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tech industry insights

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RESEARCH

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ABSTRACT

Smart home technology (SHT) is being promoted for the enhancement of occupants' convenience, as well as more efficient and sustainable energy consumption. However, recent research indicates that convenience often takes precedence over energy reduction, threatening to affect inhabitants' everyday practices in a non-sustainable way. In order to understand the social and environmental consequences of SHT, the meaning of convenience is investigated. How is the concept of convenience developed in concert with technological development? Presenting SHT imaginaries from the industry, the paper builds on qualitative interviews with 11 SHT professionals. By exploring the practices, roles, and relations at play in SHT development, it is demonstrated how the vision to enhance convenience in everyday life is related to a user imaginary characterized by passivity and disengagement from energy savings. Furthermore, convenience is enabled and enforced through the notion of interoperability. Interoperability refers to not only technologies 'speaking together' but also a strong interdependency between professional actors. By exploring the practices at play in SHT development, the meaning of convenience is revealed to be an outcome of this interdependency as well as the collectively shaped ideas, and technological standards embedded in the industry.

POLICY RELEVANCE

SHT is shaping our domestic futures, influencing material environments as well as social life and energy consumption. Currently, SHT is promoted and supported widely in policy. For instance, the European Commission stresses automation as a means to ensure the more efficient operation of buildings, generating cost and energy savings. However, a focus on convenience risks counteracting sustainability considerations. This study shows how convenience can take precedence across various branches of SHT development, with a consequence of creating passive users who are disengaged from sustainability issues. When policymakers promote the adoption of SHTs and automation of the built environment, a more critical stance is needed toward convenience in order to avoid user passivity and masked energy consumption. Policy instruments, such as the smart readiness indicator (SRI), should not only include calculations of what is technically possible in terms of automation but also examine the outcomes, practices, and behavior that SHT promotes.

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1. INTRODUCTION: NEW TECHNOLOGIES, NEW DOMESTICITIES

> The smart home revolution has arrived.
>
> (Furszyfer Del Rio *et al.* 2020: 1)

Smart home technology (SHT) covers a wide range of products, from voice-controlled home assistants and smart speakers to automated lighting, heating, and security systems. SHT is developed and promoted with promises of enhanced comfort, security, entertainment, and more efficient and sustainable energy solutions. Given its potential, the technology is expected to spread in the near future (Sovacool & Furszyfer Del Rio 2020; Wilson *et al.* 2017). However, several uncertainties remain. For instance, a number of scholars point out that the actual energy savings from SHT are questionable and that SHT may, in some cases, lead to even more energy-intensive activities and increase energy consumption (Darby 2018; Herrero *et al.* 2018; Strengers *et al.* 2020; Strengers & Nicholls 2017). Furthermore, due to its smart capabilities and enhanced levels of automation, SHT is able to change roles, relations, and practices within the home and influence shifts in domestic labor. As such, the technology is transformative not only technologically but also socially (Hargreaves *et al.* 2018).

To create a sustainable and transparent path for the development and integration of SHT, more knowledge on its meaning and impact is required. This paper explores SHT from the professional perspective, including visions, meanings, and practices at play in SHT development. As Strengers & Nicholls (2017: 87, with reference to Wilson *et al.* 2014) point out:

> the smart home is an emerging field full of promises and aspirations, accompanied by very little empirical, social or cultural research.

SHT is developing rapidly and may yet be understood as:

> not so much a clearly defined phenomenon as a fluid and unstable field of possibilities.
>
> (Berry *et al.* 2007: 242)

These points highlight the emergent character of SHT and the necessity of ongoing research within a field that is expected to increasingly shape our homes.

Recent reviews indicate that the majority of SHT research has been focusing on the technical challenges of establishing smart home environments (Gram-Hanssen & Darby 2018; Wilson *et al.* 2014). However, there has also been some interest in social and cultural aspects, especially in studies of *users*. These studies provide valuable insights into how SHT is implemented 'in the wild' (Mennicken 2016; Mennicken & Huang 2012), *i.e.* in a real home setting, and the role it plays in everyday life (Hargreaves *et al.* 2018; Paetz *et al.* 2012; Takayama *et al.* 2012). Yet, the user perspective alone is insufficient for developing a full understanding of the meaning and implications of SHT. The professional perspective is also of central importance, as the development of technologies and their accompanying visions and ideas, *i.e.* their 'sociotechnical imaginaries' (Jasanoff & Kim 2009), are central in the shaping of our everyday lives and technological futures.

The SHT professional perspective is less researched than the user perspective, but a few studies do exist (Hargreaves & Wilson 2013; Sovacool & Furszyfer Del Rio 2020; Strengers *et al.* 2020; Strengers & Nicholls 2017). These studies explore particular visions and narratives associated with SHT. Convenience is an oft-identified core theme in these studies and stands as an overarching vision held by SHT professionals: living smart should mean living easy. The notion of convenience is linked to certain behaviors, lifestyles, and social practices promoted simultaneously by the technology. However, as shown by the work of Strengers *et al.*, the strong focus on convenience in the industry often comes at the expense of sustainability considerations, potentially risking the enhancement of energy consumption and influencing people's everyday practices in a non-sustainable way (Strengers & Nicholls 2017; Strengers *et al.* 2020).

Despite its value to professionals, convenience thus poses as a somewhat problematic element in social practices—a general point of concern that is also raised elsewhere in the literature on consumption and social practices. For instance, Shove *et al.* (2012: 147) propose 'the valuing of convenience' as a type of 'bad' element in practices in relation to climate change. To address

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this issue and the implications of convenience for the field of SHT, it is worthwhile to supplement existing research with an exploration of the meaning of convenience. A critical examination of this concept and its embedment in the SHT industry, including its practical entanglements and underlying problems, will help to broaden our understanding of the visions at play in SHT development and lay the groundwork for a critical discussion of these. Thus, this paper addresses the following question:

> How is the notion of convenience tied into SHT development and how may this impact user practices and sustainability?

To do so, the paper draws on qualitative interviews with SHT professionals representing various branches and positions within the field.

The remainder of the paper is structured as follows. Section 2 provides background information on the SHT industry, including an overview of its composition. This background is followed by an elaboration of SHT imaginaries in the form of a brief literature review, then a presentation of the concept of convenience and the paper's theoretical framework. Section 3 presents the research design. Section 4 gives the main analytic themes concerning the meaning of convenience in user imaginaries, the connection between convenience and interoperability, and the practical aspects of SHT development, including various processes, actors, and relations. The fifth section summarizes the findings and discusses the relations between the analytic themes.

2. BACKGROUND, CONCEPTS AND THEORY

2.1 A MAPPING OF THE SMART HOME ECOSYSTEM

The SHT industry is expanding rapidly, thus, mapping its potential size is difficult, and estimates vary (BCG 2018). However, the major consulting firm Boston Consulting Group's (BCG) analysis of the SHT field is a useful starting point for an overview. As BCG points out, investments in SHT are increasing greatly. The development in this field can be characterized by tech giants, such as Google, Apple, and Amazon, acquiring valuable SHT companies. For instance, Amazon purchased Ring (smart doorbells and cameras), and Google purchased Nest (smart thermostats, smart smoke detectors, and other smart items). In their analysis, BCG identify around 1500 SHT companies that can be divided into 11 sectors: security and safety systems (21% of SHT investments), audiovisual (15%), smart energy (13%), software platforms (12%), heating, ventilation and air-conditioning (HVAC) and lighting (10%), components (8.2%), artificial intelligence (AI) and natural language processing (6%), connected health (3.5%), wearables and mobile apps (3.5%), smart kitchen (2.7%), and robotics (2.2%). However, these sectors are not completely mutually exclusive since many companies deliver products across different sectors, thereby positioning themselves more strategically in the market.

> Amazon (with Alexa) and Google (with Google Home) are among the digital giants that recognize that smart speakers and digital assistants serve not only as a gateway into the home but also as a critical control point within the smart-home ecosystem.
>
> (BCG 2018)

BCG identify Amazon, Samsung, and Google as 'the most aggressive investors' in SHT. In spite of the heavy presence of these big tech companies, the SHT market is not described as being dominated by them but rather as being a 'robust environment populated by multiple key players in various subsegments' (BCG 2018). In this paper, this multiplicity will be explored in terms of, for instance, the various roles, practices, and strategies at play in SHT development.

2.2 SMART HOME IMAGINARIES

As mentioned in the introduction, a small number of scholars have already conducted research into the ideas and visions that prevail in the SHT industry. Hargreaves & Wilson (2013) conducted a content analysis of SHT marketing material that explored representations of the technology, users, and technology–user interactions. Strengers & Nicholls (2017) conducted interviews with Australian

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SHT professionals and analysed media articles to explore the particular visions and narratives associated with SHT. Sovacool and Furszyfer Del Rio's (2020) study includes interviews with British actors from SHT companies, organizations, and research institutions on what they perceive as the potentials, benefits, and barriers to SHT adoption. Apart from identifying convenience as a core theme in SHT visions, these studies also indicate that SHT professionals often have low expectations regarding users' engagement in technical matters and involvement in questions of sustainability and energy efficiency. As such, users are often imagined to be passive and disengaged.

The SHT visions that these studies illustrate, which also include understandings of users and the relationship between humans and their material environments, can be seen as examples of 'sociotechnical imaginaries', a concept introduced by Jasanoff & Kim (2009). Sociotechnical imaginaries express shared understandings and dominant ideas regarding what is scientifically and technologically possible and desirable. They are broadly represented by actors, such as authorities, utilities/institutions, businesses, policymakers, and experts, and, as such, express collective and institutionalized norms (Jasanoff & Kim 2009).

Sociotechnical imaginaries shape not only the design of technologies but also our futures, and the concept has been used in many studies of technological transitions, *i.e.* studies of new energy systems, low carbon housing, and smart homes. Strengers *et al.*'s (2020) study of SHT visions in media articles detects a sociotechnical imaginary, which the authors term 'pleasance', revolving around themes such as frictionless convenience, aesthetics, entertainment, and effortless energy savings (however, as those authors show, in reality risking energy intensification). Cherry *et al.*'s (2017) study of low carbon housing imaginaries among UK experts detects a vision of smart homes in which carbon emissions are reduced, but in which existing behaviors and lifestyles are left unchallenged, and users are regarded as passive and disengaged. In addition, the authors identify a 'techno-fix discourse' (Cherry *et al.* 2017: 40) running through this vision in which the public is imagined as lacking knowledge and interest in technology and climate change.

As these studies show, sociotechnical imaginaries also include particular ideas of users, which can be termed 'user imaginaries' (Ryghaug & Toftaker 2016; Skjølsvold & Lindkvist 2015). These ideas also have implications for how the future is imagined and designed, and the present paper considers how convenience is present through this lens. Sociotechnical and user imaginaries illuminate how designers and other tech professionals play a prominent role in deciding what people's everyday practices should look like. As Strengers & Nicholls (2017: 88) note in their study of SHT professionals, although the professional field does not necessarily reflect actual change in practices within homes, it does reflect visions of how these practices *should* change. Thus, SHT imaginaries are connected to everyday practices, and this link will receive attention in the present paper. The next section will elaborate on how the connection between social practices and technology have been theorized in the literature and present the framework for conceptualizing convenience.

2.3 STUDYING CONVENIENCE IN SOCIAL PRACTICES

Explorations of sociotechnical developments, as exemplified by the above studies, consider general currents within design and consumption research that pay particular attention to the structure of practices. As Shove *et al.* (2012: 12) point out, new forms of technology not only reconfigure the materiality of our daily lives but also, and importantly, they affect social practices, cultural and symbolic meanings, and the skills needed to possess—the latter sometimes resulting in the 'disappearance and cultivation of different forms of competence'. In terms of the present study, the development and spread of SHT also relate to new forms of practices, the cultivation and disappearance of competences, and notions of convenience. In the studies of Strengers and others, convenience appears as a vision and narrative maintained by SHT professionals. Strengers & Nicholls (2017) take a practice theoretical approach and draw on Shove *et al.*'s (2012) three elements of practice: meanings, competences, and materials. They locate convenience as a practice element, interpreting narratives as corresponding to the 'meaning' element (Strengers & Nicholls 2017: 88). This approach is also taken in the present paper, as convenience is explored as a meaning in SHT practices.

In Shove's writings, convenience is defined in various ways, *e.g.* as a standard of normality (Shove 2003b: 194); a promise held by, and ascribed to, technology (Shove & Southerton 2000); and a dominant convention or ideal (Hand & Shove 2007: 94). The concept is problematized in relation to sustainability and described as one of the 'environmental hotspots of consumption' (Shove 2003a: 3). With regard to SHT specifically, Nyborg & Røpke (2011: 1850) note that:

> Smart home technologies can in effect become a dynamic that normalises new energy-demanding practices and supports the construction of new normal expectations to comfort and convenience.

Following these points, this paper unpacks the meaning of convenience within SHT development and explores its implications for everyday practices.

The present research approach is informed by theories of practice. The practice approach illuminates the connections between different practices, *i.e.* 'the here-and-now of the situated practicing and the elsewhere-and-then of other practices' (Nicolini 2009: 1392). Everyday living and household practices involving SHT are connected to the SHT industry and its sales and development practices. These practices (*e.g.* product development, strategizing, and management) are located in different places and temporalities, and an exploration of a professional field must consider the practices involved and their mutual connectedness (Nicolini & Monteiro 2017).

3. RESEARCH DESIGN AND METHOD

In this study, 11 professionals occupying various niches within the SHT field were interviewed during the spring of 2020 via Skype (physical meetings were impossible due to COVID-19). Two participants from the same company were interviewed together. A semi-structured interview format was followed to allow for an open-ended structure and flow of conversation while adhering to a general list of topics (Bernard 2006). Theories of practice informed the interview guide by facilitating an exploration of technology development as a practice field (Nicolini 2009), meaning that the interviews focused on identifying the various practices involved in technology development, among other topics. For instance, participants were asked about their tasks, job descriptions, routines, materials, and technologies they work with, the skills and knowledge they use in their work, and how they collaborate with others. For the questions used for interviewing participants, see the supplemental data online.

The 11 participants represent 10 different companies, of which seven are Danish, three are multinational and one is Norwegian. Participants work within various branches of the SHT industry (*e.g.* smart heating, smart home system apps, smart energy management) and on different levels of the production chain (research and development (R&D), sales and marketing, software programming, management, and prototyping), thus enabling diverse insights into the processes, priorities, and decisions involved in SHT development. One exception to the online interview format was an on-site visit to a participant who is an electrician specializing in SHT installations. The author conducted a walk-along interview (Kusenbach 2003) with this participant during his/her workday in a luxury villa where s/he was setting up various SHT installations. Of the 11 participants, nine are men and two are women. To avoid conjectures about gender, all pronouns are written as 's/he' and 'his/her'.[1]

The sample provides a qualitative excerpt from the professional SHT field and contributes in-depth insights into some of the various practices performed in SHT development. However, it is important to acknowledge that this limited group of research participants does not represent all stages of SHT development, and quantitative generalizability is beyond the scope of the paper. In spite of this limitation, general trends in participants' responses are apparent, despite heterogeneous perspectives, and exemplify various practices, roles, and relations within the field. For instance, user imaginaries and expressions of convenience were quite similar. As such, the sample provides clear thematic tendencies, which is an indicator of saturation in the material (Small 2009; Merriam & Tisdell 2015).

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Participants were recruited by contacting engineering researchers in the SHT field with knowledge of relevant actors in the SHT industry, and referral from these enabled snowball sampling, among others including access to key actors in management positions. Participants at this level in the production chain were important to include because they possess knowledge concerning the strategies and visions of their respective companies and have an overview of their organizational structures. Designers and developers working within R&D, on the other hand, possess skills, technical knowledge, and practical know-how concerning SHT development, and their inclusion illuminated other central aspects of the field, especially those related to the technical challenges of SHT development. The different companies the participants represent are highly variable in size, ranging from a start-up company with only a few employees to multinational corporations with many thousands of employees. The diverse sample of participants enables a closer look into the complex field that SHT development constitutes.

Before the interviews, informed consent was gathered from all participants, who were told that they would remain anonymous in order to provide a confidential space and encourage openness. For the different companies and a summary of the participants, see the supplemental data online. Numbers have been used to tag the participants (P1–P11).

Interviews lasted approximately one hour (from 50 to 80 minutes) and were subsequently transcribed verbatim and coded in the software program NVivo. The coded themes relate to either SHT visions and user imaginaries, or to the practical aspects of SHT development (actors, processes, roles, and relations). The interviews provide the basis of the analysis, and, in the following section, quotations will illustrate and exemplify the most significant takeaways.

4. THE MEANING OF CONVENIENCE IN SMART HOME DEVELOPMENT

When asking about the particular SHTs and participants' focus areas in working with these technologies, prevailing themes were comfort, ease, and savings (of time, hassle, energy, and money)—often with an emphasis on underpinning current user practices, temporal rhythms, and forms of sociality. SHT should not be too disruptive; rather, the technology should work in a smooth and perhaps even seamless manner, thus sparing users from dealing with practical tasks and arrangements in their homes, such as heating and lighting practices. A shared vision among participants was that SHT should make life easier and be easy to use. Thus, *convenience* was an overarching theme in all interviews.

In the following subsections, extracts from the interviews will illustrate the meaning of convenience in user imaginaries, and the relation of convenience with the concept of interoperability. To understand how convenience is brought into being, the work *behind* the technologies is also taken into account. Thus, a section will follow on the roles, relations, and practices that form the work behind SHT development in which the meaning of convenience is embedded.

4.1 CONVENIENCE FOR THE PASSIVE USER

The vision that convenience should be enhanced was brought forth through several cases and scenarios in the interviews. For instance, the smart thermostat is a concrete product that several of the participants work with, either by developing it, selling it, or making apps and platforms with which it can be integrated. One participant, P8, described how his/her company connects smart thermostats to their SHT platform, aiming for 'the least amount of user interaction as possible'. S/he explained the procedure:

> What we do with the thermostat is that you [the user] tell me what your comfort temperature is that you like when you're home and awake, you tell me what your minimum temperature is, and we do the rest. So, we use AI to learn your habits. So, if you come home every day around 5 from work or university or whatever, then the system picks up: 'Hey, there is a pattern here, that [name] comes back every day at 5.' So, we'll make sure that at 5 o'clock, the house is at the comfort temperature that you set before. So, if that means that your house has to start heating at 3, it starts heating at 3.

As P8 formulated it, the system 'picks up' the habits and temporal rhythms of the user. In this manner, a heating solution is created that does not require user interaction, apart from initially setting up some preferences. As such, the integration of the smart thermostat is synchronized with and underpins existing practices, *i.e.* sleeping, leaving for work, returning home, *etc.* The integration supersedes the previous task of adjusting the heat manually while also adjusting to external factors, such as the weather and the changing seasons.

The smart homeowner targeted by several participants is not particularly technology savvy. Most of the companies hope to reach a broad segment of the population and imagine the user as the average 'Mr. and Mrs. Smith', as one participant, P5, formulated it (translated from Danish: 'hr. og fru Jensen'), while shortly after adding: 'the totally normal, average Dane'. A widely shared aim in the technology development is to interfere as little as possible in people's everyday lives and avoid confrontations between humans and technology. P8 illustrated this sentiment in the following scenario:

> So the scenario would be, if you have your house fully automated, you step on the train—let's assume you commute by train—the [smart home] app already knows you're on your way home. So, the app turns on the heat when you come within range, the alarm is disabled, the doors open. So, you step in, the motion sensor detects that you're in the living room, so lights go on that you have programmed to go on, say, when its dark, or the outside light goes on.

Ideally, P8 added, the user should not have to use an app or a phone to trigger the technology. Rather, the technology should be able to turn itself on and off according to the user's needs. In general, the companies do not wish to challenge people's existing everyday practices as such. They hope to relieve people of burdens by creating technology capable of automating, for instance, lighting, heating, or home security. Preferably, the implementation should be completely smooth and absent of any barriers, as the following quotation by P10 illustrates:

> There have to be no barriers to the implementation of a product. Any barrier, the least barrier to buy or use a product will turn people off. They have to be completely barrier-free.

Furthermore, P10 pointed to the importance of what s/he termed 'soft' or 'warm benefits' related to sociality and comfort, rather than 'cold benefits' related to costs or energy savings. According to him/her, users are primarily interested in the former; therefore, these benefits were prioritized by P10's company:

> We spent 30 years trying to educate people on how they can reduce their energy consumption, and it doesn't work. People don't listen, people don't turn off their oven 10 minutes before they finish cooking. [...] What people want to hear about is the warm benefits of a product. Like when I leave, I always know that my kids' bedroom is at the right temperature. Or a warm benefit is like maybe I'm sitting down at dinner, I've got some friends over, and I want to turn the lights down because it would make it more nice. [...] The soft, warm benefits, that's what we should talk about.

The soft, warm benefits—features that make the everyday 'more nice', as P10 puts it—outweigh the focus on energy savings in this user imaginary. Another participant, P4, also spoke about the dilemma between comfort, on the one hand, and energy savings, on the other, as being weighted heavily toward the first priority. In fact, as P4 saw it, this had been the case for years:

> If you wind back five years, then almost everything was about energy savings. [...] But it's becoming less and less the principal element. I mean, it's becoming more and more [about providing greater levels of] comfort, etc. A Sonos speaker is also about increasing the [level of] comfort in your home. If you have to save energy, then you shouldn't buy a Sonos speaker. After all, it consumes energy as well, right?

The view that energy savings is not a top priority was also expressed by P9, an electrician specializing in setting up SHT installations in affluent people's homes. In his/her work, the main focus is on providing aesthetic and comfortable solutions rather than energy-efficient ones:

> It's a lot about cosmetics. And, as I say, it's not energy optimization or anything, it's comfort and aesthetics optimization.

Two participants who did speak about energy savings as a priority in their work with SHT were P6 and P7 (from the same company). However, just like the other participants, they noted that people are not too interested in the topic. Thus, the company has some special requirements for technological solutions. First, lots of energy savings are needed for the technology to have 'a real impact', as P7 expressed in the quotation below. Furthermore, the technology has to be able to run on its own, without the need for people to continuously adjust or tinker with it:

> Take a look at how many people will want to spent time on tinkering with some app and figure out how to save some energy, and keep doing that year after year. That's a very small number. And it won't have a real impact after all, either in terms of CO_2 or commercially. It has to be something that has some big chunks [of energy savings] to it. [...] It has to be set up and then mind its own business and be able to run on its own and provide its functions, without anyone having to go about tinkering with it, right?

A few minutes later, P7's colleague, P6, elaborated on this point by indicating the passivity of the user and the autonomy of the system:

> The general consumer expects the heat to be on when they're in their house, and whatever happens aside from that, they take a very minor interest in. So, that's why we need to have automatic systems that switch on and off according to the need for heating.

Thus, a general view in the interviews was that the technology should be designed to ensure convenience and support what P10 termed the 'soft, warm benefits', *i.e.* aesthetics, preferences for heating, and sociality. P10 provided examples of this type of benefit involving adjusting the lighting when having friends over for dinner or ensuring that the kids' bedrooms are at the right temperature when there is no one home to adjust the temperature. As the interviews indicate, users were imagined to be passive in that they should not be confronted with technical challenges or too much information, and they should not have to play an active role, *e.g.* regarding energy savings. SHT is designed to 'take care' of such issues automatically—independently of, and perhaps even invisible to, users.

4.2 CONVENIENCE THROUGH INTEROPERABILITY

To enhance the convenience that SHT aims to facilitate, it is of central importance that the different technologies are able to 'speak together' to adjust to each other and thus provide integrated and smooth solutions. All participants highlighted that this aspect was important during the interviews. SHT professionals are at work in a market characterized by competition and rapid development and thus need to adjust to other actors, position themselves strategically, find their market niche, manage relations, and form partnerships. This co-dependence obviously involves more than just other actors and is inherently related to the technologies as well. Several of the participants noted how different SHTs operate on different apps, control systems, and protocols, which can make it difficult to combine certain SHTs into one integrated solution. As P1 noted:

> The problem today is that there are so many who are making great products. Then you have an app for that, and you have an app to control your solar cells, you have an app for your heat pump, and you have an app for this, and an app for that. Eventually, you have so many things that should be able to speak together on the same platform, the same control system. And I know, there is a major need [...] that people really want to have this bigger general overview. Something that is easy to access, something that doesn't require much, but a place to go to, and then that is where they can see how things run.

Several of the participants represent companies that develop SHT control systems, *i.e.* operational systems that group and connect different SHTs into an integrated solution. The focus of technology development for these companies is then to increase the range of SHTs that can be added to the system, as the quotation by P8, who works with smart home apps, illustrates:

> So, the thing we are mostly working on is increasing the range of products we support. New lights, new smoke sensors, [...] water leak detectors, and etc.

These visions of implementing more SHTs into one system and making it 'easy to access', as P1 formulated it, show how interoperability is integral to the enhancement of convenience. In order to be accessible and convenient to users, the different technologies should be able to 'speak together'. As such, the two themes do not constitute separate visions; rather, interoperability is vital in ensuring convenience and making the smart home 'barrier-free' (as in P10's formulation). One company addressed interoperability by selling monthly smart home subscriptions. Users pay a monthly fee for an SHT starter kit (with interoperable SHTs), an app from the company with a single interface connecting all SHTs and access to customer support. Thus, convenience is ensured through preconfiguring and preselecting certain SHTs to be combined into one interoperable package with remote access for the company and support for the user when needed:

> Interviewer: How come you need to have a subscription, can't you just do it yourself [select and set up SHTs]?
>
> P5: Sure you can. You can easily buy all the items and then fix it yourself. [...] But what we do is that we take these three [SHT items: a smart thermostat, smart lighting, and sensors] and say, you don't need to—you need our app, then we control it for you and make it more intelligent so you don't need to sit and spend several hours on YouTube. [...] We make it easy and simple so that you can install everything in less than an hour.

The quotation exemplifies how companies make the technology 'easy and simple' to use, as P5 said, by taking on the responsibility of making the SHTs interoperable. Through its subscription packages, P5's company relieves users from dealing with issues of interoperability. Furthermore, users are relieved from the need to learn about technical matters (*e.g.* by watching tutorials on YouTube, as P5 indicated), as the company takes care of this. In P5's words, his/her company 'make[s] sure that you are comfortable with it'.

When asked about where SHT development might head within the next five to 10 years, participant P2 also highlighted interoperability and pointed to the potential for a unified standard to enable the connection of all devices:

> I think we are heading into a unified standard for smart home technology. So, you can have a device, and it doesn't matter if you have Google Home or you have [name of an SHT system developed by the participant's company] or Alexa or it's an Apple HomeKit. Automatically, you are able to connect it.

SHTs' ability to 'speak together' and connect across different brands made up a widely shared vision among the SHT professionals interviewed in this study. Such a finding is also present in other SHT studies (Balta-Ozkan *et al.* 2013; Furszyfer Del Rio *et al.* 2020; Sovacool & Furszyfer Del Rio 2020), and the issue of interoperability has been a challenge in the field for decades (Edwards & Grinter 2001). Sovacool and Furszyfer Del Rio (2020: 10–11) point out that interoperability is not only a question of SHTs working together but also of SHT companies forming cooperative relationships. The interviews of the present study show that the vision of convenience cannot be separated from the notion of interoperability, as the latter is key in providing a convenient and flexible user experience in which different SHTs can be mixed and matched in a functional and smooth manner across different brands. By enabling more devices to be used at the same time, the notion of interoperability also promotes an increase in SHT purchases. Therefore, an awareness of its potential negative impacts is important because it may lead to intensified energy consumption, extraction of resources, and e-waste.

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4.3 THE WORK BEHIND CONVENIENCE

The process of recruiting participants and the initial contact with these individuals provided early insights into the specialized and diffuse character of the SHT professional field. SHT is not invented, designed, and produced in one singular place; rather, development and production cuts across different locations and actors. Thus, a first step in the analysis consisted of preparing an overview of the different processes and actors involved and then gaining insights into how people work, what their actual activities consist of and what kinds of practices SHT development involves.

Most participants represent companies that do not work exclusively with SHT, and some of these companies only recently added SHT to their existing portfolio of products and services, or developed the latter into smart solutions (*e.g.* a heating company developing and selling smart thermostats and smart heating services). As such, participants spoke about following general developments in the market. For instance, when asked about how P5's company started working within the SHT field, s/he pointed towards a general trend among similar companies:

> Interviewer: In terms of smart home—which is quite new to your company, right? How come you thought it was relevant to you? Does it relate to your other services or —?
>
> P5: The reason is that we saw smart home generally being adopted by energy and tele companies. So, you see [lists several examples of foreign companies launching SHT solutions]. I mean, we could see this trend of more and more of these big companies going this way.

Thus, the practice of observing and following trends in the company's area of business is a way to initiate work within SHT. Another participant, P3, represents an old corporation in which SHT work is only an emerging and unofficial part. However, as the company indirectly works with comfort in their line of products, there is some potential for SHT here, as technology developers see it as a means of achieving convenience. R&D departments are key driving forces in such development forces because they have the capacity to research and explore new opportunities for companies:

> Interviewer: But you also said that [name of P3's company] is not working very much with the smart technology path?
>
> P3: So, this is something that we as researchers [in the R&D department] are trying to introduce and propose to them. [...] Can we maybe make some packages together, can we sell some kind of comfort service instead of selling materials individually? And [...] if you are starting to sell a comfort service, then it would make sense to have some kind of smart technology that allows you to control the comfort package. And this is the stuff I'm trying to push.

P3's role in the company is to conduct a research project on user behavior and interaction with an SHT system. S/he has found the need to improve the communication between the system and the users, make room for negotiation, and enhance the users' feeling of control:

> It's like this kind of fine line where you respect occupants' wishes and make them feel good about what is going on in their homes but also still trying to save energy and use energy when the wind is blowing and things like this.

P3 pays careful attention to users' experiences and studies these in his/her work of developing new SHT. Although s/he initially hired assistants to conduct user interviews, P3 ended up conducting many of these interviews him/herself to gain a more thorough insight into users. Several of the participants highlighted the importance of insights into users, but mostly only big companies with many resources can afford to conduct systematic user research. P3 has no commercial responsibilities but is free to explore and push some limits as to what the current technology is able to do—for instance, by challenging the notion that users are passive and should be excluded from technological processes. P3 wishes to enhance users' understanding of the automation process and give them 'the perception of control', as s/he put it. Thus, the task is to find a balance between energy savings done autonomously of users and savings involving users to some degree to give them a sense of control.

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Another participant, P11, also represents a big company and works in R&D. P11 is a user experience designer and does not work directly with SHT, although their work involves smart technologies and AI. Like P3, P11 has no direct commercial responsibilities. In P11's work, s/he uses the so-called 'research through design' approach. P11 is part of team that develops digital design by simultaneously studying how it is applied and adopted by users. P11 spoke of technology development as an iterative process, *i.e.* as trying things out and simultaneously studying the interaction between the user and technology. Thus, the technology is considered to be evolving and, to some extent, unpredictable:

> The technology is so new in many ways that we do not entirely understand it yet. I mean, even though I am designing it and have done so for many years, then it's also a lot about sometimes we just have to try something and then see how people will use it, in order to really understand what it is and what it does.
>
> (P11)

This point reflects the generally emergent and processual character of the technology. P11's way of addressing this character is to experiment with and study the technology while developing it at the same time. P11 and P3 express different user imaginaries and slightly different approaches to technology development. While P3 wants more engagement from the users and to provide them with more control, P11 takes an open-ended approach to technology in that s/he awaits users' responses in order to understand the technology's capabilities. In these SHT imaginaries, the meaning of convenience is shifted somewhat because it is decoupled from users' passivity and disengagement. Importantly, both participants have no commercial responsibilities. Thus, it might be within these lines of thought that a more sustainable path for SHTs is to be found.

In the interviews, several participants noted that the competition within the business is fierce and that everyone wants to play with (rather than dare to match) the heavyweights, such as Google, Apple, and Amazon. Most of the participants mentioned the importance of their company 'knowing its place' in relation to other actors in the market and targeting their products and services feasibly, thus securing their particular market niche. For instance, some companies specialize in software and app development, while others focus on developing concepts and services that match their existing customer base (to whom some of the companies, for instance, supply heating and electricity). All the companies have partnerships with other actors in the business. For instance, several of the large companies do not have the capacity to make all the hardware and electronic components they require themselves, and it is much cheaper to buy some of these components from specialized companies that are usually located abroad. However, one company represented in the interviews also carries out 'actual' technology development by building Internet of Things (IoT) devices (and software)—so-called white-label products—and selling these products to companies to use in their own solutions.

These partnerships characterizing all the companies illustrate the complexity of technology development and how the creation of SHT by no means follows a linear course. Rather, SHT development is the result of many different processes and actors negotiating with each other (*i.e.* about customer needs, technological problems, and solutions) while navigating in relation to other companies and competitors and, especially, adapting to existing products and services offered by the big tech companies, such as Google, Apple, and Amazon. As such, imaginaries of technology and users as well as visions of convenience are not just individual expressions of single companies or employees but should rather be understood as deeply entangled within a larger network of businesses embedded in the global financial market of consumer goods.

5. DISCUSSION AND CONCLUSIONS

This paper has explored the meaning of convenience in smart home imaginaries based on interviews with professional actors occupying different positions within the field. By taking their visions and work into account, it was possible to detect the practical entanglements of convenience and explore how it is brought into being and enforced in technology development.

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In this concluding section, the findings of the paper will be summarized by highlighting three major points: (1) the meaning of convenience in SHT user imaginaries; (2) the connection between convenience and interoperability; and (3) the embedment of convenience in collective practices used in SHT development.

In the interviews, users were primarily imagined as passive and disengaged, lacking interest in what one participant termed the 'cold benefits' of SHT, *e.g.* cost and energy savings. In this view, SHT should not require too much interaction or technological skills from the user, and the latter should be able to behave as usual. As such, users' everyday practices are left unchallenged. Thus, the meaning of convenience was framed as something that does not require any particular competences, *e.g.* no need to tinker with the technology or be confronted with issues regarding energy savings. This view mirrors the techno-fix discourse described by Cherry *et al.* (2017) and may impact energy consumption negatively since user imaginaries not only contribute to new norms of convenience but also risk impeding intended energy savings (Nyborg & Røpke 2011; Strengers *et al.* 2020).

Second, the interviews showed that the meaning of convenience in SHT imaginaries cannot be separated from the notion of interoperability, as the latter is seen as integral in forming the material arrangements of the former, *i.e.* providing a convenient and flexible user experience requires several SHTs to be integrated smoothly. Convenience and interoperability are also reflected elsewhere in the SHT literature (Balta-Ozkan *et al.* 2013; Furszyfer Del Rio *et al.* 2020; Sovacool & Furszyfer Del Rio 2020), but their interconnectedness has not been highlighted in particular. This paper shows that the two are mutually constitutive in that convenience as a meaning in practice is enabled and enforced through interoperability in the material arrangements of SHT. The connection between convenience and interoperability deserves ongoing awareness in policy and research, as interoperability promotes increased SHT purchases and may also increase energy consumption and e-waste. Policymakers should play an active role in ensuring that the enhancement of interoperability takes a sustainable direction, *e.g.* by minimizing e-waste, and that the development of unified SHT standards supports energy efficiency and sustainable consumption.

Finally, focusing on practices in SHT development illuminated the many different roles and skills contributing to, and drawing on, collectively shared understandings and visions among SHT professionals. For instance, the interviews showed that all companies are in partnerships with other companies and that they draw on each other's specialized skills, knowledge, and technological components through these partnerships. For example, ideas about what the technology should do are formed by mutual influences and commercial interests, but also R&D practices, such as user research. Such practices show how technology development follows a convoluted rather than a linear course. Different SHTs are developed for interoperability, often in alignment with popular products and services provided by big tech companies, such as Google, Apple, and Amazon (BCG 2018). The notion of interoperability thus also has implications for SHT development practices since sales and innovations are dependent on being in compliance with those of other actors to ensure a convenient user experience. Thus, interoperability highlights the close reliance of smaller companies on big tech companies, while user imaginaries are equally shaped by this dependence. The specifics of such influences cannot be concluded from this limited study, but they indicate that further research on professional relations and interdependencies in the SHT ecosystem, which is a yet an under-researched topic in the literature, is necessary.

Earlier SHT studies have shown that visions of convenience in the SHT industry risk overruling sustainability considerations (Herrero *et al.* 2018; Strengers *et al.* 2020; Strengers & Nicholls 2017), and this study concurs. However, convenience is often framed as a vision and narrative in the existing literature (Darby 2018; Strengers *et al.* 2020; Strengers & Nicholls 2017), with limited consideration being applied to the practices and relations forming the SHT ecosystem. The present study illuminated the practical embedment of SHT visions and showed that sociotechnical and user imaginaries are an outcome of relations, interdependencies, and collective practices in SHT development.

To challenge the meaning of convenience, researchers and policymakers need to address all SHT development practices with an awareness of the large commercial powers at play. When SHT is promoted in policy, *i.e.* as a means by which to enhance energy efficiency and savings (European Union 2020), an awareness of user imaginaries in the industry and masked energy consumption in the name of convenience should follow. Policy instruments such as the smart readiness indicator (SRI) should not only include calculations of what is technically possible in terms of automation but also examine the practices and behavior that SHT promotes.

NOTE

1 The SHT field is, in general, male dominated in terms of users as well as professionals. This dominance is a significant aspect; however, a discussion on gender is beyond the scope of this paper. For an elaboration of this topic, see, for example, Strengers (2013, 2014) and Strengers & Kennedy (2020).

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COMPETING INTERESTS

The author has no competing interests to declare.

DATA AVAILABILITY

To ensure participants' anonymity, public access to interview data is not available.

ETHICAL APPROVAL

Informed consent was obtained from all research subjects participating in the study. Personal data were anonymized. Research was performed in accordance with the Declaration of Helsinki and was approved by Aalborg University.

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SUPPLEMENTAL DATA

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REFERENCES

Balta-Ozkan, N., Davidson, R., Bicket, M., & **Whitmarsh, L.** (2013). The development of smart homes market in the UK. *Energy*, 60, 361–372. DOI: *https://doi.org/10.1016/j.energy.2013.08.004*

BCG. (2018). *Mapping the smart-home market*. Boston Consulting Group (BCG). *https://www.bcg.com/publications/2018/mapping-smart-home-market.aspx*

Bernard, H. R. (2006). Interviewing: Unstructured and semistructured. In H. R. Bernard (Ed.), *Research methods in anthropology: Qualitative and quantitative approaches* (4th edn, pp. 210–250). Altamira/Rowman & Littlefield.

Berry, M., Gibson, M., Nelson, A., & **Richardson, I.** (2007). How smart is 'smart'?—Smart homes and sustainability. In A. Nelson (Ed.), *Steering sustainability in an urbanizing world: Policy, practice and performance* (pp. 239–252). Ashgate.

Cherry, C., Hopfe, C., MacGillivray, B., & **Pidgeon, N.** (2017). Homes as machines: Exploring expert and public imaginaries of low carbon housing futures in the United Kingdom. *Energy Research & Social Science*, 23, 36–45. DOI: *https://doi.org/10.1016/j.erss.2016.10.011*

Darby, S. J. (2018). Smart technology in the home: Time for more clarity. *Building Research & Information*, 46(1), 140–147. DOI: *https://doi.org/10.1080/09613218.2017.1301707*

Edwards, W. K., & **Grinter, R. E.** (2001). At home with ubiquitous computing: Seven challenges. In G. D. Abowd, B. Brumitt & S. Shafer (Eds.), *Ubicomp 2001: Ubiquitous computing* (pp. 256–272). Springer. DOI: *https://doi.org/10.1007/3-540-45427-6_22*

European Union. (2020). Commission Delegated Regulation (EU) 2020/2155 of 14 October 2020 supplementing Directive (EU) 2010/31/EU of the European Parliament and of the Council by establishing an optional common European Union scheme for rating the smart readiness of buildings (Text with EEA relevance). No. 32020R2155. *Official Journal of the European Union* L 431/9. *http://data.europa.eu/eli/reg_del/2020/2155/oj/eng*

Furszyfer Del Rio, D. D., Sovacool, B. K., Bergman, N., & **Makuch, K. E.** (2020). Critically reviewing smart home technology applications and business models in Europe. *Energy Policy*, 144, 111631. DOI: *https://doi.org/10.1016/j.enpol.2020.111631*

Gram-Hanssen, K., & **Darby, S. J.** (2018). 'Home is where the smart is'? Evaluating smart home research and approaches against the concept of home. *Energy Research & Social Science*, 37, 94–101. DOI: *https://doi.org/10.1016/j.erss.2017.09.037*

Hand, M., & **Shove, E.** (2007). Condensing practices: Ways of living with a freezer. *Journal of Consumer Culture*, 7(1), 79–104. DOI: *https://doi.org/10.1177/1469540507073509*

Hargreaves, T., & **Wilson, C.** (2013). Who uses smart home technologies? Representations of users by the smart home industry. *Paper presented at the European Council for an Energy Efficient Economy (ECEEE) Summer Study on Energy Efficiency in Buildings*. *https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2013/6-appliances-product-policy-and-ict/who-uses-smart-home-technologies-representations-of-users-by-the-smart-home-industry/*

Hargreaves, T., Wilson, C., & **Hauxwell-Baldwin, R.** (2018). Learning to live in a smart home. *Building Research & Information*, 46(1), 127–139. DOI: *https://doi.org/10.1080/09613218.2017.1286882*

Herrero, S. T., Nicholls, L., & **Strengers, Y.** (2018). Smart home technologies in everyday life: Do they address key energy challenges in households? *Current Opinion in Environmental Sustainability*, 31, 65–70. DOI: *https://doi.org/10.1016/j.cosust.2017.12.001*

Jasanoff, S., & **Kim, S.-H.** (2009). Containing the atom: Sociotechnical Imaginaries and nuclear power in the United States and South Korea. *Minerva*, 47(2), 119–146. DOI: *https://doi.org/10.1007/s11024-009-9124-4*

Kusenbach, M. (2003). Street phenomenology: The go-along as ethnographic research tool. *Ethnography*, 4(3), 455–485. DOI: *https://doi.org/10.1177/146613810343007*

Mennicken, S. (2016). Designing inhabitant-centered experiences for future smart homes (Dissertation, University of Zurich, Faculty of Economics). DOI: *https://doi.org/10.5167/uzh-135624*

Mennicken, S., & **Huang, E. M.** (2012). Hacking the natural habitat: An in-the-wild study of smart homes, their development, and the people who live in them. In J. Kay, P. Lukowicz, H. Tokuda, P. Olivier & A. Krüger (Eds.), *Pervasive computing* (pp. 143–160). Springer. DOI: *https://doi.org/10.1007/978-3-642-31205-2_10*

Merriam, S. B., & **Tisdell, E. J.** (2015). Designing your study and selecting a sample. In S. B. Merriam & E. J. Tisdell (Eds.), *Qualitative research: A guide to design and implementation* (pp. 73–103). Wiley.

Nicolini, D. (2009). Zooming in and out: Studying practices by switching theoretical lenses and trailing connections. *Organization Studies*, 30(12), 1391–1418. DOI: *https://doi.org/10.1177/0170840609349875*

Nicolini, D., & **Monteiro, P.** (2017). The practice approach: For a praxeology of organisational and management studies. In A. Langley & H. Tsoukas (Eds.), *The SAGE handbook of process organization studies* (pp. 110–126). SAGE. DOI: *https://doi.org/10.4135/9781473957954.n7*

Nyborg, S., & **Røpke, I.** (2011). Energy impacts of the smart home—Conflicting visions. In *Energy efficiency first: The foundation of a low-carbon society, 1849–1860*. *https://orbit.dtu.dk/en/publications/energy-impacts-of-the-smart-home-conflicting-visions*

Paetz, A.-G., Dütschke, E., & **Fichtner, W.** (2012). Smart homes as a means to sustainable energy consumption: A study of consumer perceptions. *Journal of Consumer Policy*, 35, 23–41. DOI: *https://doi.org/10.1007/s10603-011-9177-2*

Ryghaug, M., & **Toftaker, M.** (2016). Creating transitions to electric road transport in Norway: The role of user imaginaries. *Energy Research & Social Science*, 17, 119–126. DOI: *https://doi.org/10.1016/j.erss.2016.04.017*

Shove, E. (2003a). *Comfort, cleanliness and convenience: The social organization of normality*. Berg.

Shove, E. (2003b). Users, technologies and expectations of comfort, cleanliness and convenience. *Innovation: European Journal of Social Sciences*, 16(2), 193–206. DOI: *https://doi.org/10.1080/13511610304521*

Shove, E., & **Southerton, D.** (2000). Defrosting the freezer: From novelty to convenience: A narrative of normalization. *Journal of Material Culture*, 5(3), 301–319. DOI: *https://doi.org/10.1177/135918350000500303*

Shove, E., Pantzar, M., & **Watson, M.** (2012). *The dynamics of social practice: Everyday life and how it changes*. SAGE. DOI: *https://doi.org/10.4135/9781446250655*

Skjølsvold, T. M., & **Lindkvist, C.** (2015). Ambivalence, designing users and user imaginaries in the European smart grid: Insights from an interdisciplinary demonstration project. *Energy Research and Social Science*, 9, 43–50. DOI: *https://doi.org/10.1016/j.erss.2015.08.026*

Small, M. L. (2009). 'How many cases do I need?': On science and the logic of case selection in field-based research. *Ethnography*, 10(1), 5–38. DOI: *https://doi.org/10.1177/1466138108099586*

Sovacool, B. K., & **Furszyfer Del Rio, D. D.** (2020). Smart home technologies in Europe: A critical review of concepts, benefits, risks and policies. *Renewable and Sustainable Energy Reviews*, 120, 109663. DOI: *https://doi.org/10.1016/j.rser.2019.109663*

Strengers, Y. (2013). *Smart energy technologies in everyday life: Smart utopia?* Palgrave Macmillan. DOI: *https://doi.org/10.1057/9781137267054*

Strengers, Y. (2014). Smart energy in everyday life: Are you designing for resource man? *Interactions*, 21(4), 24–31. DOI: *https://doi.org/10.1145/2621931*

Strengers, Y., Hazas, M., Nicholls, L., Kjeldskov, J., & **Skov, M. B.** (2020). Pursuing pleasance: Interrogating energy-intensive visions for the smart home. *International Journal of Human–Computer Studies*, 136, 102379. DOI: *https://doi.org/10.1016/j.ijhcs.2019.102379*

Strengers, Y., & **Kennedy, J.** (2020). *The smart wife: Why Siri, Alexa, and other smart home devices need a feminist reboot*. MIT Press. DOI: *https://doi.org/10.7551/mitpress/12482.001.0001*

Strengers, Y., & **Nicholls, L.** (2017). Convenience and energy consumption in the smart home of the future: Industry visions from Australia and beyond. *Energy Research & Social Science*, 32, 86–93. DOI: *https://doi.org/10.1016/j.erss.2017.02.008*

Takayama, L., Pantofaru, C., Robson, D., Soto, B., & **Barry, M.** (2012, September). Making technology homey: Finding sources of satisfaction and meaning in home automation. *Paper presented at UbiComp '12: Proceedings of the 2012 ACM Conference on Ubiquitous Computing*. DOI: *https://doi.org/10.1145/2370216.2370292*

Wilson, C., Hargreaves, T., & **Hauxwell-Baldwin, R.** (2014). Smart homes and their users: A systematic analysis and key challenges. *Personal and Ubiquitous Computing*, 19, 463–476. DOI: *https://doi.org/10.1007/s00779-014-0813-0*

Wilson, C., Hargreaves, T., & **Hauxwell-Baldwin, R.** (2017). Benefits and risks of smart home technologies. *Energy Policy*, 103, 72–83. DOI: *https://doi.org/10.1016/j.enpol.2016.12.047*

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