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SUSTAINABLE PRACTICES IN OFFICE BUILDINGS: APPLYING SOCIAL PRACTICE THEORY AND REFLECTIVE DESIGN INTERVENTIONS

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Abstract

Energy efficiency in office buildings has focused primarily on technological developments for the optimization of energy building performance. In this effort occupants' behaviour has often been simplified or ignored. This in turn has resulted in solutions that either have a short-term impact on energy savings or in the long-term the measured impact differs largely from the theoretical estimations. A user-centric view is therefore needed to capture the complexity of occupants' behaviour in the design of energy saving technologies. Social practices theory describes this complexity as the everyday practices that are characterized by interactions between people's diverse sets of values and competences and the materials of the environment in which they engage in. Whereas people are constantly adapting their environment to meet their needs, they often perceive an 'inability to act' when explicitly asked to change. This opens an opportunity for the design research community to reconsider design interventions not as ends for behavioural change but as means to support practitioners in their discovery and appropriation of materials, competences and values to achieve optimal changes. From a design research perspective supporting these processes requires methods that a) empower occupants to create, test and assess interventions and b) fit in their everyday activities. This paper presents an in-situ and practice-based design process implemented in Living Lab settings with methods that aim to support a multidisciplinary team in the development of reflective design interventions to empower active involvement of building occupants in appropriating changes. The paper presents preliminary findings of an ongoing project and envisages future work to better understand hierarchy of practices and its potential impact on how occupants engage in changing activities.

1. INTRODUCTION

Energy efficiency in commercial buildings has deserved plenty of attention from academia over the last decades. Several different world views have been taken to investigate on the same problem. For example, technology efficiency has deserved attention among researchers in engineering to develop innovative solutions aiming at optimizing consumption in offices, for example by the development of automated HVAC systems (heat, ventilation, air condition) [1], [2]. One of the main critics of this view is the lack of control that occupants perceive in the presence of automated technologies, which results in great discomfort. Therefore, recent work in the development of automation of HVAC has emerged by involving human sensoring and occupants' participation to implement adaptive algorithms that consider occupants' individual and/or social thermal preferences [3], [4], [5]. Technology centered solutions have been also criticized as not reaching the initially estimated reductions in energy consumption, partially due to the influence of occupants' behavior in the building's performance. For example, rebound effect is one of the reasons that explains the mismatch between estimated and calculated consumption. Rebound effect refers to people's reaction to energy efficient technologies that may result in a perception of energy advantage and therefore feeling granted to increase comfort or adopting an energy passive role. In this respect, occupants' behavior has become an important focus of investigation to inform the design of sustainable solutions [6], [7]. However, critics on what is called the 'behavioral gap' address the limitations of framing the problem as an isolated phenomenon centered on a rational and economical individual. This rational approach seeks to represent the 'average consumer' with static views of attitudes, behavior and choices. Instead, social practice theory repositions the understanding of behavioral change on practices rather than on individuals. It brings a holistic view of sustainability in which practices as entities (meanings, skills and performances) and as performance (act by doing) describe and explain changes in social life [8].

In this paper we adopt a social practice view on how to develop interventions beyond behavioral change. The presented approach is based on the work presented by Strengers and Maller in their recent book: "Social practice, intervention and sustainability: beyond behavioral change" in which several authors contribute to the discussion of the role of design interventions when considering a social practice approach [9]. It has been primarily drawn from research in household consumption thus our work aims to contribute to similar discussions in the context of office buildings. The paper will first briefly present the existing work in the area of social practices, sustainability and design interventions and the particular approach of Living Lab to facilitate design research activities on sustainable innovations. We will then introduce the proposed in-situ and practice-based design process based on reflective design interventions and illustrate with two case studies the role of these interventions to empower occupants in the adoption of sustainable changes in the office. The paper ends with a discussion on the role of bottom up reflective interventions in the office environment and concludes by indicating the possible presence of a hierarchy of practices and the implication for the implementation of activities of change.

2. RELATED WORK

This section starts by presenting an ongoing discourse in social practice theory and sustainability on the role of design interventions. It complements the discussion with the vision of Living Lab and user-centric innovation and the state of the art of methods to support in-situ and participatory design research.

2.1. The role of interventions in Social Practice Theory

In social practice theory there has been different ventures to capture and intervene the inherently dynamic and uncontrollable world of practices. Strengers and Maller [9] present and discuss the role of design interventions beyond behavioral change and redefine the problem of sustainability in terms of how social life happens and how it changes. Within this redefinition, interventions in social practice relate to the processes of recrafting, substituting and interlocking practices with possible effects on emergence, persistence or disappearance of practices.

From the work on household consumption of Pink and Mackley [10] interventions are considered as part of the existing activities people already engage in. The authors define household consumption as 'multiple flows', householders as 'managers of flows' and 'improvisory interventions' as reactions to the contingencies of householders' environment. Multiple flows of people, material things and non-material resources represent the messiness and on-goingness of everyday life in which invisible flows pass at different speeds and intensities. As managers of flows, people are capable to (re)direct some of these flows, becoming improvisors of their own practices. Improvisory interventions are depending on how people sense the 'feel' of their environment and how they make and remake their everyday world to 'feel right'. Within this view, the role of design interventions is envisioned as "integrating change comfortably into an activity in which people already habitually and on-goingly engage in" [10]. As a consequence, changes might be integrated into people's life in a sustained and lasting manner.

Considering the specific context of the office environment, in his work Hargreaves [11] has presented a case study of an Energy Champions program, describing a bottom up intervention in which employees become ambassadors to involve their colleagues in defining and achieving own goals of energy reduction. Hargreaves emphasizes on a particular intervention performed in the form of an audit by the ambassadors, to benchmark energy consumption at the start and end of the program. The knowledge provided by the audit resulted in the possibility for employees to detach from existing practices and been open to think of new, pro-environmental directions they aim to explore. A challenge on its own, as stated by Hargreaves, considering that practitioners go on in everyday life in an unthinking manner. In Hargreaves words "The audit process was thus vital in helping to re-materialize inconspicuous consumption patterns, and also in localizing and connecting 'the environment' to everyday practice… the audit can be seen as problematizing the links between the images, skills and stuff of a whole bundle of practices". Likewise, Prost et al [12] have described the challenge as people's perception of the inability to act due to personal, social and cultural aspects. The authors identify five levels of empowerment in the design for sustainable practices, where the first and second level refer to

gaining awareness on individual and social responsibility and to acting by knowing one's own behavior and its impact. We postulate that the benefits obtained from a one-time audit could be extended to more frequent activities that aim to empower practitioners in understanding and acting upon sustainable changes within the dynamics of their daily practices.

2.2. Sustainable Living Lab and User centric methods

Sustainability Living Lab (SLL) offers a socio-technical infrastructure for sustainable innovations to emerge, be implemented and tested with and by potential users [13]. Three elements characterize SLL as a user-centric process:

- The design is situated in real-life) and realistic settings
- The focus is on behaviours and experiences of daily life practices
- The approach addresses the technical, social and temporal dimensions of practices in large scale and longitudinal setups.

Sustainability Living Lab supports a user-centric and contextualized innovation process [14] in the context of living and working practices. As discussed by Krogstie (2012) [15], Living Lab serves as a platform to combine design research with innovation praxis in which knowledge is generated through the building and deployment of designed artefacts. Sustainability Living Lab combines social, engineering and behavioural sciences with design research to unleash and manipulate the factors that sway experiences around behaviour and technology. As a user-centred process, SLL relies on future users' participation to understand practices in the presence of designed artefacts. Where the first generation of Living Lab focused on the large scale deployment of innovative technologies, a second generation of Living Lab is emerging that focuses on the adaptability [16] of these technologies so users can appropriate them in the complexity of their own contexts [17], [18]. The goal, as stated by Scott et al. [19] "extends beyond improving environmental product performance toward shifting lifestyles in more sustainable directions".

Considering the advance of sensor networks, ambient computing and interactive visualizations, mixed design interventions [20], an integration of in-situ self-reporting and sensor-based monitoring methods, have been proposed as reflective design interventions to contextualize practices and their impact from a user perspective and at different time frames. This enables comprehending practices within the complex ecosystem of users' experiences and lifestyles. The overall integration gives priority to qualitative methods in supporting practitioners understanding, experimenting and evaluating changes in practice supported by reflective technologies. Quantitative methods are embedded offering an objective and subjective layer to measure impact. Following this approach, the expected impact is twofold: interventions enable participants to engage in dynamic processes of adoption of sustainable practices by activities of understanding, creating, testing and assessing changes in practice; secondly it addresses the appropriation of technology and practices that aims to empower this process.

3. AN IN-SITU AND PRACTICE-ORIENTED DESIGN PROCESS

The process presented in this paper is based on in-situ and mixed design interventions developed for Sustainable Living Lab settings [21], [20]. The main goal is to empower

occupants' active participation in the process of understanding, creating, testing and assessing their own reflective interventions and related impact. The outcomes are expected to be of direct benefit to participants to improve their working practices and their working environment. Considering practices as entities the process of understanding, creating, testing and assessing them aim to address occupants personal and social values and meanings, their abilities and the infrastructure in which they engage to.
We do this by implementing an iterative process in which a multidisciplinary team consisting of design researchers and different occupants' roles engage in co-creation workshops, prototypes development, testing and evaluation [22]. A sensor-based modular and incremental technological platform supports these reflective activities as part of occupants' daily practices, i.e. in-situ - in time and in context of use. A starter kit was designed to monitor and sample objective and subjective data related to indoor climate variables. Figure 1 shows the starter toolkit which includes sensor boxes (left) to monitor indoor climate variables, tangible self-report tools (middle) to capture occupants' overall mood, and comfort levels with regards to sound, light and temperature and web-based visualizations (right) to provide integrated feedback of the collected objective and subjective information.

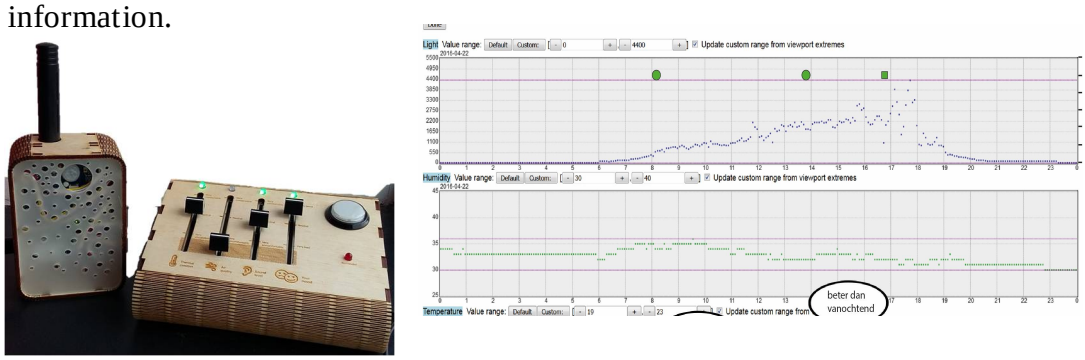

Figure 1: BOCS starter toolkit – Left sensor box and self-report tool; Right integrated feedback

Each intervention in the process has a two-fold goal: a) to facilitate the (re) development and appropriation of the toolkit so it fits into participants' values, abilities and infrastructure; and b) to facilitate the evaluation of the success or non-success of the intervention and the impact on energy and comfort, considering personal, social, and cultural aspects.

4. CASE STUDIES

As part of the Building Technology Accelerator (BTA) program of the European Climate Knowledge Innovation Community (C-KIC), the project Building Occupancy Certification System (BOCS) aims at developing an evaluation system focused on the buildings' occupancy instead of only the building characteristic [22], [23]. In this paper we are referring to two of the three case studies that are currently running as part of the BOCS project. Each case study is represented by a company that has expressed interest in BOCS and willingness to participate in a full year project. Case study 1 relates to company A, an international company situated in the Netherlands, characterized by individual and shared

offices and a high rotation of employees on a yearly basis. Case study 2 is represented by company B, a Dutch company also situated in the Netherlands, offering open and flexible workspaces to their employees. The outcomes of the first two interventions of Company A are briefly described with the purpose to illustrate initial insights on how occupants invest time in managing their comfort. It concludes with a proposal of the next iteration to further understand the observed phenomenon. The first intervention of Company B is presented as a quick and dirty activity to further explore an alternative proposal to what's been observed in Company A. Results will be discussed to establish the extent to which empowerment technologies should to provide flexible interactions to responds to the demands of busy working environments.

4.1. Sustainability, comfort and productivity

The starting point for all case studies consisted of an individual activity done in collaboration with the researcher to inventorise values, competences and materials that occupants of the buildings of one company identify in relation to their working practices and sustainability. This was done in the form of a structured interview conducted by the research assistant of BOCS. It became clear that in the area of values productivity and personal/social comfort (including health and wellbeing), are main factors that influence occupants' positive experience. General and specific knowledge about the sustainable impact of their practices were reported as missing and the overall infrastructure was perceived as limited. These insights are in line with what has been previously reported [11], [12] and further identify the need to support the know-how of occupants (their abilities) and test the role of reflective technologies (empowering materials) in exploring benefits (their values) to act in a sustainable manner.

4.2. Company A, Cycle 3 – Management practices as waves

The first two interventions of case study 1 involved iterations of co-creation and evaluation of concepts around self-reporting and monitoring. This included ways to engage occupants to self-report about their satisfaction with indoor climate while monitoring indoor climate variables. Self-reporting was prototyped as tangible and personal devices positioned at the worker's desk. Despites the early involvement in the creation of the prototypes where occupants defined use cases as well as identifying possible benefits of the data collected for the next intervention in the design process, workers experienced high levels of real costs to provide daily inputs compared to the indirect benefits of participating.
These interventions were characterized by co-creation, testing and evaluation activities with the purpose to adapt the material to empower participants (see Figure 1) in understanding their own practices and its impact. The self-reporting and feedback tools (materials) were developed considering the idea to support 'managers of flows' as earlier described [10]. In intervention 1, the requirements were translated into developing a simple interface which consisted of 1 slider to indicate overall comfort and 2 buttons to signal discomfort with regarding to noise and air quality. The evaluation after the testing period highlighted that the simplicity of the interface was experienced as too limited and therefore meaningless. In the second intervention, the prototype was updated by replacing all inputs by 4 sliders to indicate levels

of thermal comfort, noisiness, stuffiness, and mood and a submit button. The evaluation again testified a low engagement in reporting despite the redevelopments.
The interventions revealed a possible hierarchy between the different types of practices taking place in working settings. From the preliminary analysis of the testing and evaluating assignments, the presence of a hierarchy of practices could explain occupants' priority given to work related activities as primary and overruling any other activity in favour of productivity (values). Practices not directly related to work, from now on named as 'management practices', were considered important to adjust the working environment and practices for the sake of higher productivity and wellbeing. However, in reality they were assessed as secondary and therefore not taking part of the continuous flow. Small changes in the flows of heat, light or sound were considered irrelevant and only after certain threshold was reached a change was perceived worth of attention. In terms of Pink's work [10] this insight suggests a different characterization of consumption (indoor climate in this case) as senses that are perceived in waves rather than flows, and therefore react to that in a similar manner.
To further understand the concept of managers of waves the next intervention is designed to generate specific knowledge on breaks at work. The purpose of this intervention is to a) empower occupants in generating awareness of their break practice, b) describe an existing practice that functions in waves and c) seek for opportunities to reuse break elements in the appropriation of wave-like sustainable exercises (understanding, creating, testing, assessing).

4.3. Company B, Cycle 1 – Daily feedback implemented in waves

In the co-creation session of cycle 1 occupants specified their interest in the monitoring and self-reporting interventions with a preference for touchscreens and mobile interfaces. The characteristics of open spaces and flexible desks made it unsuitable to have tangible and fixed interfaces for self-reporting. Occupants also made clear the need for online feedback to understand their sustainable impact. From an interaction design perspective, the design of the touchscreen interfaces for self-reporting and feedback require several iterations to design an interface that fits the specific target group and context of use, in particular, considering the insights on wave-like management practices. Therefore, for the first intervention it was decided to build a quick and dirty prototype based on small adaptations of existing developments with the purpose to focus on the natural rhythms adopted to report and access information. The evaluation will inform the development of a mobile app which will be followed by a co-creation to define the wave-like protocol and privacy issues (see figure 2).

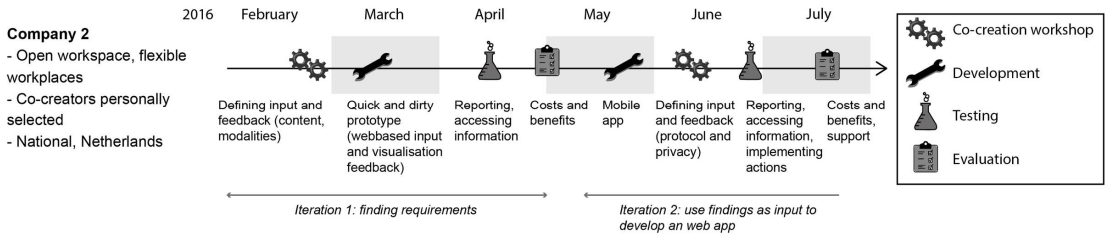

Figure 2: Timeline of first intervention in company B

The two-weeks intervention ran in April this year included a web interface with a login screen to visualize monitored indoor climate data and the reports on personal comfort variables. Besides the web interface, sensor boxes were located in few places partially distributed in the open space area and in two meeting rooms. The selection of participants was based on the physical proximity to the contact person, where eight employees were invited to collaborate previously involved in the pre-set activities (inventory of practices, observations, etc.). In the first week, the researcher prepared daily feedback for each participant presenting separate graphs for the daily indoor climate and comfort values recorded. It provided a group overview (table) and personal overview (graph) representing the responses. In the second week, the group and personal views were combined into one timeline visualization integrated with temperature (see figure 3 (2) for a snapshot of one variable: temperature). The feedback was expected to be sent by the contact person at the end of each working day via email. As seen in figure 3 (1) the feedback (↑) in the first week was sent every two days (except for day one) while in the second week the daily views were all sent together once at the end of the week. Self-reports (↓) seemed to be slightly affected by the lack of feedback in week 2.

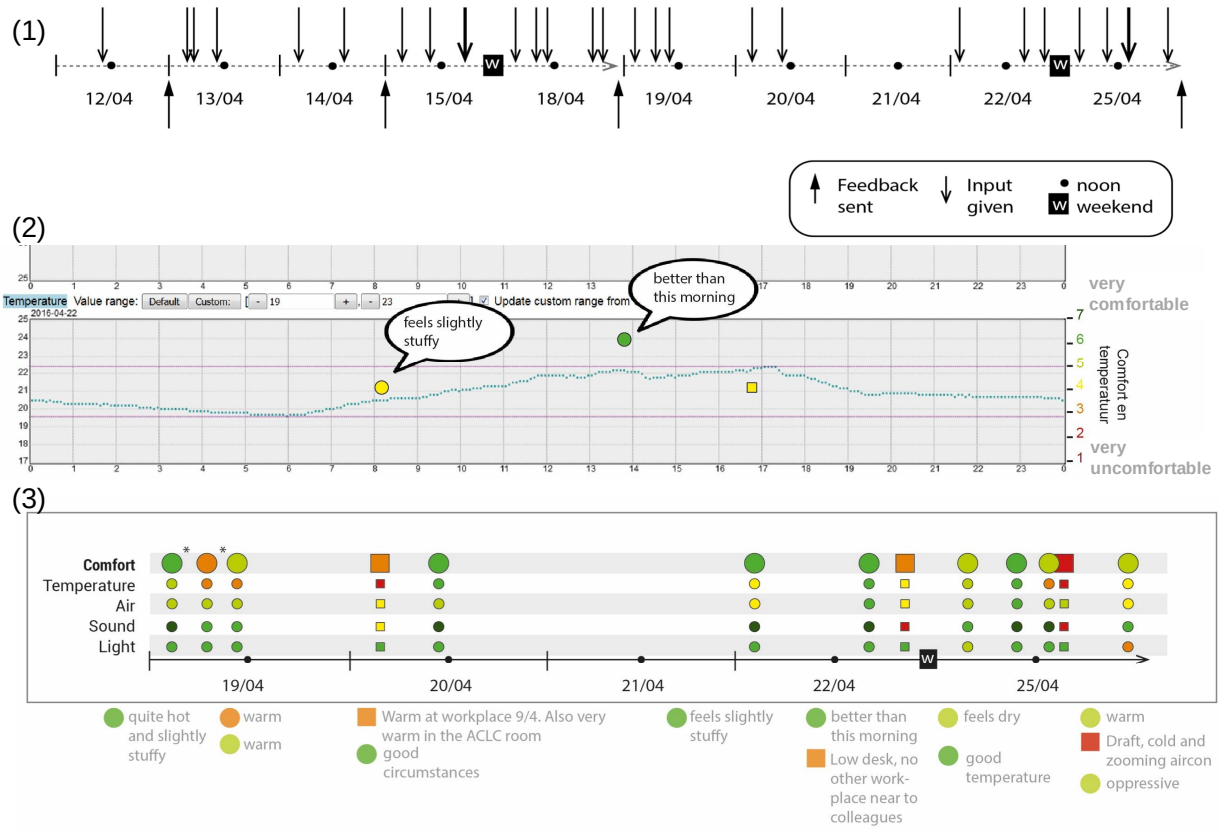

Figure 3: information of 2 weeks intervention in company B. Top – feedback (↑) and self-report (↓) distribution; Middle – Daily Integrated visualizations sent via email to each participant: blue line indicates temperature, circle and square are the self-report of two participants color coded depending on their value (see scale at the left); Bottom – one week overview of the self-report distribution and content of two active participants

As seen in figure 3 (3) of the second week and similar to first week most reports were sent by one active participant (represented by circles) and a second less active participant (represented by squares) Content wise it was observed that the overall negative mood (larger circle and larger square) was often related by a discomfort in either temperature and or sound, while discomfort on light and air were hardly reflected in the reported overall comfort.
When preparing and conducting the assignment a number of limitations became apparent:

- The physical space that was measured was too small to capture occupants' movement between areas and preferences for certain areas.
- The contact person was in charge to forward the feedback emails to the employees, but due to other commitments he did not have the time to send the feedback daily.

This unfortunately did not allow the researcher and occupants to discover the possible benefits of integrated feedback though they could still evaluate and reflect on the intervention.

4.4. Preliminary insights on active engagement

Despite the initial interest and willingness to participate that was initially expressed by all occupants involved in the development of the interventions, and even when most participants enjoyed and benefitted to some extend from their participation, their overall engagement was low. Primarily because they considered the assignments highly demanding as it felt unnatural and often as stealing time that they would have otherwise used differently. So far we (as the design research team) have been trying to explore the benefits of immediate access to integrated views of information to empower occupants to understand, create, test, and evaluate changes in practices as they are experienced. However, the notion of hierarchy of activities, and an apparent high threshold to perceived changes in comfort, result in a 'state of inertia' in which occupants do not react as often as changes in comfort may occur. This requires a rethinking of the way the information should be requested and presented, and also how information should be visualized to support occupants managing their comfort in ways that are more fitting their own needs. Getting out of the inertia could be the next challenge to implement natural triggers to consciously yet effortless empower occupants to report and benefit from information to engage in management actions.

5. DISCUSSION AND FUTURE WORK

Living Lab settings in combination with technological tools to support active and reflective interventions are promising design research activities to actively involve occupants in the adoption of changes as part of their routines. By means of understanding, creating, testing and assessing potential benefits of empowerment tools they can become aware and active towards adopting energy and comfort positive working practices. In theory it is known that this active involvement comes with a price: it involves real costs (mostly in terms of time investment) with less clear immediate benefits. Occupant's involvement as active collaborator is a role that is expected to be embedded in occupants' daily working activities. From this ongoing project, several factors have been identified as interfering in this involvement process:

- Technological barrier: the project started with an available platform that supports

modular prototyping of monitoring, self-reporting and feedback tools. The stability and modularity of the platform are expected to enable small iterations within a intervention but in reality the possibilities for incremental changes have not been as quickly as expected. Therefore, in many situations, quick and dirty prototypes have been used to keep the momentum at the costs of unfinished, unstable and too low technical tools. This creates extra unnecessary burden to occupants not willing to look through the first layer of inconveniences as they were perceived to immediately hinder their working routines with no clear benefit.

- Organizational barrier: the culture within a company prescribes to a great extend the appropriateness for top-down or bottom-up strategies to design and implement interventions. Office based organizations with high rotation and international employees seem to be characterized by an individualistic working style where top-down or individual strategies could be more fitting to the context and type of relations. Whereas organizations with a homogeneous and permanent staff may benefit more from bottom-up or social strategies even when considering open and flexible working conditions. Direct accessibility to the stakeholders is paramount to support active participation. Multiple channels of communication are also experienced as beneficial to extend the scope and possibilities of the interventions. Strong consideration is needed to avoid information overload.
- Cognitive/psychological barrier: every employee of an organization is unique in developing own strategies to reach personal and organizational objectives. In doing so employees constantly deal with technical, interpersonal, and environmental tensions as constitutes of their working days. The criteria to assess these strategies are weighted by organizational and personal gains. Finding the balance is not easy. Occupants' acknowledgement that the action of taking breaks is beneficial but it does not fit their working style depicts the challenges when intending to introduce sustainable practices. Therefore, to bring meaning and value to these interventions there is a need to identify plausible starting points to engage occupants in the process of reflecting the use of technologies to support behavioural change. A plausible starting point (e.g. taking breaks) could bring real benefits to the costs invested.

Hargreaves [11] has argued that practitioners go on in everyday life in an unthinking manner rather than been active 'flow managers'. In the workplace this could be more prominent due to the working culture that may negatively influence personal and social commitments to anything but their primary goal: productivity. The preliminary insights of the presented work questions the idea of continuous flows to characterize the management of consumption and comfort and distinguishes a process that is more sporadic and less spontaneous. We propose the notion of waves instead of flows to describe the occasional way office workers will manage their comfort.

6. CONCLUSIONS

This paper presents an in-situ, participatory and practice-based approach to support a bottom up process for the development and implementation of design interventions in Living Lab working settings. The interventions are envisioned to empower occupants in understanding,

creating, testing and evaluating changes to improve their own comfort as well as their consumption. The empowering role of these design interventions is supported by in-situ and mixed methods. The paper contributes to the design research community interested in designing for sustainable practices by examining the success and failure of interventions that have been co-designed and implemented by employees of two different companies. The preliminary insights of the presented interventions highlight a) the presence of a strong hierarchy of practices described by primary (those directly related to work: desk work and meetings) and secondary (those not related to work: breaks and management of the environment) and b) a state of inertia that overemphasizes the importance of primary practices to achieve productivity. These insights led to rethinking the initially characterization of changes as an ongoing and habitual activity. Instead a more fitting characterization indicates that changes come in waves depending on occupant's threshold to perceive discomfort at work. Future work will address the development of in-situ and mixed design interventions to support the management of waves.

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