A Smart Approach? Raising Uncomfortable Questions about Building Automation in the Workplace

CHRISTINA BREMER, Lancaster University, United Kingdom

Building automation in the workplace is argued to open the door to a more energy-efficient and, thus, more sustainable future. The need for human interaction is replaced with automatic control and allowing algorithms to make autonomous decisions for the buildings' energy systems, like heating, lighting and air conditioning. However, automation takes away the occupants' agency leading to unexpected rebound effects, and may itself require energy-consuming elaborate algorithms, new sensors, data storage and computational infrastructure. I ask, is office building automation really a viable approach for the people and the planet? Or is the rhetoric of automation helping us turn a blind eye to the fact that we should invest our energy fundamentally differently? In this position paper I raise questions about the social and environmental sustainability of office building automation and the power of those who are made uncomfortable so we can all feel a little bit better about ourselves.

CCS Concepts: • **Social and professional topics** → **Sustainability**; • **Human-centered computing** → *Human computer interaction (HCI)*.

Additional Key Words and Phrases: energy, automation, human-building interaction

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1 INTRODUCTION

The construction and operation of buildings consumes vast amounts of energy. In fact, the buildings and construction sector is responsible for 36% of the consumed energy and 39% of CO_2 emissions, globally [10]. With the current climate crisis, it stands to reason that we as humans are actively trying to reduce the energy consumption of buildings to meet our climate targets. An approach that presents itself is building automation. In other words, we are aiming to make buildings more energy efficient by centrally monitoring and controlling their internal systems, including heating, cooling, ventilation, air conditioning and lighting [7]. With improved data and models, it is argued, we can even address the well-known energy performance gap, where buildings do not deliver on their promised design performance (e.g. [8], [9]). While there exist other reasons to automate buildings, linked improved security and comfort, energy savings often provide an important incentive. Critically this forgets the occupants, the impact of their responses but also the many ways in which the energy and carbon footprint of a building is governed by the building and its infrastructure, and not day-to-day activity.

Building automation can be implemented in many kinds of building. This position paper focuses on office buildings and workplace environments. Compared to domestic environments, offices do not come with a small and well-defined set of stakeholders that financially benefit from energy savings and that have a personal relationship to the gathered energy data. This can make them challenging research contexts, but all the more interesting if we wish to do something

Author's address: Christina Bremer, c.bremer@lancaster.ac.uk, Lancaster University, Lancaster, United Kingdom.

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Website: http://everyday-automation.tech-experience.at

about their climate impact as many of us spend a significant amount of time in office buildings, and thus have a stake in this challenge.

2 BUILDING AUTOMATION'S HIDDEN COSTS AND VARIABLES

A key aim of building automation is to reduce the building's operational energy. As opposed to embodied energy, operational energy is used for everyday maintenance and to create comfortable conditions for building occupants [15]. While it sounds like a compelling case, the amount of energy a building requires to be maintained, independent of its occupancy status, sets boundaries for the energy-saving potential of efficiency measures. More troubling still, potential efficiency gains can paradoxically lead to worse environmental performance: Jevons paradox, perhaps the most well-known paradox in environmental economics, describes an energy consumption increase following from energy-efficiency improvements due to increased demand [2]. At the same time, building automation itself requires energy to e.g. run and maintain the sensor equipment, algorithms and data storage [12]. Additional overhead which is seldom factored into the analysis of promised improvements.

If we decide that building automation is a worthwhile pursuit nevertheless, we still need to tackle the energy performance gap observed in traditional buildings, i.e. a widespread discrepancy between the predicted and measured energy consumption. A 2018 meta review shows that the actual vs. modelled consumption of buildings can be up to 2.5 times higher [19]. Another study analysing 62 non-domestic buildings in the UK found the average discrepancy to be +34% [18]. The reasons for the gap, including sub-optimal modelling strategies, malfunctioning equipment, operational practices and occupant behaviour, equally apply to automated buildings. And the material and algorithmic complexity of these buildings won't make closing the gap any easier. The reasons behind the energy performance gap also highlight the socio-technical nature of energy systems, including broader rebounds from the impact of occupant behaviour. Encouraging occupants to behave more sustainably is difficult, as can be seen from sustainable HCI research which has traditionally focused on behaviour change to lower energy bills [6]; both the limited impact of this approach [13] and underlying assumption that people behave as rational actors [4] have been widely criticised. At the same time, the human-building interaction community has raised important questions about the role of data and occupants, addressing fairness and organisational aspects (e.g. [5], [14]). I believe that such questions can also enhance big picture discussions about the goals and potential of building automation.

3 THE ROLE OF OCCUPANTS

Occupant behaviour and response to automation can have a substantial knock-on effect in terms of energy impact. Office workers who are too cold in the office may well not limit their response to putting on a thicker jumper. Instead, they find workarounds to adjust the room temperature, defying the energy-saving purpose of building automation. Interviewing building and energy experts working on Lancaster University's main campus, I learned that this is a common occurrence. One engineer suggested, "*people not using electric heaters*" as the key measure to reduce the energy consumption on campus. Another expert described the role of occupants as, "*They [the occupants] have huge control even though the engineer might not think that they do. I mean they leave windows open and they they walk in and out of the building. They can complain about things. Building is an ecosystem made up of the building management system and the people, isn't it?*". Similar patterns were noted elsewhere: an in-depth study of energy consumption and management in a workplace found that participants raised a lack of thermal control, yet the authors observed various adjustments to circumvent systems and policy for participants to regain control over their personal environments [3]. These findings indicate that energy savings from building automation can be substantially reduced by occupant behaviour. An indication that should let us think carefully about the prospects of success of building automation as a top-down approach.

When we automate buildings in which people work, we take away peoples' agency. Where they could make their own, albeit often communal decisions, these are now made by algorithms. This shift is not inherently negative, but it can become so. Occupants are not per se against building automation in the workplace—in fact they often welcome it—but their individual habits, needs and preferences differ. In a 2015 scenario-based survey, participants preferred less automated energy conservation systems (but not manual) when they were concerned about comfort, and more automation (but not full automation) when they were concerned about energy savings [16]. In a residential context, a study by Ahmadi-Karvigh et al. [1] shows that individuals' personalities and demographic characteristics also affect automation preferences. This important diversity is often forgotten in favour of considering 'generic occupants'. For instance, in one of the most major areas of energy demand, achieving thermal comfort: standards regulating office temperature are derived from early climate chamber studies involving 'a default male' metabolism and dress code. These do not cater for women, who prefer higher room temperatures than men, and feel both uncomfortably cold and uncomfortably hot more often [11]. As workplaces call for productivity and collaboration, leaving workers uncomfortable or effectively ignored can negatively impact their performance and job satisfaction. From a fairness perspective, how uncomfortable are we allowed to make people? And does this depend on how good our intentions are?

4 DISCUSSION

Considering the different thermal needs and preferences of office workers, automated energy systems can easily lead to discomfort. Paired with reduced agency, research suggests that office workers will find workarounds—which defy the energy-saving purpose of building automation. But if we need to hand back (some of) the control to avoid such workarounds, should we automate buildings in the first place? We certainly cannot expect occupants of automated office buildings to behave like robots, just as Strengers [17] points out that we cannot expect residential energy consumers to behave like 'resource men'. Occupants are human, they are us. And what kind of building would you like to live and work in? Would your answer change if you knew the contribution it made towards climate change mitigation? What if that contribution was small, would you still invite discomfort into your everyday work life?

Research suggests that building automation might not save us as much energy as it promises, ignoring rebounds, occupants and how buildings are really used, and that very significant demands are linked to the buildings' infrastructure and not linked to occupant behaviour at all. Yet the claimed potential for automation gives us the impression that we are doing something to mitigate climate change. In some areas of life, every little helps, but when it comes to climate change should we not think carefully about the most promising path to success? If we invest in a technology that reassures us without helping much, could that not make matters worse? Smart buildings and cities are still in their infancy so there is much to test, explore and innovate. But it also means that we can still shape the message and associations that come with smart buildings. And we can redirect our focus if we come to the conclusion that our energy is better spent elsewhere.

5 FUTURE WORK

In my PhD research I investigate the sustainability promises and potential of building automation from a socio-technical perspective. This includes the role and impact of occupants. Using the Lancaster University campus as a case study, I am currently analysing the energy patterns before and after the onset of the first lockdown to better understand the energy-saving potential of occupant behaviour change. Currently on hold due to COVID-19 is an intervention study I designed to further explore the reactions of occupants to office building automation; these reactions can reduce the calculated energy savings and drive rebound effects. I believe that taking part in the workshop and discussing automation experience in the workplace with HCI experts will help me interpret the data I have collected and broaden my horizons for upcoming research. In return I can offer my knowledge on buildings, energy systems and workplace psychology.

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