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Anthropocentric urban sustainability: Human significance in building automation

Lara Anne Hale

Department of Management, Society and Communications, Copenhagen Business School, Dalgas Have 15, 2000 Frederiksberg, Denmark

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ABSTRACT

As sustainability in cities relies more on measurement technologies, and *biometric devices* – communicative biological measurement technologies – proliferate, building automation threatens to extend technological systems beyond the involvement of the people living in the buildings. Too many technological expectations of building users can lead to building system failure, but this article argues that attempts to uproot *anthropocentricism* – the centric focus on humans – can be just as erroneous, leading instead to technocentricism. Combining concepts from the Technological Acceptance Model (TAM) Science & Technology Studies (STS), this paper uses Active House building demonstrations to illustrate how building users' interactions with technology serve to shape technological design bidirectionally with users, driving design that is relevant for and meaningful in sustainable cities. It presents potential modes of agency and a model of how experimental, interactive design within developing systems proceeds through stages of piloting, automation, overshoot, and then balance. This paper advances the discussion of the future of urban sustainability in that it: a) proposes a combination of TAM and STS, b) argues that experimentation is needed for sustainability-oriented technological systems, and c) presents modes of agency and a model that can be used to guide design.

1. Introduction

This paper examines the development of relations between building technologies and the user experience in sustainable buildings, using the case of the Active House sustainable building experiments. It presents the research in context of the coining of the modern epoch as the "Anthropocene," that of planetary dominance by humans (Davies, 2016), which has resulted in *anthropocentricism* – societal focus on human interests – as being viewed as the root of environmental destruction. At the same time, *technocentricism* – the belief in technological innovation as the solution to social and environmental problems (Reid, 2013) – and *sustainability transitions* – development "towards more 'sustainable' modes of production and consumption" (Manning & Reinecke, 2016, p.618) – are accelerating. The building sector is particularly interesting for the intersection of technology and sustainability, as it accounts for approximately 30% of global CO_2 emissions (Laski & Burrows, 2017); and technology has the potential to facilitate a reduction in operational impact. Although technical monitoring of buildings has been conducted for decades, and *post-occupancy monitoring* (done while people are living in the building) has likewise been undergone for years, the advancement of *biometric sensor systems* – systems that integrate measurement data on biological organisms, i.e. humans, based on micro sensor devices, such as fitness tracking devices so small that they can be worn on the wrist – mean that technical buildings are themselves the new basis of post-occupancy monitoring. The issue at hand is that the acceleration of technical dominance of the building's functionality threatens to bypass co-development with the building inhabitants, potentially leading to non-democratic self-learning systems that do not "consult" humans, contradicting the aims of sustainable development, which should provide for social sustainability, as well as economic and environmental sustainability. "Virtually every aspect of how to respond to climate change remains open to debate" (Bailey and Wilson, 2009, p. 2324); but what if technological focus shuts out human debate in the design of technological standards? In other words, society could shift from the Anthropocene to the Technocene, wherein technology dominates human systems (Hornborg, 2015).

This is not to say that consultation with other forms of life in the environment – through ecological principles or otherwise – should not be incorporated into urban sustainability, but rather to caution against drifting too far into technocentrism, wherein technology becomes both the tool and the purpose. Attention to ecological consequences is fundamental in sustainability transitions; however, this paper focuses on the relationship between humans and building technologies while solving sustainability problems. It also draws attention to a historical lack of distinction between anthropocentricism and technocentricism, such

E-mail address: lh.msc@cbs.dk.

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as with the writings of O'Riordan (1981), wherein he positions humans and technology together against the environment, an ongoing perspective in debates on environmentalism and deep ecology (Morpeth & Yan, 2015). Yet in many ways the recent history of computational advancement distanced technology from the focus on humans in buildings: computer systems enabled virtual modeling building performance and also the formulation of thermal comfort systems based on sensor-rigged dummies (i.e. Madsen, Olesen, & Kristensen, 1984).[1] However, these models, disconnected from the user experience, fail to anticipate real outcomes wherein people interact regularly with their building environments, known as the *performance gap* (Frankel, Edelson, & Colker, 2015) – referring to how actual energy use in buildings can be as much as double the modeled predictions (Frankel et al., 2015). It has long been suspected of resulting from variations in behaviour and can often be closed with post-occupancy monitoring (Bordass, Cohen, & Field, 2004; Fedoruk, Cole, Robinson, & Cayuela, 2015; Menezes, Cripps, Bouchlaghem, & Buswell, 2012; Sunikka-blank & Galvin, 2012). The main failures are a non-consideration of building inhabitants, lack of an integrated design process, and lack of real-time data (Frankel et al., 2015), all of which promise to be advanced with biometric technology, building management systems (BMS), and their interconnection in *Internet of Things* (IoT), the vast internet-connected network of everyday objects. In other words, there is an issue in the development of urban sustainability that the very people who are meant to inhabit buildings are not considered, and rather so-called sustainable buildings are standardized disregarding both the effect of their inhabitants on the buildings and the effect of technified buildings on the inhabitants. In addition to the problem of standardizing buildings that serve technologies rather than people, the performance gap is increasingly significant because of an increasingly urgent understanding of the built environment's role in climate change and an increasing demand (organizationally and legally) for performative building standards and measurement systems that further sustainability transitions (American Institute of Architects (AIA) (2012)).

This paper investigates Active House sustainable building demonstration experiments with varying levels of building automation and biometric sensor controls in order to gain insights into the significance of anthropocentricism in technology standards and, ultimately, sustainability transitions. Engineering determinism paired with the trend towards "post-human" design (Fry, 2000) argue for a decentering of anthropocentricism (McIntyre-Mills, 2013) and a greater focus on technological objects in standards for systems design (Fry, 2000; Qvortrup, 1996). And why not? Is it not possible that the technological systems have advanced to a point where they can more effectively operate *without* humans' conscious participation? Why is user focus significant in experimental standards for technological design? This study investigates these questions and argues for a move in the other direction, closer to the deliberative development of standards for technological design. It draws from the Technological Acceptance Model (TAM) to reflect upon how technological acceptance has been approached in the literature. The theoretical approach is then further inspired by Rip and Kemp (1998) use of STS to analyze technological change in the context of global climate change. They open an intriguing discussion on the ability of technology to change institutions and shift "sociotechnical landscapes" (Rip & Kemp, 1998, p.2), in part through standards. One of the contributions of this article is its combination of concepts from TAM and STS. In the same spirit, during sustainability transitions there is space for reconsidering previous design and policy decisions, opening up for not just social change, but paradigm shifts (Bailey and Wilson, 2009). However, we need to better understand the difference between the sociological and the technical, and the ways that they combine to drive these changes. From a combined TAM and STS perspective, I use the case of measurement and evaluation in Active House demonstration building projects to a) propose a combination of TAM and STS, b) argue that experimentation is needed for sustainability-oriented technological systems, and c) present modes of agency and a model that can be used to guide design.

The paper is structured as follows: In Section 2, I give a background on biometric technologies and introduce theoretical aspects of the Technological Acceptance Model (TAM) and Science and Technology Studies; followed by a description of the Active House case and the research methodology in Section 3; Section 4 presents the analysis and results, as well as a discussion of the implications; and finally Section 5 concludes with regards to the future of urban sustainability.

2. Background and theory

2.1. Biometric systems

As society seeks solutions to modern sustainability challenges, technological fixes have great appeal, with smaller sized devices, lower prices with scaling (from just one central unit to expansion with several interconnected devices across rooms, but also whole geographies), and more ready access to the natural resources demanded for their manufacture. There is an undeniable proliferation of not just sensors, but indeed a whole ecosystem (an open, adaptable, disbursed system, as inspired by nature) termed the Internet of Things (IoT), in which technologies and other objects gather and communicate. The smaller (and thus less consciously noticeable) size and cost of technologies have had no small role to play in this rapid realization: "Most dramatically [at the beginning of the 21 st Century], wireless transponders that could identify physical objects had shrunk to the size of a pinhead and the cost of a few cents, and billions of them were being produced and deployed" (Mitchell, 2004, p.3). Whereas this study is derived from demonstration buildings, the adoption of home-based biometric technologies spreads well beyond, with a set of sensors, remote controls, and management applications costing only a couple hundred Euros (perhaps half that cost if self-assembled and programmed by a tech-savvy homeowner).

The relationships formed around biometric data are rapidly developing and expanding. Wang et al. (2015) explain that sensor technology has been around for a long time, but that sensor networks have served as the foundation of the IoT, and that in turn the IoT has driven the sophistication of sensor networks into *fused sensor networks*. The difference between fused sensor networks contrasted with historical sensors is that they contextualize the information being shared. In his white paper on the role of fusion sensors in the IoT, Karimi (2013) describes how the fused data of several sensors gives more information than compiling information from individual sensors (the whole is greater than the sum of its parts). He details how this is accomplished by fused sensor data enabling the reconstruction of the context, specifically the identity, location, time, and activity related to the data (Karimi, 2013). For example, it is relatively meaningless for a device to just know how many calories you burned in a day, or for a device to know your sleep patterns in an evening; but when the two are combined, patterns between your activity and sleep levels can be derived. Maguire (2014) refers to such networks as pervasive systems – systems wherein "information processing is integrated into everyday objects and activities" (p. 167). The network of objects surrounding people in their homes begin to synthesize enough data about them to "know" them, at least in terms of numerical data.

Yet, the trend is to shift the design of networks towards no longer involving the people they measure and serve (Jethani, 2015; Thomas, 2006). Already towards the end of the 20th Century, systems design theorists were attempting to debunk Cartesian epistemology – the self-transparent human mind as validation of knowledge and truth – as a

[1] This was a surprising development in the opposite direction anticipated by early 1990's technology research, represented by articles such as "Touching Big Brother: How Biometric Technology Will Fuse Flesh and Machine" (Davies, 1994).