Sustainable HCI and Encouraging Retrofitting

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ABSTRACT
Sustainable HCI has seen a large growth in the amount of research taking place in the field. However, are we taking the most effective route to generating sustainable sustainability? In the Sustainable HCI community, a large focus of the research has been on persuasive psychological techniques to change individuals’ behaviours to be sustainable. Nevertheless, individual behaviour change has limited energy saving potential, and can be hard to sustain. Therefore, in this paper, we propose an area of research - which has had limited focus so far in the Sustainable HCI community - namely encouraging retrofitting of buildings to be more efficient and sustainable. This field has larger and more sustainable potential energy savings, but sets a unique challenge to the Sustainable HCI community which is very different in character from the traditional focus on everyday behaviours and habits, as retrofitting requires a considerable commitment, from both, individuals and society.

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Sustainable HCI; Energy Efficiency; Retrofitting; Persuasive Sustainability; Sustainability

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H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous. K.4.m Computers and Society

INTRODUCTION
The EU has committed to a 20% reduction in its greenhouse gas emissions and to achieving a target of deriving 20% of the EU's final energy consumption from renewables sources, both by 2020 [12]. This is going to generate a unique challenge to all the member states involved, and it is going to provide some great opportunities for academics and industry experts working in the growing field of Sustainable HCI. The Sustainable HCI community has acknowledged that mankind can’t keep carrying on with its current unsustainable behaviour around energy, and, since Blevis [2] first coined the term “Sustainable Interaction Design”, we have learnt how Sustainable HCI could have the potential to help change cultural attitudes, beliefs and habits. However, are we focusing our Sustainable HCI research on the most effective method to reach our targets? DiSalvo et al. [7] highlighted that about 45% of the Sustainable HCI corpus is based on persuasive technology, and in the investigation of persuasive sustainability papers performed by Brynjarsdottir et al. [3], it was found that 50% of the papers were related to energy consumption. These facts show the large focus the Sustainable HCI community has put on using persuasive technologies to reduce overall energy consumption. Meanwhile, Pierce et al. [25] have highlighted that Sustainable HCI needs to go beyond isolated interactions between humans and computers, and start to include the more social practices involved. However, we feel that it needs to go further, and start to look at the larger operating environment surrounding the individuals. Therefore, throughout this paper we look to argue the fact that there is an application of research within the Sustainable HCI community which has been under researched: Retrofitting. Focussing effort on retrofitting could help the Sustainable HCI community realise a much greater reduction in the overall greenhouse gas emissions generated, in both the domestic and commercial energy markets, and help European countries meet their emissions targets.

In this paper, we first set the scene by reviewing the current sustainable HCI landscape; secondly, we define the reasoning behind choosing to focus on retrofitting and show the benefits it could have to the Sustainable HCI community; and finally we look at how sustainable HCI can support retrofitting.

THE SUSTAINABLE HCI LANDSCAPE
In recent years there have already been a number of studies which review the state of the Sustainable HCI landscape. One of the first was the research completed by Goodman [13], who highlighted three core areas of environmental discourse: sustainable interaction design, re-visioning consumption and citizen sensing. This research was then further developed by DiSalvo et al. [7], who took the three core discussion topics and explained them into five genres of Sustainable HCI:

1. **Persuasive technology** — The research focuses largely on the use of psychological techniques to drive individuals to change their behaviour towards a more sustainable level. The genre is grounded by the research completed by Fogg [9]. The genre has drawn a large focus of attention, and Brynjarsdottir et al. [3] undertake a review of how persuasion is used within sustainability.

2. **Ambient awareness** — Tries to draw the individual’s attention to the topic of sustainability through the use of visualisations. Ambient awareness can come in two types [7]: direct visibility, which draws the users attention to the unsustainable behaviour (two examples of this include the Power-Aware Cord [14] and the Energy Orb [8]); and desired visibility, which looks to highlight the desired behaviour through visualisation.

3. **Sustainable interaction design** — Firstly, defined by Blevis [2], it looks to push sustainability through industrial de-
sign philosophy, which drives a change to manufacturing, use and disposal practices [13].

4. Formative user studies — This takes a more bottom-up approach, through trying to understand the householders’ and users’ cultural values, beliefs and norms towards being sustainable. The research focuses more on the assessment of the users’, rather than directly looking to change their behaviours and actions.

5. Pervasive and participatory sensing — Burke et al. [4] define a clear and concise definition for participatory sensing:

“Participatory sensing will task deployed mobile devices to form interactive, participatory sensor networks that enable public and professional users to gather, analyse and share local knowledge.”

Along with the development of low cost mobile devices, we are also seeing a increase in low cost sensors, which are now collecting data from a wide range of sources, including: body movements [23], home temperature [22], and sleep quality [15]. This rise in low cost mobile devices and sensors is allowing the Sustainable HCI community to implement more adventurous citizen science projects. Examples include the Sensonomy project by Miyaki and Rekimotot [21], which looks to evaluate air quality; and the Close the Door project by Massung et al. [19], which uses mobile devices to highlight when local shops leave their doors open.

The five genres laid out by DiSalvo et al. [7] provide a good overview of Sustainable HCI. However, their research does highlight the large focus on changing individual ongoing behaviours through persuasion. In the sub-genres of sustainable HCI, there is little mention of persuading individuals or groups to change the physical properties of their environment, or consideration of one-off large decisions which impact the environment. Mankoff et al. [17] split the concept of Sustainable HCI into two devisions:

1. Sustainability in design — this is focused on how we can design the physical products around us to be more sustainable, and is closely related to sustainable interaction design, but looks into more detail at the life-cycle of the products.

2. Sustainability through design — this involves looking at how the products we develop can support a more sustainable lifestyle and help individuals make the right sustainable decisions. Sustainability through design includes the persuasive technologies, ambient awareness and the participatory sensing genres from DiSalvo et al. [7].

The research by Mankoff et al. [17] is interesting, as we feel that the Sustainable HCI community is focusing too much of their attention on sustainability through design that encourages individuals to change their behaviour, while more focus should be placed on using sustainability through design to get individuals and groups to change the design of their environment (sustainability in design). In changing this focus it will also cause the individuals and groups to become the designers of their own sustainable environment. As Kaplan [16] illustrated, allowing individuals to participate is a key element in behaviour change.

In conjunction, if we can encourage individuals to think of sustainability in the design of their household and in their environmental choice around products, we can start to generate sustainability which is more durable; this is where we feel the application of retrofitting fits into the sustainable HCI community. In the next section we look to highlight why we have placed such a large focus on retrofitting as the core change an individual can make in their environment.

WHY RETROFITTING?

In the Sustainable HCI community, we have an overwhelming focus on changing individuals’ behaviour; DiSalvo et al. [7] highlighted that 70% of the 157 papers they reviewed were targeted at individual consumers. However, simple behaviour change can only save a limited amount. Examples of behaviour change include turning your thermostat down by 1°C from 19 to 18°C (which saves about 13% per year on energy used for space heating [24]), and turning off radiator valves in unused rooms (which saves around 4% per year [24]). Likewise, providing visual feedback of energy consumption can have limited results of between 5% - 15% [5]. Finally, Young [28] has also shown that behaviour change techniques used to reduce energy consumption are reliable in the short-term but struggle at achieving durable change; this was, again, a similar story in persuasive sustainability [3].

These facts show that individual behaviour change can save energy, and it is correct for a proportion of the Sustainable HCI community to research the benefits of behaviour change. However, the relatively low potential energy savings highlight the need to drive the Sustainable HCI community into a different direction: considering how to encourage and support citizens and authorities to rework the infrastructure of their communities to be fundamentally more sustainable. This can lead to significantly more transformative and lasting solutions than those addressed at specific ongoing behaviours within existing infrastructure, but are also significantly more challenging to enable. Changing infrastructure requires investment of money and time, as well as commitment of individuals, authorities and infrastructure providers. Retrofitting of properties is one example of infrastructure transformation. The aim should be to get householders to make larger commitments through energy efficient retrofitting of their property, for instance through the installation of improved insulation, heat recovery systems and low-carbon and renewable energy sources. The Sustainable HCI community can then start to take advantage of the higher yield potential retrofitting provides: current research has shown that retrofitting can yield potential energy savings which range from 45% [1] up to 80% in some cases [26]. Correspondingly, retrofitting results in long-term energy savings, as once the measure is installed, it will save energy for the whole of its life time, including when new occupants take over the household or office space. Despite the positive benefits it provides, retrofitting requires a major commitment of time, energy and money by
householders and businesses, and this provides an interesting challenge for the Sustainable HCI community to tackle.

Currently, communities are locked into a social norm of not considering energy efficiency when renovating (beyond a legal minimum), and only those who are seriously committed for environmental reasons go against this norm. As has been discussed before, IT has a role in changing community norms [19], and we feel that the Sustainable HCI community can also play a vital role in changing the way retrofitting is portrayed in our society, and can help change the norm over time to one in which retrofitting is at least actively considered, and often implemented.

For these reasons, the authors feel that the Sustainable HCI community needs to start focusing more of its research in a direction of retrofitting, both on an individual household and community level.

HOW SUSTAINABLE HCI CAN SUPPORT RETROFITTING?

In understanding the reasons behind retrofitting, it shows the high potential impact it can have from an environmental perspective, and so is a good application for the overall Sustainable HCI community. In this section, we look to the ways in which Sustainable HCI can support retrofitting.

1. Psychological Encouragement of Retrofitting — this investigates the potential use of psychological techniques to promote individuals or groups to change their physical environment to make it more sustainable. For example, ideas and techniques research on persuasive technologies growing out of the work of Fogg [9] can be applied to larger infrastructural decisions. We can also investigate how current behaviour change frameworks could be used to provide insight into the householder’s decision process and what the barriers and drivers are for retrofitting. Examples of this are Defra’s: “Pro-environmental behaviour framework” [6] or the “Power law of engagement” by Weeks et al. [27], which is more focused on retrofitting. In this field there is also potential to investigate wider sociological techniques that can promote retrofitting within our society; this would also help the Sustainable HCI community to move away from the current core research that is mainly focused on individuals, which Pierce et al. [25] highlighted as a issue. As retrofitting requires a large commitment (time, finance or lifestyle change) by the householder, the Sustainable HCI community will have to take a slightly different approach to behaviour change, and look into psychological techniques that encourage the purchase of high priced items. Which psychological models are appropriate for large one-off decisions, and what IT can be used to support their application, is a rich area for research.

2. Information Provision for Retrofitting — explores the way HCI can be used to increase both the awareness and knowledge of retrofitting. Massung et al. [20] proposed a number of barriers to retrofitting, which include a number of informational barriers, such as:

- Lack of reliable information about products;
- Difficulty in finding a trusted builder to carry out the work;
- Lack of understanding of levels of disruption required in the work;

Digital technologies can be used to help reduce the barriers highlighted above. If we can help provide individuals with data and information that answers their questions and concerns, we can increase the probability of them modifying their household to make it more energy efficient. It is important that we don’t only just show householders their energy consumption and hope they will change their actions and behaviours. There are already a number of applications that implement functionality to show energy consumption [10, 11, 18]. We need to go further and provide data that informs individuals how to re-shape their household to make it more sustainable.

Retrofitting as a challenge is an opportunity to use Sustainable HCI techniques already developed, and to develop new ones appropriate to this new class of problem, to increase the number of individuals re-designing their physical environment to make it more sustainable. It is important that we don’t just focus on the large changes, like installing heat pumps, solar panels or heat recovery systems, but that we investigate smaller but equally permanent changes as well, like smart thermostats, energy saving light bulbs or remote control radiator valves.

Finally, so far a large focus has been on the concept of individuals or groups changing the physical properties of their household. However, retrofitting doesn’t have to be limited by this boundary, future research can look into the evaluation of implementing physical changes in co-working spaces or community shared spaces, like offices, village halls or local churches, but we do feel that individuals will have limited control over these environments, due to the fact that, in a majority of cases, the properties are not owned or rented by the individuals or groups. Such research will need to look at systems working with a number of stakeholders to reach agreement on how to progress.

CONCLUSION

In this paper we have investigated the current landscape of Sustainable HCI, and we have proposed the application of retrofitting as a valuable opportunity that we feel is under-researched, but has great potential to generate large energy savings and reduce the overall amount of greenhouse gases produced, especially in the domestic sector. The intention of the paper has been to stimulate discussion around the concept of retrofitting, and also to show the great opportunity we have to use the current research already completed in Sustainable HCI, but in a more effective way to reach the required EU emissions targets, and help develop a world in which we are more sustainable.

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REFERENCES