provides an opportunity for a new kind of entrepreneurship in both urban and rural centres and regions. At the regional level the need for natural areas accessible to citizens and tourists is becoming a larger issue, not only locally but also internationally. The development of geotourism has been observed and its market is growing globally. Nature experience and well-being have been subject to several studies, which confirm the significance of natural areas for citizens and their recreation.

The articles and case studies presented under this theme discuss, for example, the impact of vegetation on local climate and thermal comfort that citizens are sensing in different circumstances. Monitoring research areas brings forth evidence of the environmental impacts. Questioning of younger children creates another kind of perspective to climatic changes and demonstrates attitudes and hopes for the future city environment. Noise reduction is another challenge in many cities; it can be achieved with the help of vegetation, but also with different constructions, as one research study presents. Health and well-being are discussed in a case presenting a university-level programme aiming to improve the health awareness and condition of staff and students working in the same campus area. However, challenges are faced in the ambitious programme. One case study introduces several examples of global geoparks from the perspective of citizen involvement and the increase of environmental awareness. The aim of the study is to bring different perspectives into the planning process of an aspiring geopark in Lahti region.

Buccolieri, R., Rui, L., Gatto, E., Gao, Z. & Ding, W.

Application of green indices to evaluate the impact of central green space on air quality and microclimate in Nanjing (China)

Research Article

Abstract

This study is devoted to the assessment of the influence of green spaces on air quality and microclimate of typical residential districts of Nanjing (China) by employing the CFD-based model ENVI-met 4. Three types of vegetation are defined (lawn, shrub and tree) and meteorological conditions are those typical of an average summer day in Nanjing. Five different indices are selected to investigate the impact of different layouts of green space located in the center of the residential district: the grass and shrub cover ratio, the green cover ratio and the ecological landscaping plot ratio (which are green quantity indices determined by the green area and the proportion of vegetation); and the landscaping isolation index and landscape deviation (which are green structure indices related to the layout of the green space). Results show that the thermal comfort is enhanced, even though to a slight extent, with increasing green quantity (especially trees), whose influence is larger than the layout of the green space. On the other hand, more trees may increase the wind blocking effect with a consequent increase of pollutant concentration. In this regard, separate patches of trees located in the central part of the green space are preferable. The employed indices constitute useful green space control variables for studying the relationship between green space morphology, microclimate and air quality.

Keywords: residential district, greening design, ENVI-met, air quality, thermal comfort

1. Introduction

Thermal comfort and air quality are major concerns for people living in urban areas. In the built environment temperature is generally higher than in the surrounding rural areas, because of the low short-wave albedo of city surface, the high heat capacity of building materials, the blockage of outgoing long-wave radiation and natural ventilation by the urban geometry as well as in low evaporation rates. Moreover, traffic-induced emissions are one of the major contributors of air pollution, emitting harmful pollutants in the form of particulate matters, such as PM10, PM2.5 and Ultrafine Particles (UFP) (Bo et al. 2017), and gaseous pollutants such

as nitrogen oxides (NO_x) (Beevers et al. 2012, Michiels et al. 2012) and carbon monoxide (CO) (Chen et al. 2011).

Vegetation has a positive effect on reducing local temperature through shading and evapotranspiration and wind flow blocking especially on cold windy days (see recent reviews by Livesley et al. 2016; Salmond et al. 2016). In addition, many studies have shown that vegetation can remove pollutants more efficiently from the atmosphere than artificial surface, because vegetation foliage can absorb gaseous pollutants through their stomata and remove particles by deposition (see recent reviews by Abhijith et al. 2017; Buccolieri et al. 2018).

Within this perspective, this study aims to discuss how to improve the microclimate and air quality in the presence of different green space layouts. The green space influence in typical residential districts of Nanjing (China) is evaluated using both greening quantity (the green cover ratio, the grass and shrub cover ratio and the ecological landscaping plot ratio) and greening structure (landscaping isolation index and landscaping deviation index). Wind, thermal environment and pollutant dispersion are obtained from numerical simulations using ENVI-met 4.0 and general suggestions are provided, which can constitute a guidance and reference for the design of green spaces in residential districts.

2. Methodology

2.1. Green indices

Five indices were employed to evaluate the effect of green space on microclimate and air quality

2.1.1. Green quantity indices

The three green quantity indices employed here been recently summarized by Rui et al. (2018) and allow to describe the horizontal and vertical distribution of vegetation.

The grass and shrub cover ratio (G_g) is defined as the percentage of grass and shrub area:

$$G_g=(A_{grass}+A_{shrub})/A \quad (1)$$

where A_{grass} and A_{shrub} are the area of grass and shrub (m^2), respectively, while A is the total area (m^2) taken into consideration. Gg reflects the percentage of area in which the thermo-physical properties (e.g. conductivity, specific heat and albedo) of ground surfaces are changed with covering grass and shrub, which cannot provide any shading effect. From the urban planning perspective, this index reflects the area of open space that can be used to build infrastructures for residential purposes.

The green cover ratio (C_g) is defined as:

$$C_g = A_s/A \quad (2)$$

where A_s is the vertical projection area of the vegetation (m^2) which can be estimated from plan view. C_g refers to the percentage of projected area of all types of vegetation (grass, shrub, and tree) and thus represents the quantity of all types of vegetation in a green space. Larger values of $1-A_s/A$ mean larger areas of the hard pavement without shading.

The ecological landscaping plot ratio (R_g) is defined as:

$$R_g = (A_{grass} + 15 \times A_{shrub} + 30 \times A_{tree})/A \quad (3)$$

where A_{tree} is the vertical projection area of the tree crown (m^2). This index gives information on the ability of absorption of carbon dioxide (CO_2) by vegetation which is considered one of the key parameters for low-carbon eco-city development in China. In fact, the CO_2 absorption efficiency ratio between grass, shrubs and trees is 1:15:30 (Lin 2007). These values are those employed in the definition of R_g (Eq. 3).

2.1.2. Green structure indices

The landscape designers often set a large area for a specific plant community, such as massive bushes or trees, to create a different landscape atmosphere. The location related to the centre of the green space may have some influence on its environmental performance and thus the landscaping deviation is introduced as follows:

$$P_i = d_{oo}/d_{max} \quad (4)$$

where d_{oo}' is the distance between the patch of trees and the centre of the landscape, d_{max} is the maximum distance between the patch of trees and the centre of the landscape.

The green quantity indices described above do not reflect the distribution pattern, such as the aggregation of vegetation (particularly trees), which may have a different influence on the local environment. To consider the vegetation distribution pattern, the landscaping isolation index (F_i) is employed (Chen & Fu 1996):

$$F_i = D_i / S_i \quad (5)$$

where $D_i = \frac{1}{2}\sqrt{(N_i / A)}$ is the distance index for landscape type i which

only considers the influence of the number of the patches on separation of landscape distribution, $S_i=A_i/A$ is the area index for landscape type i which represents the cover ratio of landscape type i and, in this study, refers to the cover ratio of trees. N_i is the number of the patches, i.e. the number of groups of trees, and Ai is the area of landscape type i (m^2). A large value of F_i implies the patches are far from each other. This index reflects the degree of separation of landscape distribution and allows studying the influence of the aggregation distribution of trees. For further details see Rui et al. (2018).

2.2. Description of the residential districts

Based on the statistics of residential building size and street width of Nanjing (Shen et al. 2017), an idealized residential district model was set up as shown in Figure 1a. It is made of blocks aligned along the north-south direction and the height, length and width of each six-story building are 18m, 48m and 12m, respectively. The distance between buildings in north and south is 24m and the distance between east and west is 16m, resulting in a planar area index (ratio between the planar area of buildings and the total lot area) λ_p = 0.25. The widths of road in residential district and main traffic road are 24m and 32m, respectively. Considering the impact of the model boundary on the result of the simulation area, one half of block was added around the residential district area. The final simulation area (computational domain) was 416m × 448m (see Rui et al. 2017 for further details).

Starting from the base case of grass only (Case A in Figure 1b) and based on the general layout features of residential central green space, several layouts and types were considered in the central portion of the district ("central green space" hereinafter) as shown in Figure 1b. For each case, ENVI-met was run for a 48-h period, starting at 06:00 a.m. Jun 22nd to 06:00 a.m. Jun 24th, with model output every hour, using the parameters listed in Table 1.

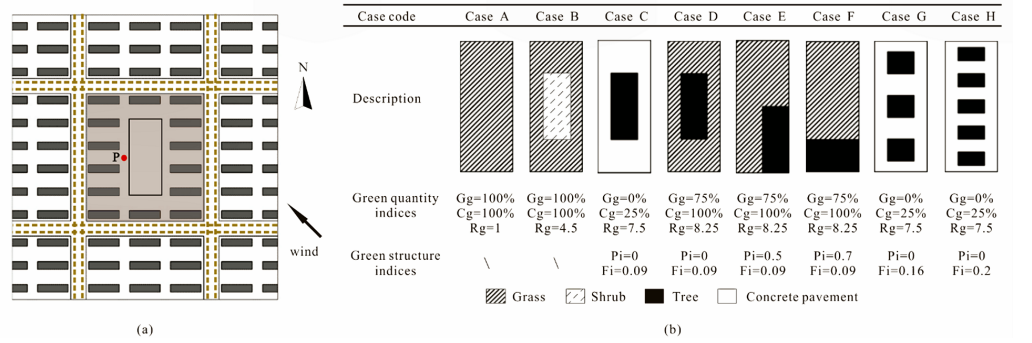

Figure 1. a) The residential district (highlighted in brown) of size 184 m × 200 m, where P is the receptor at pedestrian height (1.4m) and the dashed lines are the pollutant line sources (from Rui et al. 2018). b) Green space layouts and types models (48m × 120m) investigated.

Table 1. Initial and boundary conditions used in ENVI-met.

Parameter	Definition	Values
Location	Nanjing/China Latitude (deg,+N,-S), Longitude (deg,-W,+E)	 32.05, 118.78
Meteorological condition	Wind speed measured at 10 m height (m/s) Wind direction (deg) Roughness length at measurement site Initial temperature of atmosphere (°C) Specific humidity at model top (2500 m, g/kg) Relative humidity at 2m (%)	3 135 0.1 22 7.0 65
Pollution source	Species Source geometry Emission rate	PM10 Linear source at 0.4m height 0.1mg/m-s
Vegetation cover	Type Height	Grass\Shrub\Tree 0.4,1.2 and 8m

3. Results

3.1. The influence of green quantity indices on thermal comfort and air quality

Cases B, C and D, characterized by different values of green quantity indices in the central green space, are considered here in conjunction with the base Case A to study the relationship between green quantity and microclimate. Since ENVI-met requires spin-up time before the flow field reaches stability, the analysis focuses on the second day of simulation (23rd June).

Figure 2 shows the hourly temperature variation at point P at pedestrian height (1.4 m) from 8:00 to 17:00. The maximum temperature is found at 15:00, while the minimum temperature is at around 8:00. The temperature in Case B (grass and shrub) is a little bit lower than in Case A (grass), despite the G_g (grass and shrub cover ratio) and C_g (green cover ratio) are the same. Besides, the temperature in Case C (trees surrounded by pavement) which has a lower G_g and C_g but higher R_g (landscaping plot ratio) is close to Case B. Under the same C_g, Case D (trees surrounded by grass) with highest R_g has great cooling effect. Compared with Case A, it can lead to a maximum reduction of approximately 1°C at the hottest hour (15:00). Due to the grass surrounding trees in Case D, the temperature in this area is generally lower than that of the hard pavement in case C. In addition, the cooling effect of the whole residential district is not evident as the local effect, such as P point, but the average temperature at pedestrian level in residential district (not shown here) is in Case A>Case B>Case C>Case D, i.e. 26.3 °C, 26.2 °C, 26.2 °C, 26.1 °C at the hottest hour (15:00), thus the temperature slightly decreases with increasing R_g.

The hourly variation of wind speed at point P is shown in Figure 2. The wind speed in Case A (grass) is higher since the grass has less effect in blocking the wind than shrubs and trees (Cases B, C and D), and it can almost reach 1.65 m/s. The blocking effect of shrubs is relatively larger than grass, so the wind speed in Case B is below 1.6 m/s with relatively higher R_g. It is also noted that the wind flow blocking of trees is more evident, since wind speed in Cases C and D with high R_g were close to each other with a reduction of about 0.25 m/s compared with Case A. In addition, the average wind speed at pedestrian level in residential district (not shown

here) in Case A>Case B>Case C>Case D, i.e. 1.41 m/s, 1.37 m/s, 1.36 m/s °C, 1.34 °C at 15:00, suggesting that the relationship between wind speed and R_g is opposite, thus the blocking effect of green space increases with increasing R_g.

Figure 2 also shows the hourly variation of average predicted mean vote (PMV) at pedestrian level in the residential district. The PMV is a parameter based on the heat balance of the human body, taking into consideration the influence of four meteorological parameters (air temperature, mean radiant temperature, wind speed and relative humidity) and personal factors (heat resistance of clothing and human activity) on thermal comfort. The range between 0 and 1 in the figure is the thermal comfort zone, while the PMV of 2 is evaluated as hot and above 3 as very hot. The PMV curves from 8:00 to 17:00 are in the shape of "M", only the hour 8:00 is within the comfort zone, while 14:00–16:00 are very hot. Case A (grass) has higher PMV, especially in hot hours, than other cases. Besides, the average PMV in Case A>Case B>Case C>Case D, indicating that the effect of central green space on improving the outdoor thermal comfort in residential depends on the configuration of green space (C_g and G_g) and R_g. The thermal comfort gets better with increasing R_g.

Finally, the hourly variation of PM10 concentration at point P in Figure 2 shows that the concentration decreases from 8:00 to 13:00 and then increases. PM10 concentration at point P in Case A is relatively lower than other cases which show an increase up to about 5% than Case A. The average PM10 concentrations at pedestrian level in residential district (not shown here) in Case A<Case B<Case C<Case D, i.e. 7.6 μg/m3, 7.6 μg/m3, 7.7 μg/m3, 7.7 μg/m3 at 13:00. This is mainly due to the higher wind

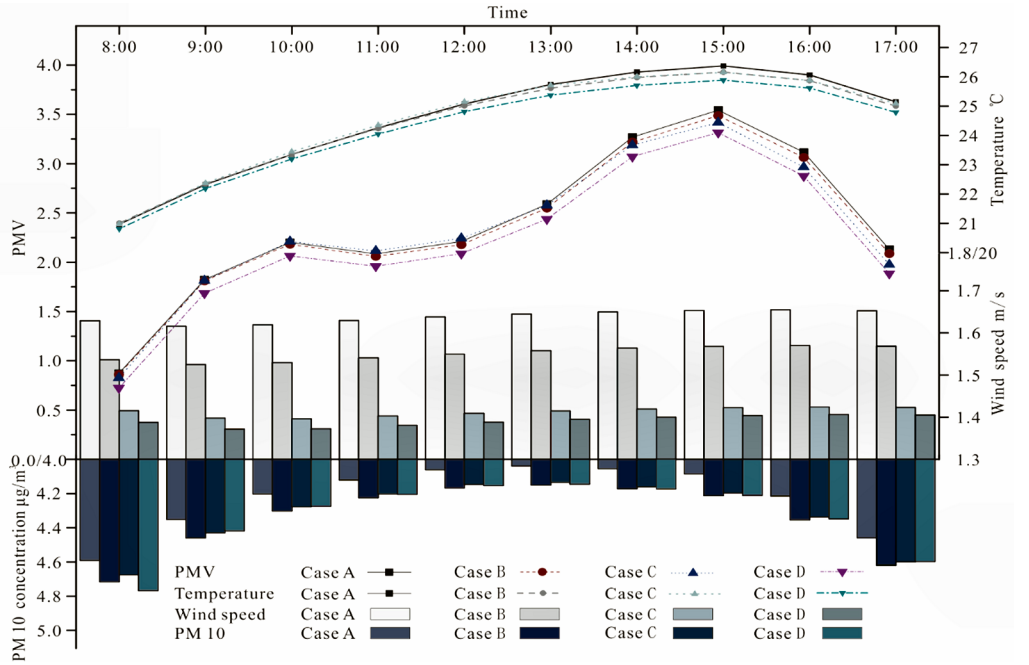

Figure 2. Cases A, B, C, D: Temporal profiles of temperature, wind speed and PM10 concentration at point P and average PMV at pedestrian level in the residential district and under different green quantity indices.

speed and higher temperature which cause the particles to disperse more rapidly.

3.2. The influence of green structure indices on thermal comfort and air quality

Cases D, E and F (same G_g, C_g, R_g and F_i), characterized by trees surrounded by grass, but trees of different forms and located in different positions within the central green space, are compared to analyze the influence of the landscaping deviation of tree patch (P_i). The hourly temperature variation at point P and the average PMV in the residential district in Figure 3a show a slight influence of the landscaping deviation. Considering the average temperatures at pedestrian level in the residential district (not shown here), i.e. 26.1°C, 26.1°C and 26.2°C at hottest hour (15:00), respectively, it can be concluded that the cooling effect of green space on both local area and the whole residential district mostly depends on the green quantity (see subsection 3.1) and the landscaping deviation index only affects the general distribution of temperature and PMV in residential district (not shown here). The landscaping deviation also slightly influences the wind speed and PM10 concentration at Point P (Figure 3a). The average wind speeds at pedestrian level in residential district (not shown here) are 1.34 m/s (Case D), 1.34 m/s (Case E) and 1.35 m/s (Case F) at 15:00, respectively, which reflects the facts that the relation between the average wind speed and the landscaping deviation is not so evident as local wind blocking.

To further study the green structure effect, Cases C, G and H (same G_g, C_g, and R_g), characterized by trees surrounded by pavement, but trees of different forms and located in different positions within the central green space, are compared. The landscaping isolation index F_i (degree of separation of landscape distribution) increases from Case C to H, with the same total area of trees but increasing the number of tree patches. From the temporal profile of temperature and PMV in Figure 3b, it can be noted that F_i has little influence on cooling effect, still suggesting that the cooling effect is mostly dominated by the green quantity (see subsection 3.1). However, F_i mainly influences the temperature and PMV distribution (not shown here), making the ambient temperature around the central green space more even with larger F_i. As for wind speed at point P, tree patches in Case G have less wind blocking effect than Case C (single tree structure). Appropriate increasing the landscaping isolation helps ventilation, however larger landscaping isolation does not mean good ventilation. More tree patches in Case H implies that the ventilation spacing becomes narrow, which strengthens the wind disturbance and decreases the wind speed. The average wind speed at pedestrian level in the residential district (not shown here) decreases in fact with increasing landscaping isolation index, i.e. 1.36 m/s (Case C), 1.35 m/s (Case G) and 1.34 m/s (Case H). This is because the area where airflow is affected gets larger due to the scattering layout of tree patches. Finally, the effect of F_i on PM concentration is negligible as shown in Figure 3b. Case C experiences a bit lower concentration likely because trees planted in relatively concentrated structure (lower F_i) have a larger filter effect of PM10.

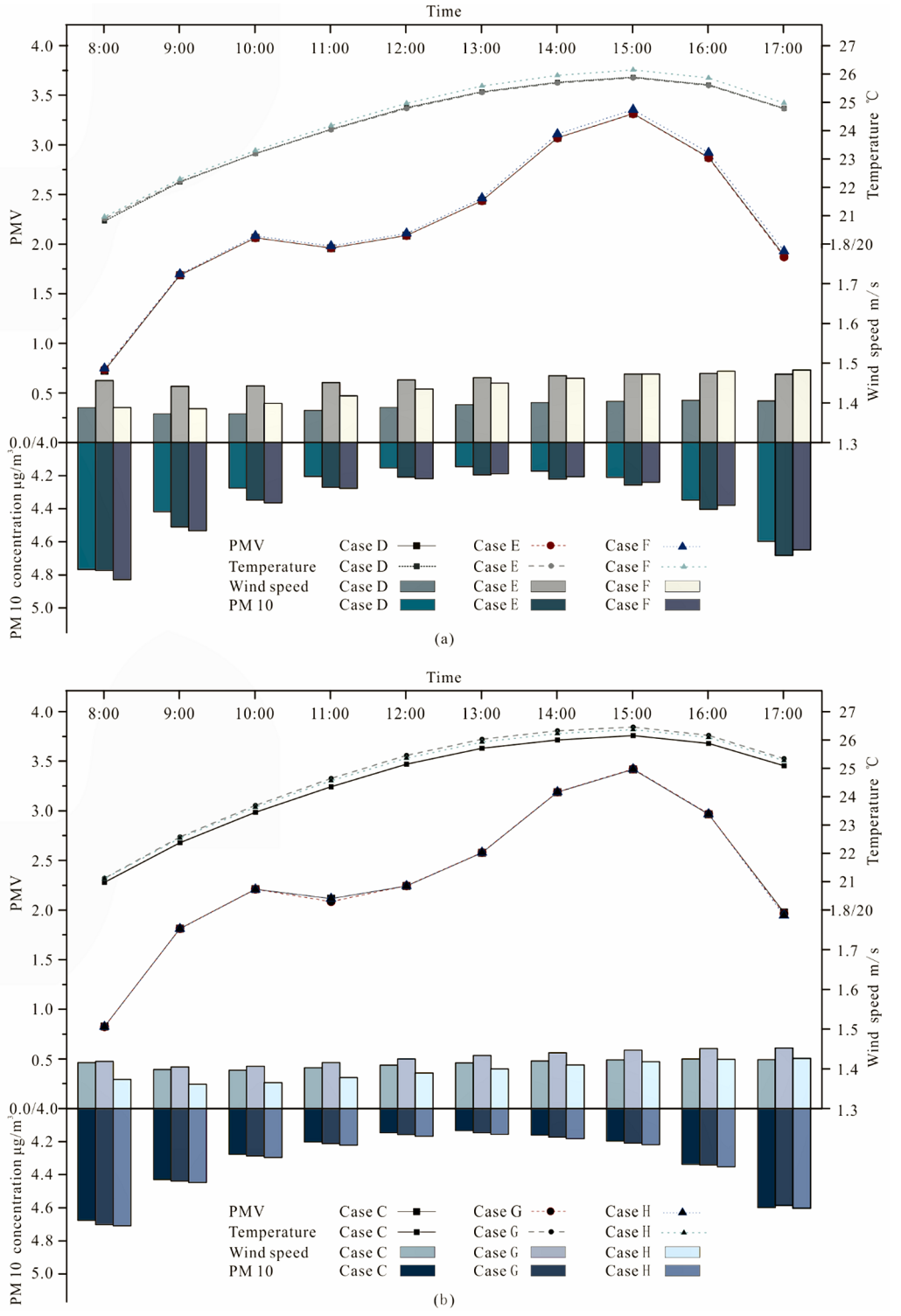

Figure 3. Cases D, E, F: Temporal profiles of temperature, wind speed and PM10 concentration at point P and average PMV at pedestrian level in the residential district and under different landscaping deviation index P_i (a). Cases C, G, H: Same as (a) but under different landscaping isolation index F_i (b).

4. Discussion and conclusions

The effects of vegetation on microclimate and air quality are complex, and the green indices proposed here can be employed to take into account not only the total area covered by vegetation, but also its layout and degree of separation. Here the application of such indices to idealized typical districts of Nanjing (China) has allowed to make a link between several green space morphology, microclimate and air quality. From the perspective of residential green space design, some conclusions can be drawn:

- a green space located in the center of a residential district can improve the thermal comfort and the cooling effect is proportional to the green quantity (evaluated in terms of the grass and shrub cover ratio and the green cover ratio);
- high values of ecological landscaping plot ratio, which expresses the weight of carbon dioxide absorption and is larger in the presence of trees, can enhance the cooling effect and thermal comfort, but decrease the ventilation with a consequent increase of PM10 concentrations;
- under the same green quantity indices, the position away from the center of green space (expressed by the landscaping deviation index) has a limited and lower influence on thermal comfort than green quantity, but mainly influences the spatial distribution of temperature and PMV. Also the effect on local wind speed and PM10 concentrations is negligible;
- similar to the landscaping deviation index effects, a concentrated structure of the vegetation (i.e. a large landscaping isolation index which reflects the degree of separation of landscape distribution) enhances the general thermal comfort as it evens the ambient temperature around the central green space. The increase of landscaping isolation index slightly decreases the average wind speed due to the influence of scattering layout of tree patches on airflow, but with a negligible influence on PM10 concentrations.

In summary, the green quantity is found to have the largest positive influence on thermal comfort, in particular in the presence of more trees. However, more trees also may imply a larger wind blocking effect with a consequent increase of pollutant concentration. In this regard, it is preferable to have several patches of trees located in the central part of the green space to enhance the general thermal comfort, ventilation and air quality. It is worth mentioning that the above conclusions are only valid for configurations with similar characteristics of those studied in this paper, and these findings are limited to the simplified test cases investigated here with a single wind direction. Care should be adopted when considering a real neighborhood and more parameters should be considered, such as different street aspect ratios, building height variations, local meteorology.

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Portugaller, B., Leeb, M., Fallast, K., Struger, N. & Reiter, T.

Traffic noise reduction through acoustic absorption panels, integrated in prefabricated facade elements

Research Article

Abstract

Over the last decades, Burgfried's inhabitants have been dealing with a deficient living environment. Burgfried, one of Hallein's districts (Austria), is characterized by multi-story residential buildings, built between 1930 and 1980. Burgfried's urban structure does not satisfy its inhabitants' needs. Much of the urban open space surrounding the buildings cannot be made use of due to traffic noise pollution. Since there are numerous residential areas facing these or comparable challenges, finding a comprehensive solution to these issues may concern not only Burgfried's but also other local planning authorities.

A novel concept for traffic noise reduction is developed. Cement-bonded wood-fiber absorption panels (produced by Velox Werk Gmbh), implemented in prefabricated façade elements are easily attachable to the consisting building stock in the course of a façade refurbishment. Five prototype variations, differing in insulation and façade materials, are measured in a reverberation chamber.

Results show that the mean absorption factors (α) of prototype variations implementing Velox panels are significantly higher, compared to façade elements with wooden cladding. This effect arises due to the Velox panels letting acoustic energy pass through the first construction layer, enabling the insulation to contribute to the absorbing performance. At the same time, wooden cladding reflects large parts of the acoustic energy, negating that effect.

The influence on surrounding urban spaces was determined by an acoustic simulation. The application of façade elements including wood-fiber panels improve the noise level in patios by 1 - 3 dB in the current state of development.

Keywords: district renewal, minimally invasive retrofit, multifunctional façade, urban noise control, smart skin

1. Introduction

Burgfried, a district in Hallein, Austria, is characterized by multi-storey buildings and serves as an examination object for researching

refurbishment systems. Urban residential districts like Burgfried, with a building stock that was built between 1930 and 1980, face numerous challenges concerning their transition to livable areas as required by modern standards, in terms of energy-efficiency, thermal comfort and accessibility. The districts' livability is heavily influenced by traffic-caused noise pollution as well.

Urban circumstances worsen the acoustic situation, too. Burgfried is located along the B159, a highly frequented road, used by up to 21 000 vehicles per 24 hours (Karnutsch et al. 2017). Open urban structures allow for noise to spread throughout patios and yards; consequently, open spaces, usually used for recreational purposes, remain unfrequented. Measurements show that the perceived continuous noise levels (LA,eq) exceed 55 dB at noon and in the afternoon, even at the building's backside.

38.7 % of Austrians stated that they feel disturbed by noise in their residence in 2015, 3.9 % perceive a very strong and 7.6 % a strong disturbance. 49.1 % report an increased disturbance from 2012 to 2015. Traffic-related noise sources, including busses, cars and single-track vehicles, make up to 40.4 % of the noise pollution, trains and trams 4.9 % (Statistik Austria 2017). Considering that there is a clear link between traffic noise exposure and psychological distress, this issue is of great relevance (World Health Organization 2009).

Recent studies concerning passive noise reduction address building geometries, morphologies and densities (Xiaopeng et al. 2018). Other approaches utilize vegetation belts as noise barriers (Ow & Gosh 2017).

2. Objectives

A reconstructed façade seems to be an adequate way to improve the thermal comfort, acoustic comfort and energy efficiency of buildings in Burgfried. The research concept in question aims to create a façade-system that is suitable for prefabrication and that can be attached easily in the course of refurbishments. The existing building stock will remain mostly untouched, only applying the prefabricated elements on the exterior wall and replacing old windows with new ones. This reconstruction method represents a convenient process for the inhabitants, being minimally invasive and of short duration. The aim is to provide a multifunctional refurbishment system. Three main functions characterize this concept:

2.1. Renewing the building envelope

Compared to modern building standards, a great part of the building stock in Burgfried is outdated. Its living space is neither thermally comfortable nor energy efficient. While windows were replaced and/or composite thermal insulation was applied to some buildings, others have not been renewed since they were built between 1930 and 1980 (Karnutsch et al. 2016).

Heat energy demands reach values up to 140.9 kWh m^{-2} a-1 (gross floor area)

(Karnutsch et al. 2016). The building with the address Salzachtalstraße 32-34 (in the following referred to as test object), which was selected as a representative test object, shows a heating demand value of 136.2 kWh m-² a-1 (gross floor area) (Karnutsch et al. 2016). Losses through transmission contribute significantly to this number. Refurbishing the building envelopes offers a considerable potential for saving heat energy.

2.2. Providing noise absorption

Cement-bonded wood-fiber panels are already used to absorb noise around railroad tracks and highways. Applying such absorption panels onto exterior walls has the potential to reduce noise levels in open spaces throughout the district. Furthermore, a construction consisting of massive wood and insulation forms a mass-spring system, consequently improving the absorption once more, while reinforcing the thermal insulation of the building.

2.3. Replacing the building's heating systems by central heating

Embedding heating circuits in the exterior wall represents an innovation as far as the thermal component activation is concerned. Benefits include the substitution of existing decentralized heating systems in a multi-unit residential building by central heating. The fact that losses may occur due to the heating circuits being very close to the exterior is assumed to be problematic, but can be handled by separating the heat source and the sink through insulation. Early studies show this concept working, while further examination and a prototype aim to validate it. For more detailed information, the reader is referred to "Integrative development of a multipliable modernization concept in urban districts" (Karnutsch et al. 2018).

3. Research process

This research is based on the construction of a prototype, which is examined in test-runs and applied to existing buildings on a small scale. After updating the construction by making use of absorption measurements (see 3.1 below) and a small scale operation (3.2 below), the refurbishment of an entire building envelope with this construction is used to validate the concept. Although the main focus of the paper lies on the measurement of acoustic absorption, the overriding research plan will be explained in order to give an impression about the validation of the concept as a whole.

3.1. Measuring acoustic absorption

The prototype's absorption behavior is measured in a reverberation chamber, complying with the ÖNORM EN ISO 354:2003 standards. Acoustic absorption can be determined by the subsequent decaying reverberant,

which builds up when a sound source operates in an enclosed space. Class 1 microphones (IEC 61672) are used for this task. The geometry and interior equipment of the reverberation chamber provides a diffuse field, ensuring that no sound incidence or standing waves occur. These events would distort the outcome. Results show the absorption factor for each 1/3 octave band (from 50 Hz to 50,000 Hz). For each test run and variation, elements with a total surface of 9 m² (split into three elements, 3 m² each) will be prefabricated and measured.

To find the most efficient composition of materials and diameters, three test runs are set up, each of them containing up to six different variations of the basic element. The results of each test run determine the variations for the next session. This way, the construction can be optimized step-by-step, leading to an efficient and effective prototype. In order to classify the results, an acoustic simulation showing the effects on surrounding urban space was conducted. For this purpose, the software Immi was utilized. Immi is an appropriate tool for representative sound propagation simulations as it respects all influences of acoustic relevance, calculating algorithms are validated through ÖNORM EN ISO 9613-2 and noise emissions are determined in accordance to RVS 04.02.11.

3.2. Applying the prototype on a small scale

While the absorption measurements take place, an early version of the prototype measuring 25 m² is applied to the test object in Burgfried. This test aims to spot weaknesses in the prefabrication and application process within the architectural aesthetics of the construction.

Additionally, heating slopes are implemented in order to form a thermal activation system, replacing the heating systems in the whole building and centralizing them. This thermal activation system is part of a related research project (see above).

3.3. Applying the prototype on a use-case-scale

The last step of the research is refurbishing the whole building with the created construction in order to find weak spots and optimize the application process on a use-case-scale. The building will meet the typology of a three-storey residential building, which is characteristic of Burgfried and many other districts, providing comparability and reproducibility. Furthermore, a related project will study whether the thermal activation is efficient and fully functional or not.

The exterior continuous sound level is expected to decrease substantially around the building, considering it being coated in absorbing materials. This effect will increase if more buildings surrounding a courtyard will be reconstructed in the discussed way.

The long-term goal is to create a reproducible and architecturally attractive refurbishment solution, which may be used in comparable districts that are facing similar challenges.

4. Prototype

The basic construction consists of 10 cm massive wood, 16 cm insulation and 5 cm rear ventilation level, covered by a closing façade element. For comparability, five different variations were tested. Variations include different insulation and façade materials and wooden shutters inside the construction (Fig. 1). Constructions including wood-fiber insulation contain an extra wood-bridge in the insulation layer, needed for structural reasons. They all fulfill the criteria, which render the elements suitable for preconstruction.

4.1. Velox absorption panel

The absorption panel (Velox WSE 80 mm), implemented in three variations provides acoustic absorption, appropriate for façade-implementation. In contrast to the wave pattern of popular absorption elements along highways and train tracks (i.e. Velox WSO 80), this structure resembles bark (see Fig. 2) and has a more natural appearance. The panel consists of cement-bonded wood-fiber. Due to the pattern, the thickness of the panel varies between 3 and 8 cm, with a gross weight of 750 kg m³.

The panels are expected to provide acoustic absorption. Due to the product being launched onto the market only recently, there is no information about its absorption behavior.

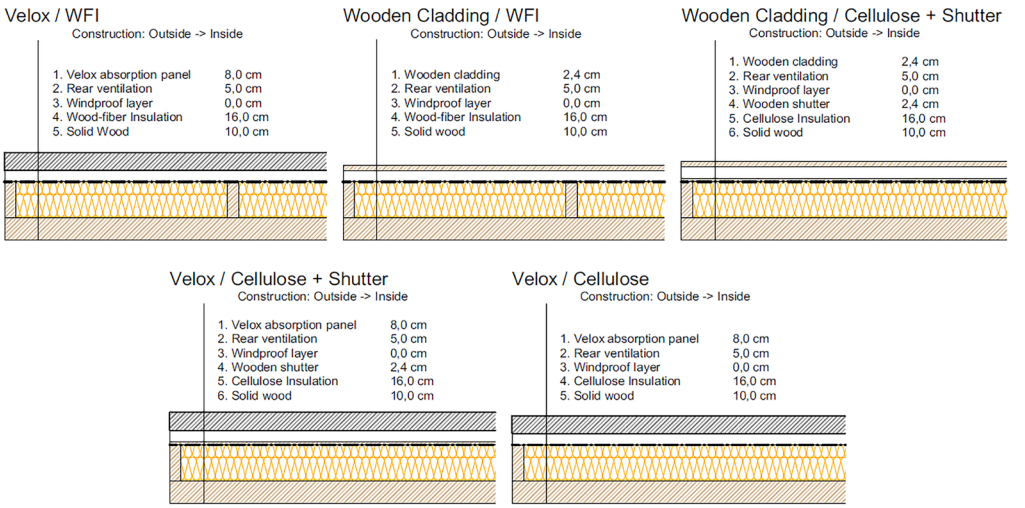

Figure 1: The five prototype variations for the first test-run. (Salzburg University of Applied Sciences)

4.2. Wooden cladding

The application of wooden slabs in ‘Wooden cladding / WFI’ and ‘Wooden cladding / Cellulose+Shutter’ provides a comparison to usual façade design. They are screwed gaplessly to each other with a tongue/groove conjunction to the underlying counter battens.

Figure 2: Texture of the Velox absorption panels. (Velox Werk Gmbh)

4.3. Insulation

During the test-runs two different insulation materials were measured, which show different consistencies. Cellulose has a structure that gives the particles more room to move inside the construction layer, whereas the wood-fiber is bond into sheets, where movement is more limited.

4.4. Solid wood back

The backbone of the construction consists of solid wood. In contrast to usual solid cross-laminated timber, which needs glue to keep layers together, these elements work without glue. Long dowels, prepared with an amino acid-mixture, are used to attach the layer permanently to each other.

5. Results

5.1. Acoustic Absorption Measurement

All measured variations had an absorption factor between 0.00 and 0.77.

'Velox / Cellulose' achieved a maximum of 0.77, which means that 77 % of the acoustic energy is absorbed by the construction at a frequency of 1250 Hz (as far as 1/3-octave band values are concerned). All data referred to are raw values and were not adjusted to human perception (i.e. frequency weighting A, referring to ÖNORM EN 61672-1 annex E). In compliance with ÖNORM 11654 the values were converted from 1/3-octave bands to octave bands (see Fig. 3).

The five variations split up into two groups of closing façade materials. 'Wooden cladding / WFI' and 'Wooden cladding / Cellulose+Shutter' (group a) showed a lower mean absorption factor, whereas variations 'Velox / WFI', 'Velox / Cellulose +Shutter' and 'Velox / Cellulose' (group b) reached higher values.

5.1.1. Group a – Elements implementing wooden cladding

These constructions, which are enclosed by a wooden cladding, achieved a mean absorption factor of 0.14, with a peak of 0.25 at 200 Hz ('Wooden cladding / Cellulose+Shutter'). Both constructions absorbed no acoustic energy at 4000 Hz. Values mostly varied between 0.10 and 0.20.

The constructions contained different insulation materials, being wood-fiber in ‘Wooden cladding / WFI’ and cellulose in ‘Wooden cladding / Cellulose+Shutter’. Total diameters differed by 2.4 cm.

5.1.2. Group b – Elements implementing Velox absorption panels

The mean absorption factor of group b amounted to 0.51 (‘Velox / Cellulose+Shutter’) – 0,54 (‘Velox / WFI’ and ‘Velox / Cellulose’). The whole group showed similar performances from 4 000 to 500 Hz, with values between 0.70 and 0.50. While ‘Velox / WFI’ stayed constant after this point, the other two variations peaked at 250 Hz. All samples showed a declining absorption factor as they approached 63 Hz.

This group shared the implementation of the Velox absorption panels as an exterior layer. Insulation materials differed, as ‘Velox / WFI’ contained wood-fiber insulation and the other two embedded cellulose.

5.2. Effect on surrounding urban spaces

Due to traffic noise being a multidimensional phenomenon, describing performance with a single value hides multiple inaccuracies when it comes to interpreting results in situ. Noise spreading is highly influenced by the geometry off surrounding buildings and the distance of noise sources, which are roads in our case. Hence, in order to classify the effect of the façade on the surrounding urban space, a simulation was conducted.

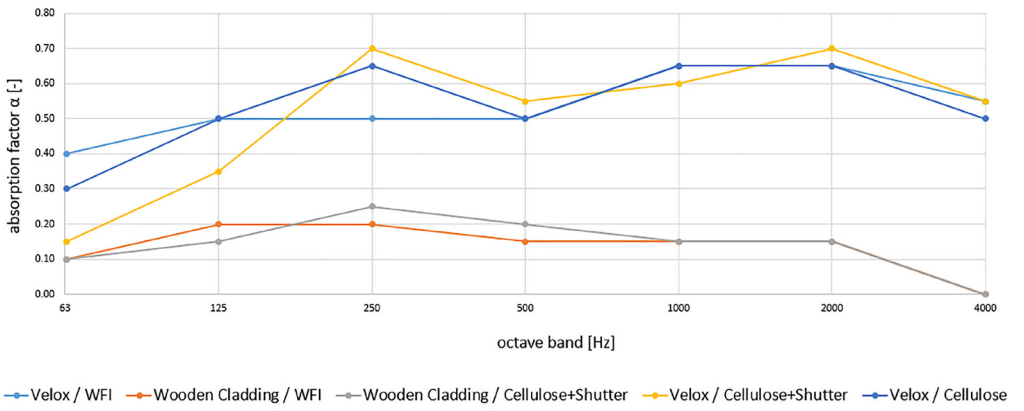

Figure 3: Results (absorption factor as a function of octave bands) of the first test-run. (Salzburg University of Applied Sciences)

The two best-performing façade elements ‘Velox / WFI’ and ‘Velox / Cellulose’ were implemented in the simulation, as they promise to have the highest impact on the surrounding urban space. A rating of all variations was determined by the mean absorption factors. While the values of variations utilizing wooden cladding were around 0.14, ‘Velox / Cellulose+Shutter’

reached 0.51 and the two mentioned above amounted to 0.54.

The simulated area includes four buildings (dark blue in Fig. 4) enclosing the same patio, one of them being the test object (north-east). The patio measures approximately 2000 m². Acoustic absorbers and diffusors like hedges, trees and parking cars were not considered in this simulation. Each of the four surrounding buildings is assumed to be reconstructed with 'Velox / WFI' or 'Velox / Cellulose' façade elements, having a continuous absorption factor of 0.54. Due to the software mapping noise exposure by utilizing the mean absorption factor, both 'Velox / WFI' or 'Velox / Cellulose' obtained the same results. Sound sources were calculated by the number of passing cars, in accordance to ÖNORM S 5021. Figure 4 shows the impact of the discussed façade elements on the patio, compared to a usual façade design. Usual façade design is defined by a mean absorption factor of 0.21 in this simulation. Three different time periods were calculated, as they show different traffic volumes, resulting in different noise levels. Due to daytime being most impactful on recreational use of urban spaces, those results are showed in Figure 4.

Judging from simulated results shown in Figure 4, the façade elements 'Velox / WFI' and 'Velox / Cellulose' have an impact on the patio. Noise reduction from 1 to 3 dB (measurement height equals 1.5 m) was observed. Noise reduction reached its maximum alongside the buildings, at a distance of approximately 2 to 5 m from the façade. The aisle on the north shows how geometry influences penetration depth of the noise into the patio. Furthermore, improvements near neighboring buildings, where the absorption factor of the façade remained unchanged (0.21), can be observed near the building's north- and southwest sides.

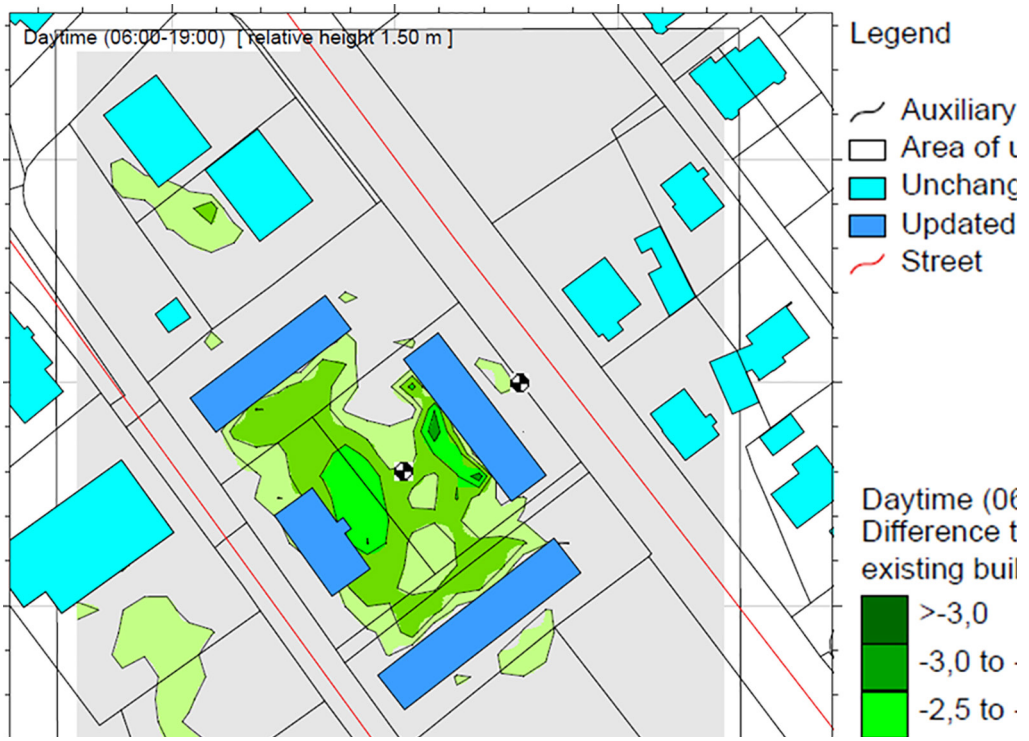

Figure 4: Improvements [dB] through reconstruction with 'Velox / WFI' or 'Velox / Cellulose'. (PLANUM Fallast Tischler & Partner)

6. Interpretation
6.1. Acoustic Absorption Measurement

It can be stated that the implementation of a Velox acoustic absorption panel (WSE 80 mm in this case) leads to a higher absorption factor of the construction. A wooden cladding enclosing the element has a negative impact. The high flow resistance of wood hinders acoustic energy entering the construction, whereas the cement-bonded wood-fiber Velox panels do apparently not share that effect of hindrance to the same amount. Some of the acoustic energy can pass through that first layer, which enables the underlying spring-mass system consisting of insulation and wood to absorb acoustic energy.

Different absorption peaks, which occurred during the measurements, can be explained by wooden slats mounted on different spans. Spans influence the resonant frequency, which leads single components inside the construction to absorbing exceptionally well on a particular frequency.

6.2. Effect on Surrounding Urban Spaces

What can be observed, is that the façade elements ‘Velox / WFI’ and ‘Velox / Cellulose’ have an effect to the surrounding urban environment. Improvements between 1 and 3 dB are possible with the prototype at this stage of development in the observed patios. Positive impacts on neighboring patios imply that effectiveness increases by the number of surrounding buildings reconstructed with absorbing elements. Furthermore, the simulation suggests that geometrical characteristics have a significant impact on noise penetrating the patios. Closing gaps would reduce noise levels.

Vegetation belts seem to be a more effective method when it comes to noise control, as they are able to cause a reduction up to 12 dB. Still, in urban environments space efficiency is a highly important topic. A vegetation belt needs a depth of about 10 m to provide a reduction of 9-11 dB. (Ow & Gosh 2017).

7. Conclusions and Outlook

When it comes to creating noise absorbing constructions, the ability to let acoustic energy pass through the first layer is mandatory if underlying materials are expected to help improving the absorption factor.

Reconstructing buildings with absorbing constructions of districts charged by noise pollution is effective to a reasonable degree. The created façade elements ‘Velox / WFI’ and ‘Velox / Cellulose’ provide acoustic absorption, which is perceivable on very limited areas around the building.

The prototype is in an early stage of development. The research plan includes two more test-runs in the reverberation-chamber, where the focus solely lies on improving absorption. Subsequent steps include different perforation patterns and flexible mounting, which is expected to

influence absorption positively. When the prototype is finalized, concluding simulations will show if a reasonable performance in form of extensive and perceivable improvements in noise levels are provided.

As far as maximized noise reduction is concerned, a combination of gap closure and application of absorbing constructions seems to be an effective measurement.

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Bickerdike, A., Dinneen, J. & O'Neill C.

'A Healthy CIT': A case study outlining the initial development of a campus health promotion initiative in an Irish Higher Education Setting

Best Practises and Case Studies

Abstract

Embedding health and sustainability into all policies and practices within Higher Education Institutions, in accordance with the fundamental principles of the 'Health Promoting University' has been proposed as a means of enabling synergistic collaboration between the disciplines of public health and sustainable development.

In Ireland, healthy campus/university initiatives have emerged in practice within many Higher Education Institutions (HEIs). A Healthy CIT is a new campus health promotion initiative at Cork Institute of Technology (CIT) in southern Ireland. This initiative aims to maximise the health and wellbeing of students, staff and the wider community. To date, A Healthy CIT has been strategically managed via a designated research arm within the Institute's Department of Sport, Leisure and Childhood Studies.

This paper will be of interest to potential collaborators who wish to develop cross-sectoral, sustainable solutions to maximise health, wellbeing and quality-of-life for both present and future generations. An overview of the experiences during the first two years of the development of A Healthy CIT is presented. The designated research arm has made significant progress, with data collected from 2 268 students and 280 staff members using cohort specific web-based health questionnaires. Further strengths include the collaborative culture that exists within the Institute, aided by the positive engagement of students and staff with pilot campus initiatives to date. Barriers that jeopardise the long-term sustainability of A Healthy CIT include the absence of a dedicated human resource to manage and drive this initiative, financial constraints that impact physical resource needs, as well as related organisational barriers as a consequence of the increasingly pressurised higher education environment.

Keywords: Healthy Settings, sustainability, wellbeing, campus health promotion, healthy university

1. Introduction

The rationale for health promotion is clearly evident in light of the global burden of non-communicable diseases [NCDs]; chronic, non-infectious diseases such as cardiovascular disease, respiratory conditions, diabetes and cancers, that collectively constitute the leading cause of global deaths (World Health Organisation [WHO] 2014). Although the determinants are complex; poorly planned urbanisation (Maas et al. 2006, 2009), ageing of the population and globalization, a number of modifiable behaviours have been attributed to increasing the risk of NCDs such as harmful alcohol consumption, unhealthy diets, physical inactivity and tobacco smoking (WHO 2013, 2014). In this context, it has been previously established that efforts to enable healthier lifestyle behaviours can be facilitated at a macro-level within the settings of society (WHO 1986).

As influential settings, Higher Education Institutions [HEIs] have been urged to become leaders in health promotion by the Okanagan Charter for Health Promoting Universities and Colleges (2015). As a life stage, the transition to tertiary education is traditionally a period of separation from parental influences and supports (Scarapicchia et al. 2017). However, increased autonomy coupled with financial stressors can result in third-level students adopting risky lifestyle behaviours (Breitenbach et al. 2016; Deforche et al. 2015; El Ansari et al. 2011) that, if maintained, could be associated with developing a NCD later in life. Certain detrimental health behaviours have been consistently reported among HEI student cohorts worldwide. Binge-drinking and alcohol-related harms remain ubiquitous in Ireland (Davoren et al. 2015; Hope et al. 2005; Mac Neela et al. 2012), the United Kingdom (John & Alwyn 2014; Jones et al. 2014; Quigg et al. 2013), Switzerland (Studer et al. 2015) and North America (Jones et al. 2001; Zakletskaia et al. 2010). An increase in Body Mass Index [BMI] has also been reported during the transfer from second to third level education, behaviourally associated with reduced sports participation, increased internet use and reduced fruit and vegetable intake (Deforche et al. 2015). From a mental wellbeing perspective, a recent Institute for Public Policy Research Report highlighted that wellbeing among UK students appears to be lower relative to the general population (Thorley 2017).

HEIs are also prominent workplace settings, employing heterogeneous cohorts of academic, administrative, management and technical staff. In Ireland, total HEI staff figures (both academic and non-academic) have increased by 7% to over 24 100 in 2016 (Higher Education Authority 2018). Surprisingly, there is a relative dearth of research examining the health behaviours of this cohort in comparison to the abundance of literature pertaining to student health. One particular health concern that has been reported is occupational stress (Gillespie et al. 2001; Viljoen & Rothmann 2009; Winefield & Jarrett 2001). This may be a consequence of the cultural shifts within the higher education sector over the past number of decades that have resulted in greater student numbers, diversified academic workloads (Winefield & Jarrett 2001) and unprecedented accountability (Kinman 2014) in terms of output and performance. Occupational stress not only impedes job performance, but can physically manifest as musculoskeletal back pain, headaches, hypertension and reduced

immunity (Gillespie et al. 2001).

In light of the existing burden of NCDs, HEIs are uniquely positioned to generate, disseminate and implement knowledge for the purposes of improving the health of present and future generations (Okanagan Charter 2015). The current paper aims to contribute towards existing knowledge by outlining the preliminary development of a new campus health promotion initiative (A Healthy CIT) within a multi-campus Institute of Technology in southern Ireland.

2. Cork Institute of Technology

The majority of Cork Institute of Technology's student services, staffing functions as well as the Academic Council operate within the largest central campus located in a western suburb of Cork city (Bishopstown). A number of satellite campuses are also situated in the inner city (Crawford College of Art and Design, CIT Cork School of Music) and Cork county (National Maritime College of Ireland).

2.1 'A Healthy CIT' - Background, Concept and Objectives

A Healthy CIT is a campus health promotion initiative that aims to place health, wellbeing and sustainability at the core of the Institute's culture. Internal records document an intent to establish CIT as a health-promoting institute in 2002/2003, however anecdotal evidence suggests that such efforts were not sustained. Although a myriad of student services are offered on campus, there has never been an Institute position solely dedicated to health promotion and/or sustainable development.

The present concept of A Healthy CIT initially emerged in 2014 as a proposed student engagement and retention initiative. In 2015, a designated

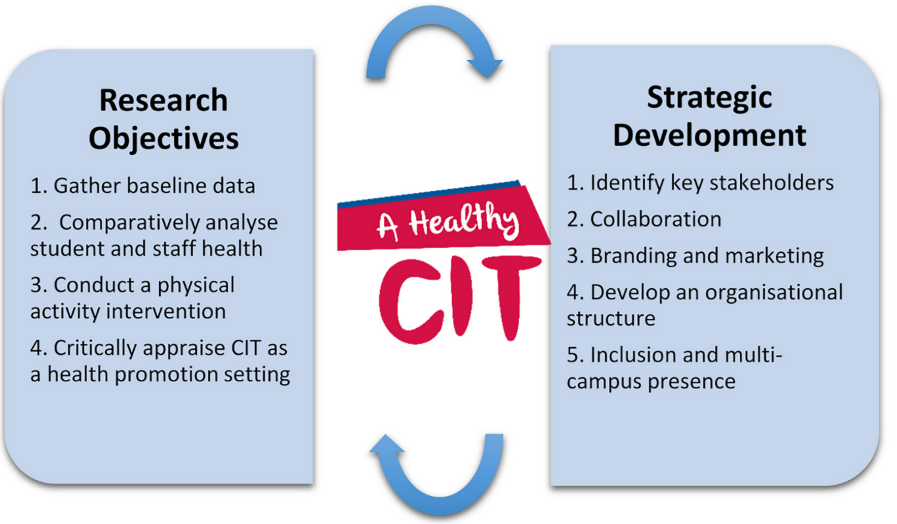

Figure 1: 'A Healthy CIT' Operating Consept; synergistic research and strategic development.

research unit for A Healthy CIT was established within the Department of Sport, Leisure and Childhood Studies. In the absence of a Health Promotion Officer/Co-Coordinator, it was decided that the research team (postgraduate student and two academic supervisors) would oversee the Institute-wide strategic development of A Healthy CIT, as an adjunct to teaching and research activities. Following an extensive review of the relevant literature, an initial operating concept was constructed and a series of synergistic research and strategic objectives were outlined (Fig. 1).

The fundamental research aim was to gather baseline health data from both student and staff cohorts to directly inform the ongoing development of this pioneering initiative. Specific objectives were to; examine the health behaviours of students and staff within the context of the campus setting, comparatively analyse the health of CIT students and staff, design and implement a campus-based physical activity intervention and critically appraise CIT as a health promotion setting.

The strategic objectives were informed by collated insights obtained from a review of the original conceptual framework of a Health Promoting University (Tsouros et al. 1998), local and international case studies (Freudenberg et al. 2013; Perry et al. 2012; Sellers et al. 2014), HEI campus health promotion websites, as well as the seminal works of Dooris and colleagues regarding the application of the settings approach to health promotion within HEIs (Doherty & Dooris 2006; Dooris 2001, 2006, 2009; Dooris et al. 2010; Dooris et al. 2014).

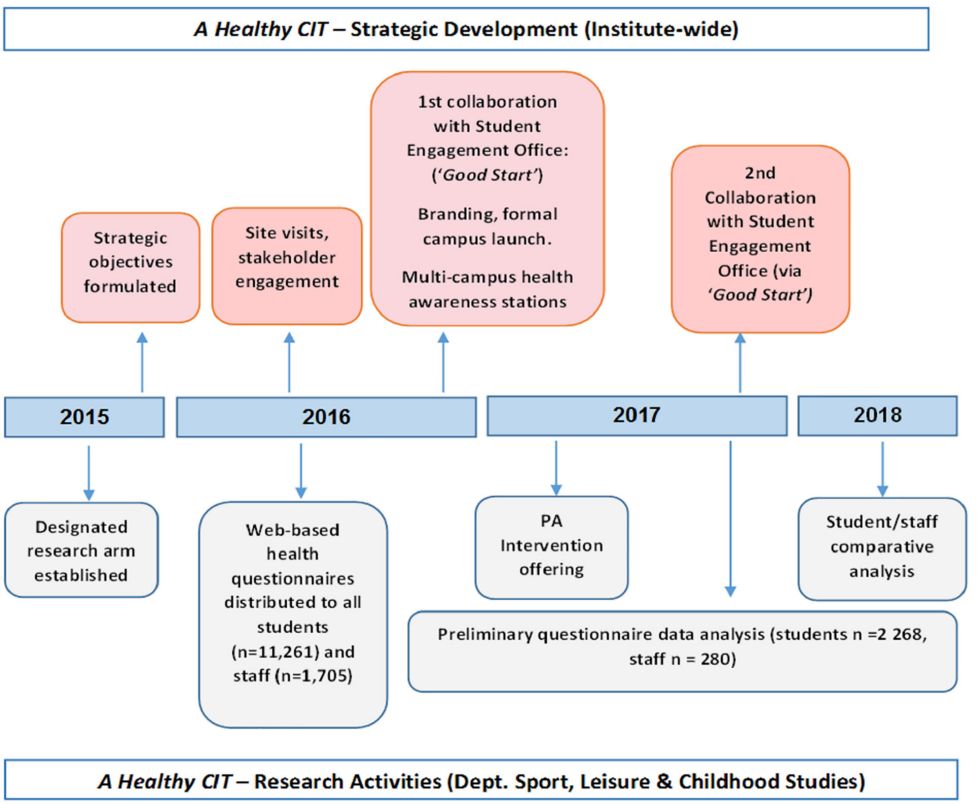

Figure 2. Research and strategic milestones during the first two years*of A Healthy CIT's development* (academic Years 2015/16 and 2016/17)

3. A Healthy CIT; Initial Development

Figure 2 presents a chronological timeline of key milestones in terms of research activities and Institute-wide strategic development.

3.1 Stakeholder Identification and Collaboration

Dooris and colleagues (2010) described a myriad of higher-education and public health 'drivers' and 'inputs' in their theoretical conceptualisation of a 'Healthy University'. The strategic development of A Healthy CIT began in 2015 with an internal/external stakeholder analysis for the purpose of identifying both the potential receivers and influencers likely to play a part in the development of A Healthy CIT, as outlined in Table 1.

Table 1: Internal and external Stakeholder Analysis.

	Receivers	**Influencers**
Internal stakeholders	Students	Senior Management
	Staff	Sports Officers
		Medical Staff
		Counselling Services
		Campus Catering Services
		Buildings & Estates Officers
		Staff with health/recreation/physical activity as part of their employment remit
External Stakeholders	Local Community	Health Promotion Unit of local health service
	Alumni and future policy makers	Local Sports' Partnership
		Potential academic collaborators

It has been proposed that collaborative practices in health promotion maximise resources and shared knowledge (Whitehead 2001). A Healthy CIT has relied heavily upon collaborative approaches to date to execute pilot activities (outlined below). Furthermore, in 2016, CIT became an overseas associate member of the UK Healthy Universities' Network (Healthy Universities 2018) gaining access to a knowledge-sharing platform as well as an established network of potential collaborators.

3.2 Branding and Marketing

The development of a 'Healthy University' may require a dual approach to implement high-visibility 'ground level' projects in conjunction with less tangible efforts to generate organisational change at a macro level (Dooris et al. 2010). In 2016, to maximise visibility, efforts began to develop a logo and marketing materials to encapsulate the ideals of A Healthy CIT. A logo, tagline (*'Your Campus. Your Health. Your Choice'*) and a number of corporate display materials to reflect the core goals and inclusivity of the initiative were designed (Fig. 3). These marketing materials have been displayed at all initiatives and collaborative events to ensure A Healthy CIT is visible to the Institute community as an active entity and a part of campus life.

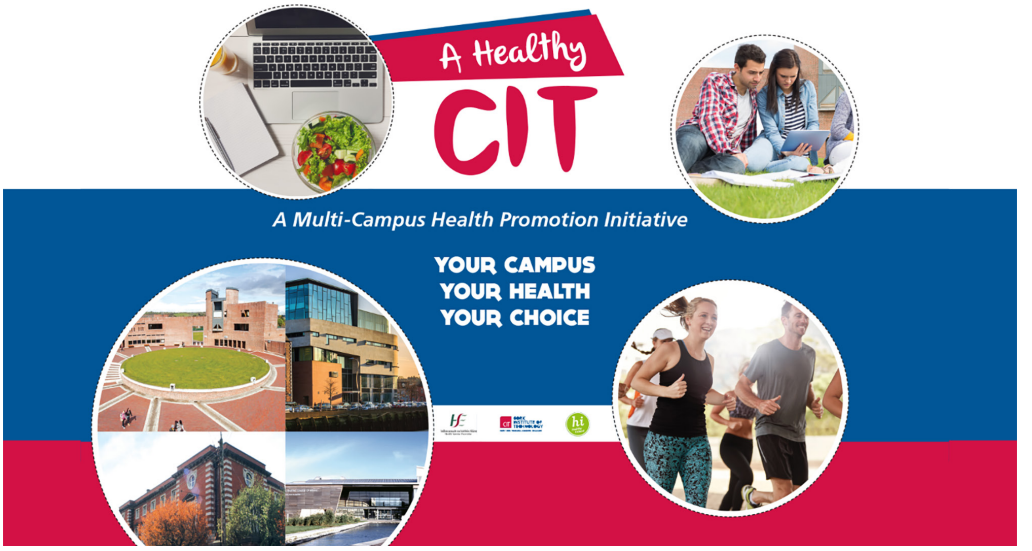

Figure 3. Sample of A Healthy CIT's Marketing Materials

3.3 Creating and Sustaining a Multi Campus Presence: Progress to date

During years 1 and 2, a number of pilot initiatives took place to position health promotion at the forefront of student and staff consciousness as well as on the Institute Management's agenda. In October 2016, a week-long collaborative pilot of A Healthy CIT was rolled out as part of the Institute's student induction programme ('Good Start' - under the remit of the Student Engagement Office). Initiatives included a healthy cooking demonstration (in further collaboration with the Department of Tourism and Hospitality), a series of health-related blog posts as well as multi-campus site visits and information stands to promote awareness of A Healthy CIT. Building on the momentum generated from these events, in November 2016 A Healthy CIT was formally launched as an Institute-wide initiative, serving both students and staff. Further collaborative events to date have included multi-campus health awareness stations, participation in a Linked Schools Mental Health information day (led by the Institute's Access Service), further healthy cooking demonstrations and a Guest Lecture by a visiting Adjunct Professor to the Department of Sport, Leisure and Childhood Studies, Prof. Elaine Rush from Auckland University of Technology. Although all campus events have been well-attended, the cooking demonstrations on the Bishopstown (primary) campus have been particularly successful, with interest in the event consistently exceeding the venue's capacity.

4. A Healthy CIT's Research Activities

The research arm of A Healthy CIT has developed a mixed-method study to gather baseline data regarding the health status of CIT students, staff and the overall characteristics of the CIT campus setting in terms of facilitating healthy and sustainable lifestyles.

4.1 Institute-wide Health Questionnaires

During the Spring Semester of 2016, two web-based health questionnaire instruments were administered to all students (n = 11 261) and staff (n = 1 705) of the Institute. Both instruments contained a combination of previously-validated scales, newly-devised campus-specific items and free text qualitative items to gather data regarding physical activity, nutrition, alcohol, smoking and mental health, all contextualised in terms of the CIT environment and setting. The student instrument contained further cohort-specific items in relation to academic achievement, sexual health, substance abuse and social media usage. In total, 2 268 (20.1%) responses were received to the student questionnaire and 280 (16.4%) responses received to the staff instrument. The comparable scales/items used in both instruments will facilitate a forthcoming novel dual-cohort analysis of student and staff health within an Irish HEI setting.

4.2 Physiological Parameters

Physiological health parameters (blood pressure, resting heart rate, standing height, body mass, waist/hip/abdominal circumference) were measured in a random sample of students (n = 195) who engaged with A Healthy CIT's 'pop-up' health awareness stations on each individual campus in November 2016.

4.3 Campus-Based Physical Activity Offering for Staff

In January 2017, a ten-week group-based campus intervention, requiring participation on three occasions per week (lunchtime) was offered to the CIT staff cohort. The intervention was offered completely free of charge, under the research remit of A Healthy CIT. Inclusion criteria were medically-fit staff members who were not engaged in sport or achieving 150 minutes' per week of moderate-vigorous physical activity, as per Irish national guidelines (Dept. of Health & HSE 2009). Following general indications of interest, less than 10 staff participants were in a position to complete all elements of the intervention and it was ceased following baseline testing. Subjective evidence suggests the lack of participation was predominantly attributable to timetabling constraints.

5. Discussion

Since its initial conceptualisation, significant progress has been made to develop A Healthy CIT in terms of baseline research, branding, campus presence, ground-level engagement of stakeholders and internal collaboration. A fundamental strength is the designated research arm that aims to inform the future direction of the initiative. A needs assessment is appropriate during the planning stage of any health promotion initiative (Smith et al. 2006) and it is postulated that the research arm will prove cost-effective in terms of identifying evidence-based areas of action or

working groups. At the time of writing, the student (n = 2 268) and staff (n = 280) datasets are subject to analysis and stratification by sex, age and area of study/job description (as appropriate).

In relation to student lifestyle behaviours, the current study will enable comparisons with the College Lifestyle and Attitudinal National Survey (Hope et al. 2005), a study that remains the national reference point for the health behaviours of undergraduate students in Ireland despite being published over a decade ago. The research will also address the dearth of literature pertaining to employees in tertiary education. Direct comparisons will be made between students and staff cohorts, to elicit any convergent/divergent needs, behaviours and campus interactions. To date, there is no evidence of any study that directly compares the health of both students and staff within the context of their shared HEI setting. This is surprising considering the omnipotent reference to a 'whole-university' approach advocated in the health promoting university conceptual framework (Tsouros et al. 1998).

Cork Institute of Technology's culture of collaboration has been a potent facilitator of the strategic development of A Healthy CIT. In light of financial constraints, internal traction and campus visibility to date have been largely achieved through collaborative initiatives with internal stakeholders that maximised the potential of the existing campus facilities. For example, the 2016 healthy cooking demonstration took place in collaboration with the Institute's Department of Tourism and Hospitality as well as the Student Engagement Office. The former provided skilled culinary lecturers, ingredients, tasting samples and access to a cooking demonstration theatre, whereas the Student Engagement Office funded administrative costs, provided an established student induction platform ('Good Start'), access to social media accounts and the assistance of the designated 'Good Start Leaders' to assist with the promotion and implementation of the event. A continuation of this collaborative approach will be paramount to the gradual integration of health and wellbeing into campus life at CIT.

Despite the significant progress, a number of barriers have been encountered in terms of financial constraints and the absence of a dedicated human resource to manage and drive A Healthy CIT. For the past two years, a research team (postgraduate student and two academic supervisors) have assumed the roles of quasi-coordinators. Logistically, this has placed limits on the amount of collaborative projects undertaken. Furthermore, although campus visibility initiatives have been well received, it must be borne in mind that the entire theoretical basis of the settings-approach to health promotion, and in particular healthy universities, centres around the integration of health and wellbeing into the culture, educational activities and governance policies of a HEI at a macro-level (Dooris et al. 2014; Newton et al. 2016; Okanagan Charter 2015; Tsouros et al. 1998). The absence of funding or a campus driver of this agenda creates a danger that A Healthy CIT will become merely another segregated campus service as opposed to a truly holistic and whole-system implementation of the ideologies of a healthy university.

Barriers posed by the accepted constraints of the higher education

environment (such as increased student numbers coupled with reductions in funding) have also impeded the strategic development of A Healthy CIT. From a governance perspective, although an organisational structure (Steering Committee, Executive Committee and Special Interest Group) has been proposed by the research team, timetabling constraints and heavy workloads of senior Institute figures have meant that the Steering Committee has not formally convened to date. We believe that this is not due to a lack of appreciation of the importance of health promotion, but due to heavy academic workloads which is consistent with the increased academic demands reported in the literature (Houston et al. 2006).

Similarly, subjective evidence suggests that wider organisational barriers were a determining factor in the failure to recruit staff participants for a campus-based physical activity intervention. This intervention was entirely free of charge and state of the art facilities were available within the Institute's Department of Sport, Leisure and Childhood Studies. However, barriers to participation reported anecdotally by participants were predominantly timetabling commitments and heavy academic workloads. At present, academic staff are often timetabled to teach during the traditional lunchtime hour and the increase in working hours imposed by a National Public Service Agreement in 2010 has resulted in many administrative staff taking a reduced lunch break of thirty minutes. At the level of the individual, it is also possible that the target staff cohort were not at an optimum level of readiness ('Action Stage') to change their sedentary lifestyle, in the context of the Transtheoretical Model of Behaviour Change (Prochaska & DiClemente 1982). The overall lack of participation points towards the existence of complex and multi-factorial barriers to physical activity ingrained within the constraints of the higher education environment, further reinforcing the need for an initiative such as A Healthy CIT. Questionnaire data gathered as part of research activities outlined in section 4.1 above will determine the habitual physical activity levels of the CIT population, identify any culturally-specific barriers experienced and enable future triangulation and dissemination of findings in this regard.

6. Summary and Conclusion

As a diverse HEI with a strong collaborative culture, significant progress has been made to develop A Healthy CIT through inter-departmental collaborations and utilisation of built-environment facilities. In addition, research activities have progressed to establish significant baseline health datasets. Nevertheless, although general support for the ideals of the initiative has been forthcoming from all stakeholder levels (students, staff, senior management), progress is in danger of reaching a plateau if current levels of commitment to sustainable change are not surpassed. True application of the 'healthy university' approach will require support beyond present levels in terms of resources, funding and senior management 'buy-in'. This is not a challenge confined to Cork Institute of Technology, and is further compounded by the lack of published national guidelines or official government-level framework for healthy campus

initiatives in Ireland. Future opportunities to engage senior management and external stakeholders are likely to arise following dissemination of existing research data, particularly a novel dual-cohort analysis.

Note: questionnaire instruments available from lead researcher on request

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Improved awareness of environmental and sustainability issues leads to more responsible citizen involvement: case Geopark concept promotion

Best Practises and Case Studies

Abstract

This paper looks at a number of studies of existing areas in different countries where nature-based tourism is carried out, with especial reference made to experiences with geoparks. One is Lankawi Geopark, located on an island in Malaysia. This achieved UNESCO Global Geopark status in 2007, and research was carried out in 2009 on how the local community relate to the geopark, where it was found that the empowerment through it was of key importance. Another example is from the higher developed and urbanised territory of Hong Kong, where visitors to nature park areas were found to be very heterogeneous in their motives. A study from the Araripe Basin Geopark in Brazil looked at how traditional and mystical folk narratives and scientific narratives contribute both in their own different ways to emphasising the special natural features of the area worth preserving. An on-going initiative is the preparation for achieving UNESCO Global Geopark status for a selected region of geological significance that includes Lahti city. The Salpausselkä Geopark is at present at the early stage of preparing the application process, and already has an active enterprise stakeholder network. In planning how to promote the geopark concept to the general public, and raise awareness of the geological significance and related cultural heritage of many features of the region, it is important to note and learn from how this process has succeeded in existing geoparks and nature areas.

Keywords: environmental awareness, nature-based tourism, geoheritage, UNESCO Geopark

1. Introduction

Consumers, and city-dwellers in particular, are subject to a continuous stream of information and guidance, which can be both difficult to interpret in terms of what is beneficial and what is not. Those wanting to act sustainably, consume ethically and otherwise reduce their impact on the environment often lack the educational background and technical knowledge on which to base their choices.

The motivation of people and organisations acting to promote environmental

protection and sustainable development is not important, in the behaviour of those in business and industry responsible activity of any kind need not essentially have a moral or emotional basis; enterprises are expected to have a sustainability policy to be competitive, whether or not the members of the management really care about such issues (Sekerka & Stimel 2011). In making choices about the use of natural resources a variety of factors need to be considered and different individuals' decisions depend on both their own backgrounds and on received external information (Mehmet & Øystein 2013). Tourism can be one means of consuming natural resources; the motives of visitors to natural areas is presumed to be positive towards conservation, but as with the business world this does not have to be the case; tourism can also involve destructive behaviour of different forms. Lack of knowledge about fragile natural features can easily lead otherwise well-intentioned visitors to cause damage (Cheung & Fok 2013). This paper deals with a number of research studies carried out on different perspectives of nature based tourism, on motivations for environmental protection and on approaches to increasing environmental awareness. It focuses especially on a relatively new type of specific tourism in the natural world; geotourism, based on visiting locations in the growing UNESCO Global Geopark network (UNESCO 2018).

A variety of international examples is taken; there are nature protection areas in Europe, Asia, Africa and South America. Some of these are geoparks and are near urban locations, while others are in wilderness areas. Research into people's attitudes is sociological in character, judging attitudes and awareness demands carefully planned questions and observation. Trying to ascertain the best approaches to public awareness raising-, as well as the effectiveness of efforts at getting the intended message across, is very challenging indeed. A number of the following studies emphasise how people tend to gain an understanding of concepts at a level appropriate to their own ability and needs.

2. Studies and Locations

2.1. Lankawi, Malaysia

Azman et al. (2010) refer to experiences from the Lankawi Geopark, located on an island in Malaysia. This achieved UNESCO Global Geopark status in 2007, and research was carried out in 2009 on how the local community relate to the geopark. In particular the interview-based study had the objective of finding out how awareness of locals is translated into positive conservation attitudes and practices. This study looked at five main values: knowledge and understanding, shared values, benefit and opportunities, roles and responsibilities and empowerment. Although the geographical and cultural context is very different between this region in Malaysia and the Lahti region of Finland these same values are certainly very relevant to both situations.

One central finding was that despite attempts to get the locals involved and empowered, including benefits through tourism income, from e.g. boating services, there was little real awareness of what the geopark concept

really meant. An interesting additional observation of Azman et al was that many of the local community interviewed referred to the geopark as a brand; however, while the researchers refer to this as a misconception, for tourism marketing purposes it is not necessarily a negative interpretation.

2.2. Hong Kong, China

Two different studies dealing with Hong Kong are covered here: one deals with the motivation and environmental attitudes of nature-based visitors to protected areas (Cheung & Fok 2013), the other looks specifically at how Hong Kong Geopark-related geotourism contributes to sustainable urban tourism (Ng 2014). The first of these, dealing with ecotourism and the city parks in general (covering over 40% of the territory) involved a very systematic questionnaire study of visitors to three different areas, including one geopark. A statistically relevant number of 585 correctly completed questionnaires identified first eleven motivations for visiting these areas, then carried out a Principal Component Analysis on the data received. On the basis of this a further subdivision was made into three main factors: travel for novelty, travel for recreation and travel to escape. The single largest motivation, one belonging to the first factory category was "Having fun, being entertained", followed closely by "Being free to act the way I feel".

The second Hong Kong study started by referring to an earlier classification of the characteristics of geotourism (Downing 2011) into these five: (1) geologically based (i.e. focusing on geoheritage), (2) environmentally sustainable (i.e. fostering geoconservation), (3) informative (achieving through geointerpretation), (4) beneficial (i.e. economically viable and community enhancing) and (5) tourist-satisfactory. Although the first three of these can be seen as specific to geotourism, the fourth and fifth are very much in line with the findings of Cheung & Fok for nature-based

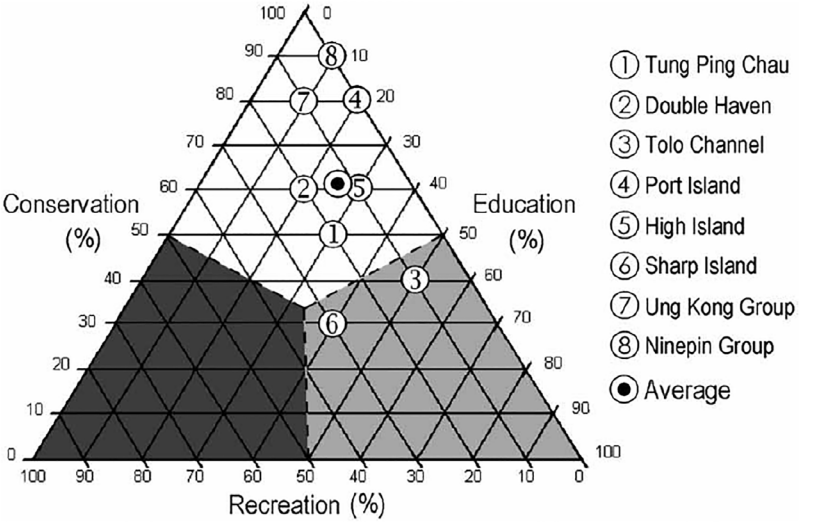

Figure 1: A ternary plot for multipurpose features of Hong Kong Geopark (Ng 2014, modified from Ng, Fang& Lee 2012)

tourism in general in the region.

Multipurpose features are a characteristic of all park areas for Hong Kong and also within the UNESCO Geopark area, as can be seen in figure 1, some geo-areas emphasise more education, conservation or recreation.

This recognition that users have different needs is taken well into account in the specifically accredited geo-guide system called A2G and aimed at assuring the quality of geo-interpretation in Hong Kong and thereby improving the level of tourism services being offered. Ng further describes a five-level interpretation system developed there and based on the user structure: ranging from Kid (simple, interesting and pictorial), through Learner, Intelligent reader and Serious reader to Expert (professional and in-depth explanation). It is further described that although entrance to the geopark is free and direct commercial activity is restricted there, there are nevertheless economic benefits, as part of the goals of sustainable tourism; this is explained by it being an urban geopark and so the benefits for the city as a whole are taken into account.

The economic aspect was also considered in the first-mentioned study of Hong Kong (Cheung & Fok 2013), where a second principal purpose of the questionnaire study, in addition to ascertaining the motivations of tourist, was to determine the environmental attitudes of nature-based visitors. For this purpose eight targeted EA (Environmental Attitude) questions were asked and the results again arranged into a Principal Component Analysis. The factors that attitudes were classed into were: Conservation and Development, Conservation Priority and Leisure Rights. The group answering according to the first factor was seen to support conservation of the natural environment after their own needs had been satisfied. The second factor had two items indicating avoiding development to maximize conservation efforts, but a third question stated: ”The supply of natural resources is inexhaustible and will not be used up”, showing that also this well-intentioned group did not fully understand the limits of natural resources. The third factor group was deemed the most anthropocentric and least pro-environment: “Human beings have the right to satisfy their own needs by altering the natural environment”. Cheung & Fok point out that although these attitudes might not lead to anti-environmental behaviour, they still could pose a risk in such people visiting sensitive areas. However, other studies are referred to (Ryel & Grasse 1991, Orams 1996, 1997) where it is suggested that also this group could benefit from environmental education programmes to improve their environmental attitudes and help them to become more nature-based visitors.

2.3. Araripe, Brazil

A study into the Araripe basin geopark in Brazil (Slater 2011) deals with folk narratives and how with the aid of them cultural awareness and geological aspects can complement each other in promoting environmental protection. It is subsequently argued that using local populations as stakeholders in environmental projects brings great benefits. As well as being an area of natural beauty and of great geological interest, Araripe contains sites of

pilgrimage based on a Roman Catholic priest who is regarded (unofficially) as a saint in the area.

The narrative approach to documenting the features of the area, to support the mainly scientific texts accompanying the original application to UNESCO for geopark status, consisted of a set of articles accompanied by photographic images (by Daniel Roman, see fig. 2), they are described as being of stunning grandeur and notably lacking in imperfections, such as litter of any kind. The second type of narrative involves a collection of orally transmitted stories by pilgrims and residents built up over decades. Although different in style and purpose, Slater identifies five common features between the two types of narratives: seeing the natural world as ancient, as fluid, being composed of interrelated elements, being mysterious and being "deeply worthy of protection". She proceeds to explain in convincing detail the contents of each of these "Points of Contact", and then the implications of these connections. As an example, the last one listed deals with how environmental destruction is a serious threat, with activity like the illegal fossil trade destroying important geological features, needing to be identified by the scientific texts. The traditional folk narratives describe how human attack on the natural world can lead to enchanted features, only sometimes visible to pilgrims, withdrawing to another realm of existence. Slater stresses that although these oral stories are different to the scientific ones, they both refer to a sense of impending loss, overlapping insofar as potential features not yet discovered (be they mystical or geological), could be threatened by present human activities.

Figure 2. The Batateira River in Crato, which figures in numerous pilgrims' stories. (From Slater, C. 2011, Courtesy of the photographer Daniel Roman).

While one set of narratives is aimed at the international educated public, the other involves local populations, often lower in the social hierarchy and traditionally oppressed. Nevertheless, this Araripe case of combining common goals expressed in different narrative forms the sort of alliance that would support UNESCO as a point of reference for developing other geoparks in the Americas.

2.4. Other studies

Farsani et al. (2014) studied 25 geoparks of which 20 were in Europe, concentrating on their roles in rural development and conservation. This study starts by mentioning that sites of geological interest, geoheritage, are not new attractions, but have previously received less attention because they were regarded as not as vulnerable as other areas of environmental interest (Reynard & Coratza 2007). The electronic questionnaire led to results confirming that the involvement of local communities in the conservation of geoparks and providing education is widely recognised and leads to economic development in their regions. Both the conservation activities themselves and the development of educational programmes have a benefit in this regard.

This study also stresses the importance of geoparks in knowledge management and thereby knowledge transfer. This transfer is explained as occurring in four ways: tacit to tacit (socialisation via meetings and team discussions), tacit to explicit (externalised through brainstorming and the use of developers, a priority for tourism), explicit to explicit (moving knowledge around a network from one organisation to another, which is relevant for destinations) and explicit to tacit (taking explicit knowledge such as a report and generating new ideas). Specifically referring to geoparks, in this fourth type of knowledge transfer a range of very creative consumer targeted ideas is mentioned: geo-products, geo-sports, geo-tours, geo-play parks, geological gardens, geo-cookies and geo-desserts.

Migoń et al. (2018) describe the situation in a geoheritage region called Waldviertel in Austria. Here there is awareness of the importance of the area, and it is protected to a certain extent, but the study points out that understanding of the formation of special features in the area, notably tors and boulders, occurs at too general a level. On the other hand, having more signposts and notice boards in areas of natural beauty, despite providing more detailed information, could be intrusive on the landscape. The authors stress that more national and international appreciation of the value of the geoheritage in the region would lead to better targeted preservation, and that further study is needed into the best means of awareness raising.

2.5. Finland

The only Finnish UNESCO Geopark at present is Rokua Geopark. In association with this the term trademark or brand has been used in the positive sense, for example in the context of a rural development Leader project for the Oulujärvi Region in which it is situated.

While environmental and sustainability awareness-raising is part of the normal activities of the relevant municipal services division, it typically requires specific projects and thematic initiatives to provide impetus and motivation to get citizens involved. As an example of this Lahti Region of Finland, there has been the Green City project, the European Green Capital Award bid and the Green Flag award for city parks. The Salpausselkä Geopark is at present at the early stage of preparing the application process and already has an active enterprise stakeholder network. In planning how to promote the geopark concept to the general public, and raise awareness of the geological significance and related cultural heritage of many features of the region, it is important to note and learn from how this process has succeeded in existing geoparks.

3. Discussion & Conclusions

If citizens are more aware of-, and knowledgeable about the special features of their own region they are more likely to be active in protecting and promoting it. The challenge of how to provide environmental, geological and cultural heritage information in an understandable and acceptable way remains.

Compared with the population of Lankawi Island in Malaysia the Lahti area population has a higher level of formal education, but this does not automatically endow the latter with a better appreciation of the geopark concept; there is the danger that it too could be regarded as "just another project". Although the geographical and cultural context is very different between this region in Malaysia and the Lahti region of Finland these same values are certainly very relevant to both situations.

As Finland is a relatively recently urbanised country Finnish city dwellers tend to more aware of- and knowledgeable about the natural world than, for example, their continental European counterparts. In planning public awareness-raising activities for an aspiring geopark, such as Salpausselkä Geopark, it is necessary to take into account the existing knowledge of a large section of the potential future visitors, and subsequently there may be a demand for quite detailed geological and cultural heritage information. Nevertheless, it also applies to this country that different members of the local population understand their natural environment in different ways; approaches to environmental- or geoheritage awareness raising need to take all user types into account.

Hong Kong represents an interesting example of having areas of natural interest and a geopark near a large urban area. The results of one of the two studies from there showed that visitors' environmental attitudes and their motivations were found to be closely related, indicating that visitors with higher environmental concerns tended to travel for novelty and those exhibiting lower environmental concerns travel to escape. Certainly these motives for travelling cannot be judged as good or bad, genuine or false; the behaviour while travelling is more important, and based very much on existing attitudes to nature and natural resources. In the Austrian example it was seen that an awareness that the Waldviertel region is of geological

importance exists, but the specific understanding of why it is so still evades most visitors.

Providing the opportunity to learn and increase the environmental-, or geological knowledge of visitors is a widely recognized requirement for municipal environmental services, for nature park- or UNESCO Geopark organisations. Whether different individuals change their attitudes from anthropocentric to more ecocentric can only be hoped for (for the benefit of the natural environment). However, it is not really important what a visitor's motivation is, all long as they behave responsibly. Attempts to raise the awareness of the public lead to messages reaching individuals at their own levels. All the studies described subscribe to the value of striving towards increasing environmental awareness, whether referring to specific geological knowledge or a more general message about the need to protect the natural world, it is always a worthwhile goal.

Much of the further study needed would have be carried out on a user group level, meaning at the educational-, and socio-economic level, also taking cultural differences into account. Nevertheless, there are similarities between people from quite different parts of the world, as observed from the studies described. The broader issue needing to be addressed in further studies is the appropriate level of knowledge required is to appreciate the natural world and act responsibly towards it.

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The iSCAPE – project, improving green infrastructure for more human well-being and less air pollution – case Vantaa Living Lab in Finland

Best Practises and Case Studies

Abstract

Successful city planning demands for citizen involvement. In new approaches to city planning the number of stakeholder groups are increased by involving special groups like school kids, elderly people and groups of people who are suffering temporally from different environmental stresses such as bad air or noise. Additionally several high-end scientific tools as micro-climatic modelling software are used. The iSCAPE -project tries to support city planning by showing different ways to combine stakeholder groups and scientific research with modern city planning.

Keywords: urban climate simulation, urban planning, air quality, living labs

1. The iSCAPE – project 2016 - 2019

The European research and innovation project iSCAPE (Improving the Smart Control of Air Pollution in Europe) (iSCAPE – project, 2018) focuses on integrating and advancing the control of air quality and carbon emissions in European cities in the context of climate change. The research is done by developing sustainable and passive air pollution re-mediation strategies, policy interventions and behavioural change initiatives. Living Labs (LL) are defined as user-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings. In co-operation with the European Network of Living Labs (ENoLL, 2018) in six iSCAPE cities different approaches were used such as low boundary walls in Dublin (Ireland), info-wall for citizens about the daily air quality situation in Surrey (Great-Britain), air quality and public transportation/ behavioural changes in Hasselt (Belgium), the influence of changing green infrastructure on air quality, wandering trees in Bottrop (Germany), the influence of annually changing green infrastructure on car traffic pollution in Bologna (Italy), and the influence of green roofs and green infrastructure on air quality in Vantaa (Finland).

2. The Vantaa Living Lab (LL)

The Vantaa Living Lab aims to establish a forum among stakeholders for discussions about the use and benefits of green infrastructure in city planning, in particular. City planners and decision makers, city inhabitants, health support group representatives and members, children, school kids, and elderly people are invited to participate in open discussions and active planning events.

The stakeholders include the Vantaa city planning division as the executing authority, and the Finnish Science Centre HEUREKA (2018) as well as special groups representing people who are directly or indirectly affected by episodes of poor air quality.

The Vantaa LL took its first step towards the user-centred approach in co-operation with HEUREKA. Science camps for children were carried out during the summer months June to August. The children were aged between 7 and 15 years. In the first month of the summer camps younger children, aged from 7 to 12 years, participated in simple experimental tasks demonstrated meteorological impacts on the environment and air quality. In the first phase there were almost 160 to 180 children. The elder children aged between 13 to 15 years were encouraged to reflect their own physical environment spaces: Home Street, school, and town (Figure 1).

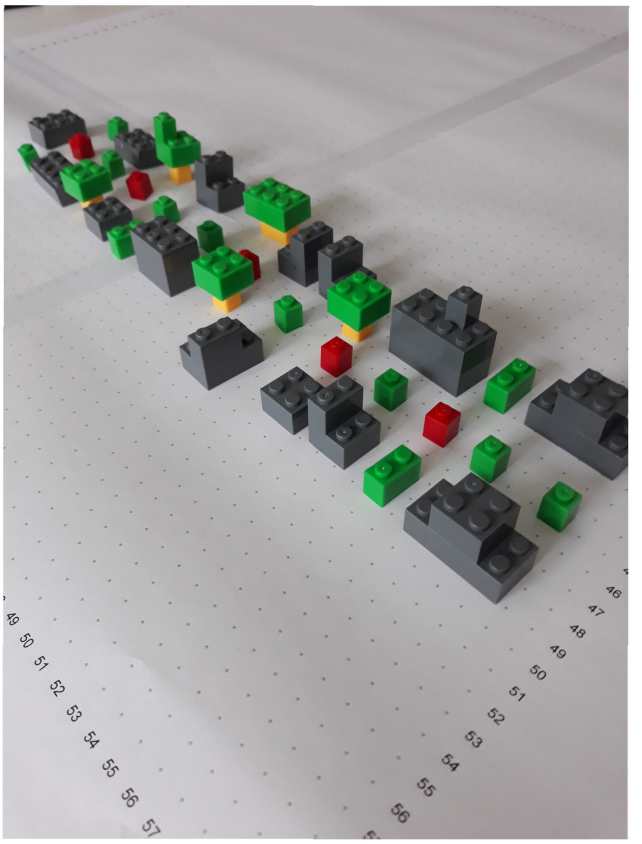

Figure 1: Brick-stone simulation model for the HEUREKA summer camp, grey: buildings, red: other obstacles, green: trees and bushes, on ENVImet SPACES planning grid paper. (Photo: Achim Drebs)

They got the possibility to plan and to build-up their 'ideal' surroundings by using different types of coloured play bricks in two approaches. In the first approach they were advised to think about air quality, human well-being, and reasonable city planning. It was pointed out to recall personal familiarities. In the second approach the children could express their ideas and wishes to describe how in their opinion a healthier environment looks like.

After this creative phase the 'ideal' surroundings built-up by the children were transferred into the ENVImet v4 surface-plant-air model (ENVI-met; Ozkeresteci, et al., 2003; Huttner and Bruse, 2009) and run for a 24 to 48 hours simulation. The simulation runs were made with and without vegetation.

The results of the simulations were discussed with the children in separate sessions. The results will be also presented to the Vantaa city authorities and planners as examples of young and future inhabitants' involvement in sustainable city planning.

In a questionnaire the children were also asked twice a day about their thermal perception during their inside and outside activities during the summer camp week. They had to answer on a scale from 1 to 5, where the number 1 stands for cool or cold, 3 for thermal comfort and 5 for hot. The children had also the possibility to use the so-called low-cost Smart Citizen Sensor (SCK) (Smart Citizen, 2018; IAAC, 2017) to investigate various situation of air pollution situation in Vantaa.

Beside air temperature, humidity, light, and sound, the current basic version 1.0 of the SCK is capable of recording carbon monoxide and nitrogen dioxide, both air pollution products of the car traffic combustion. In the next up-coming generation of the SCK PM10 (particulate matter) sensor will be implemented.

About 15 measuring devices were distributed to voluntary city inhabitants, and health support group member for several weeks to make their own observations to support their understanding of air quality. During this phase they got training for the installation of the SCK and how to use the application coming along with the SCK. The SCK devices were circled among interested people and groups to reach as much as many of them.

3. The ENVI-met v4 model and SURFEX/TEB - model

ENVI-met v4 is holistic three-dimensional non-hydro static model for simulations of surface-plant-air interactions with horizontal resolution from 0.5 to 5 meters. The model consists of several modules to simulate the solar radiation, wind flow, air pollution, building physics, and thermal comfort. Until now the model is only driven by static meteorological parameter given in the initial phase. These parameters are the diurnal course of air temperature and humidity and a constant inflow of wind at the edge of modelled area. The micro-scale simulation software allows to implement i) different sources of air pollution into the simulated area and ii) different types of vegetation. Different types of vegetation are reflected regarding

the uptake of carbon dioxide. Different air pollution concentrations can be examined based on the air flow in the modelled constellation of buildings, vegetation and other obstacles. Other outcomes of the simulations are to point out favourable locations for human well-being indicated by thermal indices (Parson, 2003; Rupp et al, 2015). Thermal indices (TI) are used to describe the human well-being in urban surroundings. All TI try more or less to combine the following human well-being influencing factors: the human metabolic rate, clothing insulation, air temperature and humidity, mean radiant temperature, and air speed. Several of the most common TI (PMV/PPD, PET, UTCI, SET) can be calculated with ENVI-met v4 software.

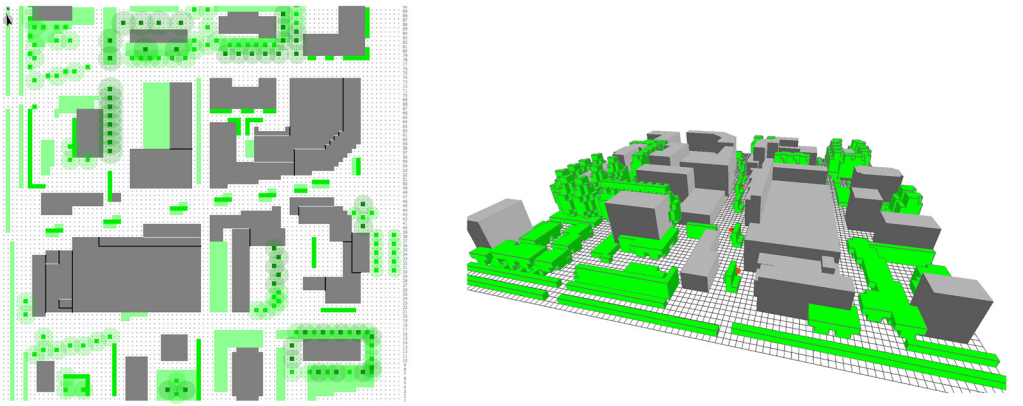

Figure 2: 2-dimensional bird-view (left) and 3-dimensional (right) ENVI-met view of the Tikkuraitti pedestrian area (plants and buildings). (Figure: ENVI-met software adapted by Achim Drebs).

For wintertime simulation in Vantaa the ENVI-met surface-plant-air simulation model cannot be used without any restrictions because no biological annual circle has been implemented yet. Wintertime simulations have to be run without any vegetation and trees and bushes.

As a test site for the simulations the 250 meter long central pedestrian area Tikkuraitti in Tikkurila, Vantaa, was been selected. Tikkuraitti contains a shopping mall, several restaurants and other shops with some cultivated areas in the midst and trees and bushes at its side (Figure 2).

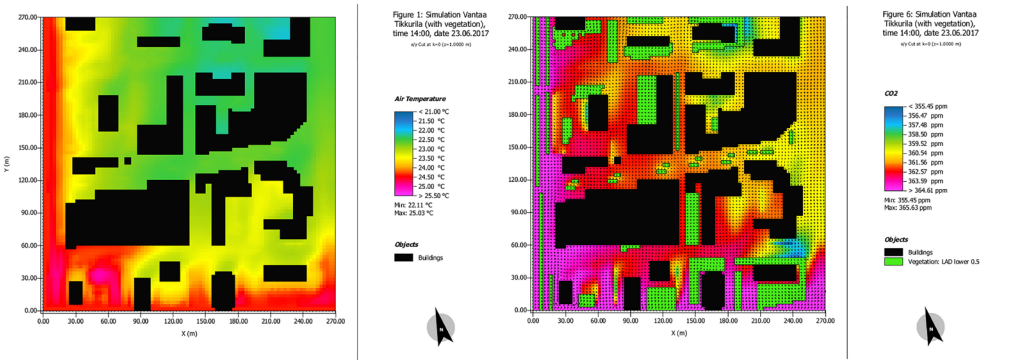

Figure 3: Vantaa Tikkuraitti pedestrian area ENVI-met simulation run for a clear-sky mid-summer day (23.6., 14:00 time), left: air temperature, right: carbon dioxide concentration, wind vector and vegetation leaf index, both at 1 meter height. (Figure: ENVI-met software adapted by Achim Drebs). Furthermore Tikkuraitti is favourite site to meet in the summertime. For

this pedestrian area control runs were also made for summer day with clear sky conditions with and without vegetation. In Figure 3 an ENVI-met simulation out-put for the Tikkuraitti is presented. The wind flows from south-west into the modelled area with a constant speed of 3 meters per second.

To support the Vantaa city planning division, besides ENVI-met another surface interaction model, SURFEX (Mason et al., 2013) was used for modelling of meteorological conditions in street canyons. SURFEX is a modelling platform with several modules for different environmental surroundings, such as large water bodies, vegetation and settlements. The module for urban environment is called TEB and handles the meteorological conditions for cities idealized as a homogeneous array of street canyons.

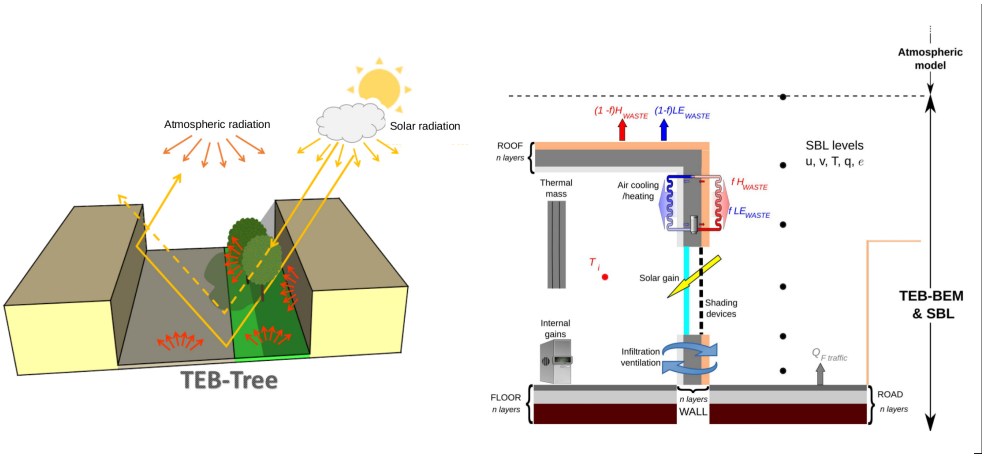

Figure 4: The generalized scheme of buildings and street canyon used by SURFEX/TEB, left: radiation paths in a street canyon, right: schematic view of modelled street canyon parameters. (SURFEX, 2018 adapted by Achim Drebs).

Unlike the ENVI-met software the SURFEX/TEB can be coupled to observed observations or simulated meteorological condition. Therefore SURFEX can be used to simulate future climates. As the ENVI-met simulations runs SURFEX/TEB also allows simulations with and without vegetation. To verify the modelled results from ENVI-met and SURFEX/TEB two automatic weather stations were installed, one in an open-space area at the Science Centre HEUREKA and one in build-up urban area. Beside air temperature, humidity, wind speed and direction also global solar radiation and precipitation intensity was recorded.

4. Conclusion

The iSCAPE -project shows that multidisciplinary approach enlarge the possibilities of good city planning by involving different groups of stakeholder. In Vantaa the iSCAPE -project was concentrated on the co-operation with the Science Centre Heureka and several special stakeholders groups. Preliminary results of the co-operation show that the increase of knowledge of environmental stresses such as bad air help to create solutions for better city planning.

Acknowledgement

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Theme B: Design, Technology and Digitalisation

The traditional concept of design has been widening to cover strategic design services, brand design, digital design and service design. Material design faces new challenges in the field of circular economy, where fabrication processes are evaluated from the perspective of material efficiency. The principle of co-design is adapted to design participation in projects which include processes focusing on user-centred design. The role of a professional and that of a user or an inhabitant are comprehended in a new way compared with traditional positions. People are understood as resources for innovation and development – as individuals or communities who provide the essential information for processes.

The Smart City concept is gaining much attention in discussions, research and everyday life. New technological developments, together with digitalisation, provide more and more opportunities to incorporate smart solutions in living, working and public environments. The idea of the Human Smart City gives rise to the question of considering the opinion and needs of varied user groups, in order to to evaluate the usability and benefits of different technical and digital innovations.

Digitalisation is dominating contemporary discussion dealing with working life and new entrepreneurship opportunities. Digital services are a growing market in all areas of the society, both in private and public sectors. Digitalization can provide smart solutions to challenges in everyday life, starting from the individual level and reaching the levels of organisations and society. In the design of services the users are valuable informants. Concepts of service design and co-design emphasise the importance of the user´s experience and needs in the design of services, as well as the participation in innovation projects. People as resources provide another perspective to identifying actual needs for services, their development and production. Digitalisation causes also new kinds of challenges and opportunities dealing with the collection of massive data and the use of big data.

The use of geographic information systems (GIS) facilitates services and commerce based on the location information. The power of visualization of different kinds of data with GIS is able to enhance new discoveries dealing with the environment, inhabitants and services, not forgetting about research purposes.

The provision of services is at a turning point. The traditional roles of the public and private sectors are mixing, not to mention the importance of the third sector in service production. The meaning of ownership is not an issue any more, but services can be shared or bought in the manner required. One example is mobility as a service based on the idea of payment for the service used, not the vehicle itself. Support is also growing for Sharing Culture. Environmentally friendly and sustainable solutions are sought from cultural and technological perspectives. Even the new concept of the Fourth Sector has been introduced with different definitions, some of them combining elements from social and environmental principles connected

with business approaches.

Mitigation and adaptation to climate change encourages the innovation of a new technical solution causing less CO2 emissions to the environment -this emphasises traffic-based technologies, due to the significant role they play in emissions.

Challenges to start new business concepts can be supported by the help of new financing opportunities like crowd financing, which has provided a starting impetus to several ideas and services. New business concepts do not necessarily need a massive infrastructure to get started.

The research articles introduce the approaches of active citizens in smart city projects and opportunities to involve citizens more in co-design projects. A welcome perspective is presented concerning digital native citizens as service users - pointing out the typical features of the younger generation in this sense. A more specific case under the same theme discusses the opportunities for participatory budgeting in neighbourhood development. Various projects are introduced to tackle the new challenges of capacity building is waste water treatment, the Smart City concept in several European projects, integrative modernisation of urban districts, as well as energy simulation and data monitoring tools in an industrial process.

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People as active agents: citizen science in co-design of smart city services

Research Article

Abstract

The current paper explores how traditional smart cities can be transformed into 'human' smart cities. In the latter, the citizens are not only acknowledged as an active part of the community, but their sustainable citizenship is encouraged as well. This requires a social infrastructure in which the civil society and civilians are recognized and involved in different design and implementation stages of the city innovation process. In order to reach this outcome, this paper turns to the field of citizen science (CS). CS acknowledges the value of local, contextual and non-expert knowledge in the subsequent stages of the scientific process (Bonney et al. 2009). This paper takes a look at engagement mechanisms that allow active agents to steer smart cities and their offered services. Based upon lessons learned from three CS projects, we evaluate the different levels of engagement a citizen can take up in the different iterative development and design phases. Results show that going beyond the role of citizens as mere data collectors is possible by 1) enhancing learning capabilities, 2) continuously involving citizens in the co-creation of the solution and 3) offering them tools and equipment to initiate data collection and start smart city campaigns and services themselves.

Keywords: smart cities, active agency, citizen science, engagement roles

1. Introduction

Cities are facing numerous urbanization challenges that put pressure on their infrastructure, operational model and service delivery and impact their environmental, economic and social sustainable growth (Cohen 2016). To address these matters, cities are turning to new technologies and innovative solutions, with the belief that an ICT equipped city will evolve towards a more efficient society. The risk of such a technological-deterministic approach is that the role of the citizen is reduced to a passive agent and ad-hoc consumer of these deployed innovations. This "Control Room" discourse on smart cities is according to de Waal & Dignum (2017) dominated by the thought of efficiency and productivity gains. However, the intelligent technologies in which cities seek their salvation, also offer a wide range of possibilities to broaden the role of citizens in fostering innovation and growth (the "Creative City" discourse) or in becoming

public value creators (the "Smart Citizen" discourse) (de Waal & Dignum 2017).

One approach that has the potential of addressing active citizenship and opening up the black box of smart cities is citizen science (CS). CS acknowledges the value of local, contextual and non-expert knowledge in the subsequent stages of the scientific process (Bonney et al. 2009, 17). Originally used for data collection in traditional scientific projects, it is increasingly used to support citizen engagement in participatory research or environmental policy-related processes. However, as de Waal & Dignum (2017) point out, only few examples exist of active citizen involvement in smart city deployments. Since citizens are crucial stakeholders within the city ecosystem, they should be actively involved in the solution design. This requires a social infrastructure in which city-stakeholders and civilians are recognized and involved in different design and implementation stages of the city innovation process.

In the current paper, we take a look at how citizens can be engaged as active agents in shaping a human smart city and its underlying services. First citizen agency is defined and the effect of different smart city discourses on its emergence. Subsequently, Haklay's citizen science engagement framework is presented. Finally, this framework is used to illustrate the active agency roles of citizens in the three smart city cases. The analysis includes learnings and insights on the different projects and the ways in which they succeeded or failed to facilitate citizen agency.

2. Citizen agency

Agency has always been problematic to define. Although a lot is written about the concept in different domains, it is rarely characterized, nor measured (Marshall 2005). Emirbayer & Mische (1998, 962) list the different concepts that are regularly associated with agency: "selfhood, motivation, will, purposiveness, intentionality, choice, initiative, freedom and creativity". A more satisfactory explanation of agency is often given through simultaneously opposing and integrating it with the concept of structure. Emirbayer & Mische (1998, 970) come up with an inclusive definition of human agency as "[...] the temporally constructed engagement by actors of different structural environments – the temporal-relational contexts of action – which, through the interplay of habit, imagination and judgement, both reproduces and transforms those structures in interactive response to the problems posed by changing historical situations". It is further operationalized by Jyrkämä et al. (2007) into six modalities that determine the agency's execution and effect: 1) knowing how to do something (the actor's knowledge and skills), 2) being able to do something (the actor's mental and physical abilities), 3) wanting to do something (the actor's motivation and ambitions), 4) having a possibility to do something (the actor's options), 5) having to do something (the actor's obligations) and 6) appreciating something (the actor's values, feelings and emotions). In turn, citizen agency refers to the practices of the public during participation in the social and political life and in dialogue with

the encompassing constitutional structures and processes (Zanello & Maassen 2011). The six mentioned modalities are therefore also applicable here. For instance, citizens must want to identify with a community and have a sense of empowerment – relating to the third, fourth and sixth modality. Therefore, a citizen's agency and its consequential participation is not only – externally – enabled by institutional resources, but also has inherent barriers and accelerators, such as the social, human resources and time (Zanello & Maassen 2011).

3. Citizen agency in smart cities

Agency thus depends on internal skills, abilities, motivations and values, as well as on external imposing factors that influence the actor's options and obligations. Following de Waal & Dignums' approach to smart cities as "[...] an ensemble of notions, ideas, concepts and categorizations through which meaning is allocated to social and physical phenomena and which is produced and reproduced in an identifiable set of practices" (2017, 263-264), it is noted how different discourse and implementation of smart cities can enable a different form of citizen agency. In this paper, Haklay's framework (2013) is used to elaborate on this. Haklay (2013) defines and operationalizes citizen agency in four different levels of participation and engagement. As shown in figure 1, the amount of participation or cognitive engagement decreases as you move from level 4 to 1:

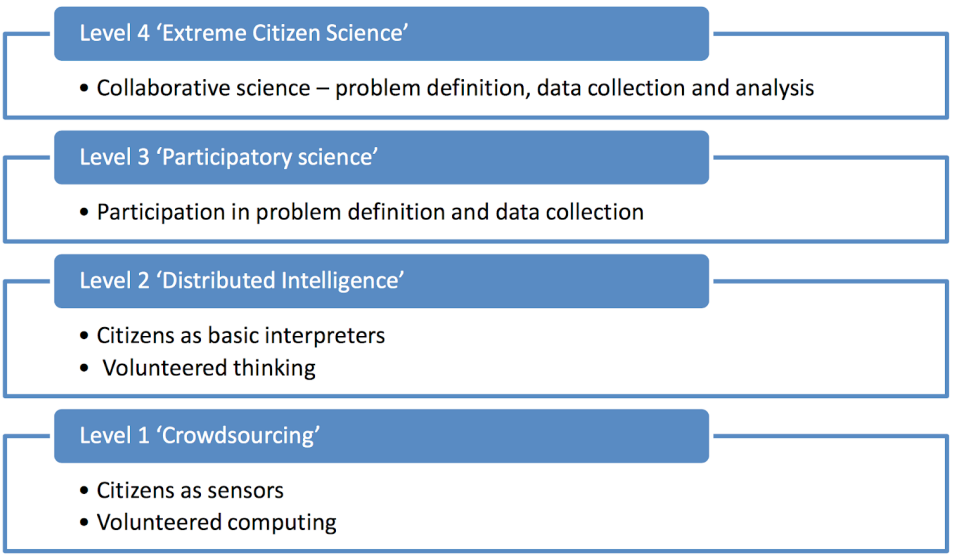

Figure 1. The different levels of participation and engagement (Haklay 2013).

The first level is "**crowdsourcing**". Here the citizens' role is to provide hardware resources for data collection or processing, without the need to use his/her cognitive abilities. A distinction is made between volunteered computing, where the unused processing capacity of participants is used for computing processes and participatory sensing, where participants carry around sensors for data collection.

The second level, "*distributed intelligence*", calls upon the intellect of citizens for interpretation tasks, be it for data collection (e.g. recognizing and counting specific butterflies in one's garden) or categorization of already collected sources (e.g. the Galaxy Zoo-case, where galaxies were categorized by participants (Lintott et al. 2008)). Usually, some basic training material is handed over before contribution.

In the third level, called "*participatory science*", citizens bring their problem and research questions to the table and are much more involved in scientific research. In a subsequent step, a proper methodology for data collection and analysis is developed in collaboration with experts. Although the data collection occurs in close collaboration between citizens and scientists, citizens still rely on the data interpretation and analysis of the scientist.

Finally, "*extreme citizen science*" is a truly integrative approach where every step in the research trajectory is co-developed between experts and citizens. The experts act as facilitators for the whole process, which potentially enables the instalment of a project both led and executed by citizens.

It should be noted that there is no such thing as an ideal level of participation (Haklay 2013). One level can be an accumulation of (previous) levels but can also exist independent from one another. Over time citizens' capabilities and preferences can also change, and thus result in a different level of engagement. Looking at the implementation of these levels today, unfortunately, as stated by a recent report of the European Commission (2016), citizen participation is still too often limited to the first level. It is for this reason that the current paper analyzes three smart city cases that aim for a more holistic view, where citizens act as a bridge between governance and community and are key enablers of social and knowledge capital (Hunt et al. 2015).

4. Research design

To investigate how active agency roles can be applied in the co-design of smart cities, different engagement roles were reviewed according to the framework of Haklay (2013). For this a multiple case study analysis was conducted on three different citizen science projects, being two European-funded projects (FloodCitiSense and hackAir), and one Flemish project (Flamenco). The analysis had the objective to analyze the process and the different mechanisms used to engage citizens, which are elements that currently still lack clarity and a theoretical foundation (Eisenhardt 1989). The data was collected between 2016 and the first quarter of 2018 and relied on main project documents and outcomes (e.g. delivery of work, deliverable reports, empirical analysis such as co-creation sessions or interviews with citizens). Three researchers, each responsible for one project, individually mapped their project on the framework. After the coding, disagreements were discussed and re-examined.

All three projects include (1) a smart city service, (2) the involvement of citizens, (3) a CS approach and (4) the collection of environmental data. However, they differ on the level of scale, project lifetime, thematic approach and citizen engagement strategy. Both hackAIR and FloodCitiSense use a living lab setup (Veeckman & van der Graaf 2015) to involve advanced as well as basic users in different stages of the project; co-creating and evaluating CS tools and collecting data. In Flamenco, researchers develop a citizen observatory platform accessible to various stakeholders which will include build-in engagement tools and guidelines for CS campaign initiators.

5. The smart city case analysis

Applying Haklay's Framework (Haklay 2013), the projects can be mapped on different levels.

Table 1. Mapping of CS projects on framework of Haklay (2013)

	FloodCitiSense	hackAIR	Flamenco
Level I: Crowdsourcing			
Level II: Distributed intelligence			
Level III: Participatory science	X	X	
Level IV: Extreme citizen science			X

In table 1, "X" represents the level of engagement supported within each project. It should be noted that this is analyzed independent from citizens' eventual engagement. The latter lies not within the scope of this paper, however preliminary insights on how citizens perceived these levels are described in the sections below.

In 5.1 more details are provided on the "participatory science" engagement level within FloodCitiSense and hackAIR. In 5.2 the level of "extreme citizen science" is explained within Flamenco.

5.1. Participatory science

FloodCitiSense and hackAIR are mainly situated in level III, "participatory science". They both involve data collection (the "crowdsourcing" level) and call on the cognitive skills of participants (the "distributed intelligence" level) but do not stop there. Both projects are focused on enabling citizens to gather, analyze and share knowledge about the data they collect through different tools, such as low-cost sensors or via citizens' smartphones.

FloodCitiSense and hackAIR thus involve citizens at a higher level than mere crowdsourcing, by a) focusing on the cognitive capabilities of the participants and b) involving participants in the early stages of the project.

There are different ways to enhance the cognitive capabilities (a):

- Face-to-face trainings and workshops: Both FloodCitiSense and hackAIR organize workshops to get citizens more acquainted with the material. Preferably, citizens are directly involved in the assembling of the tools, e.g. within FloodCitiSense, participants could assemble the flood sensors themselves;
- The provision of educational material: In FloodCitiSense, educational features are built within the application, such as a lexicon and a FAQ. This was addressed as important by the citizens to gain more understanding on the data, to make right interpretations and to enhance a common vocabulary for reporting the data. In the hackAIR project, the educational workshop material is provided through a freely available toolkit, and also motivates citizens to download and adapt the material to own needs;
- The provision of validation features: Citizens are not just involved in the data collection but can also be involved in the assessment of the quality and reliability of the data. This helps citizens to educate themselves around the topic. However, applying this feature in the FloodCitiSense project revealed that citizens do not always feel the need or confidence to validate the data. Within FloodCitiSense, different city stakeholders, among them citizens, expressed doubts on the trustworthiness of the data and the capabilities of citizens to assess the data themselves. As a solution, an intermediary (a renowned organization) was appointed who would perform a first check of the data, where after citizens are involved in the confirmation;
- The introduction of gamification mechanisms: Within hackAIR, gamification mechanisms (collection of points and badges) are used to increase the motivation of taking pictures of the sky, to collect air quality data, and to establish behavioral change. However, again within FloodCitiSense applying the same engagement mechanism did not work. Within this project receiving points and badges for reporting flooding was rather felt misplaced. One should thus be careful with implementing fun elements in application design as its appropriateness strongly depends on the project topic and the participants' motivation. Gamification in FloodCitiSense was therefore limited to the feature of missions and journeys, where people are invited to participate in a measurement campaign or in a mission to take pictures outside;
- The enabling of continued learning: In FloodCitiSense and hackAIR citizens have complete ownership of the sensors. This allows them to keep the sensors even when the project ends.

Further, in both hackAIR as in FloodCitiSense citizens were involved from the early stages on (b).

Via a co-creation track (Veeckman & van der Graaf 2015) that continues throughout the project lifetime, citizens were offered multiple opportunities to test and evaluate the tools. This allowed them to help shape the data collection tools and provide the requirements for the design of these tools.

A point of critique is that in both cases citizens were not involved in the actual problem definition of the project, mainly due to the way in which research projects are pre-funded. In FloodCitiSense this led to some citizens voicing their concerns with regards to some solutions that were proposed by the project managers. These discussions demonstrated the importance of involving citizens as early as possible. To work in a quadruple or triple helix model where not only citizens but also other important city stakeholders are involved, did help to nuance these concerns and ensure a fit-all solution. In the end, one should consider this co-creation track as it provides more inclusive data collection and tool-design.

5.2. Extreme citizen science

The Flamenco-project is most in line with the final engagement level "extreme citizen science". Flamenco has a different set-up than both FloodCitiSense and hackAIR. In contrast to the other two, it does not aim to develop one specific citizen science campaign. The main objective of the project is to create an open cloud-based software platform, specifically designed for allowing different types of (technology-agnostic) stakeholders to create and participate in citizen observatory campaigns. As a result, it is the end-user of the platform who will determine the way in which citizens become involved in specific citizen science campaigns. Future campaigns developed with the help of the platform can therefore range from typical level I crowdsourcing projects to cases of extreme citizen science. By embedding the right support mechanisms in the platform, Flamenco wishes to reduce the threshold for potential campaign initiators to set up their own successful citizen science trajectory. This offers an opportunity for citizens to take on a new role and instead of participating within the boundaries delineated by scientists or organizations, become campaign-initiators who indicate the direction of a project. One could say that the platform acts as an external institutional enabler of citizen agency. Subsequently, campaign initiators are not only enabled to act, with the help of (inter alia) manuals and guidelines, they can also acquire the knowledge on how to build a thriving citizen science trajectory (Jyrkämä et al. 2007).

Comparing Flamenco to FloodCitiSense, a clear difference can be noted as FloodCitiSense still implies some kind of hierarchy. This is the case with most research trajectories where the scientist still keeps control over the project and involves the citizen only in specific steps of the research trajectory: i.e. co-creating and testing the solution, gathering and validating the collected data. In hackAIR this is slightly different. Citizens can organize their own measurement campaigns related to specific problem settings, such as: "What is the local air quality in my front versus my backyard?". The "extreme citizen science" level is therefore implemented to a certain extent. However, one could question the maturity of this level and the ability of citizens to already take up this level of responsibility. Results from the hackAIR project show that it is still necessary to support citizens in the collection and analysis of air quality data, as they are still progressing on the learning curve in how to organize and interpret it in an independent way. The readiness of this level could therefore be an interesting topic to investigate further.

6.Conclusions and recommendations

The current paper investigated how citizens can be engaged as active agents in shaping a "human" smart city and underlying services. By the use of a case study analysis of three citizen science projects, it became clear that going beyond the role of citizens as mere data collector is possible; 1) by enhancing learning capabilities, 2) by continuously involving citizens in the co-creation of the solution and 3) by offering them tools and equipment to initiate data collection, smart city campaigns and services themselves. However, the analysis showed that implementing these levels is not a guarantee of success. For some projects certain engagement mechanisms work, for others they do not. As mentioned earlier by Jyrkämä et al. (2007), this can be explained by internal enablers of agency, i.e. "wanting to do something", "appreciating something", "knowing how to do something", are all factors that have an influence on agency. It is therefore important as researcher to learn through citizen interaction the existing barriers, and to address these. The instalment of different mechanisms, such as co-creation workshops, can help to make the latent citizen knowledge with regards to smart city services and solution design manifest. It is further important to note that there is no such thing as an ideal engagement level 'nor smart city discourse, as this highly depends on project intent, supporting technologies, participant motivation, budget, ambition and culture. However, researchers should remain critical towards their way of including participants. This could mean that pre-envisioned project solutions, such as the ones proposed in the project description, should be opened up for citizen suggestions. Moreover, the lack of trust towards citizen capabilities, specifically relating to their interpretation and validation possibilities should be countered by the provision of guidelines, tutorials and feedback moments as to enhance the participants' confidence that their contribution is precise and worthwhile.

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Digital Native Citizens as Service Users

Research Article

Abstract

The City as a Service for Young Citizens project has investigated the requirements placed on city services by 16-to-30-year-old digital natives (DN). Drawing on findings from a mosaic of explorative, participatory and design-based user research activities, especially in Lahti city, Finland has produced a rich picture of the young users' needs, skills, experiences, communication channels and behaviour as public sector service users. The research also investigated the target segment's social media use and skills in making use of digital services. The young generation's social media communication stresses short texts, visual material and, from their perspective, material that is genuine and relevant. The typical use includes the distribution of personal experiences in districted social filter bubbles, through various, differently emphasised channels and means and in real time. However, even in digital form, the official material is not easy for the young generation to use. The research demonstrated that with the DN customers, the city services should function only partly as digital solutions. Individual communication with human experts was vital when searching for help with complex, life direction types of challenges and face-to-face guidance was important. Based on the research, it was found necessary to envision service experiments that applied empathy and insight testing in real user contexts and environments. The service envisioning and experiments initialised by the project have included digital parts, materials and channels for new and old public sector services. The conclusion of the research and digital experiments recommend the material be offered in understandable and short content form, with equipment that is familiar to young generation users and require only short steps to use. Peer-to-peer recommendations and guidance are possible but with relevant, interest-provoking and authentic material preferably produced by the young citizens themselves in their own channels and filter bubbles. Interactions should be provided in real time.

Keywords: digital natives, service design, communication, young citizen.

1. Introduction

This paper describes the design research activities in the city as a service for young citizens -project executed as a part of the Finnish city research and metropolitan politics programme 2017–2018. The 16-to-30-year-old

digital natives (DNs) pose new requirements for city services. Findings from explorative user research aimed to produce a rich picture of the young users' service needs, skills, experiences, communication channels including aspects of the young citizens' digital service use: channel and social media use with limitations and demands. Service experiments emerged through the user insight consisting also of digital service parts. This paper provides learnings, how to service the DN customers through digital means including the limits of these means for this user group.

2. A mosaic of inspirational user research

DNs can be divided into the first wave of the DN generation born in the years 1980–1994, , and into the years 1994–2010 and the later born second wave of the DN generation (Dingli & Seychell 2015, 9). The 16-to-30-year-old focus groups in the city as service -project bisected both of these generations.

As DNs grew up exposed to a continuous flow of digital information, they do not find the digital complexity and constant technology updates problematic. Technology, computers and the Internet are natural components included in their daily life. They even make instant judgements based on real time sourced digital information. The young people think differently than preceding generations as their thinking is directly influenced by the technology they are using (Dingli & Seychell 2015, 9–14). When the city sector tries to communicate, inform and execute services for this age group, they need to adjust their offerings to the DN profile demands.

Services can be enablers and a transformational tool of society-driven innovation if systemic and lasting change creation is conducted with the help of user research, co-design and experimenting with prototypes (Meroni & Sangiorgi 2016, 14, 158–159). Meroni and Sangiorgi (2016, 13, 18–20) point out that service design approach relies on situated user knowledge, user empathy and collaborative and co-design activities. The insights, ideas and user engagement that result from such an approach are possible tools for redesigning public services.

Young people's services should not be created only on adult-based assumptions, but young citizens' right to participate in community development should be cherished (Groundwater-Smith et al. 2014, 151). In addition, the research approach has reflected the demands of the new Finnish KaPA law (2016) for public digital services, where user availability, quality and seamless cooperation of the services are vital.

In the spring and summer of 2017 the Lahti Design Institute organised generative and participatory user research to provide insights into envisioning young citizens' services. Drawing on ethnographic field-work the participatory tradition emphasises holistic insight and descriptive understanding of the everyday contexts and realities of the actual actors (Blomberg & Karasti 2013, 87–90). The standpoint of real-life challenges and understanding the practice requires multimethod approach. The ideas and scenarios should be concretised through prototyping and testing with

real subjects (Bratteteig et al. 2013, 120, 128–135).

Groundwater-Smith et al. (2014, 128–129) describe how participatory user research applies a mosaic of methods to canvas the user views and experiences. As accounted by Ikävalko et al. (2017) the project used emphatic, participatory approaches via visually concretised user workshops (97 girls and 36 boys), design probes for stimulating users' self-reporting (33 girls and 12 boys) and user-based production of materials (85 girls and 26 boys). These took place in Lahti city's upper secondary schools and vocational schools, at the university level and with social user networks in Lahti. According to Groundwater-Smith et al. (2014, 87–88), it is important to make participation accessible in the young peoples' congregation places.

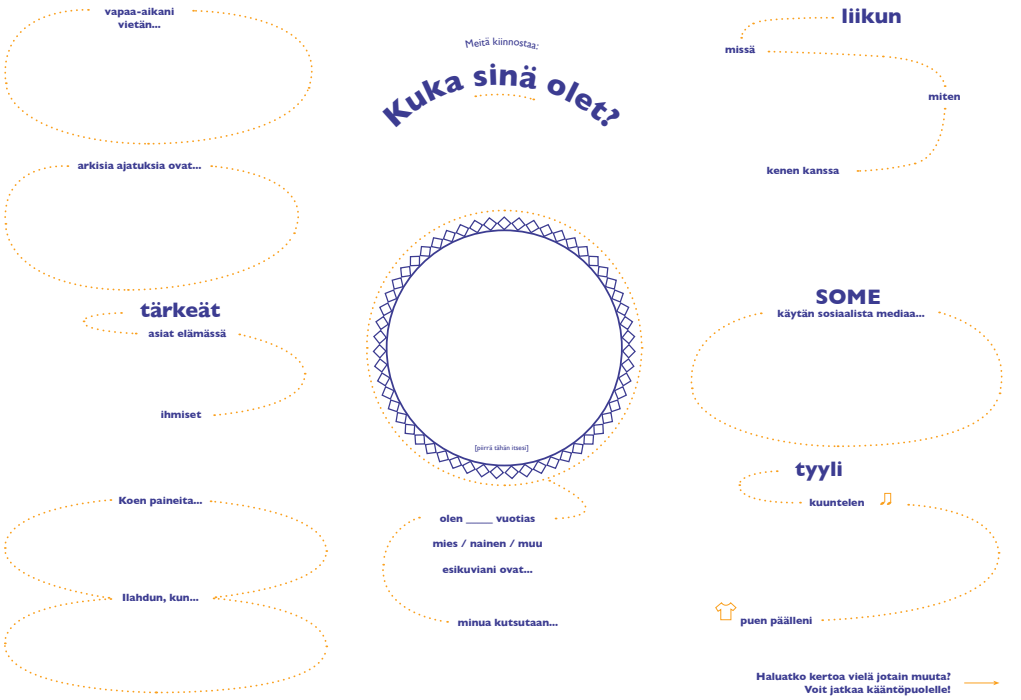

Figure 1. A visualized workshop canvas for Who are you reporting reflecting also the nature of the typical self- documenting design probe stimulation material (canvas Emmi Putkonen).

All the research methods recorded the user segment's use of digital tools integrated to their everyday life. The young participants' typical social media channels were further specified through some workshops and interviews during the summer of 2017. Lahti Jodel was followed by a peer group belonging, including young research assistant. In addition some public sector service providers from Ohjaamo career steering services were deep interviewed.

The aim was to analyse the young citizens' life-worlds holistically to clarify what the young adults need, where they move and how they search for information or partake the city-based services. A rich and deep picture of young citizens' service needs, skills, experiences, communication channels and behaviour was generated with the aim of offering insights beyond practical touchpoints for envisioning and experimenting with the services.

The information form this mosaic of user research is the source for the following user information analysis and the insight to consider when envisioning services for the DN generations. The restrictions about this Lahti based research is the emphasis on female participants restricting the game based outcomes in the results. Excluding this restriction, same findings are prevalent in several of the young users' digital channels and social media related studies in Finland (App Store 2018; Google Play 2018; ebrand 2016; Paavola 2017; Lahola 2017). The special outcome in the research at hand is the integration of digital into the other aspects of user life.

3. Results from the use of digital channels

Looking at the use profile, the following channel appropriations were discovered. **WhatsApp** with provisions for groups and calls replaced traditional text messaging and even phone calls. The messages included pictures, videos, voice messages and location information.

Snapchat was used for discussions with and for following friends and the life of celebrities in 'MyStory'. This messaging emphasised the real-time presence with pictures disappearing quickly. A variety of ready-made elements were used and opportunities to get to know new people were seen.

Instagram worked as a for distributing visual material. The major part of the communication tended to be visual as a means to distribute feeling-based experiences.

Facebook was vital as an information source as events and changes in life were announced there and help available. With flooded information, many avoided active use. Making arguments was also uncommon for fears of getting into 'some mayhem'. Kindred spirits type of people were followed, although some wanted also to encounter differing points of views. **Facebook Messenger** was used side by side with WhatsApp for sending private messages as it had Snapchat-inspired 'stories' and stamps and animated characters.

As a video sharing tool, **YouTube** has become extremely popular among the young audience. Actively followed video bloggers, vloggers are usually young people exploring in the video form their own life experiences or some interest issues such as games or animals. Because videos are a source of inspiration, tools for learning and even shopping decisions, YouTube has increased power as an information channel.

Twitter with similar functions to Facebook is used mainly for following celebrities' postings or what is happening in the world. As the discussions in Twitter are public, the young participants are not willing to use Twitter as a discussion platform.

Tumblr is a nexus for the alternative culture with a platform for distributing art, blogging, discussing behind a pseudonym and sourcing for empowerment. Tumblr provides for its own community and a world,

where young participants seek for joint experience and inspiration.

Pinterest acts as a public platform for storing visual web content and sharing ideas so it provides ideas and guidance about health and do-it-yourself makeovers related to beauty instructions and fashion innovations. It is used also for professional purposes, especially within creative fields. As it is highlighting already existing Internet material, it is not for sharing own materials.

With the ease of use, **Tinder** has revolutionised web dating in the young peoples' world. It is even replacing bars as a place to meet one's future life companion. Pictures have a major meaning in Tinder. The differentiation in the flow of pictures is challenging and can cause anxious feelings for young users.

Jodel provides anonymous, local (up to 10 kilometres) discussion forum. In Jodel, users are required to respect strict anonymity and non bullying rules with a system of the community monitors. The participatory Jodel observation revealed sharing for sensitive issues such as loneliness, sex or drug problems and searches for help.

Reddit provided for link and text sharing or commenting. The users are mainly young freaks for information and communications technology (ICT) discussing anonymously and naturally across the web in the user-moderator communities.

LinkedIn, as a professional network and virtual CV, is rising into an established position in the modern workplace. The channel is especially used by students of higher education and young professionals for joining them with employers.

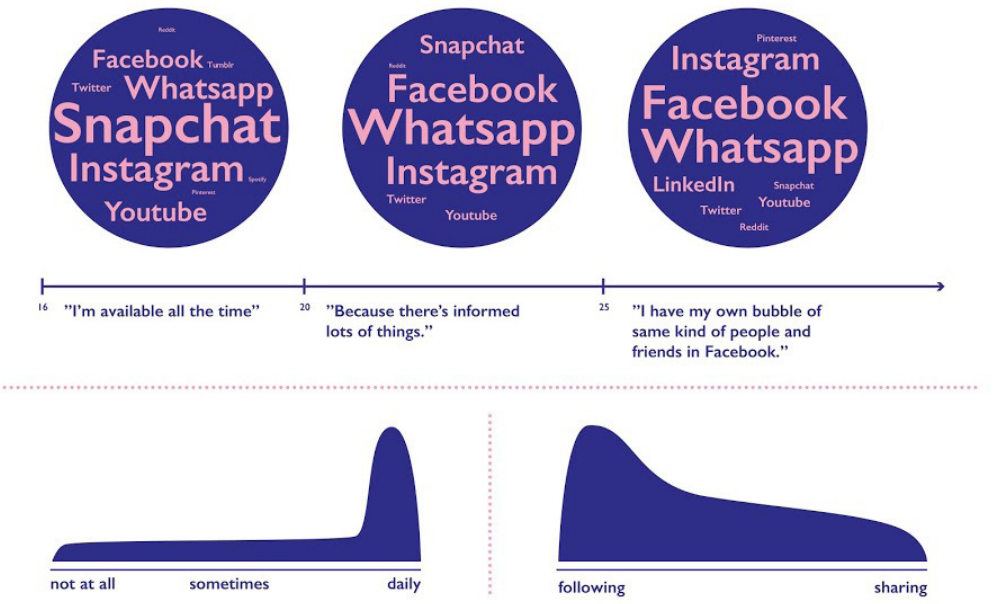

Figure 2. The frequency of social media channel use and the purposes of such use (visualisation: Emmi Putkonen).

The results from the use of these channels and their purposes were collected into a table. It was then possible to produce a visualisation describing the use frequency and purpose of the various social media services.

The typical reasons for using digital channels are for information and socialising. The swiftness and ease of usage, timely distribution of information, possibilities to identify with people and the felt authenticity are important in following, searching for and sharing content.

For the young generation, social media is a major means to share and follow information. Internet searches are for basic facts, but for advice young users turn to social media. Even if search engines still work as information search tools and YouTube makes even learning by yourself possible, there are already youngsters who first enquire from their social media circles.

For the young citizen, social media is a social forum and in the first place a visual environment. In their minds, it is related to free time and relaxed use, not so much to official or work-related purposes. The wide habit of sharing meme types of jokes and cat videos is a typical phenomenon of this.

For many of the young users the constant knowledge about the activities of one's mates and celebrities is central. For the face-to-face communication the e-presence is vital to be able to join the discussions. Social media informs also all the relevant happenings. Fears of being left outside can cause time issues if it leads to manic social media following.

The previous friendly with everyone in Facebook has turned to the value of personal communities. The young peoples' social media use includes distribution of material in the districted social filter bubbles, through various, differently emphasised channels and means. Inside these bubbles, differing ideas are easily discarded.

Distant social circles are possible and common in games and other interest issues. Digital meeting can be about gaining a new partner or a friend or extending your professional network. In the anonymous and local Jodel app, young people share feelings of loneliness and offer support or even ask strangers to meet in a park. However, social media can also cause young people to become unsocial and can create feelings of loneliness.

Young people follow content more than they publish it themselves. The constant private chatting is for one's own friends. The wide crowd sharing is common only with public material such as news although young people avoid taking a stand in serious matters in fear for negative marking.

3. Challenges in the digital service solutions for young citizens

The young generations' social media communication stresses short texts and visual material. Recent Finnish studies have reported youngsters' diminishing capabilities in reading texts and their declining writing skills (Kaseva 2017). Challenges exist in understanding public sector instructions

and files and filling in required forms for official purposes. This disrupts the idea that young DNs would be good in using whatever in digital form. If the content is not in their own type of short social media communication, they are less skilled than older generations. The notion of DNs does not actually help with Web-based digital self-service use if the structure and content of the material is alien.

Certain knowledge and skills might be lost between generations (Dingli & Seychell 2015, 9).Young citizens have problems with public sector data sources and activities. Also in new web services the official information is organised in a bureaucratic way through former social structures and earlier generations' categorisations. For instance, the construction of working life in public digital services is in the form of the earlier, rather clear, occupational routes and divisions. It does not relate to the young generation's understanding from the new, ever-changing structure of emerging jobs.

Public sector actors do share their official information especially on Facebook, but young citizens would not tend to follow this. Rather, young people follow new inspiration (learning new things), inspiring knowledge (interestingly explained news), joy (funny memes, cat videos) or the life of their friends and some special celebrities. They demand quick, easy and entertaining content where the message should be visual and any texts are short. The typical forms favoured by the young audience are feeds such as Kioski, Docventures, BuzzFeed, 9GAG, LADbible or Student Problems. The public organisations' communication starting points do not overlap with what the young DNs prefer. Digital content still provides for multiple possibilities to reach young citizens when applied from the young audience's communication desires.

The consequences of the young audiences' social media habits leads to a situation where the concentration span is getting shorter, vocabulary is diminishing and communication skills are becoming one-sided. Social media interaction is quick, easy, visual and verbally short. Producing text is not central. Even the evident solution of using more visual material in the communication is not a simple task; the visual user research showed nuanced divide between interesting and dull visual material. The interesting visualisations offered possibilities of identification and were considered to be authentic or funny.

It seems necessary to consider how to overcome the text issues and voice messages is one route for this. It has been appropriated in radio programmes for young people since it is related to the real-time, quick response type of interaction. In the digital world of constant presence, instant feedback is important so chat-based services have proved to be a solution even in public or in other services directed at supporting young people.

The popular young audience content providers seem to be producers of material in which the users can self-identify. Young people search for inspiration and role models from bloggers and vloggers who are in an identifiable way similar to the young audience and provide idea role

models. Sharing is concentrated on big media houses, bloggers and other celebrities. Advertisers take advantage of this by free sample products and other deals with the successful bloggers in order to activate peer-to-peer marketing. As one route of reaching the attention of the young audience this is something that public organisations might also emulate more.

As a place to socialise, ask for help and share experience, social media works well for peer-to-peer marketing. Communication is credible and efficient when it comes from positive peer experiences. This is one of the reasons why the public sector organisations have Facebook accounts, but the younger DN cohort moves from Facebook to other channels without parents and other older gatekeepers. Should then the public services follow the young people into the constantly emerging new channels? Possibilities indeed exist in peer-to peer recommendations, but optimisation can be conducted. The most authentic, credibility-enhancing and optimised way of reaching the new, quick response channels is to offer experiences and material that the young users would be willing to share in their own filter bubbles and channels.

Young citizens actually cautiously share their information in public social media. In the current work market, social media plays an important role in marketing one's individual skills. Different channels offer possibilities of distinguishing yourself and creating contacts with employers or marketing your skills for possible customers. With the young citizen an important question is how the relaxed, free-time social media use bends into channels such as LinkedIn when looking for work comes relevant. If it is difficult for businesses to communicate with the young, it is also difficult for the young adults to differentiate themselves for the employers. One service need is actually in between the DNs' digital social media world and skills and how the participants reach with their own material distribution to more official communication and interaction.

The technological communication channels also present safety and identification challenges. The anonymity of the channels seems to increase the willingness to distribute content especially about sensitive issues that individuals are intimidated to talk about face to face. Through anonymity it is also easy to distribute hate messages or inaccurate information. There is an interesting connection between the questions of trust and contacts. The work life-based city staff discovered that parents have given youngsters advice not to answer strangers' phone calls so the young customers did not answer when employers called for work opportunities. At the same time, youngsters get to know total strangers in the social media channels and gaming groups.

The willingness to share and discuss is a major factor how public sector activities can tackle typical sensitive and problem-causing issues such as mental health and loneliness. In addition, sexuality, gaming problems or drugs were sensitive problems that observations in Jodel revealed in anonymous channels' discussions. These discussions can provide a route to the young generation challenges as a source for public sector service inputs. Young citizens have problems with independent adult life. This is especially true for the current world, which with its variety of successful

life models and diversity of possibilities for choices is a source of anxiety.

Even young people themselves are worried about the overarching digital means for everyday interactions. The research material reflected a lack of genuine human contacts in everyday life and the feelings of unease this caused. The complex problems demand professional and adult support. The Ohjaamo staff members recounted the young customers popping in, seeking physical, face-to-face encounters and a little bit of encouragement. The important findings are also the practical ability barriers such as information searches and filling in official forms. These and deep mental support requirements indicate the importance of face-to-face services at certain points even when the digital service trend promotes savings in the public sector. Individual discussions and advice from multiple experts was vital with issues such as seeking for future life direction. Complex demands exist in career questions: analysing one's own strengths, having skills for the work, education and housing applications, organising everyday life or with mental health-related issues. The advice can partly be in digital form, as chat or other on-line solutions, but digital services alone do not cover the demanding support encounters with young citizens. In addition, one major need for young citizens discovered through user research was for spaces to hang out with friends proposing also requirements for encounters other than the digital.

4. Experiments and the advice they generated

Understanding and mapping out service ecologies with their practices, tools and environments can be a way to identify unnoticed opportunities and resources to reframe service-scapes and interactions (Meroni & Sangiorgi 2016, 22). The imagining of future service directions transforms user research-related insights into a plausible hypothesis and scenarios that can be prototyped (Meroni & Sangiorgi 2016, 155). The purpose of the city as a service for young citizens project was to quickly and flexibly take the research insight-based envisioning into practical experiments and testing. One important approach has been to involve young people in designing the service scenarios and prototypes and collaborating with them during the experiments. As Groundwater-Smith et al. (2014, 13) state, the participatory process should move beyond consultation to co-design, co-evaluation and co-implementation. Experiments serve also the purpose of learning from activities that do not work as expected.

The research results produced insights for several types of service experiments. Difficulties in feedback from the youngsters led to the conclusion that the experiments with interaction should be considered including different means. Due to the research results, the experiments with digital played only a side role in the wider experiments including digital parts, materials and channels for new and old public sector services. Some experiments tried to tackle the challenge of Ohjaamo career-related support services in getting feedback from the young customers.

WhatsApp was a possibility to cover the easy and on-the-spot type of feedback with young users and a similar type of feedback was proposed

but without the obligation to deliver the feedback through one's personal account. In the experiment a voice feedback could be given at the end of every visit using iPad, but it was not frequently used seemingly because of the equipment used and the place not beside the exit door. iPad was not the tool the young generation is typically using, so in addition to channels, even the equipment and situational aspects are important for how the digital service function.

The city environments lack spaces for youngsters to hang out so a Friday evening experiment was made to provide such a space together with small activities and food. A young student group produced digital marketing via local Jodel. The peer discussions in Jodel about the marketing efforts were active. Still, only a few young citizens came to the happening, for them, to an unknown place and to activities organised by unknown people. At the same time, a young peoples' space on the other edge of the city organised by well-known city staff members for youngsters' services was filled from the first nights on. So the trust was not built on social media but through real previous encounters with trusted city service people. In the physical space experiment, it was observable how they blended the borderline of the real and the virtual. A group of young visitors spent a longer time not with the organised activities but dancing with the help of a YouTube dance instruction video.

Multiple experiments were made around the discovered fears of the global future. Easy ways to be environmentally conscious and be inspired for

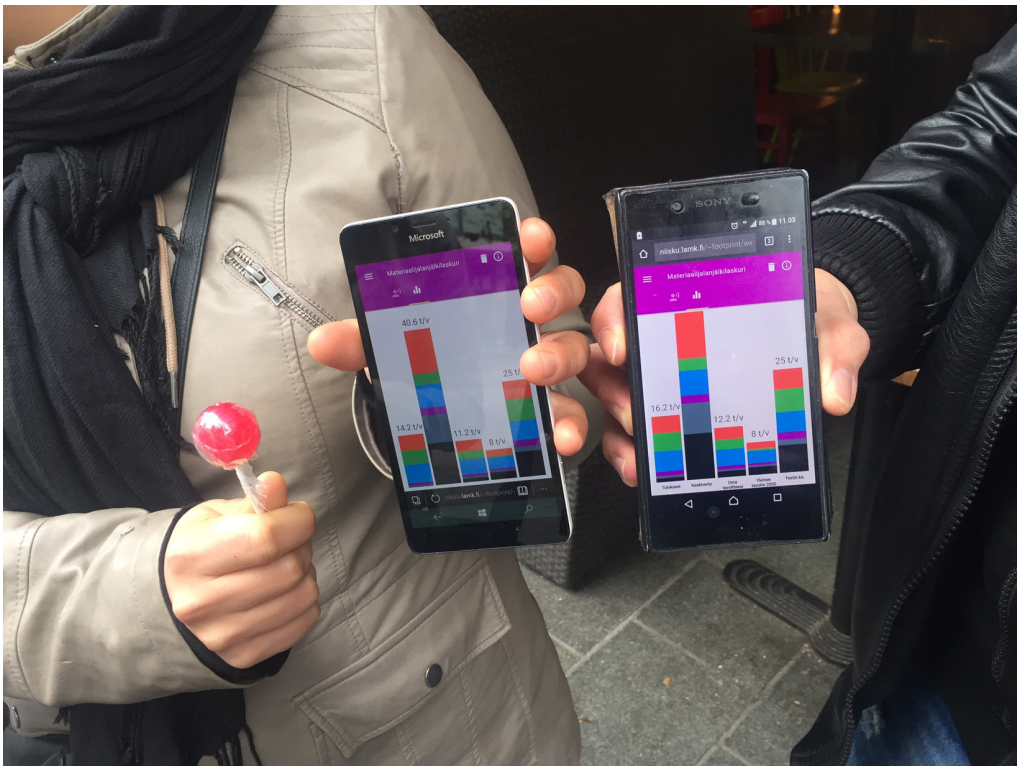

Image 1. and 2. Environmental lifestyle activating experiment in the Lahti city (photographs Kati Kumpulainen).

sustainable everyday deeds was provided during an environmental day in Lahti city. The experiment was developed also from peer-to-peer marketing possibilities. Some young students travelled on foot around the city centre with signs consisting of funny meme material to invite young citizens to stop and measure their environmental impact with a mobile calculator.

Some of the participants felt that the chosen memes were clumsy even when the young students had chosen the memes. It would be beneficial to ask the young generation even to make them as meme trends change rapidly. To avoid being pompous, communication should be from the young to the young. The memes still showed to be a suitable way to activate the young audience. The memes in the experiment had to be photographed before sending them to friends. This added a task to the peer recommendation process. The memes should be in a digital form for easy and instant sharing.

In this experiment the mobile backpack calculator address was a bit complicated and slow to write down to one's mobile phone. With iPhone the calculator did not necessarily function. The environmental education experiments continue with a school project appropriating another mobile calculator with a smooth mobile solution and an easy-to-find address or a Quick Response (QR) code to activate it. These solutions worked well. The young people were interested in having their ecological impact calculated by a mobile calculator with quiz-type questions. The structure and content questions of the calculator proved how the adults audience content does not always match with the young generation's life. The young students had problems in answering questions that were posed from the adult independent life perspective instead of living in your parents' household.

5. Conclusions

The digital solutions demand modifications to the type of communication and interaction the young adults are willing and able to understand. The city services for the 16–29-year-old DNs should not all be virtual, since human advice is vital for complex and sensitive issues. Official content understanding problems did exist with public web-based information and activity demands. The DN generation also has special restrictions with digital services and this should be accounted for when creating the content, means and choosing the equipment to use for this audience. The material and reminders should be offered on the spot, in real time, be easily available in digital form, with the equipment typical for a young audience, with short steps to use and there should be no waiting times. It is important to note that suitable hybrid services for DNs are a combination of simple digital services together with experience-based meetings. Possibilities exist in peer-to peer marketing via young people, often in real-time produced authentic material, information sharing, recommendations and the peer-to-peer support in answering each other's questions. Social media possibilities include various channels, relevant and diverse material, real-time distribution and activating the young people's content creation for trust and interest and to ensure authenticity and identification possibilities.

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Lund, V. & Juujärvi, S.

The Role of Digital Tools in the Participatory Budgeting Process in the Development of a Neighbourhood

Research Article

Abstract

Participatory budgeting (PB) is an increasingly popular method for enhancing citizen participation in allocating public resources and engaging citizens in urban development. This paper aims to examine an experiment involving PB that used a digital platform as a tool to involve citizens in submitting and voting on proposals for budget allocation in community development. The findings revealed both positive and negative aspects of using digital tools in public participation. Digital tools can engage citizens in the PB process, but public deliberation of citizens' proposals must be supported to enhance citizens' impact on local neighbourhood development. The participants were not totally satisfied with the digital platform developed for the process and they needed technical support in using it. The current findings contribute an understanding of how citizens might be engaged in the PB process through digital tools and the findings also emphasise the importance of the deliberative process and public discussion of citizens' proposals.

Keywords: digital tools, citizen participation, community development, participatory budgeting, deliberation

1. Introduction

In Finland, the right of citizens to participate in and influence decision-making processes is enhanced under the Local Government Act (1995). In addition to this legislation many cities run projects in urban areas that are aimed at engaging their residents to develop regional government and strengthen their voice and interaction with decision-makers, and thus promote public involvement. There is a need for participatory knowledge-building that recognises the place-based local knowledge and expertise of residents in community development with local co-governance (Staffans 2004), and using new tools such as informatics (Staffans & Horelli 2014). New communication means things such as local websites, mobile devices, blogs and internet crowdsourcing tools, and all are examples of ways of enabling more effective communication and citizen participation (Jarenko 2013).

This paper examines the results of the "My Idea" experiment in participatory budgeting (PB) called "My Idea" as a tool for promoting public engagement in the development of the local urban neighbourhoods in the City of Espoo, southern Finland. Residents were invited to suggest and vote on proposals that would boost positive neighbourhood development within a limited budget of EUR 10, 000 through an online-based tool developed for the project. This paper is part of a participatory action research project, in which we are interested in creating a new model for citizen participation that allows quick experimentation and implementation of grass-roots ideas through the application of the PB process. The aim of the paper is to find out: (1) how a digital platform can motivate residents to suggest ideas, (2) what is the role of the digital platform in the voting and implementation processes, and (3) how the PB process can benefit from the digital platform. First, we introduce the concept of PB and the role of digital tools in citizen participation.

2. Theoretical framework

Participatory budgeting is one of the most widespread forms of public participation around the world. From its original conception, in Porto Alegre, Brazil, with ideas of democratization and promoting social justice, it has now grown into a complex methodology that entails multiple procedures that aim to develop an active citizenry. It has been implemented so far in the decision-making processes of cities, administrative reforms and new ways of governing. Due to its flexibility, the concept of PB has been seen as both obscure and innovative (Sintomer et. al 2008). Sintomer et al. (2013) state that "participatory budgeting allows the participation of the non-elected persons in the conception and/or allocation of public finances". The PB process has to meet five criteria: 1) financial questions, which are usually unlimited, must be discussed, 2) the city level with some power over the administration and resources must be involved, 3) it has to be a repeated process over years, 4) it must be based on public deliberation within meetings, and 5) the output has to reflect the public will in the interests of accountability (Sintomer et al. 2012). The PB process has been implemented in a variety of cities in Europe with different forms of citizen participation in budget allocation concerning issues ranging from social service projects to urban infrastructure (e.g. Allegretti & Antunes 2014, Krenjanova & Raudla 2013, Sintomer et. al 2008).

According to Putnam (2000), citizens' social connectedness with their communities occurs through political, civic and religious participation. Activities such as expressing views in public, exercising rights, contacting officials, discussing politics, joining campaigns, signing petitions, and voting in elections have traditionally been used to bring citizens together and embody their social capital. Communication using digital tools and social media has the potential to provide novel and less formal opportunities to engage people in activities (Innes & Booher 2004), to enhance collaboration between experts and the public (Jones et al. 2015) and to improve interaction with citizens through dialogue (Mossberger et al. 2013). This has resulted in demands for new forms of participation

and self-governance among citizens, and to change the power relations between citizens and government. Mobile participation, for example, enables citizens to connect with each other, share information, comment and vote (Höffken & Streich 2013).

Even though city governments still trust representation as a communication strategy with one-way information, they have increasingly turned to using social media and digital tools to engage with citizens and network with the public. Deliberation, defined as "reasoning on the merits of public policy, searching for the public interest or common good" and deliberative democracy defined as "a democracy whose institutions are designed to promote the rule of reasoned and informed majorities" (Bessett 1980, 3), underline the two-way or multiactor interaction in democratic practices (Gutmann & Thompson 2004). The self-governing and democratic participation of citizens could be increased with the aid of digital tools, but they seem to lack broader consideration, compromise and conciliation (Czeoczynski 2016). Online deliberation should be built more inclusive, representative and deliberative (Hartz-Karp & Sullivan 2014). Two-way communication, including deliberation, is crucial for community development and for reaching a common understanding of developmental issues. Digital platforms with value-based information have provided a possibility for citizens to deliberate, and enhance their ability to make informed decisions (see Goel et al. 2015). Online-based engagement tools entail the 'new' power of sharing and channelling ideas, and the element of empowering citizens (Heimans & Timms 2014).

The role of citizens in helping themselves (Wells 2011) is emphasised on the agendas of policy-makers', especially in deprived urban areas; however, engaging with citizens and maintaining their participation in community development is quite a complicated process, especially in terms of addressing social structural problems in deprived districts (Foster-Fishman et al. 2007, Wagenaar 2007). The asset-based approach to community-building suggests providing economic access and encouraging the meaningful use of communication technology in many minority and low-income communities (Turner & Pinkett 2000).

3. Background to the study

The research project took place in one of the municipal districts in the City of Espoo, southern Finland. On the basis of social and economic indicators, some of the neighbourhoods in the district represent the least advantaged area in the city. The proportion of unemployed, uneducated, single-parent families, large families and people on social welfare is high. The proportion of immigrants in the area is 25 per cent, which is exceptional, and with a high number of spoken languages (over 70) in the city, which is due to the concentration of social housing (Hirvonen 2011; Residents' welfare in Espoo 2013). The lack of systematic stakeholder cooperation, the heterogeneity of interests, and residents' low engagement in development endeavours have been recognised as challenges in previous projects (Juujärvi 2016). Concurrently, the municipal programme of 'Participatory Espoo' advances

open decision-making, local activities and the participation of different groups.

Previous development projects in the neighbourhoods of Espoo Centre have failed to engage local citizens in development activities, even though civil servants and other stakeholders in the area have a strong desire to create sustainable changes and enhance residents' participation and agency (Lund & Juujärvi 2018). The goal of the PB project was to develop a new method for promoting the wellbeing of the area, reducing bureaucracy and improving communication between residents and public administration as well as financing citizens' initiatives and mobilizing the assets of the community (see Mathie & Cunningham 2003). Researchers, local civil servants, residents and a software company joined together to innovate a new model of PB with a digital platform as a tool for public participation in the development of the local neighbourhood. The City of Espoo had previously successfully implemented PB in youth services and civil servants had familiarised themselves with the outcomes of the PB model implemented in the City of Tartu (Krenjanova & Reinsalu 2013), which acted as triggers for planning the PB process in spring 2017.

The initial phase included planning, marketing and informing the public (see Figure 1). A project group, the "Regional Development Group", consisting of three civil servants, four researchers and two residents, set up the goals and instructions for the PB process. A digital platform was planned by a software company under the guidance of the project group. The purpose was to invite all local residents to make proposals to enhance the wellbeing of the neighbourhood of Espoo Centre. Residents were asked to submit their proposals to the digital platform. Submitting proposals required registration through a personal e-mail address. Proposals could be briefly explained ideas, including estimated budgets and partnerships. Proposals could be immediately seen on the website after they were submitted.

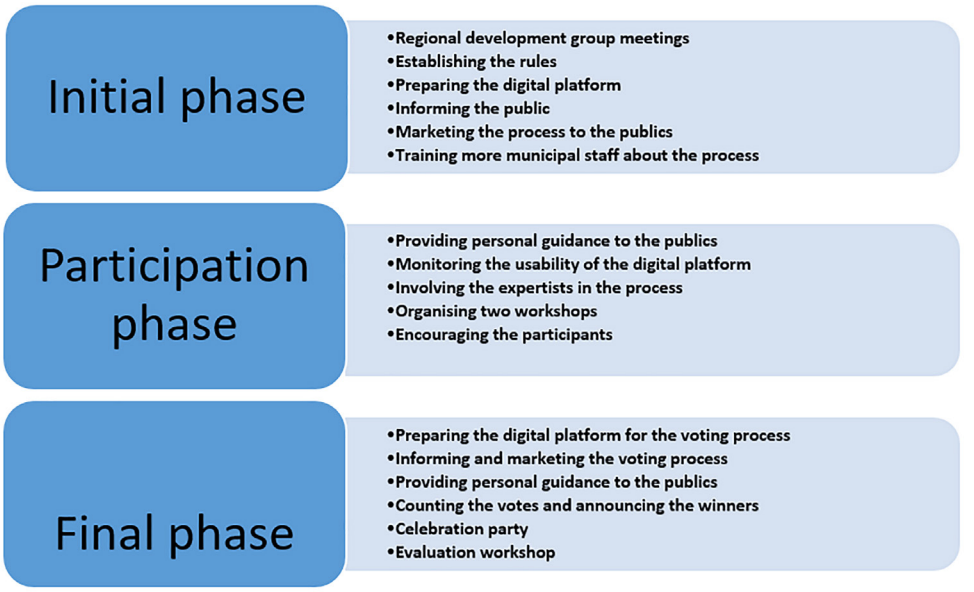

Figure 1. Phases of PB process.

To engage with residents as widely as possible, various methods of communication were planned to inform them about upcoming opportunities. The staff of the public library and the municipal service point were trained to advise and support residents in the use of the digital platform. Two briefings were held in the public library. In addition, key members of minority groups were contacted, e-mails were sent to people in contact positions, and project group members visited many associations to promote the upcoming PB process. The goals and rules were available on the city's website and Facebook, and residents were provided with personal guidance by phone and face- to- face. Thirty proposals by residents were submitted to the digital platform within one month.

The participation phase included two workshops in April 2017. Experts from the city reviewed the proposals and were invited to the workshops to give further guidance. The researchers and civil servants in the project facilitated the group discussions. The goals of the first workshop were to: (1) present the proposals to other participants, (2) clarify the proposals and develop them further with help from the experts, and (3) draw up a plan for moving towards the final phase of PB, the voting process. The participants received useful information about regulations, required permissions and local opportunities that might promote the implementation of their proposals. Sixteen participants continued to the second workshop, which aimed to finalise the implementation plan and make the proposal easy to read and visually attractive on the digital platform with the help of communications experts. The participants were also prepared to present and market their proposals to potential voters.

The final phase included voting on and deciding the winners. The proposals were available for voting on the digital platform for three weeks in May 2017, accompanied by the instructions on the city's website. Voters could first glance through the proposals, read and evaluate them, then vote by clicking on the proposal. Voters could vote for three alternatives. Voting required registration through a personal e-mail-address. Residents were again given personal guidance upon request, and there were computers made available for voting in the library and at service points. Prizes were promised to those who voted.

In total, there were 316 voters, which produced 719 separate votes. Four winners were declared and they received EUR 3,000 each to implement their ideas within one year. The winning initiatives included special sports activities for children and youth, a flower garden, a music festival and a multicultural festival.

4. Methods and data

The data consists of audiotaped and transcribed interviews with 10 residents who participated in the PB process and three civil servants responsible for the process. Interviewees included six women and seven men, of different ages, cultural backgrounds and employment status, but most of them being socially active in the neighbourhood. According to Participatory Action Research methodology (Kemmis & McTaggart 2001),

the participants were considered as co-researchers and the interviews were open conversations with an exchange of knowledge. The semi-structured interviews lasted for about one hour and included themes such as the phases of the PB process, residents' efforts to advance their interests in the workshops and their experiences of getting support.

The data was deductively analysed according to the steps of thematic analysis (Braun & Clarke 2006). A deductive, top-down analysis with semantic and explicit codable moments of the data provided a way of organising first the data and then interpreting the content of the data and recognizing its broader meanings related to the current literature and knowledge about the topic. In our analysis, we focused on coding the data in line with the pre-determined questions concerning the implementation and usage of the digital platform used in the PB process. We thus provide a detailed analysis of some aspects of the data.

5. Results

In this part, we focus on two main themes identified in the interviewees' comments about the digital platform application in the PB process (see Figure 2): positive comments of the digital platform application as a tool for participation (20 expressions), and negative comments of the digital platform application as a tool for participation (47 expressions).

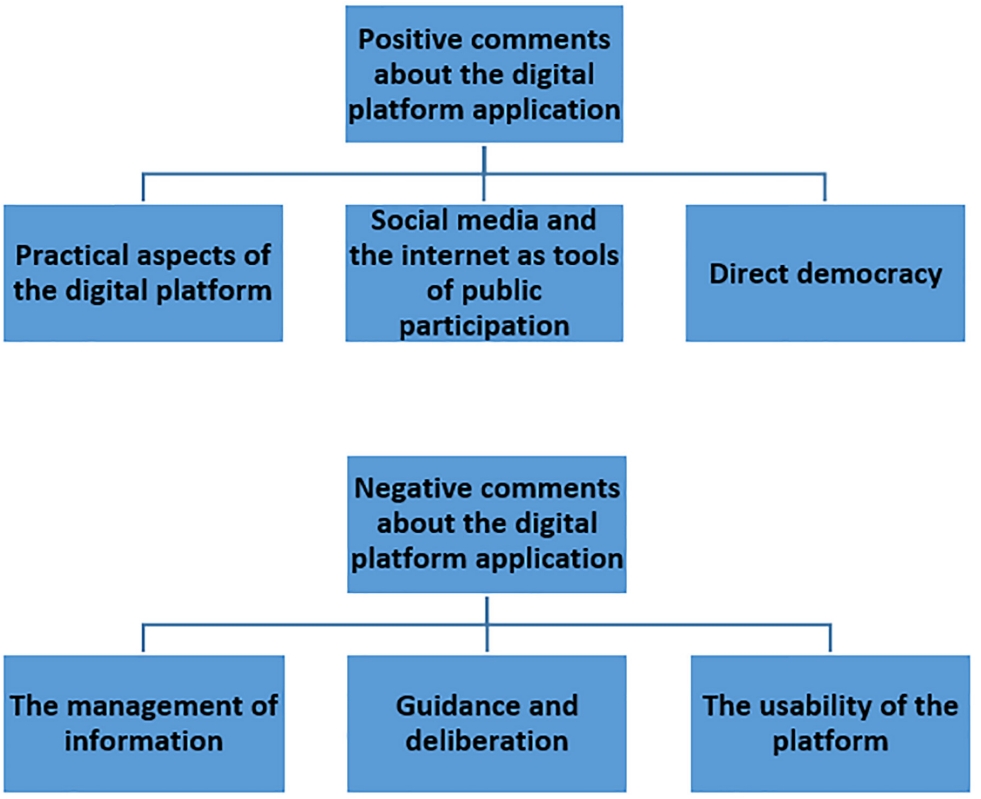

Figure 2. A thematic map showing the two main themes (see Braun & Clark 2006).

5.1. Digital tool enables access to information

We identified that the positive depictions of the digital platform application as a tool for participation concerned three aspects: a) practical aspects of the digital platform, b) social media and the internet as tools for public participation, and c) direct democracy.

Interviewees indicated the *practical aspects of the digital platform* commonly as "clear, logical and well-functioning". The platform was informative, it was easy "to find the locations on the map", it was "quick and flexible" and it provided "timely information during the voting process". One interviewee commented that "it is today's way of influencing". The interviewees were also concerned about using *social media and the internet as tools for public participation* in general. They stated that it is easy to "click the buttons" in the internet and "the visibility provides a lot of information", and it is "easy to search for further information" concerning on topic. One interviewee mentioned that "it is okay and comfortable to use all kinds of internet-based tools for public participation". The interviewees made positive comments on using digital tools connected them to *direct democracy*. They described it in terms of fairness: "people can no longer complain about the bad conditions in their neighbourhood, because they can impact things easily" and "now people have access to suggest directly what they want and that makes them think more deeply about what they want". Some interviewees made comments about the accessibility of digital tools, stating that "there were voters of all ages and from all districts", "this is how we can reach the active youngsters, but are they interested in contributing further?", and "this could be used on a larger scale, people could check from the internet what is going on in their neighbourhood, and vote and have an impact".

5.2. Technical deficits of the digital tool hinder deliberation

The negative depictions of the digital platform application as a tool for participation concerned three aspects: a) the management of information, b) guidance and deliberation and c) the usability of the platform.

Concerning *the management of information*, the interviewees claimed that "information flow in social media is impossible" and that there was "too much text to read in the idea descriptions". This was also manifested in another way concerning the readability of the information: "there should have been lively and personal descriptions of the idea, and visible 'boxes' in which to put the information". The interviewees pointed out obstacles in *guidance and deliberation* during the processing of the platform and asking for help. One interviewee claimed that it was "difficult to decide for who to vote on based on for the information in the platform". Another claimed that "voting was complicated, I almost forgot it, and luckily I received help" and further "people need help with electronic voting". When asking for help, some residents either received no reply from the platform administrator or were instructed to go to the website. Some residents were forced to help

others with the technical problems of the platform. Some interviewees demanded more social life for residents in the PB process, claiming that "we are humans not machines". Some expressed it differently, indicating that "using electronic services is not equal, democracy cannot be realised in this way". One interviewee stated that "there are always issues that ordinary residents do not understand and experts' preparations and opinions will be needed". Finally, *the usability of the platform* was seen in many records concerning the technical details that were not working during the PB process. The voting phase especially received the majority the negative feedback, drawing on the comments as follows: "the voting link was too small, there should be bigger buttons to click", "registration was too complicated and the confirmation was too slow, and it always went to the junk folder" and "nobody wants to give his or her background information to the system" and "I guided my grandfather by telephone for voting, and it was difficult". The general demands for feedback concerning the platform included "more language versions", "bigger font", "editing should function better, my photograph was upside down". The interviewees raised wishes for better instructions for using the platform, turnaround information between the voting steps and the possibility to operate with text messages.

6. Conclusion

The purpose of the current PB experiment was to delegate power to residents to decide on the allocation of a small-scale budget for improving their neighbourhood. The study aimed to explore the features of a user-friendly digital platform as part of the PB process. The positive aspects of the digital platform were its capabilities for providing access to participation in neighbourhood development and its possibilities for changing citizens' behaviour when influencing democracy. The negative aspects concerned the usability of the digital platform, its many functional problems and inappropriate demands. There were multiple difficulties with logging in, submitting proposals and voting, and the platform did not support enough deliberation, which is a critical phase in the PB process (Lund & Juujärvi in press). Two-way communication is crucial for reaching a shared understanding of issues in endeavours towards community development. As an example, the digital platform could be more deliberative, if it provides a possibility for value-based comparisons between proposals to enhance the ability of voters to make informed decisions concerning the PB process (see Goel et al. 2015).

The active collaboration of citizens and public authorities calls for new ways of participation. The results indicate that electronic participation is something people want and has the potential to empower, but as the only method it can fail to promote deliberative democracy at the neighbourhood-level. In the PB process, it is essential to meet the social needs of citizens and strengthen their capacity to act on them. Digital tools can reach and engage with citizens to submit their proposals or choices, but this phase must be complemented by facilitated public deliberation on alternatives in face-to-face meetings or on the digital platform.

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Luste, S.

Capacity Development Design for the Wastewater Treatment Plants (WWTPs) of the Baltic Sea Region

Research Article

Abstract

The training needs and the methods are changing with the general drivers of the water industry and the global mega-trends that include for example planetary boundaries, aging population, digitalization, robotization and many overlapping sectors that are relating to the resource efficiency, regulations, economy and multi-culture. However, digitalization, social media and smart technology can also work as a "tailor made" tools to develop and deliver information such as professional networks to achieve the new skills. This poses a challenge for the sustainable designing of the capacity development structures and facilities. In the general level, the future education and learning should be a non-stop experience and there is an increasing need for the individualized learning methods and contents due to the specific backgrounds and prolonging life expectancy of the employees. Thus, flexibility in learning methods and the multiple, cross-cultural, multinational experiences has needed. This development is supported also by the partly EU funded Interactive Water Management (IWAMA) –project.

Keywords: wastewater, capacity development, lifelong learning

1. Introduction

According to the World Economic Forum survey (2016), averagely 35% of core competencies will change by the year 2020. In the sector of the infrastructure and basic industry the corresponding value is 42%. In the general level, could be outlined that the competences (or their focuses) are changing from the knowledge management to the productivity, from the controlling to the sharing and flexibility (regarding content and delivery), from the programming to the reality and from the teaching to the learning (Savickas 2017). More attention should be paid to the methods how the learning could be stimulated such as the possibilities to learn in our daily interactions (Krumboltz 2009; Fischer 2000).

The lack of training, awareness and interactive international information share have been identified as a one of the major limitations regarding the energy- and resource-efficient management of the waste water processes in the Baltic Sea Region (E.g., PRESTO –project 2011-2014; PURE -project

2007-2013). Training needs and methods are changing with the general drivers of water industry and global mega-trends, such as digitalization and robotization, urbanization, planetary boundaries, aging population, climate change and the growing demand for food, water, and energy. Moreover, the water industry sector is facing the challenges that arise from the aging of the infrastructure with new technological outcomes to meet the new tightening purification requirements such as the resource efficiency needs.

Already now, the robots and digitalization in the full scale WWTPs has shown potential to make the wastewater treatment more cost-effective and efficient, when compared to the previous situations. For example in the Aarehus WWTP, in Denmark, the Drone technology is used for inspection of wastewater basins and sewage systems, as well as robotics for the maintenance of outdoor areas, when in Viikinmäki WWTP, in Finland, multivariable predictive control system is used for the optimisation of WWTP operations (Mulas et al 2015). The skill requirements in the WWTPs of the Baltic Sea region researched during the PRESTO –project are relating to the operation of wastewater treatment and electrical facilities, mechanical education, such as the additional requirements for WWTP maintenance. Regular training should include updates regarding current processes, capacity development for the future requirements and knowledge about upcoming technologies (Rettig and Barjenbruch 2017).

Due to the high technical level, previous development projects and already existing knowhow in the Baltic region, the capacity development objective in IWAMA differs from the most of other ongoing wastewater sector capacity development projects (for example in China, Peru, Jordan or Jakarta). The focus is on the WWTP staff and on the identified bottleneck areas: the best available technologies, smart sludge and energy management. These are reported to be the key elements, effecting to the maintenance of the WWTPs of the Baltic Sea (Rettig and Barjenbruch 2016). Moreover, the climate change effect to availability of drinking water is not the major risk in the Baltic Sea countries. Water supply is a regional issue. This stands in contrast to energy supply, where problems (e.g. greenhouse gas emissions) are not related or limited to particular regions (Rudolph 2011). Thus, besides the global trends, the areal challenges must identify, when the capacity development are planned.

At the moment, there is not enough information for the investment decisions or there is no international WWTP network to obtain it. There are common need for the cross-cultural multinational experiences. There are also need to narrow the gap between research and the problems faced in the practice. The staff working at the WWTPs is in many cases elderly, while on the other hand, the new employees are usually short term. This increases the value of the employee and asset a need of the individualized learning and for flexibility regarding the processes, but also the learning methods. Moreover, in the cases where the amount of the retiring employees are high, there is a risk that existence and the type of the “silent knowledge” will be lost. Part of this information is critical to ensure the safe maintenance of the processes (Sandel 2017).

Working at the WWTPs requires a multidisciplinary extensive knowhow regarding the technical observations and management of the processes. The information and knowledge are shared by working side by side, informal discussions and meetings, stories, peer learning from the more experienced and audiovisual means. However, information is not necessarily passing in the desired way. This may due to the lack of time, job prioritization, organizational structures, information sharing culture and unwillingness to share information, but there may also be a gap between elder and younger generations (Sandel 2017).

As mentioned above, the global- and the areal change forces are penetrating all the sectors in a society, affecting to the employees with the different educational- and cultural backgrounds. Moreover, also the concrete solutions, for example things in science and technology are developed and implemented with an accelerating rate for example in the ICT- and bio-technologies. The one of the "tools" to tackle the problems rising from the changes and developments in working life is the continuous learning of the new skills. This is the idea of the *lifelong learning* that is term, used for the flexible and individual capacity development of the person.

The European Union defines lifelong learning as a means of learning from pre-school to retirement age, including all formal and informal learning and forms of the "everyday" learning (European Council 2002). Today, lifelong learning is an important as the learning process, work and professional development are increasingly intertwined. This development is essential for the Europe's innovative capacity and the development of a creative and knowledge-intensive economy and society.

The following article will explain what factors are effecting to design of the capacity development facilities and what challenges and possibilities the digitalization development creates for the WWTPs around the Baltic Sea. The main idea is to mirror the situation with the WWTPs against the future needs in the field of the wastewater treatment. The present report is based to the capacity development findings from the Interactive water management (IWAMA) –project (2016-2019). IWAMA is EU co-funded co funded from the *Interreg Baltic Sea Region* program.

2. Methods and Results

The capacity development in IWAMA project is based to capacity building results of the PRESTO project (2011-2014) that was performed on the Baltic Sea area. The lack of training, awareness and interactive international information share have been previously identified as a one of the major limitations regarding the energy- and resource-efficient management of the waste water processes in the Baltic Sea Region (PRESTO –project 2011-2014; PURE -project 2007-2013).

The capacity development in the IWAMA –project have been made with the interaction of the WWTP operators, water- and wastewater associations, universities and technology suppliers from the area of the Baltic Sea (Figure 1). The goals have been sharing and development of knowhow,

methods to deliver and receive knowhow, found the national synergies and increase the international interactivity. Capacity development is focused to the WWTP operators to increase mainstreaming of the best available technologies, to promote the uptake of smart sludge and energy management in WWTPs of the Baltic Sea Region. The partners (n.17) and associated partners (n. 12) are contributing to the implementation of the activities from the ten Baltic States.

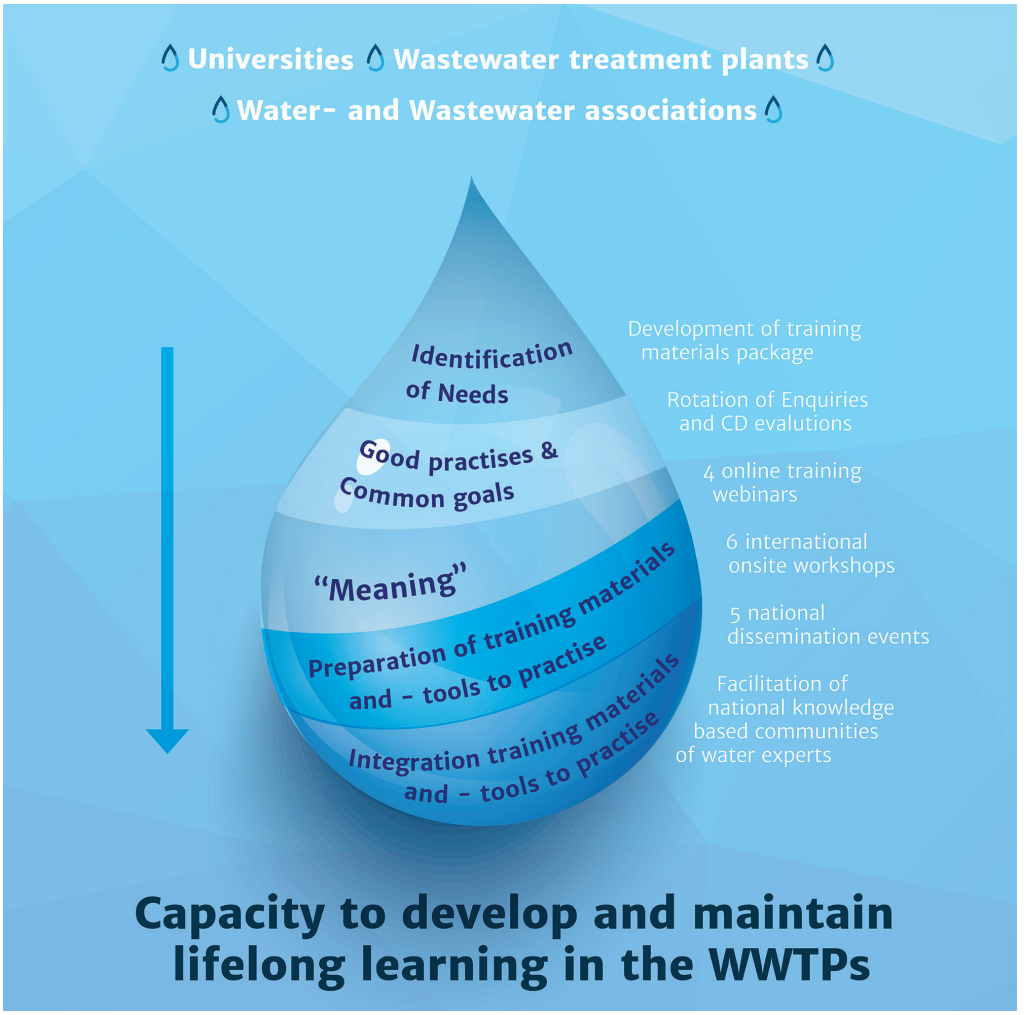

Figure 1. Capacity development during the IWAMA –project (Figure by Oona Rouhiainen).

The capacity development operations are shared to the information collection (e.g., national "state of the art" analysis, good practices, regional needs), the share and networking taking place during the project (e.g., workshop, webinars, dissemination happening) and building of capacity development tools (e.g., training material package, virtual tests, WWTP game, bench marking material, etc.). All the material will been utilized for the lifelong learning purposes after the IWAMA -project.

The surveys, whose results are presented below, was mainly collected from the WWTPs, but also from the organizations, that are responsible for the trainings and information production, such as the water- and wastewater associations and the universities (referred later as a "training institutions"). The justification of the specific capacity development tools,

generated during the IWAMA project, are appearing also in the results of the surveys. The capacity development results such as the other deliverables of the project (i.e., Hub, key figure analysis, self-audit for the WWTPs) are aiming to the enhanced International co-operation, knowledge share and dialogue, such as the delivering the missing information with the most feasible format.

Such as the faced challenge, the evaluation of the identified problems is different: Economical, educational and technological training needs are mainly concerning the WWTPs, when the general global drivers and regulatory issues are the major concern of the training institutions. The top three identified WWTPs` needs for the information are related to the aging infrastructure, financial implementation instruments and integration of automation and monitoring. The most important need identified by both WWTPs and training institutions was the technical management of the wastewater treatment from the perspective of the process entity. According to the survey made, only about 11% of WWTP personnel has sufficient knowledge of what process factors are effecting outcomes of the process (i.e., the utilization/reuse of the sludge and the energy obtained from the process).

The top ten list of the WWTPs needs are relating to the lack of the knowledge to support decision-making and maintenance of the WWTP:

- Aging of current infrastructure
- Lack of financial implementation instruments
- The integration of intelligent technology, automation and monitoring
- The creation of new operation models/methods (Sampling, analysis, reports)
- Industrial symbiosis of WWTP with operators from other sectors
- Holistic management of the process
- Local/ National legislation reforms/ The new guidelines
- To obtain reliable information for the investment decisions
- To identify the most suitable technique (Knowhow to react to extreme weather phenomena (heavy rain, floods, etc.))

The most common methods to get information and increase the personal knowhow among the WWTP employees is the “peer learning”, “seminars and conferences”, and the “internet” (Figure 2; Table 1). The “peer learning” and the electrical form learning material are considered to be, the most feasible learning tools in the future (Figure 3).

3. Discussion

According to the Baltic Sea area WWTP operators, the summarized development trend is, that “Concentrating to the larger units continues.

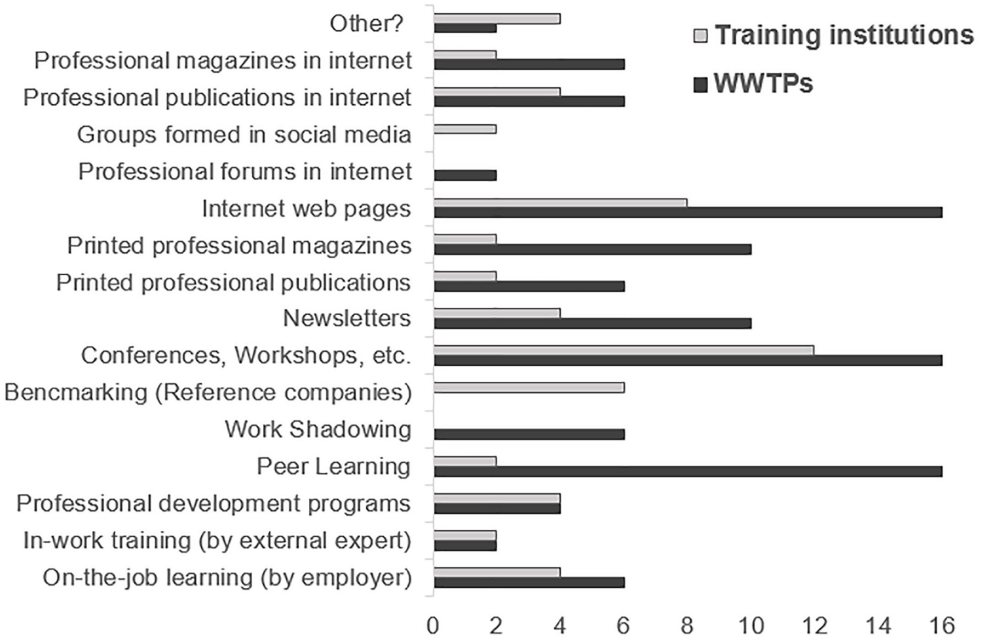

Figure 2. The top information sources for the WWTP operators and the training institutions (n. 35).

Table 1. The most used digital platforms for the learning purposes of WWTP operators and the training institutions

	WWTPs (%)	Training institutions (%)
Internet	41	43
Videos, visual material	12	14
Applications for learning (e.g. game)	0	0
Applications for mobile phones	10	7
Virtual learning environments	6	21
None	14	0
Other (e.g., Intranet)	18	14

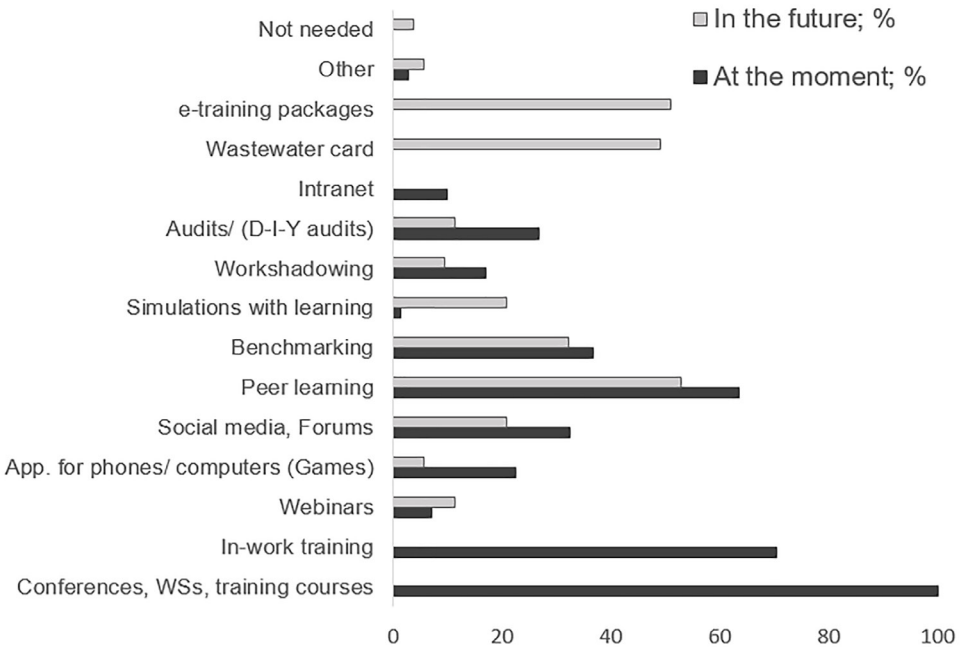

Figure 3. The most feasible learning "tools" for the capacity development (n. 78)

Things, such as automation, energy issues and sludge recovery will be emphasize in future. General trend seems to be, that the legislation of treatment requirements are tightening as well as the new requirements for the removal of contaminants and micropores (e.g., plastic, medicine residues). New technology, such as the membrane processes are becoming more and more widely used. Cross-sectional interfaces in every level of education" (IWAMA workshop WWTP interviews, 2017).

In connection with the description above, the educational material is aging and it should be more practical oriented. The elder employees are not used to the possibilities created by the electric information share and networking, when the younger employees come from the different backgrounds and the duration of employers are usually short-term employee. This heterogeneous starting point makes the development of the "official" training paths very challenging and underlines the base idea of the lifelong learning, regarding the personal educational needs (Fischer 2000). Moreover, there is an urgent need to transfer "silence knowhow" between the retiring and young employees (Sandel 2017). In the future, the working places are more and more also the learning places (Fischer 2000). Thus, there has to be enough time to share the information and the selected methods should be the most effective ones for the specific purposes. The responsibility for the knowledge management and functionality of the strategy is the management persons of WWTPs (Sandel 2017). This requires not only the methods to share "tailor made" technical content, but also the development of the soft skills – both for the "blue- and white collar" workers of the WWTPs.

It is important to note, that the change drivers, discussed previously, could also be the part of solutions. This may also be the case, when the maintenance of WWTPs such as collection and transportation of the

wastewater is done by the robots. This may reduce the need of the physical workforce, such as cleaning, but will increase the remote control and remote monitoring tasks. Digitalization and robotization has estimated to open up new types of holistic work tasks with the need of the new hybrid competences (Linturi and Kuusi 2018). Digitalization, social media and smart technology can also work as a "tailor made" tools to develop and deliver information and professional networks to achieve the needed new skills. The essential issue is to know what information has needed. Besides the global drivers and different background of the individuals, there are also national/ areal factors that may affect to the type of the information needed. According to the IWAMA surveys (IWAMA workshop WWTP interviews 2017), the main factors are: the size and the ownership of the WWTP, technological variations, age of the operator, weather and loads, local legislation and the cultural background.

According to the IWAMA surveys about 70% of WWTPs` employees of the Eastern Baltic Sea region have no primary or secondary level studies from the area of the WWT and there is more need for the "formal education". In such starting point, the most popular learning method, the peer learning, as a "tool" may increase the possibility for the "systematical error", especially, when the training has not been adequate or consistent. However, western Baltic Sea region has the need for the "flexible" on the job learning and utilization of the electronic information share possibilities. This seems to be one of the development paths also in the other capacity building –projects (e.g., GIZ 2018-2019; PURE 2007-2013). The reliability of the "peer learning" as a training method can be increased for example via the computer-aided trainings and evidence-based qualifications (i.e., skills test; Linturi and Kuusi 2018).

Moreover, the gap between the theory and the practice is further hampers the cooperation between the WWTPs and Universities. According to the IWAMA surveys for the WWTPs (n=78), the co-operation of WWTPs and universities (also universities of applied sciences) in the Baltic Sea region are the lowest, when compared to the co-operation between the WWTPs and other stakeholders, such as consult offices, associations, other WWTPs and vocational academies. This information is parallel to the general knowledge transfer between research institutions and industry that has been one of the development objectives of the European Institute of Innovation and Technology (EIT), European University Association (EUA) and research & development framework programs of the European Union (e.g., FP7, H2020).

According to the results, there is an identified need for the international information exchange, but similarly the lack of professional forums use in the internet/ social media, digital training material and the training applications has been evident. There is a common need for the practice bound training methods that also give acquirements for the for proactive decision making regarding the more monitored and automatized management technology and changes in the operation environment. In the design of the capacity development facilities it is important to understand, that there are already existing good practices, training methods and connecting platforms, that are used every day. The main issue is in the dialogue between the different

international stakeholders that should have the necessary “soft-skills” to obtain and share the tailor-made and verified information to (and from) the end users.

The so called “flipped learning” –method is already used in the official studies, that are based to the implementation of the idea of lifelong learning. In the “flipped learning” combination of the basic e-materials (e.g., videos, games), virtual tests and the advanced interactivity with the other students and the teacher is exhausted. The similar flexible methods, that are utilizing the digitalization and the existing good practices, should developed between the formal and informal study structures in the capacity development from the WWTP workers. International training material packages and virtual test that are developed during the IWAMA project are step to the right direction.

4. Summary

The capacity development based to the lifelong learning is needed to tackle the requirements that are relate to the individual needs and the change around us. The solution needs flexibility between the formal, informal and self-directed learning. The change of the knowhow has to be “correctness controlled” that increases the role and activity of the management, but also the new kind of co-operation between the WWTPs and the training institutions. Digitalization is offering tools to answer the challenge that it has partly caused. The most used education method in WWTP, the “peer learning”, could be planned so, that the basics knowhow is transferred through videos or animations, when the virtuality and enhanced e-learning enables the place-independent and advanced guiding/ teaching.

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ESPRESSO – systEmic Standardisation apPRoach to Empower Smart citieS and cOmmunities

Best Practices and Case Studies

Abstract

Innovative information and communication technology is a key element in the transformation to a Smart City. From a technological perspective, there has to be a specific degree of standardisation in the urban ICT networks. These standards have to be equally open to city administrations, companies, as well as citizens and allow innovative bottom-up-solutions. The ESPRESSO consortium mainly includes partners from Smart Cities, public administration, European standardisation organizations, national standardisation bodies, standard development organizations, industries, and research facilities.

The main target of ESPRESSO is to ensure the interoperability of Smart City solutions. This will help cities avoiding entry barriers or vendor lock-in through promoting common meta-data structures and interoperable (open) interfaces instead of proprietary ones. ESPRESSO created a conceptual Smart City information framework based on open standards to achieve this goal. For this framework, it is necessary to develop a shared Smart City vocabulary and define reference architecture and City Information indicators. This project used a case study based approach to identify the key requirements for further standard analysis activities. A Strength-Weakness analysis comprise existing as well as latest developed standards to improve the currently used standards and develop more reliable ones for future. Most of the well-known Smart Cities have concepts, which focus on optimization and efficiency, organized in a top-down manner and regarding the urban area simply as a machine, which is controllable and adjustable through the social impacts of Smart Cities. The respective standardisation approaches have to be considered and were part of the work for ESPRESSO, too. In order to ensure social acceptance of developed solutions, ESPRESSO sets up a stakeholder communication network that ensures an early dialogue between standard development organizations, technology providers, and technology consumers to avoid a mismatch between the design of technology solutions and the needs of cities and its citizens.

Supporting the theoretical approach, ESPRESSO implemented four case studies in two pilot cities, Rotterdam (Netherlands) and Tartu (Estonia).

Keywords: smart city, standardisation, interoperability

1. Introduction

The concept of a 'Smart City' is one that most people understand, but only few can define. While it is tempting to think of definitions involving sensors and other hard technologies, what really makes a city 'smart' is actually the way data is used for the benefit of its citizens.

Specifically, this 'smartness' can be downscaled to a city governed by 'big data' principles: decision makers and citizens have the ability to extract useful information from various combinations of datasets, that perhaps weren't initially designed with that combination in mind.

The major focus of a Smart City is on connecting users and data across multiple domains to share information. Data constitutes the biggest challenge for the Smart City ecosystem. Capturing, aggregating, and leveraging data from a wide range of heterogeneous systems, solutions, and platforms in a scalable, cost-effective, and timely way requires optimized designs based on key requirements linked to interoperability.

Many cities are struggling with the challenge of understanding to connect the rapidly growing volumes of data from their existing service operations, new sensors, social interactions and the like in order to deliver better outcomes for their citizens and their local economy the best way.

The aim of the ESPRESSO Project was to create awareness about standardization in the Smart City. The consortium worked towards this objective by reaching out to stakeholders and actors that may have an interest in knowing more about ESPRESSO's topics. The main target of ESPRESSO's outreach activities were: cities, SMEs, industries, and research centres interested in standards and Smart Cities, mainly from Europe, but with different backgrounds. From an initial focus on the theoretical/ high-level aspects of standardisation the attention was shifted to more specific aspects related to the case studies of the pilot cities (Rotterdam and Tartu) and their implementation.

For a period of 2 years, ESPRESSO developed a conceptual Smart Cities Information Framework that is able to guide cities in the most efficient way becoming 'smarter.' ESPRESSO is part of the EIP-SCC Urban platform. The platform is divided into the initiatives "Demand Side Management", "Supply-Side MoU" and "Standards (SCC03)". ESPRESSO is part of the "Standards"-initiative and focused on the technical approach on standards in Smart Cities.

2. ESPRESSO and the urban platform

2.1.The smart hamburger

Cities are filled with devices (equipped with sensors, actuators, and other appliances) that provide a constant stream of information that, in the past, was either impossible or relatively difficult to collect. These devices, among other functionalities, gather information about various parameters that are important to the management of day-to-day activities in the city

as well as to longer-term development planning. For example, sensors may collect information about public transport (real-time location, utilisation), traffic intensity, environmental data (air quality), occupancy of parking spaces, noise, monitoring of waste bins, energy consumption in public buildings, and much more.

Conceptually, the best way to visualise an effective Smart City architecture that can take advantage of the myriad data streams generated in a city is by a 'smart hamburger' approach. The lower 'bun' represents the devices and sensors that acquire data across the city. The 'pattie' signifies the data that sensors are creating (also known as 'Data Lake'), and the top 'bun' sums up all applications that can use this to feed visualisation, analysis, and information generation of use to citizens and decision makers (fig. 1).

The approach has been developed in cooperation with the European Innovation Partnership for Smart Cities and Communities (EIP SCC).

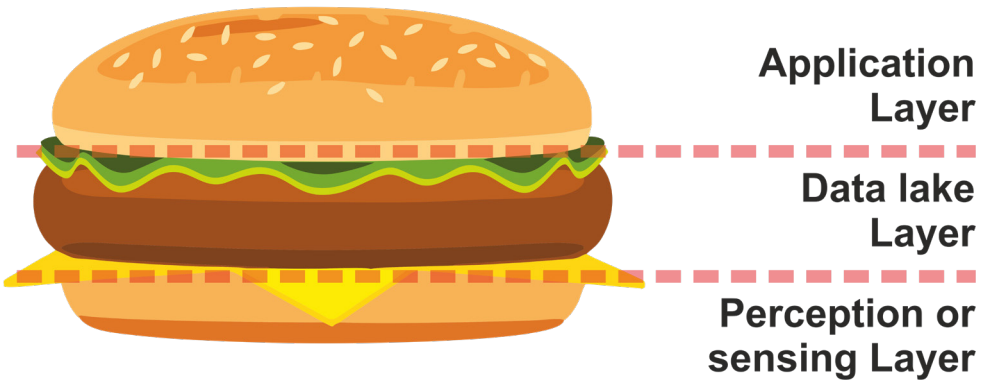

Figure 1: The smart hamburger (Own Illustration, 2018)

On a technical level, the Smart City architecture includes the following layers:

- **A Perception or Sensing Layer**: the components of the city (roads, vehicles, and end-users) are instrumented with sensors, actuators, tags, and readers.
    - The perception layer technologies consist of these smart sensors, machine to machine (M2M) communications, and the "Internet of Things" (IoT).
    - More advanced sensors could also be used to collect information, e.g. LIDARs for building 3D city models.
- **A Data Lake Layer**: enables data storage and includes an application support layer, which provides massive data processing capabilities using cloud computing.
    - Cloud computing is expected to provide the support needed to address the dynamic, exponentially growing demands for real-time, reliable data processing particular to smart city applications.

    - A cloud service maintains the collected sensor data, enables its processing to produce services, and distributes the result for either human or machine use.

- **An Application Layer**: analysing and processing data related, for example, to environmental monitoring and intelligent transportation.

Between each layer is a network layer ("the hamburger sauce") that enables data transmission between sensors, actuators and the application support layer, using wired or wireless connections. Some applications require real-time connections, others are suited for delay tolerant networks (DTN).

The requirements to implement this conceptual model of a Smart City are very simple: If data creators in a city make their data available via a standardised, open interface, then all applications can access these data by using the same freely implementable interface.

2.2. Open Data

2.2.1. Linked open Data

The Linked Data approach offers distinct advantages over current practices for creating and delivering library data while providing a natural extension to the collaborative sharing models, historically employed by libraries. Linked Data and especially Linked Open Data is shareable, extensible, and easily re-usable. It supports multilingual functionality for data and user services. Linked Data allows anyone to contribute unique expertise in a form that can be reused and recombined with the expertise of others. Through rich linkages with complementary data from trusted sources, libraries can increase the value of their own data beyond the sum of their sources taken individually.

The ability to combine data that were not made for each other defines a Smart City. Linked Data is particularly useful to do this and some cities already expose some data sets as Linked Open Data (LOD). The ISA² programme (2018) supports the development of digital solutions which enable public administrations, businesses and citizens in Europe to benefit from interoperable cross-border and cross-sector public services.

The Smart Appliances REFerence (SAREF) ontology has been identified by the ESPRESSO project as a shared model of consensus that facilitates the matching of existing assets in the smart appliances domain.

2.2.2. Open Data for Smart Cities

Cities opening their data to the citizens is a growing trend and their benefits are described in detail. Some cities are hesitant to open their multiple datasets as they fear that combining data can reveal information about a single citizen.

The city of Rotterdam, has set up a non-profit organisation to host all their

open data. This open data store is one of the largest within all Smart Cities in Europe. They share 105 different datasets (April 2018) to support the Smart City development.

2.3. Minimal Interoperability Mechanism and Pivotal Points of Interoperability

In order to implement a Smart City and the 'urban platform' with its intelligence, it is necessary to foster a breeding ground for new and currently unexpected and novel data applications and analysis. Over the course of the ESPRESSO project, it became clear that the best way to do this is to use existing standards and technologies whenever possible – e.g., using the Minimal Interoperability Mechanism and the Pivotal Points of Interoperability approaches.

2.3.1. Minimal Interoperability Mechanism - MIM

Instead of attempting to create comprehensive specifications and architectures that encompass every conceivable aspect of a city, the MIM approach does the opposite: establishing the minimal set of interoperability mechanisms that gives users just enough to link systems together when needed. In the beginning, looser couplings can patch and stitch together systems, and thus, over time, pave the way for tighter, validated ones.

MIMs are for the world of standards what a Minimal Viable Product (MVP) is for the world of services. MIMs can be seen as a precursor for well-defined basic connectivity standards such as GSM, Wi-Fi and USB. In practice, the Open & Agile Smart Cities (OASC) MIMs are a set of common APIs (to access data), common data models (to structure data), and a common, but optional, data platform (to store and serve data). In addition, a reference architecture and a reference implementation complete the set of MIMs.

MIMs help the demand-side avoid vendor lock-in, as well as the supply-side to avoid 'city lock-in', and MIMs support the need to retain legacy systems in an organic transition rather than a 'big bang' system change. An important quality is that MIMs help creating global markets of products and services within IoT and Smart Cities & Communities, and they do so by being an innovation enabler and a de-risking instrument at the same time.

The OASC MIMs are an evolving set of technical mechanisms selected from a baseline of global best practices, driven by implementation in the member cities of the network, and feeding into standardisation activities such as ETSI, ISO, and ITU.

2.3.2. Pivotal Points of Interoperability - PPI

One of the key challenges in the Smart City space is the abundance of standards and technologies available to use for IoT and Smart Cities. Yet, there are some concepts and component standards that independent

teams arrived at in common. We call these Pivotal Points of Interoperability (PPI). If PPIs are known, integrating a new component into an existing deployment is simplified. For example, knowing that the syntax of data exchanged is either XML or JSON yields a small set of boundaries for integration, if technology A (the incumbent) and technology B (the next great idea) is chosen differently. Similar simplifications occur, because most implementations use e.g. IP, TCP, REST/PubSub, and TLS. The concept is illustrated in the figure below, which shows the potential benefits to integration when PPI are known:

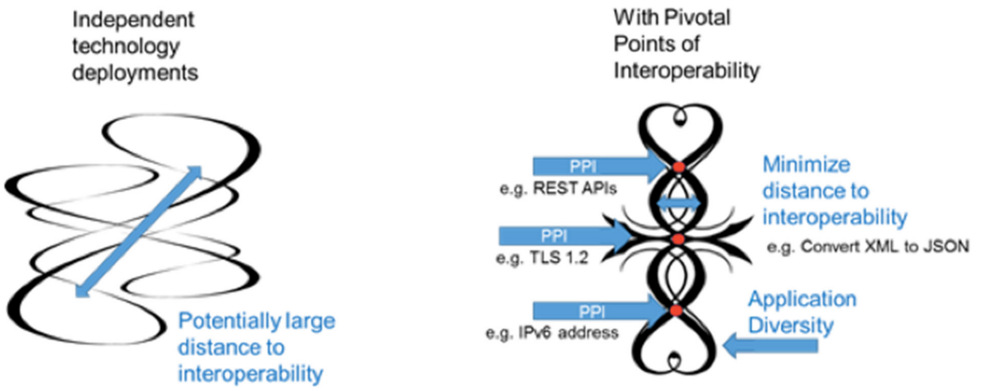

Figure 2: Pivotal Points of interoperability (Burns 2016)

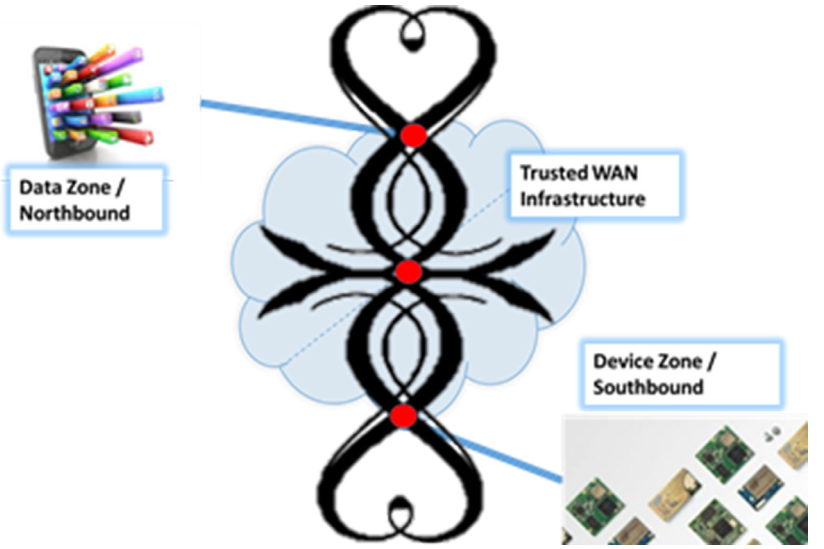

Figure 3: The PPI north- and southbound (Burns 2016)

A corollary concept is that although most Smart City applications describe a full end-to-end architecture from device to application, there are often only three important layers and two interfaces: the ‘northbound’ interface for applications, and the ‘southbound’ interface where devices attach, with a layer in-between (see figure 3). We have observed that many of the architectures we reviewed have this in common. Note that the southbound interface does not necessarily imply a single physical/data link layer as there will be many. However, the needs for device admittance into the network and overall management will be similarly independent of the underlying connection.

While this is of course a simplification, interoperability will result if the services available at the northbound and the southbound are standardized. This would allow applications to be device agnostic and devices to be application agnostic. The result is a Smart City environment where it is not necessary to sell end-to-end solutions, but parts over time.

The same reasoning can also be applied between the Data Zone and the Application Zone in the ‘smart hamburger’.

2.4. Open Standards

Many cities indicate having developed Smart City initiatives in recent years without underlying standards. Due to this shortcoming, solutions that work for a certain city cannot be deployed in another city without important adaptation efforts. However, the real challenge is the development of standards that can be applied in a number of cities and can ensure replication from one city to the next.

Open standards are the best path to interoperability and ‘future proofing’ any future application based on the urban platform. Urban platforms perform a core building block where cities could manage the current explosion in volumes of city data in a better way and can easily share this data between city services in order to improve outcomes for society. Few cities in Europe have implemented such solutions.

There is no obvious winner among all existing IoT architectures. Interoperability between different devices/ platforms is necessary. The best option is to use open standards with a holistic perspective that easily integrates any potential technological partners in the platform and ensures continuity in time. OneM2M stands out as a world wide organisation that defined a standard employing a simple horizontal platform architecture which fits a three layer model comprising applications, services and networks.

Regarding data in the urban environment, it resides in many databases and systems. Therefore, platforms capable of combining relevant information from multiple sources are needed. 3D city models are developing into a major collaboration platform.

Concerning the data exchange, CityGML is currently the most promising open urban data representation format, with increasingly wider software

vendor support.

3. ESPRESSO Use Cases

3.1. Rotterdam/ Netherlands

The city of Rotterdam has made the ESPRESSO use cases part of their 3D Digital City programme. The aim is that within a few years a high detailed 3D city model will be available online, with all kinds of additional information attached (sensor/ municipal/ business) to use for whoever can use it. There already was a 3D city model in use, but at least it was updated according to the newest CityGML specifications to an intelligent object oriented 3D city model with more possibilities. Also connecting sensor information in a standardised, flexible and scalable way needed to be further investigated. Analyzing this was done in the ESPRESSO use cases.

Three different types of sensors from different suppliers were tested. Waste container sensors, water level measure sensors and parking space availability sensors. They should all be connected using the MIM and PPI approach with the CityGML, WFS and SensorThings API standards as PPIs.

Technically, this approach seems to work well. Once the sensor information has been transformed to these standards it is easy to integrate them and use them in all kinds of applications. Most important lessons learned are that data-ownership and the formats in which the sensor information is supplied should be arranged in advance. Furthermore, it showed that although IoT is a big thing, it is difficult to find the right people with in-depth knowledge at the supplier side. This makes it difficult to really get access to the sensor information.

The MIM and PPI approach and used standards will be used as an important pre-requisite during the further development of the 3D Digital City programme in Rotterdam. Data-ownership and data delivery specifications have been put into the Rotterdam terms of delivery. The 3D Digital City infrastructure will also be used in the European Lighthouse Project Ruggedised (2018) and the Roadmap Next Economy program which the city of Rotterdam is also working on (fig. 4).

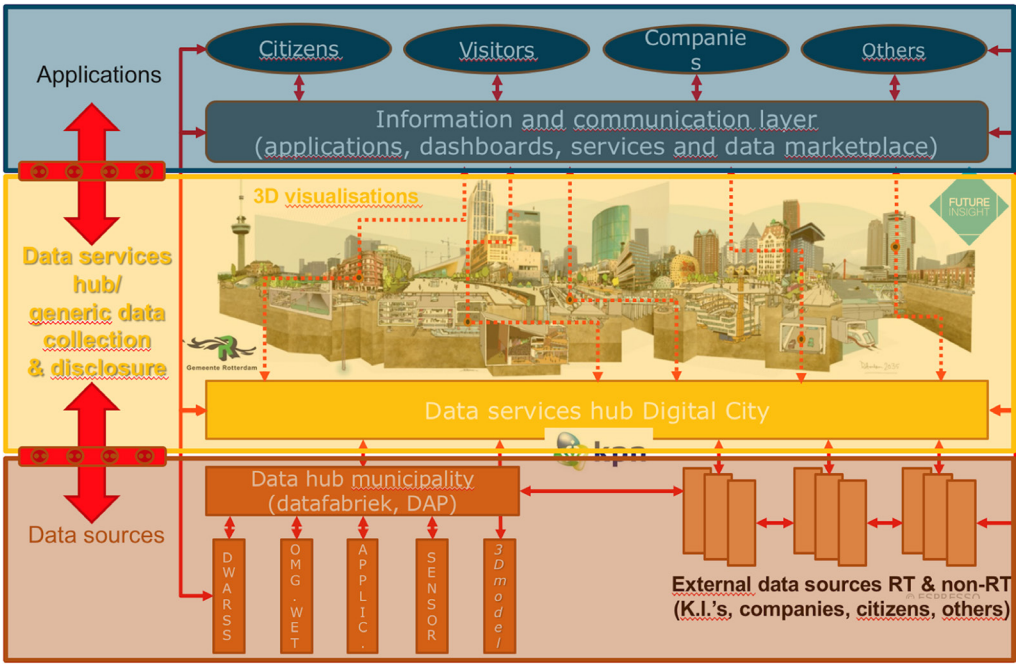

Figure 4: 3D Digital City infrastructure of Rotterdam (Own Illustration, 2017)

3.2. Tartu/ Estonia

The main objective of the pilot was to contribute to the increase of energy efficiency in the new smart district developed in the Tartu city center, where a number of old Soviet-era residential buildings will be renovated in order to meet the contemporary Smart City standards in various fields, but primarily in terms of energy efficiency in the context of the Horizon2020 lighthouse project SmartEnCity (2018). The aim is to reach the energy consumption level of 90 kWh m^{-2} a^{-1} – decreasing the energy consumption level three times from the current 270 kWh m^{-2} a^{-1}.

The more specific objectives of the pilot activities were to

- mobilise support and build momentum for Smart Energy Management among the residents of the new smart district in Tartu and the general public via better visualization of positive changes to take place in the context of the SmartEnCity initiative,
- create better informed decisions regarding the use of solar energy – based on solar potential analysis data integrated in the city information model in the context of the pilot project.

The pilot project has been carried out successfully and the advanced 3D City Information Model (based on CityGML) supports better analysis of energy efficiency situation in the pilot area, including solar potential and visualisation of relevant information, presenting the data in an understandable way to various stakeholders.

By implementing the pilot project, it revealed what is necessary to integrate different data together to implement smart solutions. The current widespread approach of using only datasets of one topic (data

silos) prevents innovative and smart solutions. The conclusion is that, in the case of Tartu, there were no major obstacles in this and the datasets involved in the pilot could be brought together in manageable time (aprox. 10 months). One of the main learning points is that establishing well-working communication flows takes time and this should not be underestimated. As the various datasets were scattered in different departments of the City Government or held by other stakeholders (e.g. Tartu Regional Energy Agency), coordinated by different individuals with a differing outlook on the tasks based on their differing everyday responsibilities, engagements and also communication skills, we experienced a level of delays.

3.3. Benefits on standards in Smart Cities

From a pure economic perspective, as it emerged from the cost-benefit analysis of the ESPRESSO use cases, standard-based Smart City solutions prove to generate significant cost savings. However these, due to generally high initial start-up costs, are characterised by rather long payback periods. As an example, the initial costs sustained by the Tartu's Energy Efficient Building Refurbishment Action amounted to 16 - 20 million €. Due to the fact that the estimated annual economic benefits account for approximately 0.5 million Euro, the solution will require several years to pay back. This could be partially overcome by scaling the solution to other areas across the city, therefore boosting returns of scale and decreasing the initial start-up costs. Projecting at a European level, significant benefits could be achieved by implementing the solution in all cities of a similar size to Tartu across the EU28 territory: by doing so, approximately 41.5 million € of savings could be generated every year.

However, the implementation of standard-based Smart Cities solutions is not only about saving money. From a societal point of view, reducing the environmental footprint appears to be the primary objective of most Smart Cities solutions in order to enhance the overall quality of life for citizens, as well as for cutting energy consumption and resource waste; e.g., the city of Tartu in its 2013 - 2020 development plan decided to reduce CO2 emissions by 20%. The Energy Efficient Building Refurbishment Action will contribute to achieve this target by reducing annual carbon emissions of approximately 1,022 total CO_2 a^{-1}. Following a similar approach, Rotterdam implemented its ambitious "Rotterdam Climate Change Initiative" in order to make the city 100% climate proof by 2025. Both, the groundwater levels measurement and smart parking solutions will go in this direction by enhancing the city´s resilience to climate change.

A key role is given to adoption of standard-based 3D City Models that support towns and cities to assess a wide range of natural phenomena from energy consumption to solar irradiation. Both, Tartu and Rotterdam pilots rely on this technology. In consequence of open-standards based 3D City Models, it is possible for cities to open up data and public sector information that is fostering the creation of new products and services while promoting the entrepreneurial spirit among citizens.

3.4. Benefits on standards in Smart Communities

Smart solutions are not just important for big cities. Even in small communities, smart solutions can generate social and economic benefits and improve the quality of life of the inhabitants. Especially for these it is crucial that the chosen solutions are as simple as possible to implement. In contrast to grown individual solutions, standardized solutions can be scaled easily to fit the size of the city or community. The standardized approach requires a lower level of technical understanding to implement though detailed instructions and descriptions.

4. Conclusions

Overall, ESPRESSO has shown that the use and awareness of open international standards are required to achieve useful interoperability in any Smart City initiative, additionally allowing the city to avoid the future costs associated with breaking out of vendor lock-in and siloed solutions.

A 3D GIS is a common place for Smart Cities to bring their data together. 3D city models contextualise, visualise, and allow analyzing of static and dynamic city data from disparate and diverse sources.

MIM and PPI approaches can help to take affordable small steps towards a larger smart city infrastructure, without fear of vendor or technology lock-in.

For further information, please visit the ESPRESSO website (http://www.espresso-project.eu).

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Integrative development of a multipliable modernization concept in urban districts

Best Practises & Case Studies

Abstract

Post-war neighborhoods all over Europe are facing different kinds of challenges in order to adapt them for the use in the future. The predominant factor in many concepts of urban district modernization is the energy demand of the buildings, which sums up to approximately 40 % of the global energy demand. (Bindra and Scanlon 2010)

The target district incorporates mostly multi-family buildings, predominantly for social housing, arranged in an open building structure, which was erected between 1930 and 1960, in a period of reconstruction and housing shortage in Salzburg. It is characterized by high volumes of traffic, a high proportion of open space, which do not serve their original purpose for recreation and a high percentage of inhabitants age 60+. The neighborhood, situated in the city of Hallein in Austria, serves as a demonstration area, which can be an example for similar structures. In Austria 11 % (Statistics Austria 2011) and in Europe 18 % (Birchall et al. 2016) of the building stock are multi-family buildings erected in the same time period as the reference neighborhood.

Planning tools and measures are evaluated based on the settlement and a multipliable modernization concept is subsequently developed, which combines the newest technological developments (e.g. a multifunctional façade with thermally activated components and sound absorption) with the environment, in a system spanning approach. Beyond that, the results obtained from an externally commissioned social-scientific investigation, which ensures the acceptance of the settlement residents, are used in the project.

The paper itself concentrates on the stocktaking (i.e. systematic approach of analyzing the existing building stock) and energy analysis as well as the social science study and the description of the multi-functional façade with its benefits for the tenants and how applying it could lower the energy demand in the district.

A comparison of the stocktaking results with the results of a whole area refurbishment with the thermally activated façade leads to a reduction of the heating demand from 4.000 MWh/a to 2.270 MWh/a.

The gained insights provide the foundation for a subsequent demonstration project in the city of Hallein and ideally is transferable to other districts with similar needs for modernization.

Keywords: stakeholder inclusion, district renewal, minimally invasive retrofit, multifunctional façade

1. Introduction

In central Europe, a significant amount of settlements were built between 1930 and 1960, following the concept of the "structured and loosened city", where green spaces, natural lighting and ventilation was of high importance. Those monofunctional settlements, with its social housing complexes possess their own cultural identity, especially due to their social structure, their quality of space and fulfil the needs of socially weaker section of the population for affordable housing.

In recent years, those settlements are coming under significant pressure for renewal since they have received little to non public or technical attention due to their stable development and the fact that they are rarely socially critical areas or targets of investment interests. In addition many of those housing complexes are situated at polluted sites, due to the increasing number of motorized individual traffic, resulting in high noise and pollutant immission. Besides the loss of quality of life in the buildings also the usability of outdoor spaces is negatively affected by those developments. Based on the ageing structure of the buildings and due to the missing/poor thermal insulation as well as heterogenic energy supply systems in such housing complexes the energetic condition is an aspect that can be substantially improved.

The project analyses an integrative approach for the refurbishment of building ensembles in social housing. The Burgfriedsiedlung in Hallein was used as demonstration site. With its' high congestion, uniform and overaged building stock and the open building structure it can serve as example project for many similar settlement structures in the city and state of Salzburg and beyond. A minimal invasive refurbishment approach should guarantee little disturbance of the tenants and a life-cycle extension of the stock. Furthermore, the findings of an external social-scientific study were used, which aimed to guarantee the acceptance of the modernization measures by the residents in the Burgfriedsiedlung and the relevant stakeholders using interviews, surveys and workshops.

2. Methodology

The investigation of the target district in Hallein in terms of minimal invasive refurbishment is based on a current stock analysis and its heating demand paired with a social analysis. A step by step outline of the implemented research method is given below.

2.1. Stocktaking

Stocktaking describes the systematic approach of analysing the existing

building stock in order to determine the current state of its construction components (e.g. walls, roof, windows, building equipment). In order to achieve this, several methods were conducted to determine the overall situation in terms of energy consumption, construction standards, usage of buildings and technical building facilities. Data and plans provided form real estate owners were analysed and damages were recorded during on-site inspections. A uniform database of all buildings in the area was achieved. Each building was recorded under the use of a specially designed guideline. Following parameters were recorded:

- Visual condition of the construction components
- Realized refurbishments (refurbished parts and methods)
- Insulation thickness
- Insulation damages
- Thermal images

Establishing a homogenous database and calculating characteristic values concerning the construction physics of each building was the main goal and a prerequisite for estimating the refurbishment and energy saving potential of the settlement.

2.2. Estimation of energy demand through energy certificate software

In order to determine the energy efficiency classification of the whole project area, each individual building was recorded within an energy certificate software. Already existing certificates were checked for correctness and afterwards collected and implemented into the energy performance calculation software, GEQ 2015. To achieve a uniform data format, the calculation method was defined according to (OIB 2011). For each individual building, without an existing energy certificate, following assumptions were taken into account:

- Typical construction materials based on existing certificates and building category
- Building dimensions according to aerial photography an on-site-measurements
- Heating system according to comparable buildings and personal questioning

2.3. Social analysis

Initiated by the city of Hallein, a social analysis was conducted with the goal to include the residents within the planning process. As a method for the analysis a tested questionnaire, which has already been used in various research projects, was adapted in order to generate knowledge

about individual needs of the specific target group (i.e. inhabitants of the research area). To determine the age specific needs, all residents older than 16 years were addressed to take part in the survey. The survey is designed to gain data concerning:

- Individual living conditions (e.g. duration of stay, housing needs, satisfaction, disruptive factors, costs of living)
- Refurbishment: point of view from residents (e.g. need of refurbishment, expectations, new neighbours and densification, concerns, need of information, personal statements)

By the use of SPSS Statistics, a software package for interactive, statistical analysis, the questionnaire was analysed according to frequency distribution, significant characteristics and demographic patterns.

3. Results

Within this chapter results of the detailed stocktaking and energy consumption estimations are presented. Additionally, the outcomes of the social analysis undermine the refurbishment strategy. The functionality of the thermally activated building façade is explained and first monitoring results prove its feasibility.

3.1. Stocktaking and energy consumption

The thorough stocktaking analysis showed a highly heterogenetic condition of the individual buildings within the settlement which can be observed in Figure 1. The data for this figure was obtained from calculations performed by researchers from the Salzburg University of Applied Sciences. Although the original windows have been replaced 25 years ago and many buildings received an insulation between six and twelve centimetres, the weighted heating demand for the settlement amounts to 81 kWh/m².a. The heating demand within this paper is defined as: the required amount of heating energy needed to compensate temperature losses, resulting from infiltration, ventilation and transmission heat losses. Multiplied with the total gross floor area of the settlement a heating demand of 4.000 MWh/a is estimated.

3.2. Social analysis

From a scientific view, the survey area provides a suitable exemplary object of research for a social space analysis: rather low heterogeneity within the central area, rather stable social framework, low fluctuation, manageable structures and supportive city administration.

In the past, several buildings were partially refurbished, mainly concerning the installation of new windows and adding insulation. Those measurements are no longer state-of-the-art and the energy performance

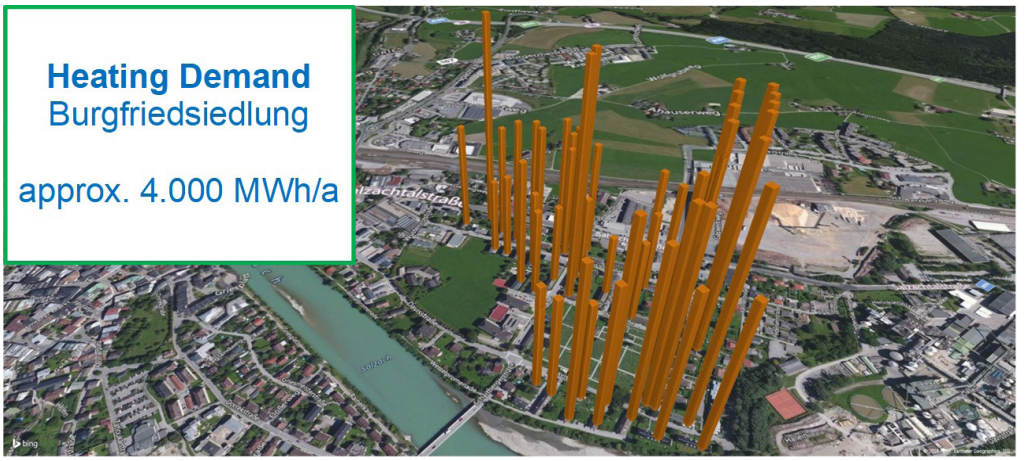

Figure 1 : Heating Demand Burgfriedsiedlung (Source: own figure 2016)

of the buildings is poor. Some buildings are still in original condition. This fact leads to a high acceptance of refurbishment measurements by the affected inhabitants. The questionnaire was addressed to all citizens, older than 16 years, within this area. Therefore, not only the opinion of directly affected tenants was collected. This leads to a comprehensive picture of the present social area. In order to enhance the participation of the citizens, discussions and workshops were held.

Due to the fact, that not all of the addressed citizens are affected by the refurbishment project the response rate of approximately 20 % from the 1.725 distributed questionnaires is a non-informative value. For further investigations, 312 out of the returned 340 questionnaires were taken into account.

In order to ensure a sustainable settlement development, a controlled smooth changing process leading to a feasible future model is necessary. The framework of the smart city project can make a significant contribution to future developments.

Based on the cost-benefit relation, almost 80 % of the addressed citizens are satisfied with their current flat situation. The major dissatisfaction arises from the size of the flats and the dysfunctional open green spaces. In order to ensure a sustainable settlement area development, especially an age specific demographic distribution, including barrier free housing, playing areas and quiet zones have to be implemented.

Due to the fact, that the majority of buildings are lacking parking spaces, further steps should include a special attention to address this problem.

In particular, the reduction of heating costs is a main point of improvement, brought out by this survey. The fear of increasing rental costs on the otherhand, can be dampened by the reduction of the individual heating demand and increasing thermal user comfort. Especially during the demonstration phase of the project, potential fears should be considered and if possible avoided. During the refurbishment process, it is obligatory to minimize the impact on the inhabitants. Therefore, it is not possible, to relocate the inhabitants during the refurbishment process. This influences especially the construction methods used to improve the thermal quality

of the buildings.

3.3. Thermally activated building facade

Based on the request of the building operator, city of Hallein, and the result of the social science survey, a special façade system was developed.

Therefore, a façade prototype was applied to the existing exterior wall, which should improve the thermal insulation and sound absorption performance of the reconstructed façade. For more detailed information about the sound absorption of the façade the reader is referred to the paper: "Traffic noise reduction through acoustic absorption panels, integrated in prefabricated facade elements" written by Portugaller B., Leeb M. et al. Built-in heating circuits, which function as thermal component activation, substitute the present heating system in the building. With these passive items, a central heating system can be created without affecting the existing building stock. Being a minimally invasive approach, indoor living spaces will mostly remain untouched. In addition to the façade elements, the existing windows are replaced, to ensure a higher thermal building standard. U-values of the new windows is 0.8 W/m²K, resulting in an improvement of 113 % compared to the mean U-value (1.7 W/m²K) of the existing windows.

In addition to optimizing the heating system and the enveloping surfaces, an innovative concept for perceived traffic noise reduction is developed. The ultimate goal is to develop one comprehensive and prefabricated construction; thus, acoustic panels are applied to the reconstructed façade. Chances are, that with such an embedded solution, a multitude of problems may be ultimately solved.

As a result of cooperation between the research team and various industrial partners, a prototype of a façade system, displayed in Figure 2,

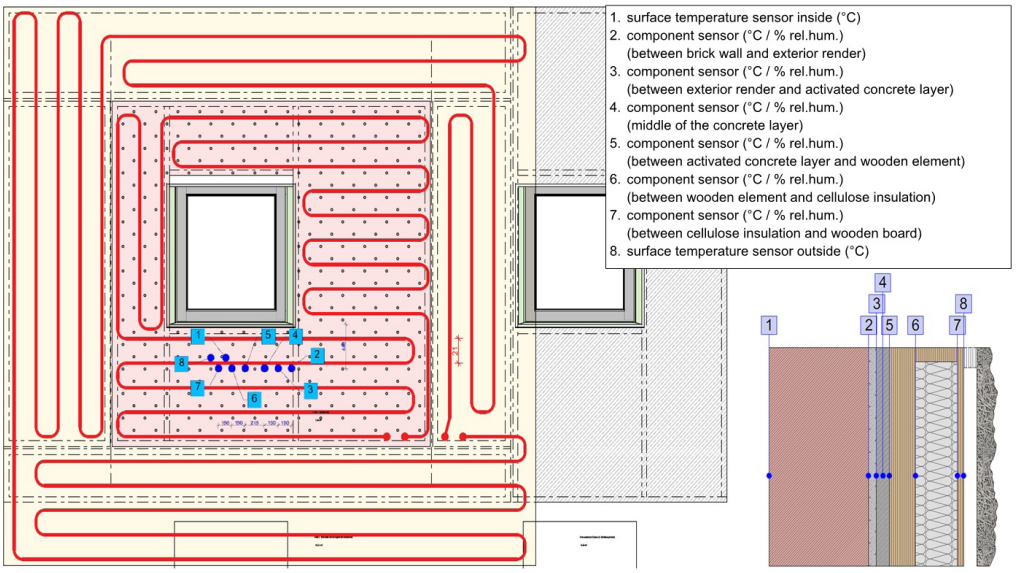

Figure 2: Facade prototype – heating circuit and wall construction (Source: own figure 2018)

was developed. The resulting u-value of the exterior wall is 0.18 W/m²K, which is a 120 % improvement compared to the actual average U-value of 0.4 W/m²K.

The prototype itself was mounted in December 2017. During the prefabrication process and the mounting of the prototype, sensors for logging data concerning temperature, relative humidity and irradiation were installed within the façade element.

For providing heating energy, a mobile heat unit was connected to the prototype. The highlighted area displays the measured area, which is surrounded by a second thermal activated heating zone, with its reason to avoid unrealistic heat losses through the edges of the prototype and to simulate a whole activated building façade.

Figure 3 displays the temperatures during the coldest week of 2018. As a result, a water inlet flow of 470 Litre/hour with a temperature of maximum 35 °C is sufficient in order to keep the room temperature at 22 °C. The temperature drops of the room temperature are caused by manual window ventilation according to a set timetable, with its goal to simulate usual user behaviour. The control of water inlet temperature is driven by ambient temperature. For the design condition at -15 °C ambient temperature the inlet temperature is set to 35 °C, linearly decreasing to 20 °C at an ambient temperature of 20 °C. The water inlet temperature is controlled by a three hourly mean of the ambient temperature, which causes the temporal offset between the ambient temperature und the water inlet temperature, seen in the graph.

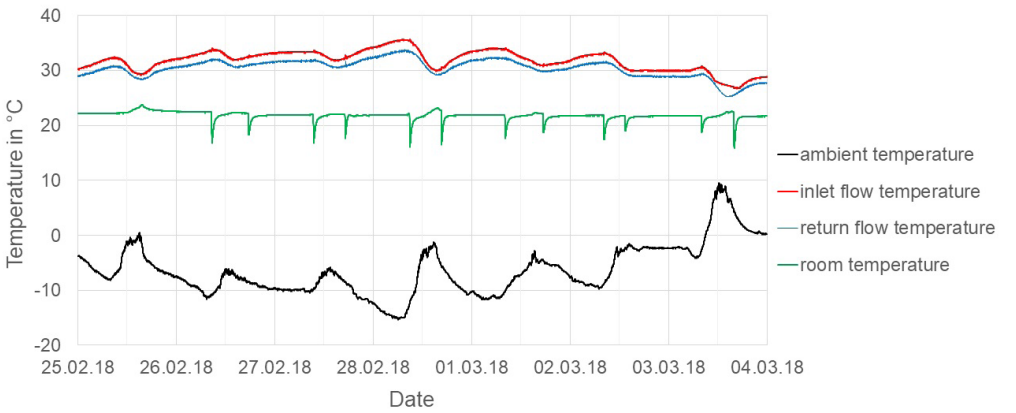

Figure 3: Logged sensor data – ambient temperature, room temperature, water temperatures (Source: own figure 2018)

Beside the on-site measurements, simulations concerning the extra energy losses towards the outside were conducted. Under design conditions, approximately 65 % of the heating energy is utilized for room conditioning. The remaining 35 % are directed towards the outside environment. Considering the entire heating period of the year, the useable heating energy increases to approximately 70 %.

Based on the actual results, refurbishment from the outside of the building, due to the wish of minimizing the impact on the local tenants, is a possible

solution and can be utilized within the whole project area.

Applying the prefabricated prototype to the exterior wall as well as refurbishing the roof, the ceiling towards the unconditioned basement and exchanging the windows without additional shading systems has the potential to decrease the heating demand of the whole district by 43 %. This number does not incorporate benefits due to the thermal activation of the exterior wall, using lower inlet temperatures. Calculating the efficiency of the energy system is at the core of further research within the project and will be executed with detailed dynamic thermal building simulation.

4. Conclusion

Based on the stocktaking analysis of the project area combined with the social analysis a fully functioning façade prototype was developed. As a driving force, particularly the demands of minimal-invasiveness from the building operator (the city of Hallein) and the tenants resulted in the special way of refurbishment. Implementing the heating system within the façade and especially the thermal connection to the existing exterior wall, caused the main problems.

Replacement of the current predominant decentralized heating units to a uniform district heating system is another benefit of the façade system. Beside those changes, the heating flow temperatures could be lowered to maximum 35 °C, depending on the ambient temperatures. Beside the impact of the ambient temperature, the window size has an influence on the flow temperatures. With the enlargement of windows, the temperature has to be adjusted to a higher value. Another design parameter for further investigations is given by the water circuit mass flow. For the prototype, the given mass flow of 470 Litres/hour is relatively high. If in further steps of planning, state of the art, panel heating distributers are used, the water inlet temperature had to be adjusted to a higher value. Due to the activated storage mass, a replacement of windows and additional insulation of the roof and basement, increased thermal user comfort is achieved. Along the changes of the heating system, the decentralized warm water preparation is replaced with fresh water modules, powered by the district heating system. In further investigations, influence of sun shading, different control strategies such as room temperature driven heating circuit regulation and implementation of heat pumps for cooling and heating should be conducted.

A comparison of the stocktaking results with the results of a whole area refurbishment with the thermally activated façade leads to a reduction of the heating demand from 4.000 MWh/a to 2.270 MWh/a. Since the exterior wall is thermally activated from the outside, additional energy losses of approximately 30 %, throughout the whole heating period of the year, have to be taken into account.

Due to the incomparable way of refurbishing, between the thermal building activation through façade modules from the outside and a conventional refurbishment by using a thermal insulation system, no economic efficiency calculation was conducted. A future project approach could deal with an in

detailed economic analysis.

Through the scientific project partner Salzburg University of Applied Sciences, it is ensured that the obtained insights are directly disseminated in an educational context. Beyond that, the results are multiplied throughout and beyond the region, with the help of the networks provided by the partners.

Acknowledgements:

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Nguyen, N. &, Dang, K.

ENERGY SIMULATION and DATA MONITORING tools: Sheet Metal Center

Best Practises & Case Studies

Abstract

Building Energy Simulation (BES) is nowadays widely used in the design stage of buildings. In the last decade, using BES during the operation stage has raised a great deal of interests in many studies (Sterling et al. 2015). The usage of an energy model throughout these stages requires continuously validation and refinement. Systematic and advance real-time data collection and management are identified to be essential aids in the audition process and simulation techniques improvement. This article shares the experience in developing Sheet Metal Center hall as a pilot for sustainable operation by integrating energy simulation and real-time data monitoring. The building is used for technology development and research testing at Häme University of Applied Sciences (HAMK), together with strategic partner Ruukki Construction Oy. The article also presents the challenges of such R&D activities in real-life.

Keywords: energy simulation, data management, monitoring

1. Introduction

It is generally recognized that buildings represent more than 40% of EU energy consumption and 36% of the CO_2 emissions in the EU (The European Commission). The EU's Energy Performance of Buildings Directive requires all new buildings to be nearly zero-energy (nZEB) by the end of 2020. The nZEBs are expected to have high-quality indoor environment and consume even less energy than the modern efficient buildings built today. Thus, energy analysis and simulation have become increasingly relevant due to the increased complexity of projects, new customer needs, and the amount of regulations to comply with. From design to operation stage, an energy model is projected to assist in the decision-making process and provide a reference for quality management during the building's lifetime. However, because of the changes occur during a building's lifetime and possible unrealistic input, such as climate data, occupant and operational profiles, technical parameters, predicted performance is often relatively different from the real building performances measured (Wilder & Jones 2014).

Thanks to the evolution of sensor and wireless technologies, as well as the ongoing development of the Internet of Things and Industry 4.0, data

communication techniques have been constantly advanced. Building automation systems nowadays include automatic data management: real-time data collection and storage, processing, and customized visualization and alerting. It is with no debate that building performance simulation will benefit from the data increase, as the model having accurate input and analytics getting a realistic reference for comparison.

The goal of the research presented in this paper is to demonstrate an approach for effective calibration of building energy model by utilizing sensors and wireless technology, which further aims at the development of different automation setting simulations. The first part of the paper gives a brief description of a pilot site and the base model constructed. Then, the design and commissioning of a programmable logic controller based system and a data server for data acquisition and visualization of the building automation system are presented. Finally, the authors discuss the preliminary works which are currently implemented for calibration by coupling with measured data, and lessons learnt during the process.

The case study in the paper is a pilot of a near-zero energy building (nZEB) in Finland. The Sheet Metal Center (SMC) research hall of Häme University of Applied Sciences (HAMK) is located in Visamäki campus, Hämeenlinna, Finland. The planning and design took place during 2013 - 2014 and during this period, the requirements from the draft proposal for nZEB was seen as the primary target. The building was put into use during summer 2015. The total area is roughly 1500 m^2, as a mix of industrial and research facility. The building is designed as an optimization in a whole, e.g. featuring ventilation system with heat recovery, hybrid solar-geothermal heating plant, and polycarbonate windows. There are often testing services which produce significant thermal loads periodically and/or locally much higher than in a standard building. Sub-meters and BAS monitoring were taken into account during the planning phase and was commissioned by Caverion Oy, a company maintaining smart energy management and automation system solutions for buildings, industries and infrastructure.

A couple of energy models for design concept, as well as as-built reference have been developed initially (Kurnitski & Fadejev 2016) using IDA Indoor Climate and Energy (IDA-ICE). IDA ICE is a whole- building simulation tool developed by EQUA Simulation AB. The software is built on dynamic multi-zone computations, with the capacity to model HVAC systems, solar gains, internal loads and so on. Both indoor climate and energy consumption results can be produced.

1.1. Post-occupancy - the base model

The SMC base model was created as a thesis work, with ten thermal zones. The model used the Helsinki-Vantaa 2012 test reference year climate profile. The weather data collected and processed at the observing station in Helsinki-Vantaa airport was the reference profile for the weather zone I in Finland. According to Part D5 of the National Building Code, Hämeenlinna belong to the same region. (Ympäristöministeriö 2013). The HVAC system and controls were mainly acquired from the as-built design

documentation, manufacturer specifications, and reference literature. Internal loads (lighting, equipment, occupants) and their schedules were created based on construction standards and interviews of the building users. The energy pile field was simplified with mirroring technique (Nguyen 2017). Figure 1 (Nguyen 2017) shows the scheme of the building's technical plant and its 3D geometry in IDA ICE.

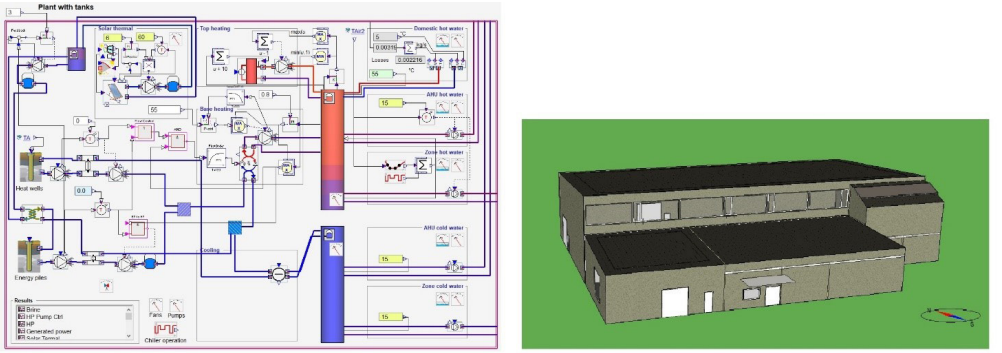

Figure 1. The base model technical plant and its geometry in IDA ICE

The initial reflection between the base model result and the metered data for 2016 (first full operation year) was summarized below:

- Solar collector performance: IDA ICE provided a whole year 14.8 MWh-heat-collected from solar collectors, which was only 8% less than the actual measurement in 2016. On average, the simulation result pattern fitted well with the recorded data, except from May to July.
- Air-handling-unit (AHU) heating energy: In 2016, SMC used 27.5 MWh, which was 3.4 times higher than the IDA ICE prediction. The major discrepancy came mainly from January and February. The metered electricity usage of the building was much lower than the simulated electricity usage at the start of the time period but was more comparable during the last few months (Figure 2).
- Heat pump total heat production: The whole year simulation was barely close to 50% of the measured data. The overall pattern, however, was analogous along with warm and cold months. The difference came mostly from the heating season, with the exception of December (Figure 2).

It should be noted that the normalization was done for measured heating energy consumed by the AHUs and the space heating network before making the initial observation. The reason was that the weather profile in the simulation was developed from the reference years in Helsinki while the actual building was located in Hämeenlinna. The initial observation discussed only the heating energy because the recordings from electricity meters in 2016 were considered defective.

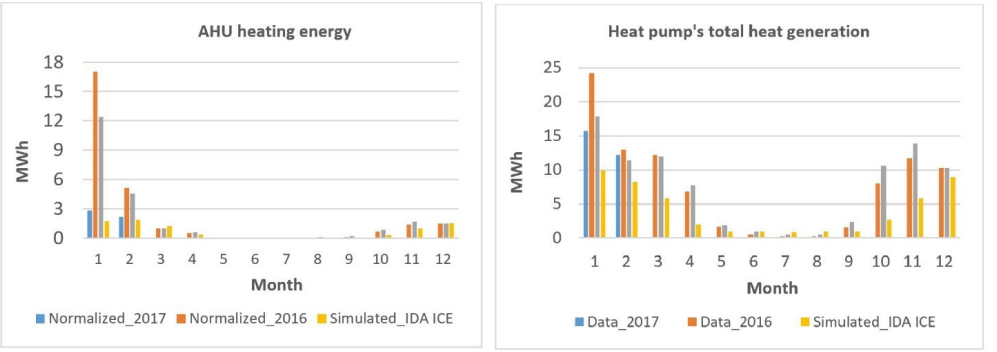

Figure 2. Comparison of the base model result and metered data in 2016

Figure 2 (Nguyen 2017) shows the comparison of the measured and simulated AHU heating energy and total heat pump heat production, briefly extended to February 2017. As noted above, the simulation results were much lower. However, the difference between recorded data and the simulation for January and February was much smaller in 2017. Since the weather pattern between 2016 and 2017 did not have too significant variants, it is suspected that technical errors in the ventilation system, certain changes in operation (e.g. continuous opening of the large service doors, and manual adjustment of controls) and/or combination of those are the cause of the dissimilarity.

1.2. Current monitoring and data acquisition

Due to access control and performance critical issues, the Caverion system needs to be air-gapped. Hence, an additional data collection system was commissioned as a thesis work and operated in conjunction with the Caverion Pyramid BAS (Building Automation System). At the edge level, the system employs a PLC with Windows Embedded Standard runtime for communication with Pyramid BAS to retrieve the BMS data. The communication at this stage was achieved using Modbus TCP and OPC UA protocols. The data was then pre-processed and packaged in JSON format, then sent to a backend server in real-time through REST micro-services. (Dang 2017)

On the server side, InfluxData's TICK stack was used as the data warehouse and processing platform, in combination with Node-RED for micro-services implementation and Grafana for visualization. All platforms were selected based on their ease of use and interoperability, as well as open-source nature. The data collected was served using two methods: public REST micro-service, and Grafana. Grafana is capable of generating graph on multiple data points and export the graph data to multiple formats, namely JSON and CSV, allowing users to quickly view the data, test their assumptions and extract the data for more extensive use. Node-RED and Grafana also enable rapid prototyping of additional micro-services and continuous integration.

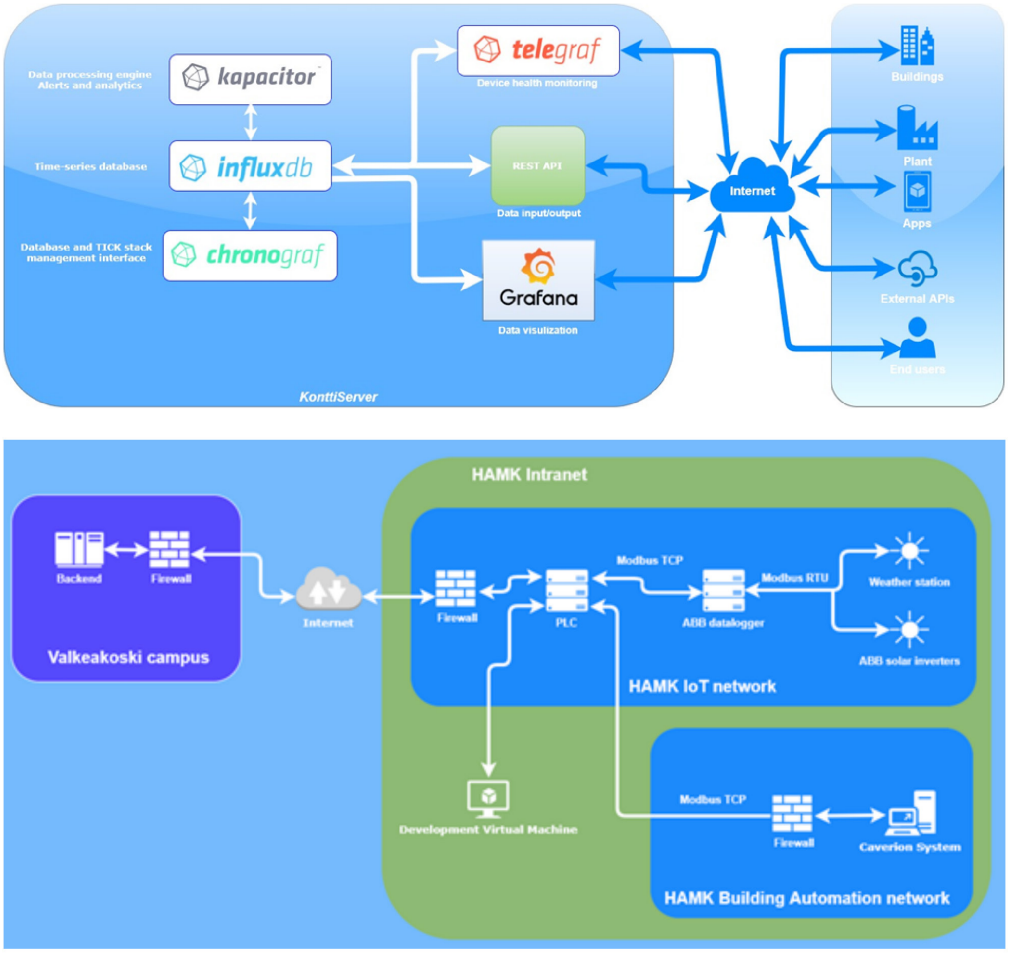

Figure 3. Dang (2017) describes the backend server architecture and the general data monitoring model applied in SMC.

Figure 3 Backend server architecture and system description diagram (Dang 2017)

The real-time data collection currently implemented at SMC includes:

- BMS data
    - Indoor environment (temperature and relative humidity of different areas)
    - Energy meters, electricity and heat
    - Heating and ventilation system components (sensors and actuators)
- Weather station with local outdoor temperature, wind speed and direction, and global horizontal radiation.
- Weather forecast data from FMI station in Hämeenlinna

The system has been taken into use and continuously developed since December 2017. In addition to the SMC, five other buildings are connected to the same backend for data collection and analysis. The data monitoring of the other buildings are currently not as extensive as the one in SMC and

mostly focuses on the indoor air quality measurements.

1.2.1. Refinement and on-going calibration

Calibration of energy models mean validation of results and fine-tuning the input and parameters. A recent research from Kurnitski & Fadejev 2015 has presented approaches to improve the accuracy of calibrated models by statistical analysis of outputs and adjustment of technical plant parameters/representation. Coakley et al. 2014 have reviewed methods to match building energy simulation models to measured data. Other work in Sunnam et al. 2015 highlighted the practical challenges in Measurement and Verification approach in real life and emphasized the importance of data collection intervals and its reliability. Overall, approaches (Judkoff et al. 2008) can be categorized into two lines:

- Analytical analysis – detailed analysis of the model, its system representation approach and selection of the inputs
- Empirical analysis – comparison of the model to the actual measured or reference data

The actual steps applied at SMC are: 1. Establish the post-occupancy model. 2. Preliminary analysis for initial calibration 3. Continuous refinement and calibration of the model.

1.2.2. Preliminary analysis – Empirical part

The calibration steps chosen for SMC case have been following ASHRAE guideline 14-2002. Calibration accuracy is evaluated mainly using the two statistical indices. They describe how close and reliable the energy consumption of the simulation model is to the actual metered data.

Normalized Mean Bias Error - NMBE:

$$NMBE = \frac{\sum_1^n (y_i - \hat{y}_i)}{(n-p) \times \bar{y}} \times 100$$

Coefficient of variance of the Root Mean Squared Error – CVRMSE'

$$CVRMSE = \frac{100}{\bar{y}} \times \sqrt{\frac{\sum_1^n (y_i - \hat{y}_i)}{(n-p)}}$$

Whereas:

n: Number of data in a specific time step (hourly or monthly)

y_i: Measured energy consumption for the ith time step

$\hat{y}_i$: Simulation-predicted energy consumption for the ith time step

$\bar{y}$: Mean measured energy consumption

$p = 0$ is taken when monthly data in use

As a preliminary analysis, the statistical indices were calculated for the base model against the data in 2016 (monthly time step), which resulted in:

- Solar collector performance – MBE 8.1% and CVRMSE 25.1%;
- AHU heating energy – MBE 64.9% and CVRMSE 165.4%
- Heat pump – MBE 46.9% and CVRMSE 64.4%

1.2.3. Preliminary analysis – Analytical part

Due to initial assumption and limitation (Nguyen 2017), and the initial observation (subsection 2.1), few areas were identified as most influential to simulation result, and most questionably unrealistic with the current profile/representation. The sensitivity was determined through simulation trials, literature review and personal experience. The priority list includes:

- Climate Profile: a more accurate, real-time actual-location-based micro-climate profile.
- Equipment loads and schedules: adequate heat generation and operation schedules
- Occupant's behavior: occupancy schedule and operation (large rolled door openings in the hall area)
- Energy pile field: initial parameters and pile distribution

1.2.4. Refinement - Current work

According to ASHRAE Guideline 14-2002, whole building calibrated simulation performance path requires the simulation model to have a MBE of ±5% and a CVRMSE of ±15% relative to monthly calibration data. If hourly calibration data are utilized, these requirements shall be ±10% and ±30%, respectively. The monthly data shall be used only when the building reaches its stable and optimal functioning. The set of data shall contain at a minimum all measurement from 12 months spanning at least one year. The calculated indices from preliminary analysis, along with values from BAS database and alteration of input will be investigated further to eventually get the acceptable ranges.

The actions which are in place include:

- Continuously store and monitor the data for 2018 (a full data set of minimal uncertainty) while working towards retrieving the available data during 2016-2017 from the Caverion system and feed them to the same database for research purposes.

- Create a custom weather profile: the primary data have been retrieved from the ABB weather station at the building site. Missing weather information was acquired from the public local weather stations in Hämeenlinna, Helsinki, and Forssa. The project team acknowledges the critical factors and necessity in development of additional measurements to enable full necessary weather parameters monitored on site.
- Create actual domestic hot water (DHW) consumption profile (from the energy meter) and push back to the simulation system. This will represent the more accurate heat demand and pattern for DHW production.
- Process updated internal gains (separate profile for lights and equipment), operation schedules as well as performance specifications that have changed during the building operation and fed back into the model.
- Plan additional meters to monitor the activities of certain heavy machineries and facility testing equipment. They are currently supplied directly from the main electricity distribution panel and periodically skews the electricity consumption measurement.
- Monitor and document the set point and control logic changes by the facility managers and/or any difference with the design intent.

2. Discussion

Although the full set of data collection for 2018 is still in process, the analysis and monitoring have been carried out continuously. The observations from the practice of making visualization and comparison have identified certain deviations and/or additional control logic of the HVAC system. It should be noted that the values from the design/commissioning documents and/or the local computer adjusting the set point (of the BAS) are often static, whereas facility managers may make certain changes for short periods of time in reality. These need to be realized and taken into consideration when preparing the measured data and actual profile input for the calibration process. Before the deployment of the new visualization and analytics tools with the web application, the engineers and modelers were often unable to effectively keep a record of these alterations and differences in the BAS system. Figure 4 (Nguyen 2018) demonstrates a few examples.

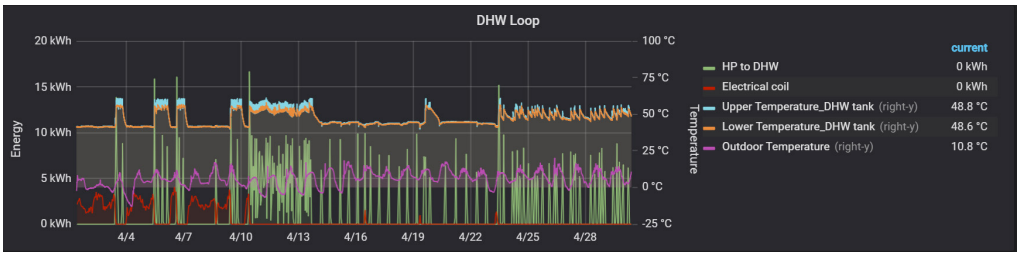

Figure 4. (1)

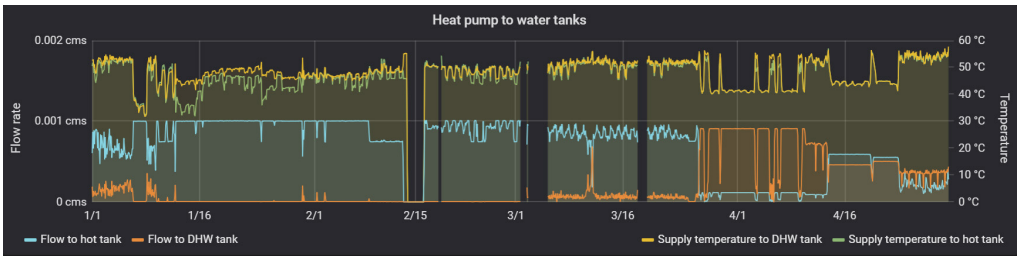

Figure 4. (2)

Figure 4. Monitoring graph (2018) in order (1) DHW loop and (2) Heat pump basic loop to two hot water tanks

As can be clearly seen from the (1) graph, the electrical coil in DHW tank was mostly activated during unoccupied time. Both the coil and heat pump seemed to keep the overall temperature in the tank not lower than 40°C during the unoccupied time or at least during weekends. This control was only acknowledged due to the continuous monitoring and still need further observations and verifications. Graph (2) on the other hand, gave a quick record of the heat pump operation. There were some expected occasions in the middle of February and beginning of March when the heat pump was turned off or the network went offline temporarily. These were confirmed immediately (at the time) with the facility manager and noted for future substituted data.

Another issue which was discovered through the data collection was that several energy meters, both electricity and heat, were installed incorrectly, leading to local energy calculation misbalances and inaccuracies. For instance, the electricity meter measuring the solar PV panels system were programmed incorrectly and only reported the energy from the grid going to the inverters, skipping the PV panels production entirely. Another case was that all heat energy meters only reported one-way energy flow and neglected the energy transferred to the geothermal storages.

Overall, the SMC building has been used extensively for technology development and research testing with energy model simulation and associated analytics, e.g. calibration and wireless data collection and management. It has demonstrated several challenges in real life when it comes to a nearly-zero-energy building's sustainable operation:

- Having too many experts involved in data management process and monitoring of sensors and meters can result in delays, errors and overlapping tasks. From the case study, an optimized team should have the actors from the design stage and the core players for the whole process, including validation and calibration of energy model. The implemented work has been much more efficient.
- Apart from the quality and interval of data collection, the solution to substitute missing data needs to be developed in order to ensure continuous research with considerate results.
- Visualization and access to data should be developed so that both engineers and end-users can get access and perform meaningful analysis from the building data.

- Network security and data ownership issues need to be discussed and solved up-front to ensure a smooth implementation and effective orientation.
- Although the initial design of nZEBs is planned to be thorough, such innovative pilots can easily encounter changes during construction and operation, just like any normal buildings. The whole process of follow-up and advanced analytics may require substantial time and effort.
- There were various interests from stakeholders towards energy simulation presented in the design and validation process. However, the thought of follow-up with calibration and further development seems not attractive, significantly due to technical demanding and resources investment.

3. Conclusion

The SMC case study presented the approach to calibrating the energy models by combining empirical and analytical analysis. The content focused on the preparation steps, consisting of the base model, data management, real-time validation, and sharing experience up to the present. This simultaneously addresses the challenges in quality management of nearly-zero-energy-buildings during their lifetime.

The calibration will be further investigated after 12 months of meter data in 2018 is available. The aim will be to ensure that the statistical indices of calibration for the model are within acceptable limits. The acquisition of the past data from 2016 and 2017 will assist in more detailed model development and other research purposes. Concurrently, the real-time comparison of design system and BAS data can help to make observations and pose retrospective questions about the operation of the building, and possible irregularities in the systems. Future work will seek to use the calibrated models and BAS sensor data to further support the development of different automation setting simulations.

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FIGURE 3. Dang, K. Backend server architecture and system description diagram. In: Industry 4.0-ready Building Automation System. Hämeenlinna: Häme University of Applied Sciences, School of Technology. 27. [Cited 06 May 2018]. Available at: http://urn.fi/URN:NBN:fi:amk-2017122222472

FIGURE 4: Nguyen, N 2018. Monitoring graph (2018) in order (1) DHW loop and (2) Heat pump basic loop to two hot water tanks. [Digital image]. Häme University of Applied Sciences. [Cited 29 May 2018].

Theme C: Circular Economy and Entrepreneurship

The adaptation of Circular Economy has changed the focus area of sustainable development in society and industry. Areas with opportunities to act in an industrial symbiosis are being researched and developed together with different stakeholders. Roadmaps to Circular Economy are in preparation at national, regional and local level. Limited availability or lack of certain raw materials (especially nonrenewable ones) forces us to find new solutions, to replace materials and to think more resource efficiently.

Due to the industrial ecosystems companies and organisations can find benefits due to the decreased amount of energy used and waste produced, as well as through more efficient logistic systems. The design, recycling and reuse of materials decrease the amount of waste, or even eliminate it, which is the goal of total circulation of materials.

The transition to the circular economy is needed to provide new action models and adaptations in practice. Replacing and redesigning old production methods or services with new ones, or the development of existing concepts are opportunities to achieve circular economy in enterprises and organisations. Good examples serve as advertisements for other actors in the field – new solutions are adapted and followed. An innovative environment with working cooperation and networks can act to promote new ideas and as a result to change practices.

The main question is how to design for behavioral change with user-driven solutions. The concept of the Circular City calls for the exploration of circulation models available in a city, a neighbourhood or a smaller area. The design of new and improved models is based on the identification of existing resources, practices and opportunities to improve the situation and create circular or resource efficient production, practices or services. Sharing economic models can be adapted in different activities in cities, such as with mobility services.

At the core of the process is the consumer. The main question is how to design for behavioral change with user-driven solutions. Different types of users are often recognised in regard to adapting new models of behavior. Designed steps are needed to encourage the behavioral changes which support the solutions based on circular economy.

The first research article points out the critical point of supporting sustainable behavior with the help of data-driven nudges, by for example showing real-time data about human behavior in cities and allowing more personalisation of the data to private citizens in evaluation of their own behavior. The second article concentrates on different circumstances introducing opportunities for circular economy in developing countries with a case study. The same theme is continued with the following article, dealing with energy production in the equine industry.

Several case studies are classified under this theme. A construction branch example is presented as a case study concentrating on the

development of digital data base of recycled materials in earth work. The theme of material efficiency is also demonstrated with the case study of textile sorting technology, very promising but still strongly under development. Opportunities of green technologies are introduced in a case study demonstrating the development points and process in China's telecom industries. Circular economy is also a very active target in the field of education which is described in a development project in the Baltic countries - identifying common goals and realizing multidimensional higher education together. Material efficiency and renewable energy are combined as themes of most of the case studies. Municipal solid waste landfills are examined as a potential source of secondary raw materials in the following case study. Also opportunities to increase the use of renewable solar energy in small and medium sized enterprises are introduced in the context of a promising experiment. Under the renewable energy theme the co-combustion of horse manure and milled peat is also examined. The last case study introduces an environmental archive for the promotion of environmental safety and low carbon practices, combining the use of GIS information with environmental data.

Smets, A., Lievens, B.

Nudging sustainable behaviour: the use of data-driven nudges to support a circular economy in smart cities

Research article

Abstract

Cities are challenged by the demands of growing urban populations and need to come up with resilient strategies for sustainable development. As a response to this challenge, the concept of a circular economy has been put forward to integrate economic activities and environmental sustainability. However, in order for this circular economy to succeed, it heavily relies on a behaviour change of industry, government and citizens. To support this, the emergence of the nudge paradigm for behavioural change has caught some attention in environmental policy-making in the last decade. Nudging represents the idea of altering people's behaviour without restricting their freedom of choice. Emerging technologies, such as the Internet of Things, and their implementation in a city wide urban setting offer a new range of opportunities to design and implement nudges. There is not only more data available about actual human behaviour, this data also becomes available in real-time. These characteristics allow for more personalized nudges that can be used in an appropriate context. This paper puts forward a framework to design, implement and evaluate this kind of nudges while holding on to a user-centred perspective. We demonstrate the approach by means of the Antwerp Circular South project in which community members are being engaged to co-create a sustainable neighbourhood.

Keywords: behaviour change, data-driven, nudge, smart cities, sustainable behaviour

1. Introduction

There is a growing need to address sustainability challenges and although the concept of sustainability has many interpretations, most of them focus on human needs, environmental resources and emphasize the long term (Childers et al. 2014). Within the current debate on sustainability, scholars are unanimous in considering the urban question as an essential aspect (Maiello et al. 2011). It is estimated that 70% of the total global population will live in urban areas by 2050 (Shen et al. 2010) and this increasing population density challenges cities to come up with resilient strategies for sustainable development. One of the proposed solutions is the concept of a circular economy, which has gained a growing attention over the last decade (Ghisellini et al. 2015). It is thereby positioned as an alternative to the dominant economic development model of "take, make and dispose"

(Ness 2008). By promoting closed loops within an ecosystem, a circular economy strives to increase the efficiency of resource use. Drawing upon literature, the most successful drivers of circular economies have been government interventions (Ghisellini et al. 2016). However, the increasing urban density puts spatial and regulatory constraints on this kind of interventions. But at the same time, this dense urban context provides a social environment that holds great opportunities to address the circular challenge by behavioural change (Khansari et al. 2014).

In the last decade, the emergence of the nudge paradigm for behavioural change has caught some attention in policy-making (McSmith 2010). Nudging represents the idea of altering people's behaviour without restricting their freedom of choice (Thaler & Sunstein 2008). Within this rationale, the concept of choice architecture has an important role since it refers to the idea that changes in the decision environment can affect individual decision-making and hence individual behaviour (Münscher et al. 2016). Consequently, nudging is about making deliberate choices about the choice architecture, i.e. the context in which people make decisions (Thaler & Sunstein 2008). The nudge paradigm is based on Tversky and Kahnemann's premise that our decision-making process is susceptible to biases and heuristics and therefore not completely rational, in contrast to the perfectly rational agents in standard economic models (Hansen & Jespersen 2013). There are various well-known examples of nudges that stimulate sustainable behaviour. For example, the use of energy labels for electric appliances tries to nudge people towards buying energy efficient appliances (Mont et al. 2014) and setting duplex printing as the default option on printers has been shown to reduce paper consumption by 15% (Egebark & Ekström 2016).

In this paper, we explore nudging opportunities that emerge through technological advancements and an increased adoption of these technologies. In the next section, we elaborate on these technologies and describe the types of nudges they allow. Subsequently, we describe the use case of the Antwerp Circular South project, where this new kind of nudges will be deployed to stimulate sustainable, circular behaviour. This is followed by a description of the framework that we will use to design, implement and evaluate these nudges throughout the project. The paper ends with some final remarks and further research.

2. Background

2.1 Data-driven nudges

The emergence of new technologies, such as the Internet of Things, and their implementation in a city wide urban setting boost nudges' scale and speed, making them a valuable tool for change (Fetherston al. 2017). Moreover, these technologies provide more data about actual human behaviour, which become available in real-time. This allows for more personalized nudges that can be used in an appropriate context. Previous research has demonstrated that both contextualization and personalization contribute to more effective behavioural change interventions. When nudges are

context-aware, we are able to prompt them at the right moment and the right place. This is extremely important in behavioural change and is often missing in interventions (Fogg 2009). Moreover, context-aware nudges allow to move from generic nudges to more personalised nudges. The latter means that for each person, the nudge that is most relevant given their current context will be presented. Within existing behavioural change techniques there is a need for this kind of personalisation, but also for a personalization of the choice of the technique (Masthoff et al. 2014). For example, the social comparison technique has shown to be only effective to reduce household energy consumption if the household's usage is higher than average (Schultz et al. 2007).

New technologies do not only result in new ways of implementing nudges, but also how we can evaluate them. Up until recently, most evaluations of behaviour change interventions were based on subjective self-report data rather than objective measures of actual behaviour (Sweeney 2009; Frederiks et al. 2016). However, self-reported data can be affected by various cognitive biases such as social desirability and memory effects (Frederiks et al. 2016). It is therefore important to measure actual behaviour, which can be realised by technology. For example, in the case of energy consumption, smart meters are able to measure the consumption of specific household appliances, which results in objective quantitative data. Nevertheless, the challenge remains as to how to attribute this proxy data to the actual behaviour. Within our proposed research approach, we will therefore rely on user interaction, which, based on these new technologies, can be large-scale contextual inquiries that allow to enrich the objective data with direct human experiences. This indicates that although data-driven nudges can deliver the right message, at the right time, in the right way, they still require a primary user-centred approach to allow for a human interpretation of the data. Therefore, we will outline a framework to design, implement and evaluate this kind of data-driven nudges while holding on to a user-centred approach.

2.2. Use case: Antwerp Circular South

This paper mainly builds upon research within the scope of the Antwerp Circular South project. This is a European funded project within the Urban Innovative Actions program that aims to co-create a circular economy within a new district in Antwerp (Belgium). Similar to other cities, Antwerp faces the challenge to create circular solutions to keep natural resources into the cycle. More specifically, the project focuses on energy, water, waste and the re-use of materials.

The development of the new district offers the opportunity to test new technologies and approaches that aim at stimulating a circular economy. The project starts from the strengths and weaknesses of the urban context in tackling the circular challenges. It considers the high urban density as an asset that lends itself to community-based solutions and consequently positions the circularity as a community challenge for the residents. This results in a search for user-centred solutions that are largely created bottom-up instead of top-down implementations. In the project, we will investigate

how technological innovations can support citizens in addressing these challenges. This research ranges from more infrastructural components, such as photovoltaics, to facilitating technologies, such as block chain and smart meters, which enable various nudging strategies.

To establish the goals, Antwerp Circular South follows a double strategy: offline and online. The offline strategy aims at stimulating the interaction between the district's residents through activities on circularity such as for example sharing of gardening tools. On the other hand, the online strategy focuses on adopting digital innovations and mainly builds upon resource consumption data of the participants. This data is then being used to design and evaluate the data-driven nudges.

3. A framework for data-driven nudges

We present a framework to design, implement and evaluate data-driven nudges while holding on to a user-centred approach. This framework outlines the general principles and guidelines and is based on an extensive literature review of behavioural change interventions. The framework consists of four main components (see Figure 1). The core element of the framework consists of the user profiles, as they allow for a personalised approach. These user profiles also play a key role in the design phase where the aim is to gather knowledge on the target population, their current behaviour and possible nudge strategies. Following the design, the actual implementation and distribution of the nudge need to be operationalised. Finally, a continuous monitoring of the nudges and their effects is needed to assess when, how and to what extent they result in a change of behaviour. To be able to continuously improve the nudge, one needs to apply these steps in an iterative way.

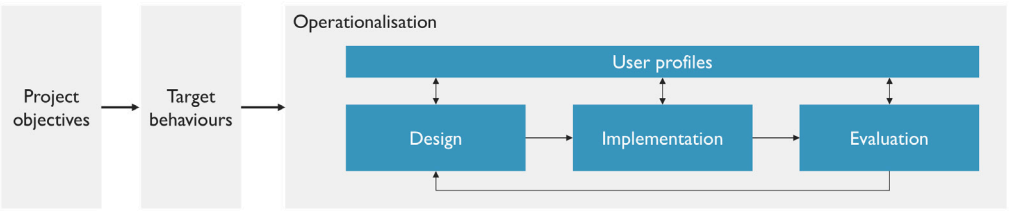

Figure 1. Framework to design, implement and evaluate data-driven nudges (Smets & Lievens 2018).

The framework builds upon the initial project objectives, e.g. less water and energy consumption. These should be complemented by specific target behaviours that have been shown to contribute to these objectives. For example, Antwerp Circular South aims to stimulate energy consumption at production time in order to avoid unnecessary transport and storage of energy. To this end, specific target behaviours such as 'preparing hot meals at noon instead of at night' are identified. These target behaviours are indicated by field experts and literature research and are the starting point for the design, implementation and evaluation of the data-driven nudges.

We illustrate the framework by means of the activities within Antwerp Circular South. We first describe the user profiles and subsequently elaborate on the three consecutive steps of the framework: design, implementation and evaluation.

3.1 User profiles

The most promising characteristic of the data-driven nudges is their power to personalize, as explained before. To allow for this personalization of both the nudge itself as well as the type of nudge, user profiles need to be created. In the case of Antwerp Circular South, this segmentation will be based on both a qualitative questionnaire and quantitative data resulting from measurements of resource consumption. This data will then be used to assign people to a specific profile. There will be, however, different categories of profiles: one general profile and four resource-specific profiles (i.e. electricity, water, waste and materials). These four categories will be implemented because it is assumed that people may have different attitudes and behaviours towards different resources. These profiles will be used throughout the entire process of design, implementation and evaluation.

3.2 Design

To design the nudges, we look into guidelines that result from research on behavioural change interventions (Bartholomew et al. 1998; McKenzie-Mohr 2011; Michie et al. 2014; Frederiks et al. 2016). The following main elements should be taken into account; first, it is required to define the target behaviours as specific as possible, including measurable and time-bound terms, making it explicit what criteria will be used to evaluate the outcome of the nudge (Frederiks et al. 2016). Previous research has shown that more concrete definitions of the target behaviour result in a greater effectiveness of the intervention. Second, the nudge intervention itself should also be as simple as possible and should only target one specific behaviour. This overcomes the issue of confounding effects caused by failure to adequately separate distinct interventions. Third, the nudge design should start from an analysis of the current behaviour and barriers that restrain people to change.

The design phase starts from the target behaviours that are derived from the project objectives. The goal is to gather a deeper knowledge on these behaviours, more specifically the reasons why people fail to perform the target behaviour. These insights can then be used to choose the kind of intervention technique and design the actual nudge (Münscher et al. 2016). This activity relies on desk research to learn from existing research and best practices as well as interactions with community members in the form of co-creation workshops. Considered that barriers to change are not homogeneous to groups (McKenzie-Mohr 2011), the use of the user profiles within the design of the nudge is important. This often means that several variations of the nudge will be designed according to the different profiles.

3.3 Implementation

The strength of data-driven nudges is their ability to be personalised and context-aware. However, it is hard to determine these features at design time and we therefore need to turn to adaptive systems: "systems that adapt the message, timing and the persuasive approach to the situation at hand" (Kaptein et al. 2015). Therefore, a computing system is required that allows to instantiate personalised, context-aware nudges based on data coming from different sources, such as smart meters. This system should allow researchers to pre-define conditions as to when a particular nudge needs to be instantiated and to whom. The innovation in this system involves the use of rules that are based on the actual data, rather than predefined, fixed settings. For example, if we want to nudge someone when they are about to cook dinner, we do not specify a specific moment in time (e.g. 6 p.m.), but rather make use of machine learning to detect patterns in consumption data, resulting from the smart meters, that point to the moment of 'starting to cook'. This might be, for example, a combination of an increased consumption of water and energy from kitchen appliances within a specific timeframe (e.g. between 5 p.m. and 8 p.m.). These patterns will be discovered by means of machine learning techniques, but to safeguard the user-centeredness it is important to pay attention to human interpretation of the data. Therefore, the implementation has to provide the ability to interact with the user, which allows users to give feedback to the system and thereby improve its performance.

Within Antwerp Circular South, we will set-up a system that integrates various technologies and thereby collects different kinds of data. At the same time, this system will act as a nudge enabler since it can trigger and dispatch the different nudges to the specific community members. This user interaction will be mainly facilitated by means of a smartphone application in which users can monitor their resource consumption. In addition, an experience sampling module will be embedded in the application, which allows to perform contextual inquiries and will be used to gather additional information in order to perform the evaluation of the nudges.

3.4. Evaluation

According to the literature on behaviour change interventions there is "an increasing trend to balance quantitative measures with qualitative evaluation methods" (Sweeney 2009). Here, qualitative data is used to contextualize quantitative data and to provide information on the process of change, which is not a linear cause and effect process, but one that can involve many influences (Sweeney 2009). As mentioned before, the advantage of data-driven nudges is their ability to collect objective behavioural data and act upon it. This allows to keep track of the implementation of the nudge and its effect on the human behaviour. However, studying how these nudges are being experienced or their possible side-effects, requires rather qualitative methods. Within Antwerp Circular South, we will rely on quantitative data resulting from smart meters to capture the actual behaviour and evaluate the effect of the

nudges. Additionally, this will be enriched with qualitative data coming from the experience sampling tool and from live interactions (interviews and group discussions) with the community members.

The evaluation of a data-driven nudge should focus on the outcome as well as on the process. The former evaluates the effectiveness of the nudge (does it work), whereas the latter addresses broader questions like how does the nudge work, in what settings and for whom does it work (Moore et al. 2015). The process evaluation takes into account the implementation of the nudge (i.e. how was the nudge implemented and what was its reach), hypotheses about the mechanisms through which the nudge brings about change and the context in which it took place. To gather data on the implementation of the nudge and its reach, one needs a monitoring mechanism. This should be able to monitor the interaction between the user and the nudges. In Antwerp Circular South, we therefore foresee a logging architecture in the application that tracks when people are triggered by a nudge, whether they are aware of it and how they react to it. This allows to evaluate which type of nudge is most appropriate for each type of user.

4. Conclusion and further research

The demands of growing urban populations challenge cities to come up with resilient strategies for sustainable development. To this end, there is an increasing interest to apply nudging to stimulate pro-environmental behaviours. In addition, new technologies and their large-scale implementation offer a new range of opportunities to apply nudging. In this paper, we touched upon the advantages of data-driven nudges: allowing to nudge at the right time, in the right way and with the right message. This personalised approached is assumed to increase the likelihood of effectively changing behaviour. To respond to the findings from behaviour change research, which stresses the importance to adhere to a user-centred approach, we proposed an initial framework to design, implement and evaluate this kind of data-driven nudges from a user-centred perspective.

In the remainder of Antwerp Circular South, different nudges will be deployed and evaluated according to the framework. The nudges will be incrementally implemented from the fall of 2018 onwards. The process of implementation and evaluation will continue until the end of 2020 in order to have a sufficient time-span to measure the effects. These nudges will aim at changing the residents' behaviour towards energy, water, waste and materials (re-)use. We assume that one of the main challenges in deploying this framework, apart from the technological ones, will be in designing the nudge. Although data-driven nudges create a range of opportunities, one should take into account the impact on the (technological) complexity. There should be a balance between the feasibility and the overall objectives. The involvement of all stakeholders throughout the entire process is therefore necessary. The presented framework and putting it into practice within Antwerp Circular South is a first attempt to learn more about these data-driven nudges. We hope to contribute to best practices and lessons learned based on our experiences within the project. Moreover, in the evaluation,

we will pay specific attention to the potential of these data-driven nudges to result in a long-term behaviour change. The conceptualisation of this framework also highlighted that there is still a need to explore techniques to augment the interaction between data and human interpretation in order to support the design and evaluation of behaviour change interventions.

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Virtanen, M. & Kojo Sakyi, E.

Circular Economy and Frugal Innovation in Ho, Ghana

Research article

Abstract

Circular economy is promoted as a solution for problems created by the overconsumption of natural resources and wastefulness of current linear economy. Frugal innovation means finding smart and affordable solutions for a problem or a demand conditioned by resource constraints. It is often characterised by local use and materials, simple usability and minimum use of resources. Circular economy and frugal innovation share potential for inclusive, sustainable innovation both in developed and developing country contexts. At best, they could assist in finding local, affordable solutions for problems characterised by resource constraints, or provide opportunities to reduce resource consumption and close the material loops. However, the sustainability of these solutions is not inherent and should be assessed carefully.

In this paper, we study the possibilities of frugal innovation and circular design in finding sustainable product and service solutions. We use as an example the cooperation between Ho Municipality, Ghana and the City of Lahti, Finland. The cooperation aims at finding sustainable, locally affordable sanitation solutions to support the regional sanitation goals. The second part of cooperation focuses on co-creation of circular economy solutions to solve visible waste problems and to create new business opportunities. The cooperation is supported by the Ministry for Foreign Affairs of Finland and coordinated by Lahti University of Applied Sciences.

The study deployed a qualitative research approach and data was collected using focus group discussions (FGD) with two groups of interviewees on sanitation and circular economy solutions. Key findings on sanitation include the benefits of dry toilet technology promoted through the cooperation. On circular economy, the frugal activity studied supports households by providing income, which is used for the payment of school fees and health bills. The conclusion from the study is that community awareness creation is lacking and should be intensified about frugal innovation and its benefits. It is suggested that the inclusiveness of the process should be improved especially at the community level.

Keywords: circular economy, frugal innovation, Ghana

1. Introduction

Hossain (2018) defines frugal innovation as a resource scarce solution designed and implemented despite resource constraints, so that the solution is considerably cheaper than its possible alternative, but good enough to meet the basic needs of customers. According to Weyrauch and Herstatt (2016), frugal innovation must meet the criteria of substantial cost reduction, concentration on core functionalities, and optimized performance level. In their literature review, Weyrauch and Herstatt (ibid.) found that attributes most often connected to frugal innovation include functional and focused on essentials, entailing lower initial costs, minimizing the use of material and financial resources, user-friendly and robust.

Frugal innovation is often resource efficient, and with the emphasis on redesign and new business models, corresponds to circular economy aims. According to a European Commission study (2017), circular economy innovations involving redesign, remanufacturing, reuse and resource savings can be classed as a form "frugal sustainability". Kircherr et al. (2017) define circular economy as an economic system that is based on business models, which replace the "end-of-life" concept with reducing, reusing, recycling and recovering materials in production, distribution and consumption processes with the aim of accomplishing sustainable development.

However, frugal innovation is not inherently sustainable as noted by, for instance, Rosca et al. (2017). As pointed out by Hossain (2018), some products have failed safety tests and, for example, sachet packaging of bulk products to make them affordable for poorest customers creates a waste crisis. Although frugal innovation is mostly inclusive with involvement of local individuals and communities, according to Meagher (2017), the scaling up of solutions often means that the benefits go to new actors replacing at least partly the local ones. Also circular economy has been criticised for failing to address sustainability issues, because of its sometimes limited focus on closing the material loops, emphasis on economic actors and lack of social sustainability concerns (see, for example, Geissdoerfer et al. 2017, Korhonen et al. 2018).

In this paper, we will look at possibilities and challenges of frugal innovation and circular economy especially in a developing country context. Examples of possible collaboration are looked at from the point of view of long-term cooperation between the city of Lahti in Finland and Ho Municipality in Ghana.

2. Frugal innovation and circular economy

Frugal innovation is characterised by resource savings, which make the cost of innovation affordable to low-income customers. According to Hossain (2018), cost reduction can be achieved through various ways, like reuse of old materials, use of locally available materials, reduction of product features and cuts in maintenance costs. In developing countries, frugal innovation is often linked to informal economy, grassroots needs

and creative capacities (see, for example Meagher 2017). Examples of frugal innovation can be found at various sectors like transport (Tata Nano, the world's cheapest car), healthcare (GE's portable ultrasound and ECG machines), ICT (cheap mobile phones), banking (microfinance schemes), energy (renewable energy solutions) and water (water purification, water kiosks) (see, for example, Levänen & Lindeman 2016 and Weyrauch & Herstatt 2016).

There is little research on frugal innovation solutions from circular economy perspective, but research has been done on the environmental sustainability of frugal innovation products and services. A main sustainability challenge is that cheap products typically have a short lifespan and end up in landfills. Some often sited frugal innovation examples, like sachet packaging of bulk products, directly contribute to waste problems (Hossein 2018). According to a European commission (2017), a challenge with circular products is to compete with low-cost manufacturers saturating markets with cheap products especially on electronics and household appliance sectors.

Frugal innovation differs from mainstream innovations in, for instance, the geographical context, and the need for different business models and distribution channels (Hossein, 2018). Key characteristics of circular design are correspondingly redesign of products and services, new value networks, business models, and distribution channels (see, for example Bakker et al. 2014). However, unlike frugal innovation, circular economy aims at wider systemic change replacing old linear economy system. Circular innovations especially on services, sharing economy, and reuse are often linked to digital solutions that enable efficient distribution channels and logistics. These solutions could be utilised also in developing country contexts as smart phones are used relatively widely in most countries. Figure 1. below illustrates similarities between frugal innovation and circular economy innovation processes.

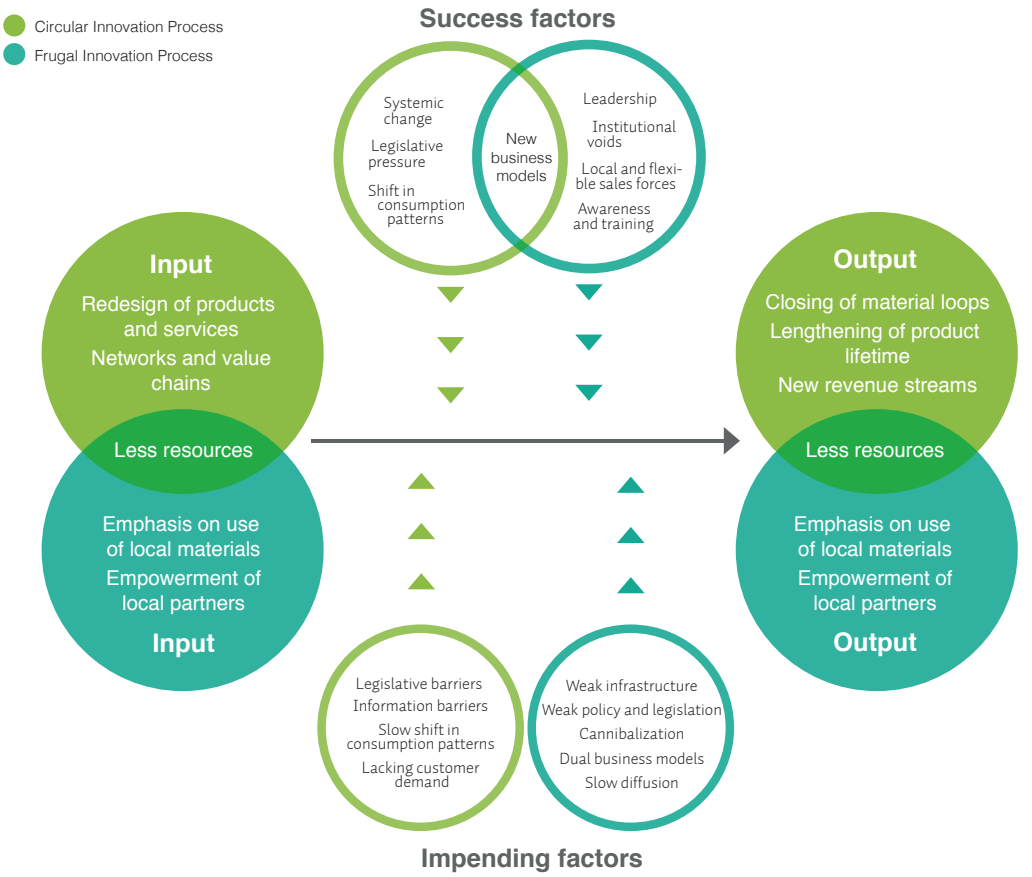

Figure 1. Frugal innovation and circular design approach (modified from Hossein 2018, figure by Oona Rouhiainen).

3. Frugal Innovation in the developing country context and in the European Union

Frugal innovation has been mainly connected to developing market context, but there is an increasing interest for it also in the developed economies. For instance, Colledani et al. (2016) see the benefits of frugal innovation arising from environmental constraints, the customer-centric perspective and co-creation of value connected to re-thinking of business models through product-service approaches. On one hand, frugal innovation is seen promising for promoting resource efficient solutions to existing markets and on the other hand for also easing access to emerging markets (see, for example, European Commission 2017).

According to a European Commission study (2017), frugal innovation has main potential in three areas for European companies: 1. smart and responsible 'second-cheapest' solutions based on circular economy thinking for consumers with constrained budgets, 2. aid-supported solutions for the bottom of pyramid customers unable to afford custom European products, 3. larger scale solutions for public sector customers. However, even though European businesses are increasingly interested in circular economy in their mutual interactions, the same does not necessarily apply to private customers. Customers already interested in

sustainable products also associate them with premium and additional costs, so cheaper price does not automatically attract them. Then again circular products are usually not able to compete with cheapest low-cost, low-quality products.

Frugal innovation can at best facilitate co-creation between informal and formal actors resulting in new products and business models benefiting all actors. However, as pointed out by various authors (e.g. Hossain 2018; Meagher 2017; Levänen & Lindeman 2016), the distribution of benefits and social inclusiveness is not self-evident. For instance Meagher (2017), underlines that the dimensions of informal economy are often not understood in Africa. The focus tends to be on micro-enterprises with little understanding for the global scale wholesale, imports, money transfer networks etc. There is a risk that the involvement of international actors and multinational companies leads to what Meagher (ibid.) calls cannibalization of informal economy, including copying from the informal economy, free-riding on existing networks, bypassing informal actors and replacing them by new ones, and shifting risks to the resellers of products working with very low profit margins.

4. Frugal innovation and circular economy in Ho, Ghana

Ho Municipality is one of the twenty-five Districts in the Volta Region of Ghana and its administrative capital. The Municipality shares boundaries with the Republic of Togo to the east, to the west with Ho West District, to the north with Hohoe Municipality and to the south with Agotime-Ziope. The estimated population of Ho Municipality is about 200 000. About 49 percent of the population is directly employed in agriculture and animal husbandry, but nearly every household is engaged in agriculture related activity. There is no large-scale industry and the small-scale businesses employ about 8 percent of the active labour force. (Ho Municipal Assembly 2016.) Overall in Ghana, about 9.5 percent of business establishments are formal, with the remaining 90.5 being informal (Republic of Ghana 2017).

The cooperation between Ho Municipality in Ghana and the City of Lahti in Finland aims to promote sanitation and to co-create circular economy road map and circular economy pilots and solutions for Ho (see Virtanen 2017). The co-creation process has included circular economy baseline studies, intensive training and a series of three co-creation workshops in Ho. The aim of workshops was to bring in different actors to: 1. specify the current status of circular economy and waste management in Ho and to identify common development opportunities, 2. identify circular economy piloting opportunities, and 3. specify the implementation of pilots. The idea behind the co-creation process was to facilitate discussion between different actors and to create new ideas for locally adapted innovations.

4.1. Data collection and analysis

This study used a qualitative research approach and data collection by using focus group discussions (FGD) with two groups of interviewees.

In undertaking the study we aimed to gain insights into participants understanding of: (i) frugal innovation; (ii) the uses and reuses of waste materials; (iii) the value of waste as avenues for revenue generation; and, (iv) the benefits of waste materials to households and communities.

A focus group is a known qualitative technique, which involves selected individuals assembled by researchers to discuss and provide information from their personal experiences on the topic that is the subject of the research (Powell and Single 1996). Zimmerman and Perkin (1982) observed that focus group offers participants an opportunity to talk and provide information that is of special importance to the investigation on how and why people behave in a particular way.

In this particular research, the sixteen (16) participants for the focus group discussions were purposively selected taking cognizance of their knowledge and appreciation of the issues under investigation. Each focus group discussion lasted for about one and half hours. The focus groups discussed the sources of waste, sanitation, uses of and reuses of waste within the context of frugal innovation and revenue generation and its benefits to households and communities. The focus group also explored, how households are using waste generated daily to create opportunity for the production of other simple but useful commodities for use by others.

Table 1. Focus Group Interview Participants (FGD1) for UDDT

Participants	FGD1	%
UDDT facility users	4	50 %
District Project Officer	1	10 %
District Planning Officer	1	10 %
UDDT Construction team Leader	1	10 %
District Health Educator	1	10 %
Total	8	100 %

The focus group moderators also asked respondents to offer suggestions on options available for reducing open defecation and related sanitation problems. To ensure that the interviews provided relevant answers, the first focus group discussion was held a week before the second focus group discussion. This was also designed to give time to check, which issues needed to be repeated or followed-up during the second group interview. The qualitative data analysis was guided by three stage procedure espoused by Strauss and Corbin (1998). During the first focus group discussion, which was essentially an open discussion, deliberations were recorded and open coded according to the key themes using constant comparison approach.

Table 2. Focus Group Interview Participants (FGD2) for Pito Brewery

Participants	FGD2	%
Women Pito Brewers	4	50 %
Male Piggery Owners	2	25 %
Female Piggery Owners	2	25 %
Total	8	100 %

The data was also audio taped, transcribed and analyzed. It is important to add that in preparing for the second focus group discussion meeting, the first focus group discussions were further analyzed through axial coding and selective coding. This helped in streamlining the discussions in the second focus group. The researchers also kept a reflective diary and compiled comprehensive notes immediately after each focus group discussion.

4.2. Cooperation on sanitation through dry toilets

In the sanitation sector, one aim is to find sustainable and affordable latrine solutions. The sanitation situation in Ghana is poor, according to the Republic of Ghana statistics (2017), only 15 percent of population has access to improved sanitation and about 20 percent practice open defecation. Furthermore, it is estimated that 97 percent of liquid waste is not properly managed and disposed of. The Volta region is below the national average with regard to access to sanitation. The Urine Diverting Dry Toilet (UDDT) technology promoted through Finnish cooperation has proved beneficial in Ho, because it is both a sustainable sanitation solution and provides needed compost and fertilisers to agriculture through the end-products (see Aalto & Virtanen 2017).

One of the challenges in Urine Diverting Dry toilets is the relatively high construction costs compared to commonly used solutions like pit latrines and improved pit latrines (see, for example, UNICEF, no date). The additional costs compared to pit latrines are related to urine diversion pipes and vents, urine tank and composting vault doors. On the other hand, cost savings are created while digging is not needed, there is no cost for emptying the toilet and end-products can be used to substitute chemical fertilisers. However, the main reason for not adopting improved sanitation in Volta region is inability to afford fees, which shows that affordability of sanitation solutions is a key issue (CLTS Forum 2017).

Image 2. Pit toilet constructed with a locally available material bamboo (photo Maarit Virtanen).

The key finding from the focus group discussions was that the UDDT technology promoted through Finnish cooperation has proved beneficial to households in Ho municipality. Key among the findings is that the UDDT involves relatively high construction costs compared to commonly used solutions like pit latrines and improved pit latrines. The additional costs compared to pit latrines are related to urine diversion pipes and vents, urine tank and composting vault doors. Interviewees reported that cost savings can be created, because digging is not needed, also there is no cost for emptying the toilet and end-products can be used to substitute chemical fertilisers. But the main reason identified by the FGD for not adopting improved sanitation in the Volta region is inability to afford fees, which shows that affordability of sanitation solutions is a key issue.

The affordability of UDDT is addressed through involvement of local artisans and communities to find cheaper solutions. One key issue is to use locally available materials for both the substructure and the building. Materials commonly used for construction in rural communities include clay bricks, bamboo, palm leaves and locally available wood. Other possibilities for innovation are in the design of UDDT, which could still be moderated so as to reduce the use of materials. The work on UDDTs continues through involving the Ho Technical University in the design process and study on user perceptions to find new approaches.

4.3. Material reuse and recycling

Resource scarcity is evident in Ho region communities both in the use of local materials and in the reuse of bought products. For example, plastic containers are used for several purposes until basically nothing is left of them. A common use for used containers is for tippy-taps, a hand washing stand both at schools and households. The resource scarcity means also that all kinds or repair and renting services are commonly used. Services are available in Ho for, for example, repairs of all kinds of electronic appliances, renting of products from chairs to fridges, and numerous dressmakers. These are the kind of services that are now being promoted in Europe as a part of circular economy.

A visible challenge in Ho and Ghana is, however, the lack of waste management and recycling infrastructure. During the circular economy co-creation process, several piloting opportunities for material recycling have been identified. These concern both materials like plastics, glass and paper, for which markets already exist in the capital Accra, and biodegradable waste. Separate collection of biodegradable waste would ease the separation of other materials, but is a new concept in Ho. Also the handling of biodegradable waste through, for example, composting is rarely done. A pilot on drum composting is going on at the time of writing. The idea there is to use low-cost materials and co-create locally suitable model for composting together with students from Lahti University of Applied Sciences and Ho Technical University.

In the second group discussion, women participants identified biodegradable waste obtained from Pito brew as very useful for pig production. Local women make the brew by mixing the malt with water and processing it through boiling and manually stirring the mixture for five to six hours for it to cook to required level. At next stage the mixed brew is left to settle and also to ferment and thereafter it is sieved thoroughly to remove the malt or chaff from the solution leaving the real brew. The process provides income from both the sales of Pito, which can provide about 120 GHS (22 Euro) for a barrel of 80 litres, and raising pigglets that can be sold for about 600 GHS each (110 Euro). The process supports households by providing income for, for instance, schooling and health bills.

Figure 3. Women brewing Pito (photo Emmanuel Kojo Sakyi).

The conclusion from the study is that community awareness creation is lacking and should be intensified about frugal innovation and its benefits. It is suggested that the inclusiveness of the process should be improved especially at the community level, since frugal innovation is often born at grassroots level from concrete needs of the poorest people. Also the knowledge and appreciation of the value of cheap local waste products for creation of revenue and wealth generation must be enhanced.

One challenge in Ho is that there are currently few actors at the waste management sector, and it is difficult to reach potential new ones. As most businesses are small-scale, household level informal activities, they are only known at community level. For instance, there are few informal waste collectors and they have not been reached to participate in the co-creation process. In the future, the aim is to involve of Ho Technical University students directly in activities, which might create a path for further participation and circular and frugal innovation.

5. Conclusions and recommendations

Circular economy and frugal innovation share common characteristics especially in the focus on resource-efficient solutions, which can be achieved through, for example, resource savings, reuse of old products or use of local materials. Both circular economy and frugal innovation require redesign of products and services, new business models and value networks. At best, solutions are co-created with various stakeholders for mutual benefit. However, the inclusiveness of the process is not self-evident as frugal innovation is often born at grassroots level for concreted needs of the poorest people. Also the sustainability of cheap products can be questionable.

The cooperation between Ho Municipality and Lahti has proved the potential of co-creating circular economy solutions with several identified piloting opportunities. However, also in this process it has proved difficult to involve all stakeholders, as most business in Ho is informal and very small-scale. To enable frugal, and circular, innovation in the future, the

solutions should be further sought with communities. The cooperation with Ho Technical University provides also opportunities to seek solutions together with students and to spread awareness on, sanitation and circular economy solutions.

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Eronen, M. & Luste, S.

Factors affecting the by-product based decentralized energy production in the equine industry

Review Article

Abstract

Horse manure treatment may contribute to resource smart development by comprising recovery of energy and nutrients for agricultural use. The quality of horse manure is highly suitable for the biological management processes, but also small-scale combustion has become an opportunity due to the EU regulative changes (Ministry of Agriculture and Forestry 2017). Farm scale and/or joint farm co-management of horse manure may also create new earning logics for the rural areas in the form of decentralized energy- and fertilizer production such as the new needed services (e.g., logistic solutions, gate fees, etc).

The article emphasizes the state-of-the-art data from the equine industry regarding the existing practices and resources that has to be identified, so that the new circular economy operations can be designed and implemented. These issues rise from the bedding materials and manure availability, which is related to ways of managing the horse farm, selection criteria of the energy production method, such as smart planning and identification of missing partners. The equine industry differs from the other agricultural animal farming regarding the facilities, maintaining of the everyday practices, the purpose of the horse keeping and the characteristics of the manure. For these reasons, the case review is needed when the most feasible energy production technique is selected.

Keywords: material flows, energy utilization, horse farm, equine industry

1. Introduction

Renewable energy sources play a key role in the EU's energy policy targets. The share of renewables is expect to be 24 % from the total energy consumption by 2030 (European Commission 2014). Renewable resources have a huge potential in rural areas, regarding, for example, an increase of decentralized energy production, the bio-economical based vitality of sparsely populated areas and replacement of the fossil fuels (Bardi et al. 2013). Horse farms are a constantly growing sector of agriculture`s entrepreneurship in the EU and the number of horses kept close to urban areas has been steadily increasing for the last decades. (Liljenstolpe 2009; Hollmén et al. 2012). This improves the co-operation possibilities, but may

also cause environmental problems if there is a lack of arable land for spreading horse manure and unsuitable methods for manure storage. The negative environmental impacts can be controlled by the proper manure management. (Hadin and Eriksson 2016)

Horse manure is a mixture of feces, urine and bedding materials, which differs between the farms (Hadin et al. 2016). In Finland, the horse manure has previously been categorized as a waste (646/2001; 1069/2009/EC), but since the EU regulation changes in Jan. 2017, it is defined as an animal by-product. This will affect the enhancement of the management possibilities of horse manure. One horse produces manure 7-12 m^3/year when the average volume weight of manure mixed with bedding (e.g., wood shavings, peat, straw) is 300-400 kg/m^3 (Tanskanen et al. 2017). Because 60-80 % of the horse manures content is beddings, those are important roles, when the most suitable technique for the manure treatment is chosen. There are 74 t horses and 16 t horse farms in Finland (Hippolis 2016) with an annual capacity of 0.35 TWh of energy production from the horse manure (50 % of horses; Saastamoinen et al. 2017).

The most common method for manure management in the Finnish horse farms is passive composting, when the alternative methods for the manure management are anaerobic digestion and incineration. All of these processes destroy pathogens, produce a stabilized end-product improving the recycling of materials (organic material, nutrients; Burge et al. 1981; Mata-Alvarez et al. 2000), but also generate heat energy. At the moment energy recovery is not effectively utilized. In order to avoid energy losses manure should be digested and composted freshly. Horse manure is not nutrient-rich, but it contains valuable phosphorus and potassium. Nitrogen is lost during the combustion process.

The present research is a part of a project called InforME - Promoting the potential of renewable energy through information design (2016-2018). The project is funded by the European Agricultural Fund for Rural Development.

2. Materials and process cases in practice

The present article introduces the current average situation of the materials used and generated by equine industry. These are the base solutions of the existing practices and resources that has to be identified, so that the new circular economy operations can be designed and implemented.

2.1. Materials

The main factors affecting the qualities of the horse manure are the type and a relative portion of the bedding material and the maintenance of the stable facilities. The moisture content of horse manure is ~60-65 % with the pH 6,8-7,1, the total solids (TS) content ranges between 25-35 % (Hadin et al. 2016; Tampio et al. 2014; Agayev and Ugurlu 2011). The C:N ratio reaches

30:1 (Airaksinen 2006), which is already close to the ideal C:N -ratio required by the composting and digesting micro-organisms (25–30:1; Kizilkaya and Bayrakli 2005). The specific methane (CH_4) production (SMP) of horse manure is 200-280 m^3 CH_4/t volatile solids (VS), when the heat value is 16-18 MJ/kg (Hadin et al. 2016; Tampio et al. 2014; Agayev and Ugurlu, 2011; Luste et al. 2013; Lehtomäki 2006).

The most common bedding materials in Finnish horse stables are peat (44 %; TS 2.7-3.1), wood shavings (38 %; TS 45-65), and straw (18 %; TS 3-3.3; Luostarinen et al. 2017). The other possible materials are, for example, paper, hemp, flax, pellets, reed canary grass, saw dust (TS 3-3.2) and different kind of mixtures of these. The choice of the material depends on the availability, storage, handling, maintenance habits and preferences. The volume of the needed bedding material changes depending on the specific material (figure 1).

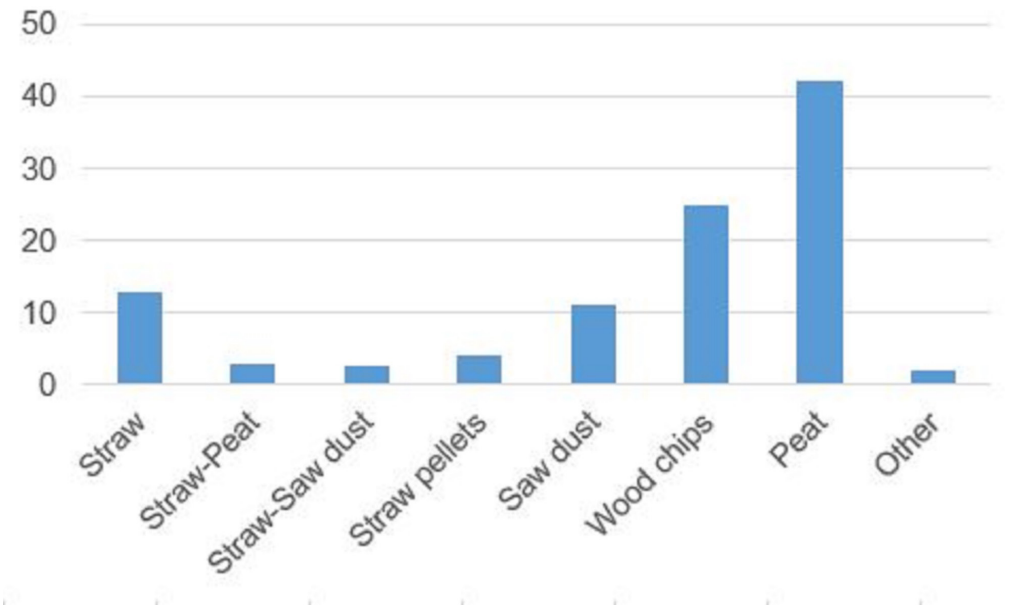

Figure 1. Residual percentages (%) of the bedding material volumes on Finnish horse farms (Luostarinen et al. 2017).

2.2 Case Statistics

According to the survey of the Natural Resources Institute Finland (LUKE), horses are mainly kept in individual stalls (61 % of the horses), group stalls (< 1% of the horses) or in the field shelters (3,2 % of the horses). About 7,7 % of the horses are kept in all of the possibilities presented above when 22 % of the horses are kept in both individual and field shelters. Almost all farm horses are in the pasture during the grazing season, when the corresponding share of the pleasure- and show horses is ~80% (Luostarinen et al. 2017). These are the main factors affecting the steady availability of the manure and selection of the bedding materials, such as the processing possibilities of the manure.

The horse urine is either absorbed into the bedding material, that is

changed regularly (78 % of the horses) or only a few times per year, when the new beddings are added on the top of the old layer (~ 6% of the horses). This is a common practice in the field shelters. Around 17 % of the stables utilize both of the practices (Luostarinen et al. 2017).

From the perspective of cost-efficiency of the circular economy solutions, the knowledge obtained from the cases already in practice are highly important. Thus, it is difficult to evaluate the average energy consumption of the horse farms. It varies remarkably by the number of horses, type of the dwelling house and other buildings such as indoor arena or grain dryer. In a horse stables, the need for extra heating is based on the difference between the inside and outside temperature, number of horses and the time the horses spend inside the stable. It should be taken into account, that horses produce heat with their bodies. The heat production potential per horse varies between 600-700 W. In Finland, extra heating is often needed (Ahokas 2016). The main concepts of the existing circular economy solutions in equine farms, which are combining the material flows with the energy productions, are presented below.

Composting: According to the Finnish legislation, every farm should have a storage for manure. Thus, the "passive" composting during the storage is the most common heat production process in Finland. The simplest way to recover the compost heat is to place a pipeline in connection with the storage (heat can rise up to 60 °C). The heat can be transferred by a circulating liquid and directed into the underfloor heating system. This kind of heat recovery system is used in Pinewood Stable in Mäntsälä (15 horses, the area is 560 m^2). The maximum heat recovery is 25 ºC. The system is maintenance-free and reliable, establishing and operating costs are low, but the system is sensitive to the heat production variations. (Ahlqvist 2017)

An alternative way for manure management is active composting with a rotary drum composting system, which can be equipped with a heat recovery system. Manure is fed to a container, which rotates and mixes the material inside. The temperature and humidity is adjusted by the changing of the rotation speed. The system is in use in two Finnish horse farms - Laalahti and Hingunniemi. In Laajalahti`s case (20 horses) the recovered heat covers the heating need of the stables and the investment costs were the same as with the regular manure storage. In Hingunniemi's case (79 horses) the manure is mixed with peat. The temperature inside the compost is 50-60 ºC. The potential energy production is 80 t kWh/year (1012 kWh/horse/year), but only 50 % of it is utilized in heating. The heat production continues after the manure has been processed and moved to the storage (Figure 2; Huttunen 2013).

No research information is yet available about the amount of heat generated in composting horse manure. Hanne Turunen (Figure 2; 2012) came to the conclusion that the net energy production from composting horse manure is 1.1 kWh/kg TS. Calculations were based on results of various flame tests where horse manure was examined. The calorific value for horse manure mixed with peat was defined to be 15.6 MJ/kg (~4.4 kWh/kg TS; Soininen et al. 2010).

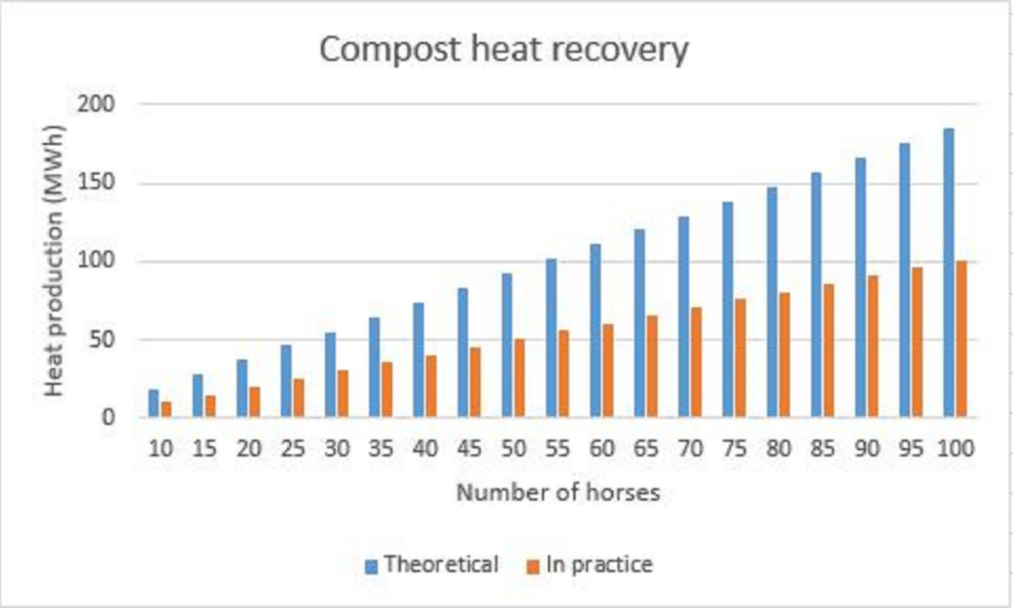

Figure 2. The potential heat production in composting of horse manure with a rotary drum composting system in theory and in practice (Huttunen 2013; Turunen 2013).

Anaerobic digestion: Horse manure is not widely used raw material in the biogas processes. There are a couple of centralized digestion plants in Finland co-digesting also horse manure as one of the materials. Horse manure is highly suitable for the biogas production (Mönch-Tegeder et al. 2013). The SMP of horse manure varies between 170-280 m^3 CH_4/tVS (Hadin et al. 2016; Tampio et al. 2014; Agayev and Ugurlu, 2011; Luste et al. 2013; Lehtomäki 2006), depending on the storage time, quality and the amount of the used bedding material (Table 1). The fresh and unmixed horse manure (without beddings) has been reported to produce methane (CH_4) > 200 m^3/t VS (Lehtomäki 2007; Luste et al. 2013).

The first case in practice was the digestion experiment with the vertical pilot reactor of the Agriculture and Forest research center. The test was made with the horse manure and peat (TS 36 %) mixture and the CH_4 production was low, 70 m^3 CH_4/t VS and (< 50 % from biogas). To improve the yield, co-digestion and horizontal dry digestion plug-flow techniques were developed (Tampio et al. 2014).

Dry digestion processes (TS 20 – 40 %; Lehtomäki et al. 2007) have developed fast during the last ten years. This has also increased the interest toward the digestion solutions on the horse stables. There are a couple of dry digestion plants constructed in Finland that are co-digesting horse manure. One of these is a vertical dry digestion batch reactor in the Knehtilä farm. The digestion process is utilizing horse- and chicken manure and green biomass, but the selection of the optimal bedding material is still on trial. The most important questions are related to the economically viable small-scale biogas production and optimization of the volume and quality of the end products.

Table 1. The specific methane production (SMP) and heat value (hv) of the most common bedding materials (Carlsson and Uldal 2009; Hammar 2001; Nilsson 2000; Puustinen et al. 2009).

	Straw	Peat	Saw dust	Hemp	Wood chips, flax	Wood pellets	Reed canary grass
SMP m^3 CH_4/t VS	180-290	-	< 100	340 – 370	< 100	< 100	290 – 430
Heat Value MJ/kg	18-19	21-23	19-20	-	18-21	19-20	-

Combustion: Horse manure is defined as an animal by-product (Ministry of Agriculture and Forestry 2017) and can be combusted in conventional incinerators. However, the terms for combustion process will demand that the gas resulting from the process is post-treated (850 °C and > 2 sec or 1 100 °C and 0.2 sec; 2011/142/EC). This is challenging for small-scale incinerators.

In the Timrå`s riding center, in Sweden, approximately 1400 m^3 of horse manure is combusted every year. The heat generated in combustion is sufficient for heating all the riding center buildings. The ash from the process is mixed with horse manure and utilized as a fertilizer by the local farmers. According to the practical cases, the combustion of horse manure may often require drying phase before the combustion process. Many of the boilers operate with a moisture content of < 50 %. This will affect the cost-effectiveness of the treatment process (Saastamoinen et al. 2017). The full power of the boiler unit may be difficult to obtain with the small amount of horses (e.g., 50 kW boiler and 66 horses; 100 kW boiler and 131 horses; Saastamoinen et al. 2017). Incineration in the bigger plants enables the lower share of the horse manure. For example, in Fortum's waste incineration plant (15 % of horse manure), there are no emission problems, which are common with the smaller scale combustion plants treating horse manure.

According to the latest research information, horse manure has rather high calorific value (16 – 18 MJ/kg; Tanskanen et al. 2017, see Figure 3). Therefore, the theoretical heat production would be 1,48 MWh/t manure. It is challenging to measure heat production from combustion process in practice, because the share of the manure is quite small and it varies. According to case study, where horse manure was combusted with wood chips and wood pellets in a heat boiler, the heat production was 1,38 MWh/t (Figure 3; Kauppinen 2005).

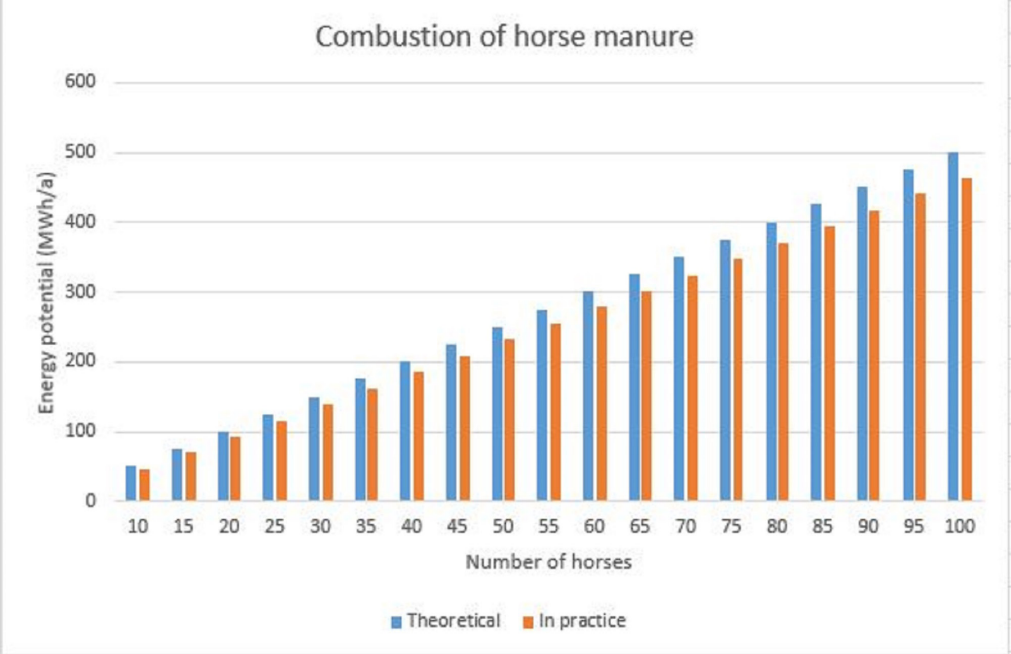

Figure 3. Heat production potential of horse manure combustion in theory and in practice (Kauppinen 2005; Tanskanen et al 2017).

3. Conclusions and recommendations

Treatment processes and the energy yields of all the presented techniques are enhanced, when the horse manure is co-treated with the specifically selected, steadily produced and relatively homogenous materials. The maintenance of the horse farm should be reviewed against the requirements of the selected technology. Moreover, the formation of the ecosystems built around the material flows, circular economy services and energy production should discuss with the identified partners.

Composting: A compost heat recovery system is a suitable solution for the single farms, when compared to the biogas plant investment. The practical solution based on the liquid heat exchange between the storage and heated area is technically the most cost-efficient solution and suitable for small units. The main challenges with this system are the measurability and the variation of the heat production. It may not be very interesting in commercial use as the produced heat is used in the stables own consumption (Ahlqvist 2017).

Too wet circumstances are supporting the anaerobic conditions, for example when straw is used as a bedding material (Alho et al. 2010). Bedding materials with the higher nitrogen content enhance the C/N balance with the faster composting rate (Airaksinen 2006). Higher nitrogen content can be found from the certain wood chips or the process can be enhanced with the addition of the chicken manure (Lundgren et al. 2009). Microbial degradation of the lignin content material is known to be slow. However, the sawdust containing dry manure is composting more rapidly, when compared to the manure containing paper or straw. In addition, the temperature in the sawdust compost maintained more favorable for microbial activity (Airaksinen 2006).

According to the literature, the net energy production for composting horse manure (with peat) would be 1.1 kWh/kg TS (~1 848 kWh/year/horse, Turunen 2012). There is a remarkable discrepancy with the actual measurement results from the case farms (~500 kWh/horse/a; Huttunen 2013). Calculations based on the estimations may not correspond to the composting of highly heterogeneous horse manure in practice. Thus, more research is needed for evaluation of compost heat production potential of the horse manure.

Anaerobic digestion: The biogas plants are not economically suitable for the individual small stables, but for centralized co-digesting ecosystems. The factors that should be reviewed are, for example, the optimization of the methane yield, optimization of the nutrient content and usability of the digestate, optimization of the possible gate fee materials, as well as the roles and responsibilities between the different actors and stakeholders.

TS content of horse manure (25-35 %) may affect the selection between the dry (TS: 20-30 %; de Baere 2005) and the wet (< 10%; Kuokkanen 2010) digestion techniques. The selection of the bedding and co-digestion materials affects the biogas process selection, but also the viability of the plant. As mentioned, the wood based bedding materials have low SMP (29–48 m^3 CH_4/tVS; Wartell et al. 2012), which decreases the biogas yield and lowers the degradation. Moreover, the lignin materials may flocculate, when co-digested with the protein rich material (biowaste, chicken manure; Luste 2011). The most suitable bedding material for digestion is reported to be peat (Pusa and Ekroos 2009). Farmers are gaining the benefits regarding the improved fertilizer characteristics of the digested manure. Part of the valuable nitrogen may escape from the process in the form of ammonia. This is depending on the pH and temperature, but could be prevented by the bedding material selections. For example, peat, flax and strain pellets have strong capability to bind ammonia to the digestate.

The green mass based bedding materials (e.g., hemp, reed canary grass) have the highest SMP (370-380 m^3/tVS; Lehtomäki et al. 2007). The optimal relation of the biomass-based material and manure is around 30 % of the dry matter (~ 9 m^3 of field-biomass/horse/a; Lehtomäki et al. 2007; Airaksinen et al. 2001).

Combustion: Compared to compost heat recovery, there is no remarkable difference between theoretical heat production and actual measurement results in horse manure combustion (Figure 3). Therefore, it is easier to measure the equipment and evaluate the investments, providing that the share of the materials is known.

The quality of the bedding materials has a significant effect on burning characteristics. Due to the moisture content (~65 %), horse manure should be dried before the combustion (<50 %) or mixed with other fuels with the higher energy content, such as wood chips or peat (Table 1). The water absorbing ability is the best with straw pellets and paper, when the weaker absorbing materials are cutter chips and straw (Alho et al. 2010). Straw has a high calorific value, but also the highest chlorine and ash content, that causes problems in the process. Using peat as a bedding material

may cause a rather high nitrogen oxide emissions (Puustinen et al. 2009). Although, wood shavings are a high energy content material (Tanskanen et al. 2017), saw dust has usually too high moisture content (Kauppinen 2005). Cutter chips are applicable, especially, when the manure has kept dry during the storage (Lundgren et al. 2009). Wood pellets are dry (when compared to the cutter chips), have a high energy content and they mix better with the manure (Edström et al. 2011). Moreover, the emissions remain low, when the moisture is <50 % (Alho et al. 2010).

One specific challenge in the combustion processes are the air emissions. Several different bedding materials have exceeded the emission limit values set in the waste incineration regulation (Puustinen et al. 2009). The combustion would require the minimum power of 100 kW to be able to reach the needed temperature (Kilkkilä 2017). In that case, the combustion may not be the best solution for small single farms. However, for the areas, where several horse farms are located closely, this change of legislation can open new possibilities.

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DIGISOIL PROJECT - Digital Services of Recycled Materials for Earthwork

Best Practises & Case Studies

Abstract

Circular Economy emphasize resource efficiency to develop solutions to get more benefit with less consumption of natural resources. Additionally to so called critical materials also very widely used material resources in earthwork like gravel, sand and rock are limited for various reasons. Traditional ways of planning and managing construction projects lead to significant material losses in our society. Virgin materials are not replaced with recycled materials very efficiently, logistics could be improved and change of surplus materials between construction sites could be more improved or started. All this requires better communication and management tools for earthwork. DIGISOIL-projects is targeting to offer a solution for those needs.

DIGISOIL-project will produce a digital solution to manage supply and demand of materials used for construction projects like streets and roads. Target is also to support the use of substituting construction materials like ash and concrete waste instead of scarce natural resources. DIGISOIL will provide a digital application for manage materials during infrastructure construction projects. DIGISOIL – project (2017-2019) is implemented in cooperation between Aalto University and Lahti University of Applied Sciences and it is funded by EAKR -program through Uudenmaan liitto and Päijät-Hämeen liitto.

Keywords: digital application, infrastructure, construction, resource efficiency, earth work

1. Introduction

In the present European environmental policy and research is mainstream to emphasize also the use of natural resources additionally to environmental burden caused by economical activities of our societies. A transition towards the circular economy is in the first sight targeting more efficient recycling but more generally the target is to get more benefit with less use of natural resources and by causing less environmental burden. Many kinds of policy instruments, strategies and means like legislation and rules, economical incentives and information based means has been developed on various sectors to support the development of the circular economy. (Høibye & Sand 2018.)

More people are moving to cities and this development requires massive amounts of natural resources for construction. Our everyday living infrastructure consisting of highways, roads, parking areas, parks, buildings etc. are one the biggest material “investments” of our society . Construction materials like gravel, sand and crushed stones are the most commonly and massively used for public infrastructure like roads and highways which are the main focus area of the DIGISOIL-project.

In Finland the amount of used nonrenewable natural resources for earth work is about 200 million tons a year. Development of resource efficient earth work construction material management would need new coordination methods and better information about amount, quality, location and timing of the need and use of different kind of construction materials. It could help to avoid unnecessary transportation and reduce the use of virgin resources by replacing them partly with available surplus soils and recycled construction materials like certain recycled concrete and ash materials. (Huhtinen, Palolahti, Räisänen & Torppa 2018.)

DIGISOIL-project will produce a digital solution to manage supply and demand of materials used for earth work projects like construction of streets, parking areas and highways. DIGISOIL will support the use of substituting construction materials instead of scarce resources like typically used gravel and crushed stones. DIGISOIL will be in demonstration phase in autumn 2018 and ready for commercial use in 2019. DIGISOIL is a joint project of Aalto University and Lahti University of Applied Sciences involving also soil construction companies and the cities of Lahti and Helsinki.

2. We do not have enough easily available and suitable gravel, sand and rock for earth work

The mostly used construction materials of gravel and rock are limited and availability of them is getting problematic and more costly. This scarcity situation is seen also in a city of Lahti, where the main 30 years old gravel source extraction permission came to an end in summer 2017. The new permit till 2029 restricts the extraction and does not allow expand and deepen the extraction area. (Aluehallintovirasto 2016.)

In the Lahti region this gravel scarcity is bound to probably the most valuable natural resource named clean ground water. Lahti region is located on the largest and best ground water sources of Finland thanks to Salpausselkä eskers. This means that we have gravel but it can´t be extracted in such a large extend if we want to keep and utilize the high quality ground water in the future. Development of recreational values instead of gravel extraction in expanding southern city zone also is seen important by the environmental authorities of the city. (Lahola 2017a, 2017b.)

3. Changes of Waste legislation and RDI-projects support the use of substituting earth work construction materials

The scarcity of natural virgin construction materials for earth work is faced in the whole southern Finland and the problem is tried to ease in many ways. Latest changes of legislation directing the use of recycled construction materials for earth work are actual (Valtioneuvosto 2017). Recent and ongoing research and development projects also present solutions to increase possibilities of the use of recycled construction materials (Motiva 2018; Ramboll 2012; Pajukallio, Wahlström & Alasaarela 2011.) A special construction material coordination unit under the City organization of Helsinki is actively developing the material efficiency of public earth work and utilization of surplus soil materials. Locally available recycled materials for example ashes, demolished concrete and surplus soils are suitable for certain construction purposes with significant volumes.

The DIGISOIL-project is based on drivers that require to develop practical management tools for resource efficient construction material management and the use of alternative recycled materials for infrastructure construction projects.

4. DIGISOIL – a digital earth work material management application

A digital solution can ease the use of resource efficient earth work practices including utilization of substituting surplus materials instead of virgin natural resources. To make this happen requires more communication and clear digital management system between stakeholders involved into decision making, planning and implementation of the infrastructure construction projects.

The service is based on a contract between the earthwork contractor, suppliers (e.g. waste generators) and transport companies. It includes geospatial data and data on the available aggregates as important elements on a truck load basis. Each company in the delivery chain share a common data, but each part can access only to its own data. In the development of the service, the principles of data modeling and transfer, InfraBim and InfraRyl, will be taken into account.

DIGISOIL solution will be build according Software As A Service model (SaaS). In this cloud based model software is licensed on a subscription basis and is centrally hosted. Solution will concentrate on order-supply-delivery chain and enhance the logistics of earth construction, ease the delivery of aggregates and decrease the transportation costs. Mobile UI enables ease of use, digital consignment note as well as accurate recording of delivered materials. Each load history will include e.g. the amount of material, origin information, delivery location and time. It will be possible to build a dashboard view monitoring the construction work progress on live. At the same time all the tracking information will be saved for archive and future needs. This is important because when using side streams

construction materials detailed follow up and reporting procedures are required.

5. DIGISOIL – Cooperation project proceeding

System architecture and database schemas has been developed together in close co-operation with Aalto University and LUAS. Aalto University has been mainly responsible for negotiations with the infrastructure construction industry. This includes testing the ideas, defining the required data and it's formats as well as user interface feedback. LUAS has been developing the User Interface mockups according the specifications. Actual coding work is divided between partners so that LUAS main responsibility is the front-end application implementation. Aalto's responsibility is focused on the back end services. This kind of separation of concerns makes testing efficient and easy: both part has its own responsibilities and the communication is easily verified by listening the http-protocol and message transactions.

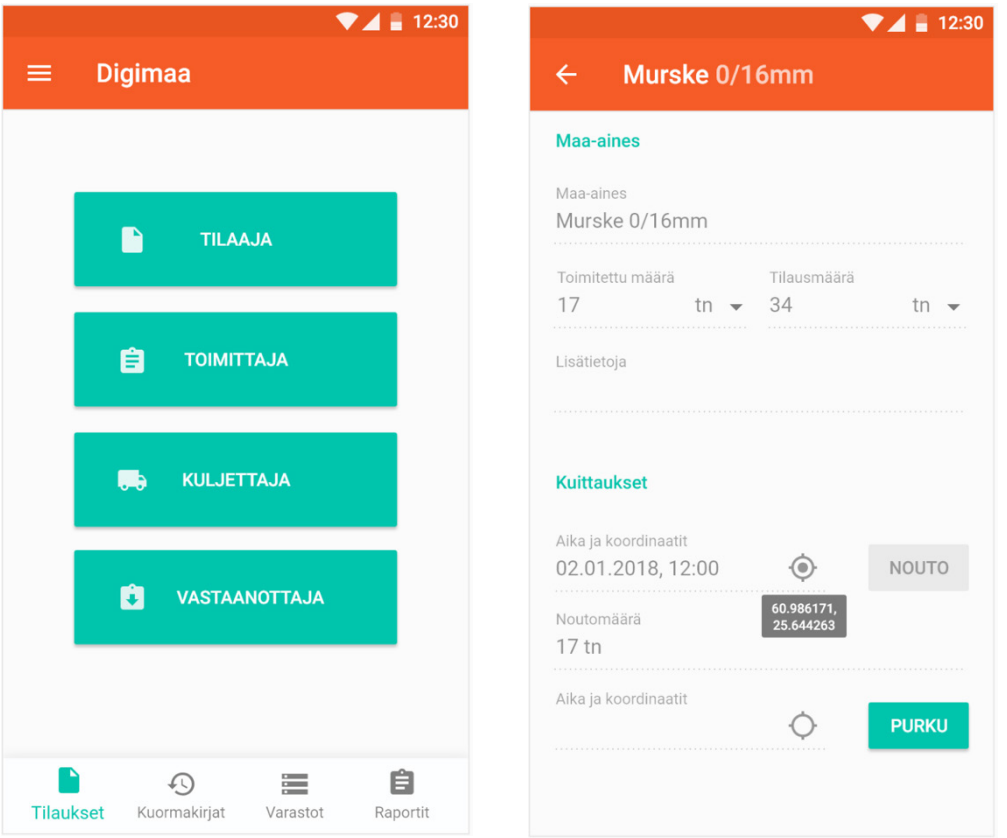

Figure 1. DIGISOIL User interface

5.1. Student involvement

Part of the DIGISOIL implementation has been integrated into studies of Information and Communications Technology workshops at LUAS. This project started at autumn 2017. Project group included 6 students from software engineering and media technology majors. By that time the implementation of the back end was still under way and the project

team decided to set up a test service that mimic the real service. Using this kind of arrangement, the team was able to test the application under development. At the end of the 2017 two students started to work for the project as project assistants. One of them is responsible for UI development and the other leads the coding. He will write his final thesis about this project too.

5.2. Cooperation with stakeholders

Cooperation with stakeholders have been intensive during the whole project. Interviews and meetings have been held on a regular basis. Project team used an iterative approach to present the current ides and gather further information concerning the user experience and process as a whole. During the spring time 2018 the UI is now fixed. It has been a laborious and challenging task to accomplish, because of different stakeholders and their proprietary needs. Despite the InfraBim and InfraRyl specifications, each actor on this field tends to have their own specific requirements and needs for this kinds of data. From the reporting point of view the gathered information must be made commensurate and equal. The application tries to standardize the terms used such as material grouping and names.

This project has also a steering group. Steering group has representatives from both universities, Aalto and LUAS, financier institution and construction industry. Steering group meetings are a way to spread information, change contacts and discuss the alternatives and options during the project progress.

6. Conclusions and future development

The development of the resource efficiency needs better communication and management tools. In the earthwork this can mean timely information about available recycled construction materials or surplus soil materials from another construction site. At the same time it is possible to make logistical arrangements more efficient. These improvements must be easy to use and additionally lighten the overall management of the construction projects in practice. Efficiency also in economical terms is essential. This can help to save virgin natural construction resources and reduce the environmental burden caused by the earthwork.

DIGISOIL-application can make it possible to fill material related management needs of constructors, authorities and other stakeholders. This is important when involving more potential material suppliers into construction projects. DIGISOIL will offer a digital solution for manage increasing amount of material related information so that essential stakeholders have online access to mass and material coordination tool for rational and resource efficient solutions on construction project level. Also timely spatial data about material sources, amounts, transportation and unloading are generated and reported.

Next phase of the DIGISOIL-project is testing phase during the coming

autumn 2018. It is essential to get feedback from the actual planned end users of this digital service. Spin of business potential after the demonstration phase is possible and able to take care of further development of the DIGISOIL -application.

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Cura, K. & Zitting, J.

Optical textile sorting technology – developing means to extract valuable materials from a heterogeneous post-consumer waste textile stream

Best Practises & Case Studies

Abstract

According to a research by the Finnish Environment Institute (SYKE 2015), more than 70 000 tons of waste textiles (also called as discarded textiles) are generated annually in Finland. Although there is a growing trend for reusing textiles via flea markets or charity networks, up to 60% of textile waste is incinerated for energy. One notable reason for the low utilization rates is the growing percentage of blended textile fibres on the market, which is problematic for most recycling techniques and reuse. Mechanical, chemical, as well as thermal recycling methods, all require a known fibre composition to yield recycled fibres with acceptable quality. Therefore a method for fibre recognition in unknown textiles is needed. Furthermore, reliable textile fibre recognition will soon be required because the EU has set a target for EU member states to organize separate sorting for textile waste by 2025 (MoE 2017). Lahti University of Applied Sciences (LAMK) is participating in a nationwide multidisciplinary project Telaketju, which aims to develop a collection and sorting infrastructure for textile waste in an effort to increase its recycling rate. Working with automated identification technologies, LAMK has designed and built a textile sorting unit based on near infrared (NIR) spectroscopy, which is capable of recognizing the organic chemical structures usually found in textile materials.

In addition to a brief introduction to NIR technology, this article describes the process of choosing and validating suitable reference materials, optimising spectral pre-processing and choosing the right identification algorithm to ensure accuracy for textile recycling purposes. The resulting identification library indicates that with NIR technology it is possible to sort different fibre types automatically for recycling processes. An efficient and reliable sorting method for textile waste would generate new possibilities for recycled textiles, as it would increase the availability of pure recycled materials.

Keywords: textile waste, sorting, NIR spectroscopy, chemometrics

1. Introduction

The European Union has set a target which claims that EU member states

need to organize separate sorting for textile waste by 2025 (MoE 2017). While MSW management companies may see this only as a logistical challenge, there is currently no active ecosystem in Finland for textile sorting and refinement at an industrial scale. This means that in order to improve resource efficiency and recycling of textile fibres, there needs to be a system for separating and processing textiles. Producing high quality recycled fibres requires knowledge about the fibre composition in the processed material. Manual identification of textile materials using the information on product labels is both time consuming and unreliable. Therefore, Lahti University of Applied Sciences has developed an automatic textile sorting unit, which identifies fibre composition in garments using NIR spectroscopy. While the development process for the REISKAtex® pilot sorting unit is still ongoing, it is clear that with a properly built identification library, the technology is capable of sorting common textile materials with a high level of accuracy.

2. Near-infrared technology, NIR

Infrared spectroscopy is a material analysis method is based on molecular vibrations. It detects molecules which vibrate with the same frequency as electromagnetic radiation in the IR-region (approx. 800-25.000 nm). When a wavelength corresponds to the natural vibration frequency of a particular molecular bond, the energy at that wavelength is absorbed by the material. Measuring these absorptions gives information about the chemical structure of the measured material. (Stuart 2004, 2-8.) While the mid-IR region exhibits fundamental vibrations of common organic bonds, the NIR region (800-2.500 nm, adjacent to the visible light region) consists of overtones and combination bands of the same vibrating bonds. These absorptions are significantly weaker and less resolved than the fundamental counterparts in the mid-IR region. However, weaker absorption allows for greater measurement depth and distance, as well as analysis of highly absorbing or scattering materials without sample preparation. (Reich 2005, 3-4.) This makes NIR technology suitable for process control, while mid-IR applications are mainly used in laboratory analysis.

NIR technology is a non-destructive spectroscopic material analysis method, and has an established position in e.g. the food and pharmaceutical industry. However, these processes often track only certain characteristics, such as protein or moisture content. The heterogeneous nature of textile waste, both in chemical composition and fabric structure, calls for further research to establish methodology that is sufficient to separate pure textile materials, such as cotton, polyester and wool. NIR applications for automatic sorting should be regarded as a secondary analysis method, i.e. it relies on primary reference data. By saving spectra from reliable textile samples and taking advantage of advanced chemometric tools in spectral evaluation and pattern recognition, it is possible to build an identification library for textiles that matches unknown samples with saved references.

The spectra obtained from each sample correspond to intra- and intermolecular bonds within the material. For example, all pure, i.e. 100%, cotton samples exhibit similar spectral features, which enables automated

material sorting. The qualitative analysis of IR spectra is based on spectral pattern recognition techniques. Mid-IR spectra can be used to identify individual absorption peaks from particular molecular bonds and the chemical formula can be worked out based on these signals. However, NIR spectra exhibit broad and overlapping features which cannot be evaluated individually. Pattern recognition of the whole spectral range is therefore performed by comparing the spectral values to known samples in the identification library.

2.1. Setup and sample selection

This research was carried out at Lahti University of Applied Sciences, Department of Technology with a ProFOSS NIR process analyser, which was equipped with Metrohm Vision™ software for spectral data management. The instrument is rigged into a sorting line (Picture 1.) consisting of a conveyor belt with pressurized air deflectors to separate identified pieces (according to fibre composition) into their designated bins. The system is designed to combine the advantages of laboratory analytical precision with industrial scale process capacity.

Image 1. REISKAtex® sorting unit. (Photo by Jaakko Zitting).

Textile sorting tests and pilots conducted by both LAMK students for the Reiska-project and multiple charity organisations (e.g. Fida and UFF), have shown that the label information on garments is not always accurate in terms of fibre composition. Checking labels for material composition is also not an efficient method for textile sorting as it is time consuming. It is estimated that 30% of discarded post-consumer textile garments don't include a label or the label is inaccurate (Cura & Heikinheimo 2017). Label information was only used to gather samples of cotton, polyester and wool to teach the NIR system each material's characteristic spectrum. In order to ensure the quality and purity of the samples used in the identification library, all the samples were validated with a laboratory FT-IR (Bruker Alpha ATR with Opus spectral library) spectrometer. If the samples did not conform with known standard fabric samples or raw fibre spectra, were

they discarded from the identification library development process.

In total, 30 samples of cotton (CO), 29 samples of polyester (PES) and 25 samples of wool (WO) were validated for library development purposes. These included pre-consumer sample pieces from fabric manufacturers and post-consumer garments gathered from collaborating charity organisations. Moreover, 10 samples of viscose (VIS) were later included to evaluate the separation of materials with similar chemical structure (CO/VIS).

3. Measurement technique

The NIR spectra of all validated textile samples were measured and saved according to fibre types. All reference samples were measured twice (both sides) to eliminate random outliers due to measurement conditions. The maximum measuring distance was defined by evaluating the increasing spectral noise from a single sample, along with increasing distance at approx. 10 mm intervals. Normalising spectral baseline shifts with measurements at under 30 mm distance resulted in insignificant variations in noise levels. Samples were also measured flat and wrinkled, with no noticeable difference in absorption levels. The instrument was set to take 32 scans during each measurement to compensate for any excess noise, and the resulting mean spectrum was used for further analysis.

After optimising the measurement parameters, the spectra still contained slight variations in absorption values. These inconsistencies arise from e.g. differences in sample density, weaving structure, pigments or surface treatments. Furthermore, polyester and wool contain chemical variance in their molecular chain branching and protein structures, respectively. Moisture affects NIR spectra by enhancing the O-H absorptions which are strongly present in cellulose based fibres, e.g. cotton and viscose. These variations must be taken into account when setting tolerances for spectral identification, but most inconsistencies can be compensated for with spectral pre-processing. The objective of spectral pre-treatments is usually to remove the effects of physical phenomena from the data set in order to make the chemical analysis more reliable.

3.1. About chemometric methods

Chemometric tools for pattern recognition vary from simple correlation and distance based methods to a more complex but statistically robust principal component analysis (PCA), linear discriminant analysis and factorial discriminant analysis. (Manley et. al. 2008, 77-79.) The two main types of mathematical pre-treatment are scatter correction and spectral derivatives. (Rinnan et al 2009, 1.)

Standard normal variate (SNV) is a common scatter correction method that is used to normalise multiple spectra within a data set when differences in e.g. particle size or effective wavelength path cause baseline shifts. Scatter correction is always recommended when measuring solid, granulate or powder samples. The spectra are normalised to a uniform base level

by mean centring the spectra and dividing with its standard deviation. (Metrohm 2015, 12.) Broad overlapping features in NIR spectra hamper discrimination between adjacent absorbance bands and they contain few characteristic features for spectral pattern recognition. Derivative functions in finite data sets can help identify underlying responses in absorption levels, as the slopes become more resolved. A drawback of the derivation process is the decrease in signal to noise ratio. Noise always has the sharpest features in IR measurements (compared to normal absorption signals) and exhibits unwanted features in the resulting derivative spectra. Prior to derivative pre-treatment, the data must be cleared of excess noise with good measurement conditions and, if needed, mathematical smoothing operations. Increasing the segment size parameter reduces noise but may lose valuable spectral information. (Owen, 1995.) Figures 1 & 2 illustrate the effect of mathematical pre-treatments on the measured spectra (same data set on both plots).

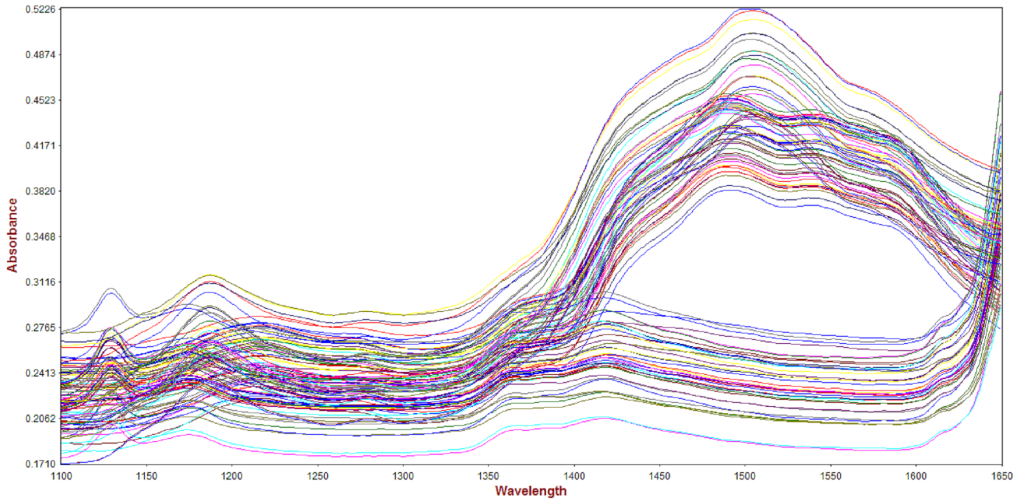

Figure 1. Raw spectra with overlapping absorption bands. (Capture from Vision™ software)

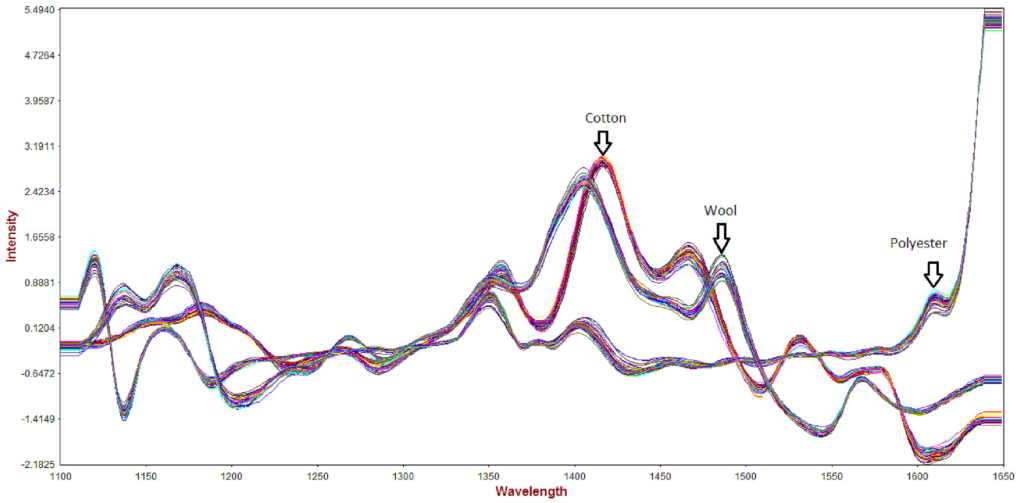

Figure 2. Normalised and derivative spectra with identifiable spectral features. (Capture from Vision™ software)

4. Library development

A simple finite element derivative function along with a scatter correction was applied to the data sets of each library product. This yielded satisfactory results as the baseline levels were correctly centred and the underlying spectral features were enhanced without a significant increase in noise levels. The pre-treatment applied to the spectra allowed reliable pattern recognition when sorting unknown samples.

The spectral manipulation software in use, Vision™, offers three algorithms for spectral pattern recognition. Principal component analysis (PCA) was regarded as a non-reliable method as it was not able to differentiate between acceptable spectral variance and clear outlier features. Correlation analysis would be ideal for ruling out absorption peaks from blend fibres, but it cannot differentiate between fibres with similar chemical composition, such as cotton and viscose. Furthermore, the varying spectra from different chemical protein structures in wool could not be combined into a uniform mean spectrum to support correlation analysis.

The most prominent and reliable identification method is maximum distance in wavelength space (MDWS), which defines the maximum deviation from the mean spectrum at each wavelength point. Since the mean product spectrum is inflated by the standard deviation at each wavelength point, it can accept sections with high natural variation, while maintaining stricter tolerances for clear characteristic features. MDWS was found to be the only method capable of identifying all products correctly without misidentifications or unnecessary disqualifications.

The parameter for maximum distance was defined by first calculating the standard deviation spectrum of each product set. When a rough range of values was established, the final tolerance value was defined by running test identifications with different values. MDWS successfully eliminated outliers while accepting good samples for identification. This identification method was tested and approved by internal cross-checking and running identification tests on known textile samples that were not used to build the reference library.

4.1. Library validation

Both internal cross-checking and testing random fabric samples yielded a 100% success rate when identifying textiles by fibre type (CO, PES, WO, VIS). All validated textile samples were identified correctly and outlier spectra were discarded (failed recognition) as expected. There were no misidentifications between CO and VIS despite the chemical similarities. Additional library testing for material impurities showed that cotton and polyester with fire retardant finishes were discarded with success rates of 83% and 85%, respectively.

5. Results and conclusions

The results of building and testing the identification library prove that it is possible to build an industrial scale textile sorting unit based on NIR spectroscopy. The sorting technology proved capable of separating unblended cotton, wool and polyester, as shown in Figure 2. It was also proven that with the correct feature enhancements and identification parameters, NIR can separate even fabrics with a substantially similar chemical composition. Viscose and cotton were identified correctly despite both being purely cellulose-based fibres.

The divergence in NIR spectra between cotton, wool and polyester would make it possible to identify these materials with just a simple scatter correction, smoothing operation and a broad tolerance correlation analysis. However, for future development of a more complex identification library, it is beneficial to have a more meticulous identification method to differentiate between unblended and blended textiles. The optimisation of pre-treatment parameters and library development were conducted with future expansion in mind to ensure high accuracy.

A full, real-time test run to determine the performance and reliability of the system is needed for further development of the sorting technology. The next step is to establish the logical control protocol and correct timing of the logical commands from the software to the sorting line's detectors. After that, the system will be ready to run routine identification analysis of waste textiles.

In conclusion, using the textile sorting technology developed, it is possible to reduce the amount of textile waste going to incineration. This will improve resource efficiency, as valuable textile materials can be kept in circulation for a longer period of time. A sorting line for pure unblended textile materials offers the potential to develop upcycling practices with more added value.

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Guo, L., Jiang, Z., Yao, Y. & Cui, H.

The Latest Development of China Telecom in the Construction of Green Communications Technologies and Business Ecology

Best Practises & Case Studies

Abstract

With digital economy's rapid development, the network scale was expanding at a high speed for a short time, and the energy consumption inevitably presents a fast-growing trend. All Chinese telecom operators implement the concept of "innovation, coordination, green, open and sharing", actively promoting energy conservation and consumption reduction, reducing environmental pollution, improving green operation and management, cooperating with related fields to innovate sustainable development practices, building and sharing green and energy-saving sustainable development societies. China Telecom regards protecting the environment as an important responsibility and actively supports economic and social green development. On the one hand, it achieves its own goals of energy conservation and consumption reduction through internal optimization; on the other hand, it provides innovative business and good support for the green development of other enterprises. This paper will share Chinese Telecom Operators' (China Telecom in particular) experience and practice in green operations, green supply, green networks and green management, and provide constructive suggestions for the development of green infrastructure in the global telecommunications industry.

Keywords: sustainable development, green environmental protection, infrastructure construction, green communications technology

1. Introduction

At present, aiming at the challenges of resource scarcity, low utilization and environmental pollution in China, Chinese telecom operators did not keep out of the affair, but have actively fulfilled the social responsibility of green development, and promoted the construction of green ecological environment through innovation of technology and business. On the one hand, they have achieved their goals of energy conservation and consumption reduction by optimizing the business layout, advancing the construction of green communication infrastructure, and reducing the cost of enterprise development by innovative technology. On the other hand, the launch of innovative business provides effective services for other enterprises to the achievement of energy conservation and mitigation. In

order to ensure the sustainable development of ecological environment, they are making contributions to build a new and environment-friendly society. In combination with their own business characteristics, operators have adopted effective measures such as green operation, green supply, green network, green management and innovation services to reduce various energy consumption, reduce greenhouse gas emissions, improve the overall environment, create a greener living environment for residents and improve people's sense of well-being.

2. Actions to build a green economy

2.1. Internally optimized layout

2.1.1. Supply-side structural reform

The structural reform of supply side is to adjust the economic structure, so that the elements can be optimally configured, and then increase the quality and quantity of economic growth. Chinese telecom operators actively implement the structural reform of the supply side and the requirements for energy conservation, emission reduction and green development, through eliminating outdated production, and implementing energy-saving technologies to achieve the results of green development. In 2017, China Telecom continued to eliminate backward aging and high energy consuming equipment and completed the traditional TDM program-controlled switching network and continued to promote cloud-based integration of business platforms into resource pools. China Telecom actively applied energy-saving technologies in communication equipment rooms, base stations and other facilities, and continued to expand the application coverage of energy-saving technologies in infrastructure facilities. It promoted the redundant optimization of basic supporting facilities, further promoted the accounting of energy consumption and also improved the level of energy saving and emission reduction. In 2017, the comprehensive energy consumption of unit information flow is 7,1 kg of standard coal/TB (China Telecom 2017). The upgrading of equipment and technology, the optimization of resource allocation, and the implementation of supply-side structural reform contribute to the green development of society.

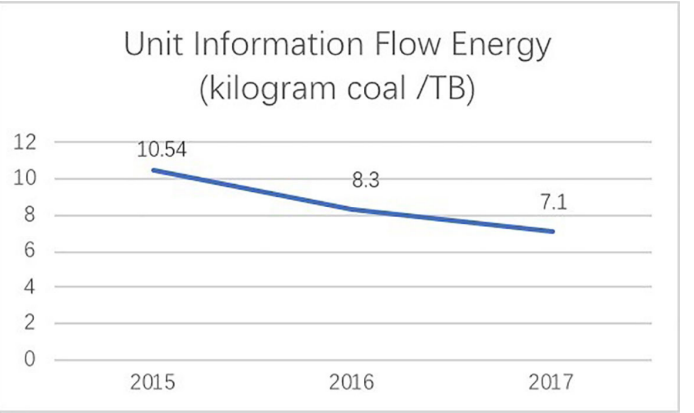

Figure 1. Integrated energy consumption of unit information flow (China Telecom 2015; China Telecom 2016; China Telecom 2017)

2.1.2. Green management of supply chain

Chinese telecom operators actively implement the green management of supply chain, the regulations of reverse logistics management, waste materials recycling and disposal management, and they also promote the recycling of waste cables, batteries, terminals and other materials. Focusing on the procurement of low-energy equipments, green procurement is the most critical part of green supply chain management. The degree of the green supply chain is determined by the environmental protection of the products purchased. Green purchasing is conducive to curbing the source of energy consumption pollution. Through green supply chain management, enterprises can strengthen their own green energy utilization rate and fulfill their due social responsibilities.

In 2017, the first procurement regulations knowledge competition was organized and more than 8700 related personnel from 40 organizations participated in the promotion of standardization of procurement. A total of 85000 purchase announcements were issued, which represented an increase of more than 3 times compared with the same period of 2016. In the aspect of green purchasing, the application of green purchasing indexes in the procurement process is continuously promoted, and the purchasing power of energy-saving products is increased. The proportion of high-efficiency power modules in the DC power modules purchased in 2017 increased to 94%, and the unit power consumption of key professional procurement equipment decreased 2,8% from 2016 (China Telecom 2017). Enterprises need to standardize the procurement process, adhere to the green procurement method, actively implement the green management of the supply chain, and promote the green development of the enterprise through the above methods.

2.1.3. Green network

Chinese telecom operators actively introduce new technologies to build an all-optical network with more energy saving and environmental protection, unify planning and construction of cloud resource pools, and integrate business platforms and IT resources. Using new technology, equipments and scientific methods to explore and practice the construction of green network. In 2016, China Telecom's independent platforms dropped to 773 units, a year-on-year decrease of 21%. The cloud rate of the service network platform reached 75%, a year-on-year increase of 19% (China Telecom 2016).

For the government and the public, the problems of arable land protection, equipment pollution, construction effect and electromagnetic radiation are all concerned, China Telecom has actively adopted environmental protection measures in the construction of communication projects. For example, the site selection of base stations gives priority to the original houses and wastelands, and the land is not occupied as much as possible. The equipment is mainly selected to be noiseless, electromagnetic free, and free of pollutants. The field communication exploration should avoid special sites such as natural relics, human relics, and nature reserves.

Carrying out monitoring and evaluation of electromagnetic environment around base station to ensure electromagnetic radiation is lower than national standard. The concept of green environmental protection is gradually internalized into the conscious behavior of network construction workers, who strive to achieve scientific and efficient management and protect the environment and save energy and reduce consumption. The network construction is more environmental-friendly, and the construction environment is continuously improved. Building an energy conservation and environmental protection network will promote the green development of the network environment.

2.1.4. Green management system

Chinese telecom operators call on employees to carry out green office and green travel activities to enhance their awareness of environmental protection, and consciously save electricity, water and office supplies. China Telecom actively promotes the statistics of paper consumption, according to preliminary statistics, about 2000 tons of office paper will be used in 2017 (China Telecom 2017). Measures are taken actively to promote the reduction of paper use in business and office, promotion of VAT electronic ordinary invoices, electronic bills and paperless business. *Actively promote effective operation, office and training methods to reduce energy consumption.* China Telecom will accelerate the development of electronic channels and continuously increase the proportion of electronic channel services to the total service volume of all channels. *And also advocate and encourage video conferencing or training and set basic standards for video conferencing and training. In 2017,* the system interface between enterprise financial system and tax bureau was established to realize the function of invoice automatic authenticity checking, and to cancel the authenticity check of paper parts. Employees actively respond to and comply with the enterprise's green management system and gradually cultivate their awareness of green energy conservation (China Telecom 2017).

2.1.5. Energy-saving and environment-friendly communication room

The Internet Data Center room has been using special precision air conditioner for its refrigeration for many years. With the development of digital economy, the number and area of the room are increasing, and the energy consumed is also increasing. In the case of global energy shortages, although the air-conditioning cooling effect has improved, the power consumption is still high. Most of the power efficiency of traditional data centers in China is over 2, and more than half of them are occupied by air conditioners. Therefore, China Telecom adopts the equipments with low energy consumption, chooses the right power supply plan and the power supply equipment, selects the suitable refrigeration mode and operation mode of the air conditioning unit, rationally arranges the room and the organization air flow, treats special equipments in a special way, and

prevents the running of the leakage and other methods to build the green energy saving and environmental friendly IDC room. The room can achieve the effect of low energy consumption, high temperature resistance, and high concentration of server clusters, mix the data center external gas into the internal gas system and circulate the temperature control system in order to realize the temperature and humidity of the room with natural cooling source instead of traditional air conditioning equipment. While ensuring the continuous and reliable operation of data centers, the power loss can be reduced by 50%.

Through internal optimization, China Telecom has achieved a good control over the total energy consumption of the whole group, with an annual energy saving of about 700 million kWh (China Telecom 2016).

2.2. External service

2.2.1. Improvement of the infrastructure and business of the IoT

Chinese telecom operators actively promote the construction of the Internet of Things, and build an omni-directional ecological environment monitoring network through the application of sensors, infrared detection, positioning system, satellite remote sensing and other devices and technologies. China Telecom pioneered the technology of the new generation of the Internet of Things (NB-IoT) in the second half of 2017, providing a good space for energy conservation and environmental protection. NB-IoT technology has the following advantages: First, the network coverage of NB-IoT technology can be reached most widely. Based on the 4G full coverage network deployment, the services of Internet of Things can be provided anywhere with a mobile network. Second, China Telecom has the largest scale of the network coverage of the NB-IoT technology, with over 310 000 base stations synchronized to upgrade. Third, the quality of NB-IoT technology is the best. The NB-IoT technology is based on the low frequency band of 800MHz, with the characteristics of stronger signal penetration and better coverage, making the network quality more stable. NB-IoT can realize real-time collection of pollution sources, ecological information, environmental quality, garbage sorting processing and other information. It can realize intelligent disposal of pollution monitoring, hydrological monitoring, sanitation treatment and other environmental protection services. From the perspective of controlling the source of pollution and reusing resources, we will promote the development of ecological civilization and environmental protection.

NB-IoT technology is also ubiquitous in daily life. China Telecom and ofo (ofo is a non-pile shared bicycle travel platform in China) signed the NB-IoT sharing bicycle application cooperation to improve the user experience of ofo electronic locks, reducing the difficulty of operation and maintenance, and provide better services for people to have green travel. Among the 20 cities sampled in the second quarter of 2017, the total number of cycling users rode over 11,98 billion km, saving 83,88 million liters of gasoline, 214 661 tons of carbon dioxide emissions and 14,1 tons of PM2.5 emissions

(Zhou 2017). China Telecom builds urban street lamp management and control system based on NB-IoT technology, replaces the existing street lamps with energy-saving street lamps, monitors the running status of the street lights and realizes the switch control of the lamps through the platform, and reduces the energy consumption of the lamps to the maximum extent by customized energy-saving rules. The comprehensive energy saving rate is more than 70%, which can save more than 100 billion kWh of electricity annually (Qie 2017). In the future, the digital city management system based on the traditional map is to be upgraded to intelligent city management by NB-IoT, which will give more reasonable plans for city dregs management, urban food waste management, smart parking solutions, and urban equipment (well cover) management, and save social resources.

2.2.2. Building a cloud service platform

Chinese telecom operators actively build the cloud service platform to alleviate the problem of heavy energy consumption. On the one hand, using cloud storage, cloud computing and cloud services through virtualization, real-time migration of power management technology, will reduce the number of running equipments and working hours, and reduce the energy consumption of the main equipment to achieve energy-saving emission reduction. On the other hand, through cloud computing, enterprises can realize the perception, collection and processing of data, make overall layout and development, and reduce the waste of resources caused by repetitive construction. China Telecom vigorously builds cloud network integration infrastructure to provide customers with end-to-end "up-cloud" and "use-cloud" services, and also strives to allow customers to experience "cloud network convergence" services that integrate high speed, security, and scalability. In 2016, China Tower's operation and maintenance monitoring system was carried by China Telecom Tianyi Cloud 3.0 platform. Through cloud computing, China Tower greatly saved the related infrastructure and supporting environment construction investment, shortened the construction cycle, and reduced the telecom industry tower related infrastructure such as redundant construction, and promoted the reasonable utilization of resources and environmental protection.

2.2.3. Communication infrastructure co-building and sharing

Chinese operators actively contribute to infrastructure construction and promote the construction and sharing of communication facilities in public transportation, scenic spots and large buildings to reduce redundant construction and protect the natural environment and landscape, saving the consumption of land, energy and raw materials. China Telecom, in close cooperation with telecommunications operators and China Tower, actively promotes the establishment and sharing of communication infrastructures such as base stations, pipelines and poles. In 2017, it provided more than

22000 lines of Shared poles, more than 1500 lines of pipelines and more than 1200 indoor distribution systems (China Telecom 2017). The co-construction and sharing of infrastructure can not only save resources, but also reduce the investment scale of the overall communications industry, save expenses, and focus on core business operations.

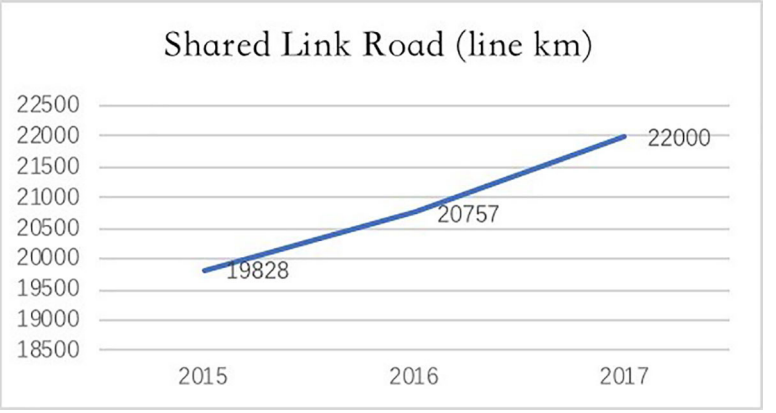

Figure 2. Shared Link Road (China Telecom 2015; China Telecom 2016; China Telecom 2017)

3. Green energy saving solutions for major events

3.1. Deployment of Green Winter Olympic Games

The 2018 PyeongChang Winter Olympics, which has just fallen to the curtain, not only brought exciting competitions, but also promoted the three strategies of “low-carbon Olympics”, “green Olympics” and “sustainable Olympics”. The PyeongChang Winter Olympics Organizing Committee successfully reduced 1,65 million tons of carbon consumption through using of wind energy and forest carbon offset projects, as well as voluntary joint donation of carbon emission rights in the private and public sectors. However, it was also revealed that the venue for opening and closing ceremonies will be demolished after the game and alpine skiing projects was built in nature reserves, which had caused huge waste of resources and environmental damage.

Sustainable development is one of the three major concepts put forward by China in preparation for the Winter Olympics Games in 2022. China will fully develop the concept of “Green, Shared, Open, and Integrity”, and present a green and environmentally friendly Winter Olympic events to the world.

To ensure the smooth hosting of the Winter Olympics, China Telecom actively deploys the network environment, co-constructs and shares with major telecom operators, and improves the utilization of communications infrastructure. China Telecom also signs a strategic agreement with the Zhangjiakou Government to jointly establish a smart city innovation laboratory and use smart transportation, smart sanitation and other technologies to improve resource utilization. China Telecom Beijing Yizhuang Cloud Computing Data Center not only bears the core communication task

of the Winter Olympic Games in 2022, but also undertakes the function of the core data communication hub of Beijing-Tianjin-Hebei integrated urban agglomeration, so that the limited resources can be efficiently and fully utilized.

3.2. Construction of Xiongan New Area

The establishment of Xiongan New Area is a major decision made by the Chinese Government to promote the coordinated development of Beijing, Tianjin and Hebei. Chinese Government upholds the concept of innovation and green, pushes forward Xiongan New Area with a high starting point, high standards, and high levels of development, and builds the spatial form of the triangular urban agglomeration of Beijing, Tianjin and Xiongan, which will build a new smart city of world-level, green and modern. The areas of intelligent building, smart street lighting and smart sanitation will fully utilize resources to reduce energy consumption.

China Telecom has fully supported the planning and construction of Xiongan New Area and has taken the lead in the construction of the new generation of Internet of Things (NB-IoT) experimental network in Xiongan New Area. In response to the call of “new technologies to improve the quality of new areas”, China Telecom actively promotes the implementation of new intelligent applications, such as in gas and heat meter reading, intelligent building, heat metering, energy saving, intelligent lighting and other fields to provide comprehensive energy management solutions. China Telecom lays out the 5G test network in the new district in advance and uses the large bandwidth, large connectivity, and low latency network characteristics of 5G to provide a good network foundation for smart city. The IDC rooms for the data center project, which supports to realize “cloud of Xiongan, digital of Xiongan and intelligent of Xiongan “, has been delivered recently. China Telecom has developed the smart city of Xiongan New Area through arranging the “Cloud, Network, and Terminal” layout, and utilizing digital twin technology to provide the best solution for urban green development. In the future, Xiongan New Area will become a new smart city with the comprehensive coverage of gigabit optical network, 5G, NB-IoT and the integration of cloud network.

4. Results

Chinese major operators, represented by China telecom, actively fulfill their due social responsibilities, actively respond to the existing environmental situation, and combine their own business characteristics to implement supply-side structural reform, implementing green management of supply chain, building green environmental protection network, deepening green management system, and build energy-saving and environment-friendly communication rooms to improve their own energy conservation and reduce consumption. By building a network of infrastructure and business, a cloud service platform, a network of infrastructure and sharing infrastructure and providing a green energy solution for important events,

to help other businesses achieve green energy efficiency, and ultimately achieve the green development of the whole society.

5. Conclusions and suggestions

With the development of the digital economy, Chinese telecom operators, represented by China Telecom, are trying to transform and upgrade to provide efficient basic network services. Through intelligent transformation, Chinese operators use intelligent connectivity, intelligent platforms, intelligent applications and smart operations to build a converged and open business ecosystem, and promote the development of intelligent information services, and help all walks of life to implement intelligent transformation and upgrading. They uphold the concept of "sharing, creating and co-prosperity" to provide more welfare to the whole society. Telecom operators promote the integration of emerging technologies such as cloud computing, big data, and the Internet of Things with various fields. In the field of smart energy, green environmental protection mobilizes energy production and consumption. In the field of smart industry, a production model has been established which is wise and environmental. In the field of smart cities, green energy conservation and refined management of the city are carried out. Emerging technologies are used to build smart city group, help the traditional industries and enterprises to reduce energy consumption, and build a more low-carbon environmental protection society. China Telecom insists on the spirit of "never forgot its original intention and its mission", while actively improving its own development, providing efficient services for other enterprises and contributes to China and the world's green development. China Telecom actively shares its own green development mode, providing theoretical and practical experience for other enterprises in energy conservation and environmental protection. Calling for companies around the world, hand in hand to build human destiny community, put green energy conservation and environmental protection in the development of the first. China Telecom will also take full advantage of international experience and take measures to improve the global sustainable development.

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A Joint Concept of Education Targeting Facilitation and Implementation of Circular Economy in the Baltic Sea Region

Best Practises & Case Studies

Abstract

Current linear approach, where the usage of virgin resources is creating product-based waste, has led to high carbon emissions, resource inefficiency and an unsustainable economy. Whereas circular economy is targeting maintaining the value of products, materials and resources in the economy for as long as possible. This goal can be achieved only when a major change occurs in product design, material selection, business and consumption models in parallel with recycling technology development. This would also be supported by changes in higher education, to ensure that there will be future-specialists and leaders who know and have vision for how to implement the new circular economy approach in reality.

One major challenge of the educational system is that it is currently so structuralized that it restricts the students to certain specialized areas. Hence, in order to get a good grip on the multi-discipline requirement, a new accession will be required to cover all the different aspects of circular economy. This means that both the teaching staff and the participating students from different faculties would be 'joining forces' to tackle real life problems raised by then involved enterprises.

A variety of tools are needed to work on the circular economy cases. Life cycle assessment (LCA) is an instrument that enables a bigger picture perspective of a product system. Other tools and approaches were also considered for example, material balance and material flow analysis, life cycle costing and industrial symbiosis.

The overview of the design, content and structure of the international multidisciplinary teaching course on circular economy is provided in this paper. The course will boost the application of circular economy in participating countries by providing specialists that will facilitate the change from linear to circular economy, and Thereby finding more sustainable and material-efficient ways of producing and consuming both products as well as services.

Keywords: circular economy, higher education, life cycle approach

1. Introduction

The driving force for the new economical approach, circular economy (CE), is based upon two facts. Firstly the world population is steadily increasing and secondly the raw material on earth is limited. Hence the old fashioned habit of produce-use-waste is no longer possible and we must adjust our thinking so that more material is recovered and less virgin material is used in the future. This is also supported by the waste pyramid, where reuse, remake and recycling are the top priorities.

On a global level, the leaders and presidents of countries as well as heads of large companies, have taken a clear direction on which way the development should go. The statement on sustainability has never been clearer; Europe are determined to take the bold and transformative steps which are urgently needed to shift the world into a more sustainable and resilient path (European Commission 2016). Also on an EU level, the urgency and need to act is clearly present in their communication about the next step for a European sustainable future and the European Commission (EC) will make use of all instruments at its disposal to ensure the step (European Commission 2017). The EC has also put forward a circular economy package which will promote and enhance the utilization of CE thinking and "closing the loop" on materials and services (European Commission 2017). In Finland different institutions supported by the government have identified fields and activities which will strengthen the industry, companies and organizations to deal with these future markets (Finnish Ministry of Environment 2018; Pekkala 2018).

More and more people live in cities and hence it is essential to realize that also cities themselves must become more sustainable, that is the resources that they command, become low carbon, resilient, and liveable (World Economic Forum 2018).

Also the ever increasing digitalization is providing new fantastic possibilities for better and more resilient material and service utilization. Examples of this are the partly remote controlled metal circulation scrap yard near Tampere in Finland, and the digitalization enabled car-sharing or the Uber taxi service.

With this background, the five higher education establishments in the three Baltic countries together with Finland, have teamed up to develop and start a multidisciplinary course for teaching circular economy in the Baltic Sea region. The transformation of the economic model will demand new skills and therefore it is important that the new concepts reach study programs as soon as possible. This paper is a report of a practical course development project – a pilot case.

The Nordic Council of Ministers has developed the NordPlus program in the area of lifelong learning that supports networking, course development and implementation in the Nordic-Baltic region. This opportunity was used to establish collaboration on developing joint course and common methods for teaching CE. The course is targeted towards students studying in the curricula of applied sciences. Hence, in 2016, the collaboration between Kaunas Technical University, two Universities of Applied Sciences (UAS)

from Latvia, one from both Estonia and Finland was established and during several seminars the information about curricula, CE experience and skills of staff were exchanged. After one year, the decision based on the discussions and brainstorming was to continue the co-operation and to apply for a new NordPlus grant to develop common approach for a joint course in 2017-18. Finally, in 2019 the elaborated methods and course will be piloted.

2. An analysis of the specific problem

The aim was to elaborate a practical approach for teaching CE in UAS. It is obvious that there are different reasons why the current teaching approaches are not directly applicable for efficient teaching of CE. One major challenge of the traditional educational system is that it is structuralized to keep the students in certain "specialized areas of study". Hence, in order to get a good grip on the multi-discipline features of CE, a new approach is required. This means that both the teaching staff and the participating students are from different faculties and would hereby be 'joining forces' to tackle real life problems. This would be a challenge for teaching staff as they would be taken out from the classroom and their planned lectures; in other words, out of their comfort zone. Furthermore, the problems of enterprises might be not covered by the teachers' knowledge and experience. Therefore creativity and adaptability is needed, when compared to usual up front teaching practice. Also the learning process, outputs and results are not fully predictable. Still this approach method will pay off, as the experience that students will gain is so valuable. They will be requested to contribute to solve real life challenges of enterprises. In this process they would apply their knowledge, and would be effectively communicating with the group mates from different fields and cultural backgrounds. Finally they will present their findings, including the collected information from entrepreneurs and industrial processes, to a wider international audience.

Certain distinctions of the planned course are also related to the fact that the course participants are students of the applied science curricula. These curricula involve considerably more practice than those of academic universities. Also the essence of UAS teaching is that it should involve more learning by doing possibilities, instead of theoretical lecturing. Therefore it is especially valuable to gain the experience of co-operation with enterprises. This will also support students in finding the possibilities for traineeship and making better decisions about their future career.

Unfortunately, in the budgets of universities sufficient funding is lacking for internationalization, although the needs and benefits of such activities are always underlined by external evaluators of the curricula. So such activities should be initiated by teaching staff, who would write projects and apply for funding. The NordPlus program is well designed to facilitate the development of cooperation between the universities and teaching staff involved. Support for different initiatives – networking, course development, and piloting - is available. However, a new project should

be written each year and no long-term funding can be secured through NordPlus.

3. Description of the proposed approach

3.1. Creating a common understanding

It was necessary to visit and listen to the current situation in both the industries and public institutions, in involved countries to understand and create an appropriate approach for teaching CE in UAS. Hence it was clear from the very beginning that these visits and the collection of real facts would be central for the design of the widely relevant, multi-cultural and multi-disciplinary educational course. So during the preparation period, companies from different fields and countries were visited with the aim to see the CE launching from the entrepreneur's point of view and to look for real cases for the planned course.

The first visit was to a waste management and handling company in the North of Latvia. Here a specific problem was raised relevant for all Baltic countries - it is very difficult to get a feasible waste management solution in rural areas with low population density. The routing of effective logistics is difficult. The way the company is sorting the waste is creating secondary material flows. Currently they have a technological solution which uses reverse osmosis for waste water treatment. Out of the biogas collected from the landfill they produce energy. However, this is a problem as there are still no users of the heat which is also produced on-site, as the place is in a remote location. The company management also emphasized that it would be important that life cycle thinking should be introduced in all universities curricula and this is also essential for introducing CE.

According to Latvian officials, organizations and companies are willing to participate in implementation of the CE targets for direct waste reduction and increase in the reuse and redesign, provided that EU is financially supporting the reconstruction of old habits and old structures of waste and material handling.

The second visit was to a brewery in the Vidzeme region in Latvia. This brewery was very focused on serving its customers with good quality products and hence the product development was at the center of the whole development process. However, they did also try some recovery of by-products and open up for circular economy solutions. This manifested as a small production of cookies made from the hops and remains of the malt used in the process. The whole by-product was not fully developed and was still handled as an in-house solution.

Image 1. Visit to IKEA board production factory in Lithuania. (Photo: K. Lindedahl 2017)

The third company visit was to the IKEA furniture board production industry in Lithuania (see Picture 1). The measures and steps taken in the production facilities are mainly targeting to increase the efficiency and the capacity of the production unit. These measures can be seen as steps towards the circular economy; however the decisive steps towards this road of new design, reuse or involving other companies to take care of by-products etc, were not yet seen in this factory fully.

Also a textile company located in Viljandi, Estonia was visited to observe the recycling and reusing processes introduced for reducing the use of raw materials for fillings of mattresses, blankets and pillows. The company is recycling all the residue from their production processes and are therefore using considerably less raw materials and producing new side products for example sound insulation boards and felt.

All visited enterprises were kindly ready to facilitate the joint course and provide information for case studies. Issues that can be tackled by the CE approach were identified in all visited industries.

3.2. The elaboration of the course approach

The possibilities in the Nordic-Baltic region are good and feasible for expansive and disruptive measures to be taken through launching of CE. Above all, these kinds of activities and measures should also be encouraged by the government and officials in all countries. Obviously a challenge is those areas in the region, which are sparsely populated, and where the collection and reverse-logistic of materials would be difficult to arrange. Other issues surface such as; where is the limitation of minimum size of recovery or waste material handling units from a pure business point of view?

Our possibilities in the higher education sector in the Baltic Sea region are to support and provide the proper background and tools for the students educated in our organizations. Hence it is obvious that a more in-depth knowledge of the CE possibilities and limitations are valuable and important to the graduates and their future employers.

Tools that will become essential for future working skills in the new circular economy era are life cycle assessment (LCA) and life cycle costing (LCC). These were considered to be used as a way of providing the students with proper information about environmental consequences of the solutions, which they could suggest for tackling the case studies during the course. The use of these tools will cause the students to clearly see the bigger picture and to discover the potentials as well as the threats to an effective and functional solution in our Baltic Sea region.

The common course development certainly supports and enhances the development of personal knowledge, skills and abilities of teaching staff of the involved UAS. The fruitful discussions about teaching methods and practice, course organizing etc were very beneficial already during the networking and course design phases, but implementation of a joint course allows learning from others in the real life teaching process. At the same time, the teaching process is well supported and pleasant when you can rely on your colleagues; this will be the case as all the teaching assignments will be implemented by two people, each from a different country involved. The varied consortium will ensure that there are all competences represented relevant for CE implementation and the most competent specialists will elaborate the teaching content and deliver the knowledge during the intensive course. Namely business and environmental management, tourism, technology and environmental engineering curricula and relevant teaching staff will be involved in the new course.

The course content was agreed to be 78 hours of student work, including an intensive week located in one of our towns of participating institutions.

The different teaching methods and didactics were evaluated and screened during preparation of the final approach for the course. In the final content only 12% of the course time will be used for lecturing (see Figure 1). It was also decided that some basic knowledge, listed below, will have to be acquired at home UAS to ensure the required background before the intensive week:

1. Principles and framework of circular economy
2. Research on a selected company, description of it in CE context; linear or circular way of operation at a company
3. Analysis of value added chain
4. Knowledge about the business environment (political, economic, social, technological, legal)
5. Preparing questionnaires, interviews
6. Data collection and presentation
7. Concept of the life cycle approach
8. Content of eco-efficiency and sustainability

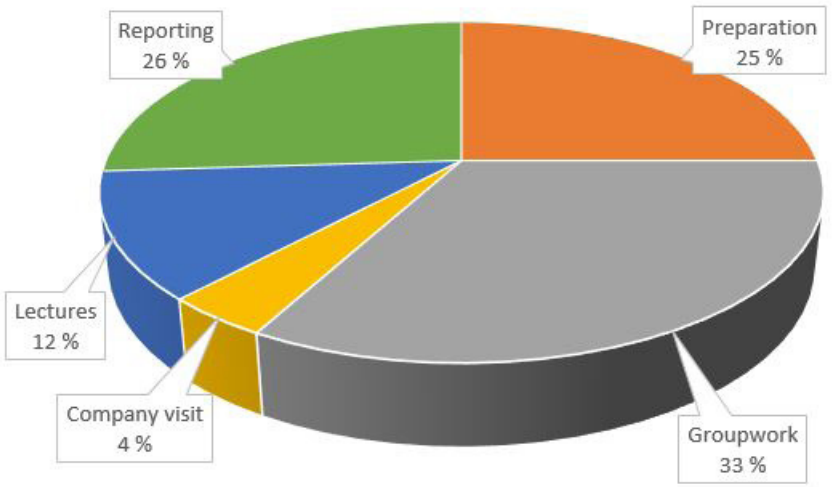

Figure 1. The time split (%) of student work during the course

The preparatory work is done at the student's home institution leading towards the group work and ending in a group report on a pre-determined subject. The aim is that this multi-cultural and multi-disciplinary course is giving the students opportunities to find their own solutions to today's problems in the companies with help of the tools which have been provided to them. The tools and knowledge are basically acquired both at the home higher educational institution, as well as during the intensive week. Table 1 provides overview of the topics included in the teaching during the intensive week.

Table 1. Learning outcomes and teaching topics/student tasks

Learning outcomes of the course	Teaching topics/student tasks during the intensive week
Student is able to apply main principles and framework of circular economy	Interpretation the real life cases in the framework of CE Comparing linear and circular economy
Student is able to creatively approach specific information for solving interdisciplinary problems	Change management Information management
Student is able to apply lifecycle thinking in solving problems	LCA software LCA measurements and parameters Examples of solutions
Student is able to analyze eco-efficiency and sustainability	UN sustainability goals Analysis of specific case
Student is able to compare several development alternatives of circular economy cases	Development of the case on society level

4. Results

From the different occasions, where we visited the companies, it has become clear that there is a demand for more education in CE in general and specifically at the university level. It was also found that there is possibilities to join forces within the Baltic Sea region to create suitable curriculums for several institutions. Further the NordPlus program also has had a catalytic impact, for example now the Erasmus+ teacher exchange possibilities are actively used by the members of the consortium, and study visits to partner-universities are organized for students.

5. Conclusions

There are challenges in the Eastern Baltic Sea region with respect to CE, and one way to handle this is from an educational perspective. The final outcome of our work is still waiting around the corner. Here the employed and working graduates are applying their skills and knowledge in their first place of work. However the conclusion which can be made based upon the strict and concentrated work done during these last two years in the CE field, is that there is a huge potential and demand for educated people. These people will have knowledge and insight into the CE and in the challenges in Eastern Baltic Sea region. The intention and will of our five institutions, is that this gap of knowledge and skills be bridged and over-come by good educational prepositions. The implementation method is focusing on an intensive course and individual learning methods. Online materials are supported by good face to face teaching methods during an intensive week implementation.

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Municipal solid waste landfill as a potential source of secondary raw materials: Case Metsäsairila, Mikkeli

Best Practises & Case Studies

Abstract

Metsäsairila municipal solid waste (MSW) landfill in Mikkeli, Finland, was investigated as part of the Smart Ground project to find out its material content (e.g. metals, plastics, wood, paper and cardboard) as well as composition of fine fraction (<20 mm). In addition to the material characterization, also the economical, environmental and social impacts of the landfill mining activity (LFM) were evaluated for Metsäsairila MSW landfill. Results showed that the amount of identified potential SRM´s (mainly iron and aluminium) was not high enough from an economical point of view to recover these metals from MSW landfill. However, utilizing additional material fractions (plastics, paper/cardboard and wood) for energy production would enhance the economic viability of LFM in MSW site. In general, operator and owner of the landfill had positive attitude for LFM activities in Metsäsairila landfill. However, from environmental point of view, LFM activity could cause risk for health damage for inhabitants living in near territory of landfill.

Keywords: landfill mining, municipal solid waste, metals, energy fraction, LCA

1. Introduction

Landfill mining (LFM) activity for secondary raw material (SRM) recovery has received growing interest in recent years in EU area and globally. It is part of a wider view of a circular economy and is perfectly complementary to urban mining and recycling in general. Availability and sufficiency of certain valuable primary materials is causing great concerns to governments and industries (Kaartinen et al. 2013). From a sustainable materials perspective, metals are important because they are not a renewable resource and their demand and consumption are continuously increasing meaning that the natural supply is decreasing rapidly (Wagner & Raymond, 2015). Presence of many critical metals in MSW landfills will mainly depend on the type of waste that was buried but the recovery of these metals through landfill mining is possible and is economically feasible only if additional materials (plastics, paper, metallic items and other) are also recovered for reprocessing (Gutierrez-Gutierrez et al. 2015). Amount of combustible materials in the landfill is of high importance for the economic outcome. Depending on the project owner’s access to a combined heat and power

plant (CHP), and their need for and access to supplementary fuel sources, the result differs a lot (Frändegård et al. 2015).

Recently ended Smart Ground -project intended to foster resource recovery in landills by improving the availability and accessibility of data and developing LFM concepts for municipal solid waste (MSW), extractive waste (EW) from mining dumps and industrial landfills (Dino et al. 2016 & 2017). One of the key elements of the project was to identify in-depth characterization methods of the target pilot landfills as also environmental, economical and social impacts of LFM activity. Beside the traditional economic and environmental feasibility analysis, the demand and reason for conducting social analysis is more and more relevant. The landfill mining has effects on society through both environmental and economic aspects.

Metsäsairila MSW landfill was selected as one of the pilot sites in Finland where all the investigations were implemented during years 2016-2017 to find out potential of LFM activity in MSW site. Material content (metals, plastics, wood, paper and cardboard) as well as composition of fine fraction (<20 mm) was investigated. In addition to the material characterization, also the economical, environmental and social impacts of the LFM activity were evaluated for Metsäsairila MSW landfill.

2. Materials and methods

2.1. Metsäsairila MSW landfill site

Metsäsairila MSW landfill is located in the South-Savo Region of Finland, nearby the City of Mikkeli (amount of inhabitants is ca. 55 000). It has both active (currently in use) and old closed parts and it has been operating since beginning of 1970´s. The surface area of the closed part is around 8 ha while the active (operating) surface area is around 3 ha. The active area has received waste since 2007. Metsäsairila landfill mainly receives municipal waste, not industrial waste. In recent years utilization rate of waste has increased a lot so only less than 10 % of total waste received by the waste treatment centre is allocated anymore to landfill area. Landfill site is located ca. 7 km from city center and there are not many people living in surroundings of landfill.

2.2. Sampling campaign and analysis of samples

Research and sampling plans were implemented together with other partners in Smart Ground -project to characterize MSW landfills. One of the Finnish project partners, VTT, together with its subcontractor Ramboll Finland Oy organized the piloting activities at Metsäsairila MSW landfill in June 2016. In the beginning, samples were drilled vertically from the landfill by a hydraulic piling rig (Figure 1). Samples were lifted to the ground with an auger attached to the hydraulic piling rig, and moved to sorting point where they were manually sorted by sieves to different particle size categories (>100 mm, 20-100 mm and <20mm) and waste fractions (metals, wood, paper, cardboard, plastics, textile, soil and others). Analysis of the fine material samples (<20mm) for elements content was carried out by an

external laboratory (ALS Finland Oy, Finland). Other chemical analysis of sorted fractions was implemented laboratories of XAMK and VTT.

Image 1. Drilling of sampling hole in Metsäsairila landfill in June 2016 (photo by Ramboll Finland Oy)

2.3. Determination of environmental, social and economical impacts of landfill mining in Metsäsairila MSW landfill

Based on the experimental and general data available and the maturity of the theoretical SRM recovery technology, a scenario was developed to investigate environmental, economical and social impacts of recovery and market chances for SRMs in Metsäsairila landfill. For environmental assessment, standard life-cycle-analysis (LCA) approach has been used: standardised LCA models and inventories were created using the collected material and energy data. All assessments were specific to 1000kg reclaimed/extracted waste from the old landfill (referred to as functional unit). Social life cycle assessment (SLCA) considered similar methodology to environmental assessment (LCA), but with focus on social impacts. A methodology and a questionnaire were developed during the project to carry out the social assessment. The survey was implemented using an Excel file having dedicated worksheets for each stakeholder, such as landfill operator, owner of landfill or inhabitant living near of landfill.

3. Results

3.1. Main characterization results

Sorted fractions >100 mm and 20-100 mm which were combined from all sampling holes together consisted mainly from energy fraction (plastic, paper, wood and cardboard, 76 %), metals (5 %), soil (17 %) and others 2 %. Amount of fine fraction (<20 mm) varied from 37 % to 47 % depending on

the sampling hole. Mainly the fine fraction included soil material but also small particles of plastic, paper and wood were present. These are typical values for MSW landfills as compared to other studies (Kaartinen et al. 2013; Quaghebeur et al. 2013). Closed area of the landfill has waste around 960 000 t and currently active area around 180 000 t (Table 1). Based on the sorting results, for example, total amount of combustible energy fraction (wood, paper and cardboard, plastic and textiles) is around 400 000 t in old landfill area and around 75 000 t in currently active landfill area.

Main focus in MSW landfill mining should be collection and selling of certain metals (iron, aluminium, copper etc.) from >100 mm and 20-100 mm fractions and utilizing wood, paper, cardboard, plastic and textiles for energy production by incineration process.

Table 1. Estimated amounts of different secondary raw materials in Metsäsairila landfill

	Average in old landfill area (%)	Average in new landfill area (%)	Estimated total amount in closed landfill area (t)	Estimated total amount in active landfill area (t)
Metals	3,70	1,40	**35 474**	**2 513**
Wood	7,93	9,54	**76 088**	**17 181**
Paper and cardboard	6,39	5,92	**61 366**	**10 649**
Plastic	21,92	18,34	**210 430**	**33 021**
Textiles	5,78	7,94	**55 490**	**14 293**
Soil	11,66	9,45	**111 891**	**17 006**
Others	0,75	1,17	**7 169**	**2 103**
Fine fraction	41,40	46,25	**397 440**	**83 250**
Total	**100**	**100**	**955 348**	**180 015**

3.2. Environmental effects of LFM activity in Metsäsairila MSW landfill

According to chemical analysis of metals in fine fractions (<20 mm), sorted samples contained primarily compounds of Ba, Cr, Cu, Zn and Pb with low concentrations. Amounts of some precious metals, such as Ag, Au and In were also rather low as expected. Amount of organic content (total organic carbon, TOC) was in same range with similar studies done earlier (Quaghebeur et al. 2013; Kaartinen et al. 2013). Measured volatile organic compounds (VOCs´) from sampling holes in Metsäsairila MSW landfill included mainly toluene, hexane, ethylbenzene and p/m-xylene. Methane gas, siloxanes and H_2S released to air during LFM activity should not be neglected either. These landfill gases have negative effects on the environment and public health, such as explosive potential of methane and toxic impacts of VOC´s and H_2S.

It was also observed that fine fraction material did not contain harmful concentrations of leaching compounds. Thus, all the leaching criteria for EU-landfill for non-hazardous waste were fulfilled.

3.3. Economical and social effects of LFM activity in Metsäsairila MSW landfill

Regarding LFM activity impacts on economy and income (Figure 1), landfill operator thinks impact is highly negative. Based on the preliminary calculations, LFM activity would not be successful business because of lack of more valuable materials in MSW landfill and high investment and operational costs. Impact of LFM on land use and territorial aspects is slightly positive as also for demography. LFM would release more land for other purposes because of smaller space needed after excavation of waste from site. In operator´s opinion local population think that the landfill and LFM activity means minimal risk for health and environment. However, operator would put first lots of efforts to minimize risks related to mining activity on site.

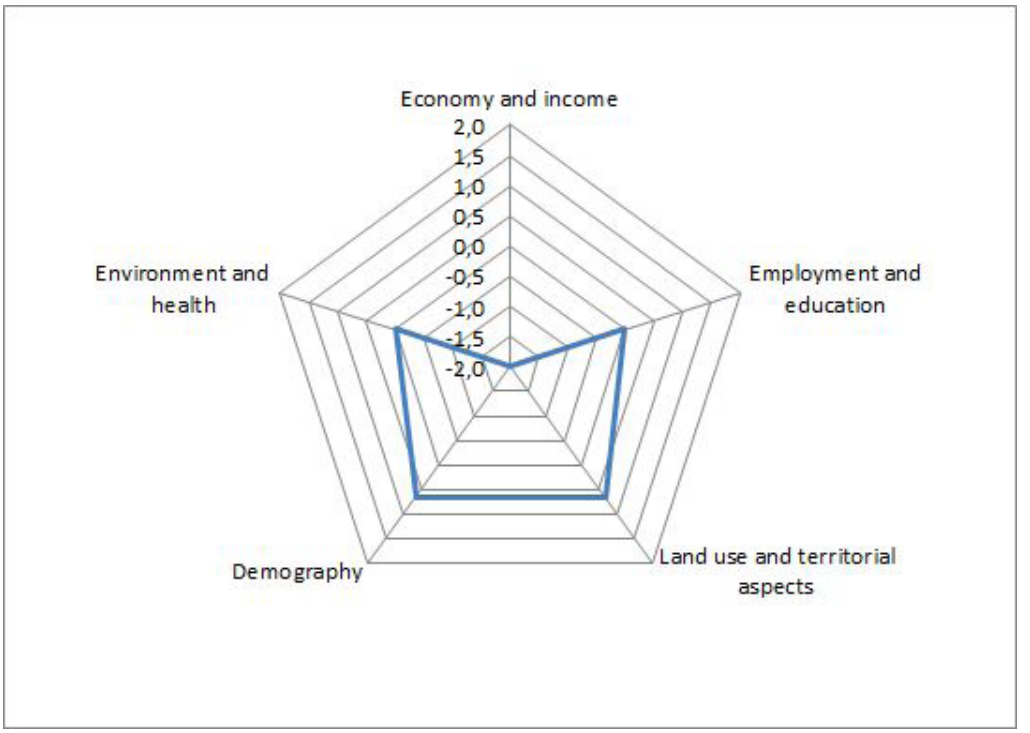

Figure 1. A spider graph presenting landfill operator's perspective on the impacts of the LFM activity

LFM activities would need significant improvement of infrastructure (roads, health and safety protection investments). Operator has made big efforts to compensate the negative effects of landfill (such as building noise barriers and water protecting systems for leachate waters and decreasing effluents to air) in recent years, mainly based on legal obligations. LFM activity would obviously need internal trainings for employees as also dominant qualification categories. However, operator thinks that LFM would not lead to significant changes in access to and power over local resources (land, raw materials). In addition, LFM would not lead to changes in the characteristics of the local population due to its effect on employment and local economy.

The expected overall social impacts of the LFM activity for SRMs excavation from Metsäsairila landfill are presented in Figure 2. The impacts on

economy and income, employment and education, land use and territorial aspects and demography are all slightly positive. Only the impacts on environment and health are considered to be slightly negative. There are mainly concerns how LFM activity will affect local water resources (lakes, rivers and swamps) and which kind of chemical emissions are released into air (including noise).

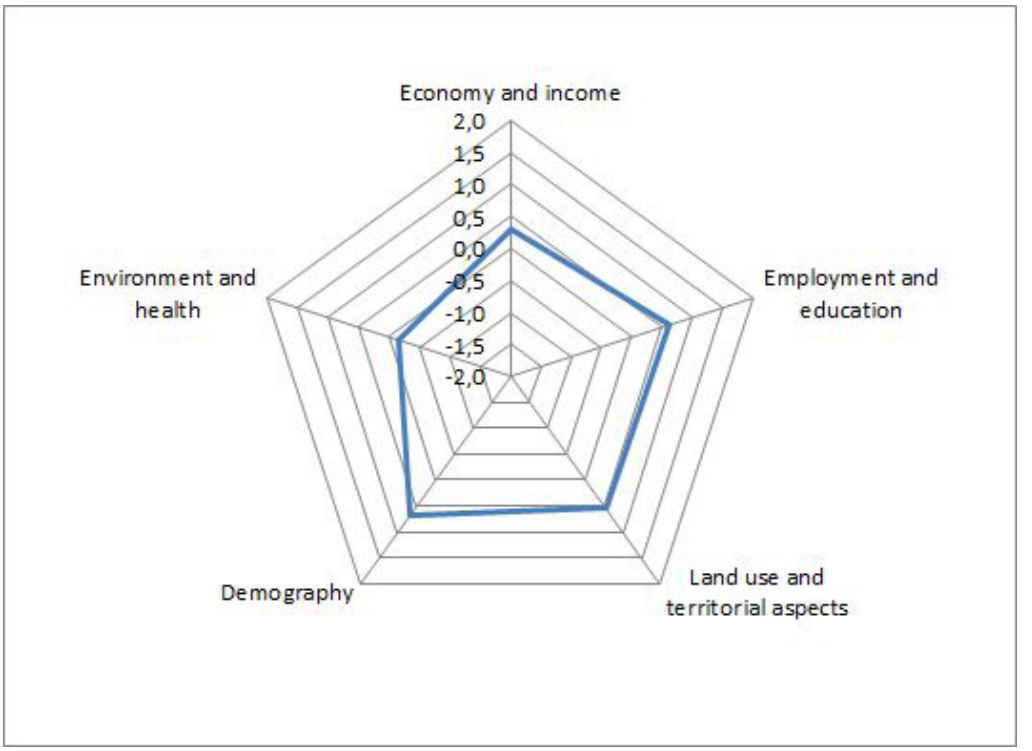

Figure 2. A spider graph presenting the overall social impacts of Metsäsairila LFM scenario

4. Conclusions and recommendations

Based on the characterization results the main fractions from the Metsäsairila MSW landfill site were the fine fraction (<20 mm), followed by the combustible (energy) fraction and the metallic products (ferrous and non-ferrous products). Thus, the economic viability of landfill mining could be increased by recovering additional material fractions such as plastics, paper, cardboard and wood for energy production. Ultimately, the mining and recovery approach leads to a further commercial opportunity in the land itself making it available again for housing or industrial estate development. However, it is possible that fine fraction and combustible fraction should be re-allocated back to landfill site because of their low quality as energy fraction or improver for soil (fine fraction). Even though landfills have the potential for both energy and material valorization, the development of a treatment plant with high resource recovery remains one of the technological challenges for further development of enhanced landfill mining.

During LFM activity, it is important to take into account differences in the composition and in the characteristics of the waste materials in different MSW landfills with regard to type, location and the operation

period. Impacts on air might be rather scarce but it is good to remember that landfill gases (methane, H_2S and volatile organic compounds) may cause health risk in landfill environment for people working there and living in neighborhood. As a consequence, it is anticipated that authorities will in most cases require an approved safety and health plan involving procedures for management of hazardous waste, systematic monitoring of air quality and how workers should be trained and equipped. There is also insufficient information available regarding pollutant emissions taking place after the landfill has been excavated; i.e., what are the long-term effects of landfill mining.

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Tanskanen, R. & Korpijärvi, J.

Promoting energy efficiency via renewable energy utilisation for small and medium-sized enterprises in the South Savo region Finland: Case of solar electricity

Best Practises & Case Studies

Abstract

The possibilities of small and medium-sized enterprises (SMEs) using solar power was studied in the South Savo region as part of a project called "Promoting energy efficiency in the South Savo region's small and medium-sized enterprises". The project aims at improving the energy efficiency of the local SMEs, as well as increasing awareness of forms of renewable energy in South Savo. In the study, the target group is represented by 14 local SME enterprises participating in the study. This study group was interviewed in order to find out their viewpoints on renewable energy utilisation possibilities. A total of ten enterprises, that is 71.4 per cent of the study group, indicated that they would be interested in utilising solar power, if it was economically feasible for them. The feasibility of solar power use for these ten enterprises was studied first by analysing their annual electricity consumption during 2017. The electricity consumption profiles of the enterprises were then compared with solar power systems to find each enterprise a potentially feasible size of solar power system to match their consumption. Furthermore, the profitability calculation took into account the price of the investment, the interest on the investment, the pricing of electricity, and the ratio at which the solar power would be utilised or sold to the grid. The profitability calculation also took into account possible governmental energy aid granted for low-carbon systems such as solar electricity. The results of the profitability calculation indicated that six enterprises out of the ten interested could utilise solar electricity in an economically feasible way. The limit for a feasible payback time in this study was considered as 10 years or less.

Keywords: solar energy, renewable energy, energy efficiency

1. Introduction

Finland has committed to a significant reduction in its carbon dioxide emissions during the coming decades (Government of Finland 2015). The targets are based on EU decisions (European Commission 2016; European Parliament and of the Council 2012) and are being controlled nationally by, for example, climate and energy-strategy measure programmes and legislation (Government of Finland 2012). Emission reductions are also

sought by using voluntary energy-efficiency agreements and energy reviews (Government of Finland 2014). In addition, renewable energy investment projects undertaken by companies and organisations are aided by the Finnish Government via Business Finland. The investment projects that are helped are those targeted at renewable energy utilisation and low-carbon technologies. In the case of solar electricity, the aid can be granted for 25 per cent of investments of 10,000–5,000,000 euros. The aim of the energy aid is to both enable the low-carbon strategy and to increase the use of renewable energies. (Business Finland 2018.)

The "Promoting energy efficiency in the South Savo region's small and medium-sized enterprises" project is aimed at promoting energy efficiency and renewable energies in the local SME sector. The core idea of the project is to enable SMEs in their energy efficiency work by offering them low-cost and easy ways to improve their energy efficiency. The first review of SME business premises may obtain even substantial savings for the enterprise. Furthermore, the project aims at creating information on how SMEs can increase their renewable energy use. This case study is part of the project's study involving specifically the possibilities of using solar electricity.

The target group of SMEs in South Savo are represented in the project and case study by 14 local enterprises. These enterprises operate in the business areas of the metal industry, wood processing industry, printing industry, restaurant and accommodation services, car service and related services, the food industry and retail shop services. The aim of this study was to demonstrate to the enterprises whether or not they should consider utilising solar electricity production.

2. Materials and methods

2.1. Target group interviews

The study began by interviewing the owners or CEOs of the enterprises taking part in the project. One area of interest was to find out the enterprises' views on renewable energies and the possibilities of increasing their use. The topic was approached in the interviews by asking about the enterprises' interest in utilising solar energy in general. Those of the enterprises who were interested in utilising solar power were asked if they were interested in solar electricity or solar thermal production. As a result, slightly more than 71 per cent of the enterprises participating in the project study disclosed that they were interested in solar electricity production. Furthermore, all of these enterprises said that if solar power proved to be a sound investment option from the economic point of view, they would consider investing in it.

Based on the interviews, the enterprises' possibilities for using solar electricity were studied in more detail. The two main areas of interest in the study, based on the interviews, was to find out how much of their electricity consumption could be produced by solar power, as well as whether the investments in solar power would prove to be a good prospect from the economic point of view.

2.2. Electricity consumption profiles and data analyses

The study case concentrated on discovering the electricity consumption profiles of each enterprise in 2017. The last annual consumption was, in many cases, the only reliable source of consumption information due to changes in energy consumption in recent times. Therefore, the electricity consumption of the enterprises was studied in detail both from the annual and summertime perspectives. The profiles were first studied from an annual perspective in terms of monthly consumption profiles. Furthermore, the hourly consumption between May and September was also analysed. The idea was to find out how much electricity each enterprise consumed during the summertime hours, when the main solar electricity production occurs.

The electricity consumption information was directly utilised as a basis for the optimal size for solar electricity system needed in each enterprise. The analyses assumed that 80 per cent of the solar electricity would be utilised by the enterprise itself, and the remaining 20 per cent would be sold to the grid. Even though the approach was to study a minimum consumption baseline (Motiva 2018), some of the electricity produced by the solar power will always exceed the producer's own consumption.

2.3. The investment in solar electricity system

In the study, the solar system investment and prising information was mainly obtained from the public solar electricity list prices of Lumme Energia Ltd and Etelä-Savon Energia Ltd. The case study calculation, however, assumed a ten per cent reduction in the list prices. The publicly available pricing information with the reduction in prices was accurate enough for the study's purposes, since the local companies also provided official offers to the enterprises. The detailed offer including the specific investment price would ease the decision-making in the enterprises, but the for the purpose of this study, the publicly available pricing data was sufficient.

2.4. The profitability calculation and cost analyses

The profitability calculation took into account the price of the investment and 3 per cent interest on the investment. The pricing of electricity was considered as being 13 cents per kWh, and the selling price for the electricity sold back to the power grid as being 3 cents per kWh. In the calculation, the electricity price was estimated to have an annual increase of 4 per cent. In addition, according to the electricity consumption profiles, generally 80 per cent of the solar electricity was assumed to go to the enterprise's own use and 20 per cent to be sold back to the power grid. There was one case where the enterprise's own use was assumed to be 95 per cent and only 5 per cent was to be sold back to the power grid.

The profitability calculation also took into account the possible governmental energy aid granted. This aid for solar electricity systems is

25 per cent of the investment cost when it exceeds 10,000 euros (Business Finland 2018). The profitability analyses also considered the limit for a feasible payback time to be 10 years or less. This is a common criterion used by Motiva Ltd in evaluating investment cost-effectiveness in energy audits.

3. Results

3.1. Main results on solar power profitability

The result of the profitability calculations and analysis indicated that the solar electricity system needed, in general, to be at least 10kW in peak power in order to be economically feasible. This general criterion was discovered to apply with the pricing information used, since only then does the energy aid of 25 per cent for these types of solar electricity system investments reach the threshold of 10,000 euros as a required investment. Investment costs lower than the 10,000 euros do not receive the energy aid. (Business Finland 2018.)

Furthermore, according to the profitability calculation performed for each of the ten enterprises interested in the possibilities of using solar electricity, six enterprises would receive the required payback time of ten years or less for their investment. Therefore, the result is that 60 per cent of the interested enterprises could utilise solar electricity and the investment could be considered as profitable from the economic point of view. All the groups of cases studied can be seen in Table 1 as average results.

Table 1. Average results of the solar electricity profitability calculation.

Number of study cases in a group	Size range of the solar systems	Production in the first year (avg.)	Investment price (avg.)	Production in the first year (avg.)	Internal rate return (avg.)	Payback time (avg.)
Group 1 (2 cases)	2000–3300 Wp	2 430 kWh	4 536 €	267 €	5 %	17 years
Group 2 (2 cases)	3400–7600 Wp	5 832 kWh	8 260 €	641 €	9 %	14 years
Group 3 (3 cases)	7700–11000 Wp	9 720 kWh	11 489 €	1 069 €	15 %	9 years
Group 4 (3 cases)	>12 000 Wp	51 840 kWh	61 277 €	5 848 €	16 %	9 years

As seen in Table 1, the sizes of the solar electricity systems varied, on average from 2 000 Wp to over 12 000 Wp, and their average prices varied between 4 536 and 61 277 euros. Furthermore, the solar electricity systems studied had average payback times from 9 to 17 years. In conclusion, the results clearly indicate that those studied cases where the investment price of the system did not exceed 10,000 euros did not prove to be profitable in terms of the payback time.

In addition, the study results indicate that if all the solar electricity systems found to be viable in the profitability calculation and analysis were built,

the solar electricity produced would replace 6 per cent of the current electricity consumption in the study enterprises.

3.2. Limitations of the study

This study case did not take into consideration certain factors that might have an influence on the outcome either from a negative or positive perspective. Firstly, the structural aspects of the solar system installation might vary to some extent from the calculated values, and this could influence the outcome of the results. Furthermore, in certain cases the solar system installation might not be possible to the extent considered in this study.

In addition, this study did not take into account certain factors that might make the solar system more profitable for those enterprises that could benefit from it in other ways, such as part of their environmental work or factors or company profile uplift. These types of factors might make the solar system more lucrative even though it does not seem that way according to the profitability study point of view.

4. Conclusions and recommendations

The aim of this study case was to clearly demonstrate the utilisation possibilities and economic feasibility of solar electricity installation to the enterprises participating in the study. The results indicated that 60 per cent of those enterprises interested in solar electricity utilisation could do so in a profitable way. The potential for sustainable electricity consumption would count for 6 per cent of the current electricity consumption in these enterprises. This potential could also be considered as future financial cost savings, when this ratio of electricity consumption was produced from solar energy. In addition, the low-carbon influence of this potential could be assessed separately for each individual enterprise participating in the study. The factors making solar energy desirable among the business owners were the possibilities of cost savings, energy self-sufficiency improvements, and possibilities in green marketing and new environmental management aspects.

The study results revealed a clear indication that the size of the solar electricity system should be at least 10kW peak power in order to be economically feasible. This information along with the restrictions of the energy aid can be utilised when assessing the possibilities of similar solar electricity systems in other SMEs. Energy aid provides strong economic support for those companies that can utilise it in their investments. Those enterprises that were not able to utilise this aid did not receive a positive indication from the profitability analysis.

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Co-combustion of horse manure and milled peat for energy production

Best Practises & Case Studies

Abstract

HevosWoima-project was carried out between March 2016 and February 2017, and the aim of the project was to study the potential of horse manure for energy production purposes in the South Savo region in Finland. As part of the project, a co-combustion test was implemented at a local energy production facility, where horse manure and milled peat were co-combusted in a fluidized bed boiler in 2016. The share of horse manure in the fuel mixture was tested for 10, 15 and 20 % in volume. The horse manure was wood cutter and shaving based stable-litter. In the study, the combustion gases were measured using a testo350 Emission Analyzer and the quality of the ashes formed during the combustion were analysed. In conclusion, the co-combustion turned out to be a very viable option for the local district heating facility both from the combustion gas and ash quality points of views. Furthermore, the results obtained from the study case indicated that the ashes formed during the combustion could possibly be utilised as nutrients.

Keywords: bioenergy, horse manure, fly ash

1. Introduction

Finland has committed to increase energy production from renewable energy sources until 50 % by 2030s (Ministry of Economic Affairs and Employment 2017). This ambitious target can be achieved if new renewable bioenergy sources will be obtained for energy production purposes. In Finland, horse manure has traditionally been utilised as nutrients in field cultivation. However, modern horse entrepreneurs do not always have suitable land for cultivation and manure utilisation. Therefore, the horse manure litter becomes a laborious and costly material for the horse entrepreneurs to utilise.

The objective of this pilot-scale combustion study was to receive information regarding the bioenergy potential of horse manure. The aim of the pilot tests was also to study whether horse manure could be used as a source of bioenergy locally in South Savo region. The pilot scale study consisted of a three-day combustion test run at a 8 MW sized local district heating facility, where the boiler operated on fluidized bed technology. In the study, the horse manure combustion was implemented using fuel mixture of horse manure and milled peat, where the outputs of the process could be monitored and measured. Additionally, the study investigated

odor nuisance that might occur during the horse manure storing, the combustion process success and ash qualities.

2. Materials and methods

2.1. The fuels used in the study

The horse manure for the study was obtained from a local horse stable, where the bedding material was wood-based chip and sawdust (see Figure 1). The horse manure in the study consisted of horse manure litter as it was collected from the stables. Therefore, the horse manure sample batch consisted of the actual manure, bedding material litter and urine. The litter material may also contain small amounts of residue food, such as hay and barley. In addition, the wood-based horse manure was selected for the combustion study, since this type of litter was available in the area from the stables taking part of the study. The downside was, that the horse manure batch collected for the study was relatively high in moisture contents (62,8%), since it came from a manure storage without roofing directly after a rainy period in October. The milled peat used in the combustion study was obtained through the district heating facility's own fuel supply. (Tanskanen et al. 2017a.)

Image 1. Sample of the wood-based horse manure litter used in the study. (Photograph by Riikka Tanskanen 2016).

In the combustion study, the fuels were mixed in order to form mixtures of 10 %, 15 % and 20 % in horse manure according to volume. The fuel mixtures were delivered at the site by a tractor-trailer transport. (Tanskanen et al. 2017a.)

The sampling from the fuels were done according to standard SFS 14778, and the samples were mainly analysed by an accredited laboratory. South-Eastern Finland University of Applied Sciences performed the analyses of densities and particle sizes. The samples were dried according to standard SFS-EN 14774-2, the densities were determined according to SFS-EN 15103, and the particle sizes were determined according to standard

SFS-EN 15149-2. (Tanskanen et al. 2017a.)

2.2. The quality of the flue gases

Each of the horse manure sample size was run for 24 hours at the district heating facility. The composition of the flue gas emissions were analysed using testo350 Emission Analyzer. The measurement point in the flue duct was directly after the electrostatic precipitators before the outlet duct (Tanskanen et al. 2017a).

2.3. The quality of the ashes formed

Samples of the fly ashes and fluidized bed ashes were analysed to determine their quality. The sampling was done according to standard SFS 14778, and the samples were analysed by an accredited external laboratory. The fly ashes quality was determined according to SFS-EN 12457-3, where the result indicates if the waste can be landfilled. The fluidized bed and fly ashes were analysed mainly for the heavy metal contents to see whether they could be utilised as fertilizers. Moreover, the densities of the ash samples were determined by South-Eastern Finland University of Applied Sciences according to SFS-EN 15103 standard. (Tanskanen et al. 2017a.)

2.4. The observations on odours control

The odours during the pilot scale study were monitored and recorded by the personnel working at the district heating facility. The group consisted of 11 individuals, all of whom observed the ambient odours during the study. The study group reported their observations by writing, where they were asked to report any noticeable ambient odours. (Tanskanen et al. 2017a.)

3. Results

3.1. Properties of the fuels and process success

The combustion scale study was carried out as planned, and the combustion process operated normally with the fuel mixtures used. During the pilot scale study, the district heating facility was operated as usual by its own staff. The only difference compared to normal situation was that the facility consumed a bit more fuel in volume when compared to the normal operation. The reason for this may be seen in Table 1, where the heating values of the fuels are presented. Horse manure contains roughly the half of the energy of the milled peat, which led to the increase in the fuel consumption. The pilot scale combustion study consumed altogether around 60 m^3 of horse manure that equalled to 20 tons. The amount of horse manure litter consumed corresponded to the environmental test permit received from the local authority. (Tanskanen et al. 2017a.)

Table 1. The characteristics of horse manure and milled peat used in the combustion study (Tanskanen et al. 2017a).

Analysed quality	Wood-based horse manure litter properties	Milled peat properties
Density of the material (SFS-EN 15103)	334 kg/m^3	380 g/m^3
Moisture contents (%) (ALS Finland Ltd. 2016)	62,8 %	47,5 %
Lower heating value, heat of combustion $Q_{net,ar}$ (ALS Finland Ltd. 2016)	4,88 MJ/kg	10,1 MJ/kg
Energy contents as lower heating value (SFS-EN 15103; ALS Finland Ltd. 2016)	0,47 MWh/i-m^3	1,13 MWh/i-m^3
Ash contents in dry material (SFS-EN 14775)	11,2 %	7,45 %

Characterization and analysis seen in Table 1 were performed by an accredited laboratory apart from the material density, which was measured at the South-Eastern Finland University of Applied Sciences. According to Table 1, both of the fuels were relatively high in moisture contents, but they differ from each other in lower heating values and in ash contents. (Tanskanen et al. 2017a.)

3.2. Flue gas composition and particle contents measured

The flue gas emissions measured during the study may be seen in Table 2, where the measured results for residue oxygen (O_2), carbon monoxide (CO), nitrogen oxides (NO_x) and sulphur dioxide (SO_2) are represented along with boiler power (MW) used. Results presented in Table 2 corresponds well in studied process, since the outdoor temperature dropped during the study period of four days, which led to increase in boiler power used. In the beginning of the study period, the temperature was around 0 degrees Celsius and dropped below zero degrees Celsius in the end. (Tanskanen et al. 2017a.)

Table 2. The flue gas emissions measured with testo350 Emission Analyser and the power of the district heating facility. The emissions are given in unit milligrams (mg) per megajoules (MJ) produced apart from residual oxygen, which is given as percentage (%) in the flue gas. (Tanskanen et al. 2017a.)

Fuel mixture	Milled peat (100 %)	Horse manure 10% and milled peat	Horse manure 15% and milled peat	Horse manure 20% and milled peat
Boiler power (MW)	4,88	5,06	5,60	5,80
O_2 (%)	6,68	6,50	6,54	6,50
CO (mg/MJ)	53,4	55,03	91,88	81,16
NO_x (mg/MJ)	131,93	147,65	122,62	110,11
SO_2 (mg/MJ)	129,32	108,29	104,02	99,67

The results in Table 2 indicate that the emissions of sulphur dioxide (SO2) and nitrogen oxides (NO_x) decrease when the ratio of horse manure increases. The sulphur dioxide decrease may be due to the natural sulphur contents in milled peat (Alakangas et al. 2016). Therefore, as the ratio of milled peat in the fuel mixture decreased, quantity of sulphur dioxide emissions was decreased accordingly (Tanskanen et al. 2017a).

3.3. The results on fly ash and fluidized bed ashes analysis

The analysis of the ashes revealed that the fly ash from the combustion study was categorised as common waste according to Finnish Government Degree 202/2006 threshold values. In addition, both the fly ash and fluidized bed ash fulfilled the requirements set by Evira for land mass utilisation in civil engineering, as well as, nutrients utilisation in forestry and other uses. Furthermore, the ashes obtained from the fuel mixture containing 20 % horse manure were also analysed for potassium (K) and phosphorus (P) contents at ALS Finland Ltd. These results are presented in Table 3. (Tanskanen et al. 2017b.)

Table 3. Potassium (K) and phosphorus (P) contents of the fly ash and bed ash from fuel mixture of 20 % horse manure and 80 % milled peat in volume according to ALS Finland Ltd. 2016 analyses (Tanskanen et al. 2017b).

	Potassium (K) content (mg/kg)	Phosphorus (P) content (mg/kg)
Fly ash results	9 730	7 460
Bed ash results	1 170	2 110

The results in Table 3 are essential when considering the qualities of the ashes for a possible use as a fertiliser. The ashes originating from combustion of animal residues must have a minimum of 5 % when potassium (K) and phosphorus (P) are summed up as K+P (Evira 2018). According to Table 3 results, the fly ash can be used as a fertiliser, but the bed ashes do not fulfill the requirement. The requirements set by Evira for animal residue combustion ashes additionally states that if phosphorus content exceeds 2,2 %, cadmium (Cd) content may not exceed 50 mg for every kilogram of phosphorus (P). (Tanskanen et al. 2017b.) The physical appearance of the ashes is presented in Figure 2.

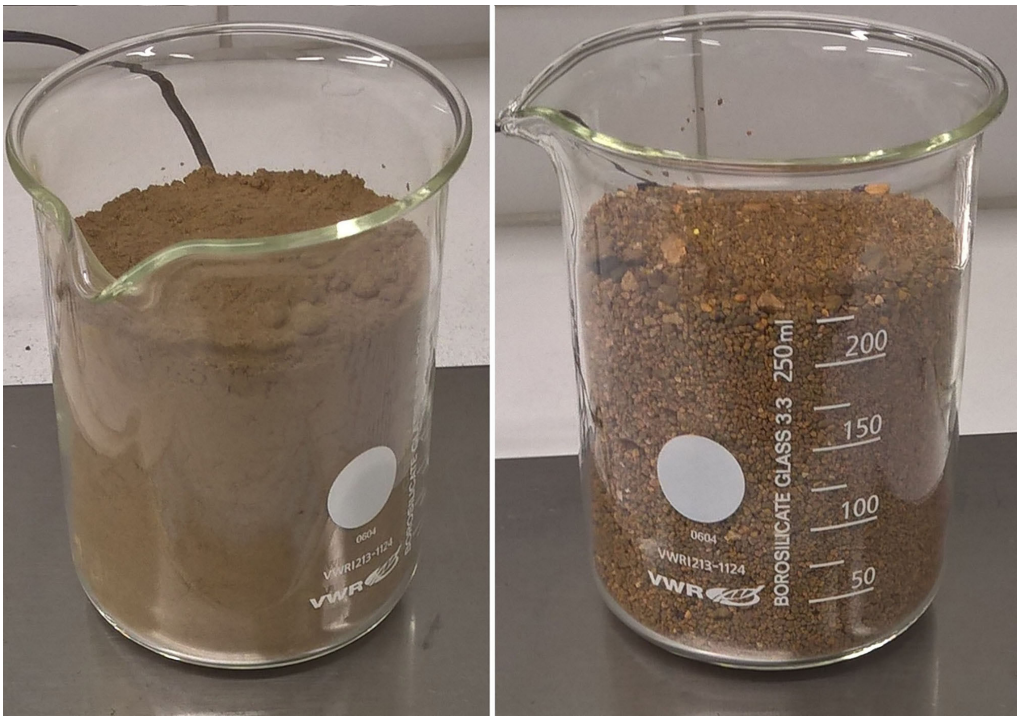

Image 2. The ashes formed in the combustion study. On the left side a sample of the fly ashes, and on the right side a sample of fluidized bed ashes. (Photographs by Riikka Tanskanen 2016).

3.4. Results from the odors detection

The study site was located right next to a food industry facility and housing areas. Therefore, the odour detection was important during the study.

The study mimicked the normal fuel logistics, and the ready fuel mixtures were then transferred to the study site. The storage time at site was less than 24 hours, since the fuel batches transferred where fed directly in to the fuel silo connected to the process.

The odor detection by 11 people did not reveal any foreign smells in the surroundings of the district heating facility. Each participant reported the same observation. As a mixture, the horse manure did not give out any detectable smell. Therefore, the fuel mixture of horse manure and milled peat did not release any smells during the short time storage or in the combustion. Furthermore, there were no reports of foreign smells in the area. As a conclusion, the test study did not release any noticeable smells to the surrounding area. (Tanskanen et al. 2017a.)

4. Conclusions and recommendations

The objective of this pilot-scale combustion study was to gather knowledge on the possibilities of horse manure act as a source of bioenergy. The study consisted on combustion tests using fuel mixture of horse manure and milled peat at a local district heating facility, where flue gas emissions to air were monitored and the quality of the formed ashes were analysed. In addition, the odors from the combustion tests were observed.

The results obtained from the study were promising, since the process worked well with the fuel mixture. In addition, the flue gas emission for sulphur dioxide (SO_2) and nitrogen oxides (NO_x) were lower when using the tested fuel mixture in comparison to plain milled peat combustion. Furthermore, the quality of the ashes formed in the combustion tests were good. The fly ash was suitable to be landfilled as a common waste (Government Degree 202/2006), and both the fly ash and the fluidized bed ash could be utilised as material in civil engineering (Government Degree 591/2006), nutrients in forestry and other purposes (Evira 2018).

Based on the odor detection, the tested fuel mixture did not release detectable amounts of odors when stored at site or combusted.

Based on the results achieved, the fuel mixture could be used as fuel in the studied site. However, the possible side-effects of the fuel to the process and components should be studied further. Duration of the pilot study was only three days, which does not give any relevant information on long-term results or possible effects on the process. Therefore, these factors should be investigated in more detail before making permanent changes in fuel composition used.

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An Environmental Archive for the Promotion of Environmental Safety and Low Carbon Practices

Best Practises & Case Studies

Abstract

South-Eastern Finland University of Applied Sciences has developed electronic archiving to promote environmental safety and decarbonisation. During the development work, the South Savo region's strengths and possibilities with regard to the collection, processing and utilisation of environmental data were better identified than before. The development work included co-operating with, for example, the South Savo Centre for Economic Development, Transport and the Environment, City of Mikkeli, and the waste-management company Metsäsairila Oy.

The electronic Environmental Archive assists in the study and development of geographical information-enabled possibilities for information management and traceability of materials. This allows for more efficient utilisation of valuable materials, a part of which currently remains almost completely unused, for replacing virgin raw materials. Implementation of the archive has an immediate effect on the improved traceability of waste materials to be utilised in regional earthwork sites, and on improving the efficiency of decision-making and planning.

Environmental Archive assists in identifying and decreasing the region's environmental risks, in directing the operations of the region's businesses in order to safeguard the environmental conditions, and also in making the company's operations, use of resources and competitiveness more efficient. Information that is more detailed than before and in simultaneous use by multiple operators creates a foundation for protecting the environment better.

Keywords: environment, environmental safety, electronic archiving

1. Introduction

The development of environmental data's electronic archiving and digital service operations for the promotion of environmental safety and low carbon practices - The Environmental Archive project was carried out in South-Eastern Finland's University of Applied Sciences, in the Faculty of forestry, environment and energy. The aim of the project was to increase the later traceability of waste materials utilised at earthworks sites. The project promoted this by developing electronic archiving and digital service operations for traceability purposes.

During the project, the properties and usability of existing environmental data was clarified. The data was used as a data source for the dataset of an interactive map and the Environmental Archive. An environmental archive application was designed and created in the project and the piloting and demo use of the Environmental Archive was implemented, and their usability as well as their ability to be duplicated was assessed with the target group during the project.

The Environmental Archive allows the environmental risks of the area to be identified and reduced, as well as allows the management of business operations to safeguard the environmental conditions, and to enhance the company's own operations, use of resources and competitiveness. Data that is available in an even more detailed manner, and to multiple operators at once, also provides the foundations for protecting the environment.

2. Environmental Archive

2.1. Piloting progress

To test the application, the data of 337 geographic features in the area of Mikkeli was collected. The data was based on the Soil Condition Database MATTI. The MATTI database contains land areas, where soil treatment operations are being carried out currently or have been carried out previously. Those are the areas, where may have been a leak of harmful substances into the soil. Also the areas which have been surveyed or cleaned up already are in the database. (Metatietopalvelu 2012.) The initial data also included documents collected from various sources.

The environmental data to be collected to the Environmental Archive consisted of the geographic features' location and event data, permit decisions and operational and research reports. The material has been distributed among different authorities, and there is no existing common material bank. Authorities that grant permits and issue decisions include the ELY centres, Regional State Administrative Agencies and the environmental protection authorities of municipalities. Research and operational reports are in use by companies, municipal authorities and consultants. (Tuominen et al. 2017.)

In the piloting of the environmental archive application, the opportunities of use for the currently available register details were studied in terms of archiving, and particularly the utilisation of archive data with the help of various search functions that combine the archive and map portrayal. The observation sites of the pilot area have been portrayed in the map in Figure 1. The same figure also presents an overview of the Environmental Archive's user interface. The geographic features' data is available in a table view at the left edge, which provides access to filtering, sorting and selection tools as well as documentation related to the geographic feature. The selected geographic features can be viewed on the map view at the right edge, in addition to which information in the documents concerning the geographic features can be searched below the map.

The archive application can either be used on a data basis via the table

view, or visually with the map background. The components have, however, been connected in such a way that the geographic features in the table view can be found on the map and the geographic features on the map can be viewed in the table view. This is a typical operating method for geographic information systems.

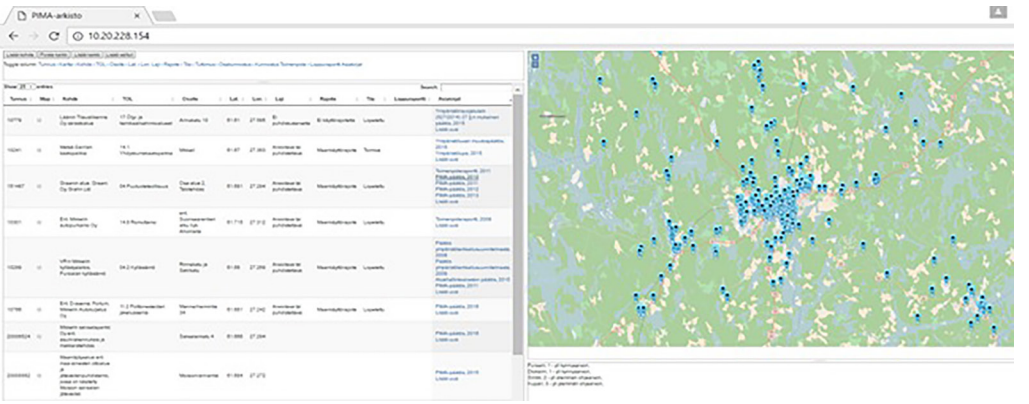

Figure 1. User interface of the Environmental Archive, where the contaminated land features in the vicinity of the pilot area are presented in map view (Hannus et al. 2017).

It should be noted that the majority of the data has been manually entered, so it may contain errors, such as spelling mistakes or data that has been entered in the incorrect field. The actual location and scope of geographic features are difficult to estimate in case of point-like geographic features.

During the piloting, the documents concerning the geographic features were searched for data on contaminating substances as well as data on exceeding threshold and limit values for each substance. Technically speaking, there is nothing to prevent other necessary data from being collected from the documents to be presented. The documents are not computer-legible to the extent that the search for data could be carried out without a person completing the search. In some cases, the search for data from documents can be automated.

In terms of the use of the environmental archive application, it is significant to note the type of user environment it is for. Fedora Commons archiving software is used in the Environmental Archive, to which information and documents related to the data are stored. The archive software can be operated with existing data systems, such as geographic information databases. The prototype of the environmental archive application, which was developed during piloting, presents some opportunities for data searching and processing. The user interface and connections to other software can be tailored to meet user needs if necessary.

In general, it can be stated that geographic data tools naturally have a lot of functions required for the implementation of this project, such as search opportunities, measurement and analysis tools and production methods for new data. The combination of data and datasets is also natural for geographic data. Part of the pilot work was completed with a geographical data add-on to the office software, part with a cloud service application

and part with solid workstation software. This also enabled experiences of different types and different levels of geographic data tools. Hereinafter, these shall be commonly referred to as a "geographic data platform".

During the piloting, all of the observation material was imported to the geographic data platform. The database of the archive application described above was used as the data source, in which geographic features have a point-like spatial attribute in the same way as in the MATTI database. The features in the geographic data platform could be e.g. searched, categorised, summarised and portrayed by means of e.g. colours or symbols according to their register information and/or locations, as well as connected to other datasets (Figure 2). The same dataset can also be portrayed quickly and easily in different ways according to needs.

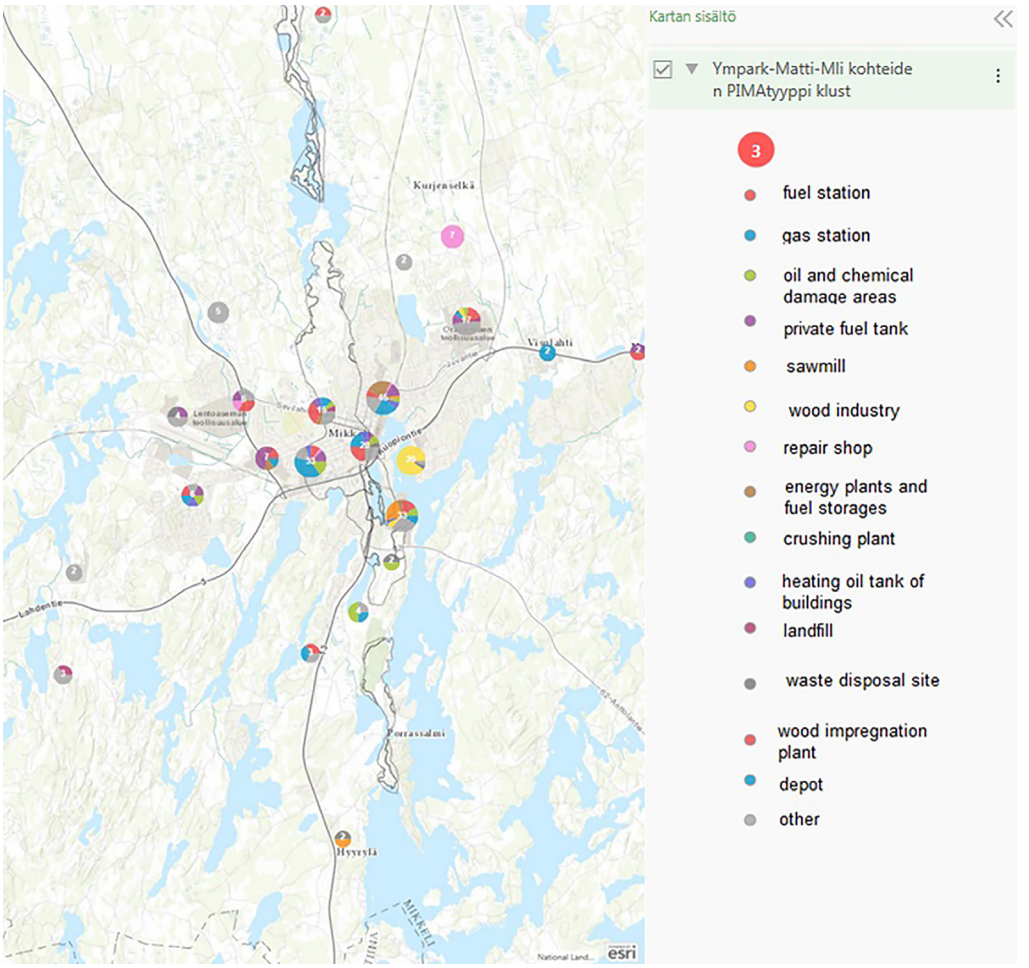

Figure 2. Summary of the number of Mikkeli's contaminated land features per surface and visualised per feature type, as well as connected as groundwater area material (Hannus et al. 2017).

However, the point-like nature of the features and the uncertainty of point locations restricted the wide-scale use of normal geographic data functions. For example, a point does not indicate the true dimension of a feature, in which case e.g. distance measurements and other similar automatic analyses, which could be carried out with geographic data tools, would provide an incorrect result (Figure 3 left). The locations of

different parts of a geographic feature cannot be clarified in a point-like portrayal method (Figure 3 right). Since the register points describe the entire feature, no data can be attributed to parts of a feature, and the dataset does not clarify whether a stored piece of data applies to the whole feature or only part thereof.

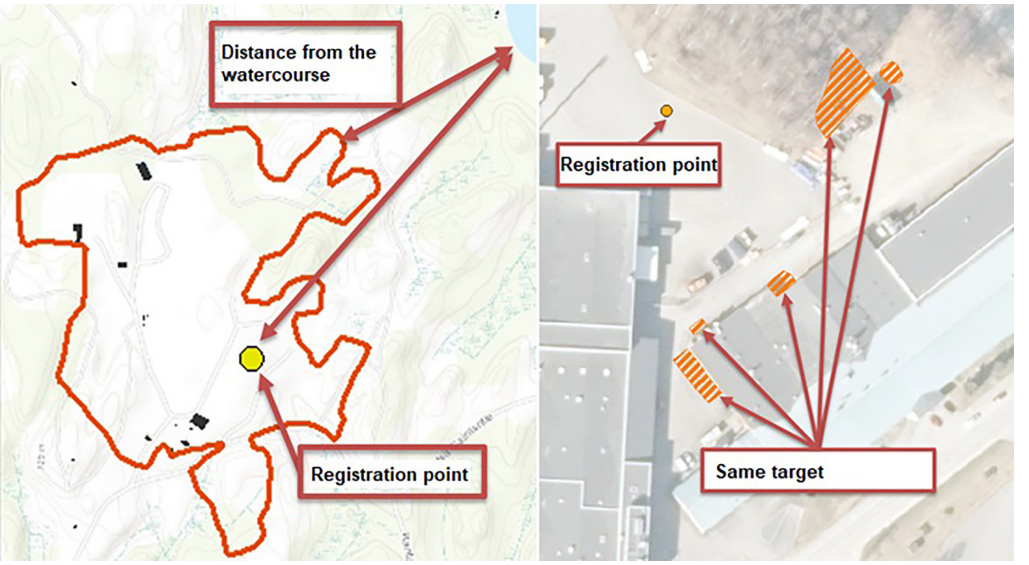

Figure 3. Point-like feature information reduces the ability to perceive feature dimensions (left) and parts (right) (Hannus et al. 2017).

In addition to the archive, application's register points and attributed documents, several geographic datasets related to the relevant surface were imported to the geographical data platform as a planar structure. These datasets included the National Land Survey of Finland's Topographic Database and orthophotos, the Finnish Environment Institute's groundwater and surface water datasets, Geological Survey of Finland's soil maps, City of Mikkeli's base map and e.g. population statistics. In addition, old aerial photos were used, which were obtained during the project, which cannot be utilised as a map layer with other datasets without rectifying them in to orthophotos. Where necessary, the datasets were converted in to a suitable coordinate system as a normal geographic data function. The application can be easily utilised any geographic datasets, which are available for visual inspection, as well as computational measurements and analyses. (Hannus et al. 2017.)

Not all this useful data about a plot feature existed in a geographic data format. These include, for example, previously mentioned sub-surfaces of geographic features and data related to them, which are more accurate than register points. Renovation plans and reports for completed renovation work on the plot feature were available in PDF format. These also included work drawings of the feature's sub-surfaces. During the pilot, the work drawings were imported as raster images to their own layers in the geographic data platform as well as placed in the coordinate system, after which the sub-surfaces of the feature were screen digitalised in to surface-like geographic data features, for which other sub-feature related data was also entered. The operations were carried out manually, although

the screen digitalisation was computer-assisted. The documentation of the geographic feature was manually used to produce new, more detailed geographic datasets. Figure 5 shows an example view of a plot feature on the geographic data platform.

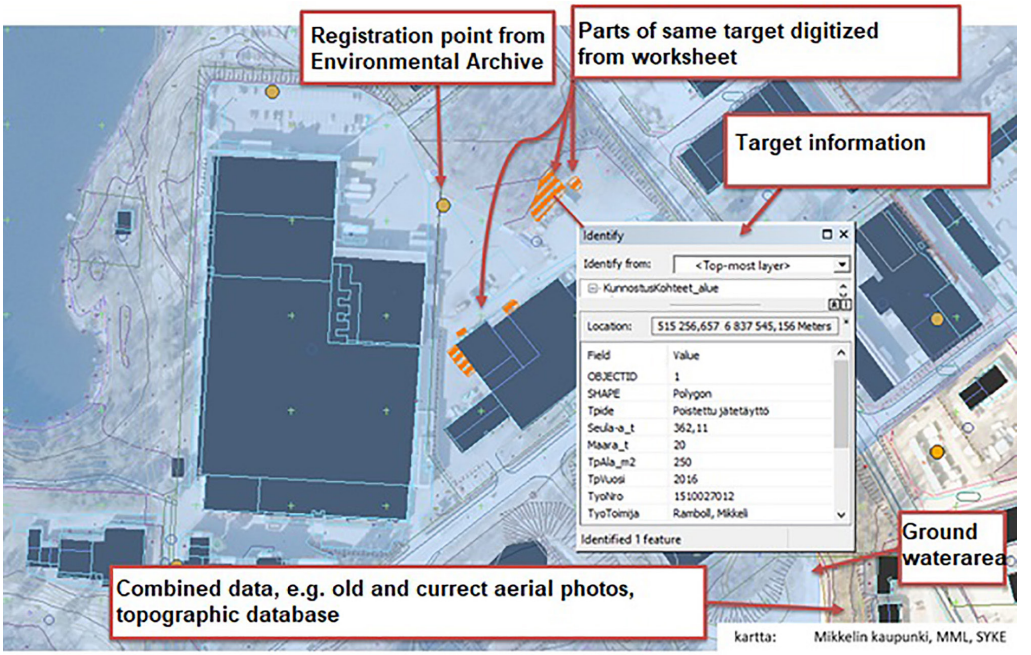

Figure 4. Pilot feature on the geographic data platform (Hannus et al. 2017).

2.2. Application feasibility

Feedback on the Environment Archive's user interface and its functions was collected during the Environment Archive's piloting. The visual map interface was considered more intuitive and easier to approach than the table view of data. The map interface was hoped to be made the primary view. For example, the most often used functions in the map interface can be made in to e.g. various function buttons, context and pop-up menus. The advantages of the table interface are apparent in more advanced use, for example, in sorting functions.

The visibility of exceeding the threshold and limit values of contaminating substances was considered good, but specific measurement values of the contaminating substances' concentrations were hoped to be made visible. The threshold and limit values were chosen to be presented, because the geographic features are easy to classify based on exceeding these values, for example, for sorting, filtering and portrayal purposes. In terms of piloting, it is good to know that there is a need for more specific feature data. This indicates that the system should be tested and tailored to meet users' needs.

The compatibility of existing data systems and workflow raised discussions. Data from existing systems would be good to be able to be used when reviewing the data of features. Additionally, if there were

already geographic information systems in use, for which employees have been trained, and which provide advanced visualisation and analysis tools, it would be good for the features' data to be able to be used in these systems.

3. Results

During the pilot, the properties and usability of available environmental data was clarified. The data was used as a data source for an interactive map dataset and the Environmental Archive. The implemented pilot work allowed the usability and copying ability to be assessed.

The pilot subjects and the documents, data and datasets made available in them, allowed both the archive application and the geographic data approach to be tested. The functionality of the archive application was tested and demonstrated. Datasets and feature data were collected in to the geographic data platform as an interactive map dataset. It also enabled the use of the archive application as a geographic data source to be tested.

The pilot work did not allow the familiarisation in the opportunities and requirements of partners' data systems and software. In this development project of information system, it was important in terms of work effectiveness that the information systems supported and reformed work processes. The pilot presented some suggested solutions for utilising the data of geographic features, but these solutions must be reviewed from the perspective of the subject organisation's operations.

If necessary, the archive application can be used as a data source for a geographic data platform. Respectively, more geographic data functions could be built in to the archive application and e.g. more accurate and diverse feature storage than points could be enabled, by further developing it. At the moment, this requires manual work in terms of information, or a change to the entry process as well as the use of geographic data tools. By combining the drawings and information of various reports, as well as other datasets, a better overview of the geographic feature's condition can be obtained.

4. Conclusions and recommendations

If the organisation already has geographic data tools in use and staff operating with them, procedures like the pilot work can be implemented relatively easily. The procedures related to the sub-surfaces of a feature, as described in the pilot, do not require an unreasonable amount of time in comparison to the benefit they provide. Data production could be implemented by means of a wide-scale digitisation project, or e.g. in stages, in connection with features that require acute processing. In addition, it can be assumed that the drawings would be directly available as geographic data features in cases such as those, where a consultant with CAD or a geographic information system software has produced the work drawings. In this way, it would be possible to collect individual survey points or procedure surfaces to cover, say, the entire area of Mikkeli, as

geographic datasets that are more accurate than point data.

On the basis of interviews and discussions, the Environment Archive application was deemed to be useful for its purpose. Although direct file transfers between different systems could not be tested during the pilot, the application has the readiness for this procedure. For example, the work of officials is facilitated by the fast visual analysis, enabled by the archive, which can be used to specify the placement of a certain feature in relation to other features and waterways. In addition, the easy findability of documents attributed to the feature provides time and cost savings. With the help of the Environment Archive, several companies and public administrative operators can view the feature's information and documents, as well as add new information each time a new report is completed, in which case the current situation of the surface is known. The Archive provides the option to combine locations and information, in which case sample points can be placed on the map, and obtained test results can be attributed to them.

The electronic archive allows the opportunities of material traceability and data management provided by geographic data to be reviewed and developed. This enables more effective use of valuable substances, a part of which currently remains almost completely unused and which can be used to replace virgin raw materials. The deployment of the archive has an immediate effect on the improvement of traceability of waste material to be utilised at earthworks sites, decision-making, and design efficiency.

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