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EXPERIMENTAL STANDARDS IN SUSTAINABILITY TRANSITIONS: INSIGHTS FROM THE BUILDING SECTOR

PhD Series 15-2017

Lara Anne Hale

EXPERIMENTAL STANDARDS IN SUSTAINABILITY TRANSITIONS:

INSIGHTS FROM THE BUILDING SECTOR

Doctoral School of Organisation and Management Studies

PhD Series 15.2017

CBS  **COPENHAGEN BUSINESS SCHOOL**
HANDELSHØJSKOLEN

Experimental Standards in Sustainability Transitions

Insights from the Building Sector

Lara Anne Hale

Supervisors: Jeremy Moon and Andreas Rasche

Doctoral School of Organisation and Management Studies

Copenhagen Business School

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Lara Anne Hale
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Foreword

When I started the PhD position, my department gifted me with a beautiful potted orchid. I had, in fact, sworn off these sensitive petaled creatures years before; but here with this new life challenge, was a smaller, living metaphor of a challenge. I told myself: “If I can keep this orchid alive, then I can make this dissertation.” Over three years later, my lovely little orchid is still thriving, even having managed a second bloom last spring. In this time it has occurred to me the truth of the metaphor. Researching sustainable building has opened me up to the significance of certain aspects humans need to live well: sufficient light (and dark), good air quality, knowledge of what to do to care for themselves, and personal attention from others. In every room I enter, I now notice the access to daylight, the ventilation systems, the social orientation of the space. And for my orchid, I make sure to turn its leaves facing broad side towards the window, crack the window to give it air, give it an orchid bath, wherein I leave it bathing in a pool of water for 20 minutes (a tidbit of knowledge my colleague lent me). I will admit that I sing to it occasionally. Just as they are melancholy projections to imagine what would happen to my orchid if I did not care for it, they are deplorable, dark realities that plague the built environment. Innocent people are sick, neglected, and withering because of their homes – though we have the means to make better homes for them to inhabit. Sustainable building is as much about health and happiness indoors as it is about energy consumption.

In some ways, it is a blessing for *sustainability* to have such manifold and ambiguous meanings. When I was submerged in Environment Studies and Biology, there was an encouraging focus on interdisciplinary connections among natural science, engineering, economics, and policy; but it was very difficult to grasp a holism that could cover all of it *and* be whittled down to an individual experience. Now, just as much as being about climate change, I can see sustainability as being about the child who lives in a poorly ventilated, shaded, apartment, exposed regularly to black mold spores and volatile organic compounds (VOCs). Perhaps sustainable building exists, but is it scalable and accessible? Understanding the problems on the ground helps me to work together with my university and with industry to nurture enlightened visions for the future and solutions to research them. Developing perspectives on how to go about this in other industries, as well, and how to refine theoretical and methodological approaches to researching sustainability and innovation has been in no small part thanks to the Innovation for Sustainability Network. I feel emboldened and supported by the friendships I have developed with the seven other PhD fellows, particularly with my travel companion and comrade at arms, Amanda Williams. Even more importantly, the I4S network has become my research family, those who can make one have hope again and believe that with these brilliant, passionate, committed people, we can get this done!

I would like to express my gratitude to VELUX, most especially to Lone Feifer, my industrial supervisor. I would like to name more people specifically, but risk negating the anonymity promised with interviewing. I have never thought of a company as being *good*, but VELUX has been instrumental in seeing that this can indeed be the case – that there can be organizations of people truly meaning to improve upon the world. The Active House Alliance has been the right arm of these efforts. At the same time, I am grateful for the research relationship we have established, including a freedom and independence that allows me to research with a sense of objectivity. I would also like to give most humble thanks to my supervisors at CBS, without whose inspiration and guidance, I surely would have been lost. I am grateful for Andreas Rasche, who is probably the most clear, structured, supportive supervisor who still manages to crack out a brilliant smile and sense of humor. Jeremy Moon, who came in further down the PhD road, always keeps his office door open, has a supportive word or two, and also has an amazing ability to correct my English. Though he was not one of my supervisors on the books, I also would like to give an honorable mention to Nigel Roome, who left our project and our world too early and is sorely missed.

I have also heard tell how isolating and lonely a PhD project can be, as it has a tendency to disconnect one from his or her non-academic social networks. But not with friends and family like mine who patiently listen to me describe what Institutional Theory is (well really what a theory is) or tell why I am frustrated by contradictions in epistemologies. Of course, my mother, Nyna Kay Hale, has been my champion, as well as my friends Oda Mogstad, Kerry Van der Merwe, Johanna Pirtinheimo, Kiri Beilby, Rachel Bullen, Mumina Hassan, Jen Shipley Barnard, and Samantha Svårdh. Anytime I start to feel that the sustainability field is too depressing, too much of a burden, all I have to do is think of the people I have listed in this foreword, and they lighten me right up again, a veritable natural daylight machine. I really do relate to my orchid: a little bit of sun, some dancing out on the lawn, and having good people around to take care of me. I only hope that I give as much or more than I take. The road does not stop here! As highlighted time and again in this disseration, sustainability is a dynamic, complex process, and there is much work to be done.

Abstract

In this thesis I address how experimental standards are used in the new governance paradigm to further sustainability transitions. Focusing on the case of the Active House standard in the building sector, I investigate experimental standards in three research papers examining the following dynamics: (1) the relationship between commensuration and legitimacy in the formulation and diffusion of a standard's specifications; (2) the role of awareness in standardizing green default rules to establish sustainable consumption in buildings; and (3) the significance of focus on humans in the development of technological standards for sustainable building. Launching from a critical realist social ontology, I collected ethnographic data on the Active House Alliance, its cofounder VELUX, and three of their demonstration building projects in Austria, Germany, and Belgium over the course of three years from 2013 to 2016. In light of the literature on standards and global experimental governance (GXG), I explicate how experiments unfold processually and how standards makers adjust the standard's development to learnings and social insights from these experiments.

In the first paper on commensuration and legitimacy, I present a standardization model based on Botzem and Dobusch's (2012) "Recursive cycle of transnational standardization." I build upon their model to show how undertaking commensuration – the conversion of qualities into comparable quantities – in developing a standard's specifications affects its legitimation, both amongst other building professionals and in the context of its application. In the second paper on green default rules – rules which as the default set the more environmentally-friendly option and require further attention and action to change them –, I construct a model of how standardizing green default rules can potentially lead to sustainable consumption in buildings, while highlighting the key role of the building inhabitants' awareness of the value of these defaults. In the third paper, I present a model of the interactive design process of technological building standards in order to show the significance of focusing on human as much technological development. Counter to prevailing discourse criticising human focus in the Anthropocene, I argue that too much focus on technological fixes will inhibit sustainability transitions.

In the current climate of uncertainty, risk, and wicked problems, sustainability transitions are not located down one path, but rather offer manifold alternatives with unknown ends, potential experiments. A pivotal element of experimentation is an academic inquiry to its processes and implications, most especially in order to feed back into the experimentation itself. This thesis exposes the role of standards in experimental governance, as well as underlining the significance of commensuration, default rules awareness, and human focus in experimental standards. The thesis' conclusions are two-fold. Firstly, the modern proliferation of quantification in sustainability transitions – be it measurement of energy usage, liveability of cities, or indoor comfort – is fundamentally rooted in social processes that if experimented with and understood, can be better fashioned as metrics based on real people in the real environment.

Secondly, even when technological optimism prevails, such as with successfully designing defaults or automating buildings, the technologies only further sustainability transitions when the people relating to them understand the technologies and are themselves understood. In other words, the transitions to sustainability are truly composed of socio-technical landscapes, wherein the the social cannot be disaggregated from the technical, and wherein experimentation and standardization offer a way of opening up the socio-technical mysteries and sharing the discoveries across societies.

Resumé

I denne afhandling belyser jeg, hvordan eksperimentelle standarder benyttes i New Governance-paradigmet for at fremme bæredygtige transitioner. Ved at fokusere på sagen om Active House-standarden i byggesektoren har jeg undersøgt eksperimentelle standarder i tre forskningsartikler vedrørende de følgende dynamikker: (1) Forholdet mellem kommensuration og legitimitet i formuleringen og diffusionen af en standards specifikationer; (2) bevidstheds rolle i standardiseringen af grønne regler for at oprette bæredygtig konsumtion i bygninger; og (3) signifikansen af fokus på mennesker i udviklingen af teknologiske standarder for bæredygtigt byggeri. Med udgangspunkt i kritisk realistisk ontologi har jeg samlet etnografisk data om Active House Alliance, dens medstifter VELUX samt tre af deres demonstrationsbyggeprojekter i Østrig, Tyskland og Belgien i løbet af tre år fra 2013 til 2016. I lyset af litteraturen om standarder og Global Experimentalist Governance (GXG) ekspliciterer jeg, hvordan eksperimenter udfolder sig processuelt, og hvordan de, der sætter standarderne, justerer standardernes udvikling i forhold til, hvad de lærer og får af social indsigt af disse eksperimenter.

I den første artikel om kommensuration og legitimitet, præsenterer jeg en standardiseringsmodel baseret på Botzem og Dobuschs (2012) "Recursive cycle of transnational standardization". Ved hjælp af deres model viser jeg, hvordan brugen af kommensuration – konvertering af kvaliteter til sammenlignelige kvantiteter – ved udvikling af en standards specifikationer påvirker dens legitimitet, såvel blandt øvrige aktører i byggebranchen som i dens applikations kontekst. I den anden artikel om grønne standardregler – regler, hvor standarden er mere miljøvenlig, og der kræves mere for at ændre dem – konstruerer jeg en model af, hvordan standardisering af grønne standardregler potentielt kan føre til bæredygtig konsumtion i bygninger, mens jeg understreger den afgørende rolle, bygningens beboeres bevidsthed om disse standarders værdi, har. I den tredje artikel præsenterer jeg en model af teknologiske byggestandarders interaktive designproces for at vise vigtigheden af at fokusere ligeså meget på menneskelig som på teknologisk udvikling. Modsat herskende diskurs, der kritiserer menneskeligt fokus i Antropocæn, argumenterer jeg for, at for meget fokus på teknologi vil hæmme bæredygtige transitioner.

I det nuværende klima, der er præget af usikkerhed, risiko og alvorlige problemer, er der ikke kun én vej fremad for bæredygtige transitioner, men flere alternativer og potentielle eksperimenter med ukendte ender. Et centralt element i eksperimenter er en akademisk undersøgelse af deres processer og konsekvenser, især med henblik på feedback tilbage til eksperimenterne selv. Denne afhandling eksponerer standarders rolle i eksperimentel styring samt understreger betydningen af kommensuration, bevidsthed om standardregler og menneskeligt fokus i eksperimentelle standarder. Afhandlingens konklusioner er følgende: For

det første er den moderne spredning af kvantificering i bæredygtige transitioner – fx måling af energiforbrug, byers livskvalitet eller indeklime – fundamentalt rodfæstet i sociale processer og kan, ved hjælp af eksperimenter og bedre forståelse, forbedres som målinger, der er baserede på rigtige mennesker i deres rigtige omgivelser. For det andet, selv når teknologisk optimisme hærsker, fx ved vellykket design af standarder eller automatisering af bygninger, fremmer teknologierne kun bæredygtige transitioner, når mennesker, der relaterer til dem forstår teknologierne og selv bliver forstået. Med andre ord, transitioner til bæredygtighed består i virkeligheden af sociotekniske landskaber, hvori det sociale ikke kan adskilles fra det tekniske, og hvori eksperimentering og standardisering tilbyder en måde at åbne op for de sociotekniske mysterier og dele opdagelserne på tværs af samfund.

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Part A: Kappe

Introduction

In 2008 I made my first journey to Scandinavia, traveling with a research group around the Danish islands of Sjælland, Lolland, and Falster and investigating engineering and policy at some of the world's most advanced renewable energy sites, including combined heat and power (CHP) waste incineration, biomass and biogas production, on- and off-shore windfarms, and even a hydrogen community. A few years later, then living in Sweden, I paid my first visit to one of the world's most sustainably rehabilitated harbour communities, Västra Hamnen, the western harbour of Sweden's third largest city, Malmö. The message in these places is the same: "Here we have the best in the world. We have the technology and the competence. But we need to find a way to make this the norm, rather than the exception." In the fight against climate change and efforts for a more sustainable future, there is a need for *sustainability transitions*, defined as "paths towards more 'sustainable' modes of production and consumption [;and these paths are] complex multi-level processes that involve interactions and co-evolutionary alignments between socio-technical systems, landscapes, and niches" (Manning & Reinecke, 2016, p.618). The exemplified are not in themselves enough – rather, the urgency is to integrate the social practices, technologies, and norms across industries the world over.

Whereas in the most recent totals the building sector accounted for 6% of 2010's global carbon dioxide (CO₂) emissions (United States Environmental Protection Agency, 2016), in Europe this sector accounts for nearly half (European Commission, 2016), making it one of the most pivotal areas for focusing the continent's sustainability transitions. But even though sustainable building approaches and technologies are available, means are needed for driving forward and normalizing their use in practice. According to sustainability and standards research, the aforementioned transitional alignments are enacted through an architecture of sustainable practice that further sustainability standards (Manning and Reinecke, 2016; Reinecke, Manning, & von Hagen, 2012). The sustainable practice nurtures learnings that inform standards, and these standards serve as building organizations' platform for communicating solutions and normalizing best practice throughout the industry. Standards are, in a sense, used to govern the normalization of sustainable building practice.

The academic contribution of this doctoral research is a multi-level investigation based on analysis in the building industry into how standards as a mode of governance are changing and how they are driving sustainability transitions. Herein, *standards* follow Timmerman and Epstein's (2010) conceptualization¹ as constructed

uniformities across time and space, through the generation of agreed-upon rules. The standards thereby created tend to span more than one community of practice or activity site; they make things work together over distance or heterogeneous metrics; and they are usually backed up by external bodies of some sort, such as professional organizations, manufacturers' associations, or the state. (p.71)

Rather than being mandatory in the sense of regulations, standards execute their own form of regulation based on social rules and norms. These rules can affect both production and consumption, two sides of the same sustainability transitions coin. Over a period of three years, I have worked with VELUX, a roof-top windows manufacturer headquartered in Denmark, in order to study their co-founded sustainable building alliance, the Active House Alliance, and experimentation with its standard, the Active House standard. The Active House standard studied herein develops rules for sustainable building design based on experiments incorporating specifications for energy, environment, and comfort. Using sustainable building as the field of study, I examine how standards serve as a pathway from experimental governance's knowledge generation to sustainability transitions. In other words, I look at the processes of experimental standardization intended to further society's transitioning through sustainable practice.

In researching the relationship between standards and sustainability transitions, I noted unique characteristics relating to Active House's experimental approach. As such, I treat these concepts as interconnecting under the auspice of experimental governance. DeBurca, Keohane, and Sabel (2014) offer a useful overarching definition of global experimental governance (GXG) as "an institutionalized process of participatory and multi-level collective problem-solving, where the problems and the means of addressing them are framed in an open-ended way, and subjected to periodic revision by various forms of peer review in the light of locally generated knowledge" (p.477). In the current sustainability climate in Europe, the built environment is a popular arena for governance experimentation (see van der Heijden, 2013a and 2016; Evans & Karvonen, 2014). Standards are fundamental to conveying alternative design

¹ Definitions of standards are manifold and fragmented, and are perhaps more useful when examined from a process perspective (Djelic and den Hond, 2014). See further discussion in Timmermans and Epstein (2010), as well as Botzem and Dobusch (2012), Demortain (2010), and Brunsson, Rasche and Seidl (2012).

approaches in the building field, serving as the experimental tools wielded to craft legislative changes. It is this relationship between the industrial standard and legislation that has been much of the focus of recent governance research in the building and design sectors. Scholars are in the early stages of delineating how governance through private standards is changing the way we do business. And in terms of sustainability, there is limited understanding as to how policies translate into sustainability-oriented practice, the sustainability transitions themselves (Manning & Reinecke, 2016).

The dynamics of experimental standards for sustainability transitions are illuminated in the three articles herein:

(1) The first paper concerns commensuration and legitimation processes in the formulation and diffusion of a standard's specifications. As standards makers grapple with representing sustainable building qualities – such as comfort – as quantitative specifications, how this is done affects the standard's legitimation, both by other technical experts and within the construction context it is applied. The paper offers a model of this process, and it shows that the legitimation processes in standards development are linked to commensuration processes in a recursive cycle.

(2) The second paper is on the incorporation of default rules for sustainable consumption in standards. These rules influence the building layout, orientation, and even encourage particular technologies (such as an outlet for electrical vehicle charging). This paper presents how these rules are represented in the building standard and argues – counter to the main conceptualization of default rules – that in order for them to affect sustainable consumption, consumers must first experience contrast and conscious awareness of the benefits imparted.

(3) The third paper regards the role of the user in technological standards design. In this paper, I offer a model of interactive design of technological standards. Based on the interactive significance of the process, I argue that anthropocentrism is necessary for the sustainability technologies standards so that they are developed for a balance between technological automation and human initiative.

Overall, these thesis papers shed light on new approaches to developing standards for sustainability transitions, using them experimentally and adapting them based on the experiments.

My approach to standards research contributes to an emerging body of scholarship that reconceptualizes governance modes through processes, transitions, and paradoxes of change and stability (see for example Kerwer, 2005; Barley, 2007; Thevenot, 2009; Manning & von Hagen, 2010; Timmermans & Epstein, 2010; Levy, 2011; Botzem & Dobusch, 2012; Reinecke, Manning, & von Hagen, 2012; Manning & Reinecke, 2016). In addition to embracing standards as guiding scripts formulated by professional committees, such as the International Standards Organization (ISO) or Fair Trade International (FLO), I explore a broader conceptualization of how standardization activities are being reimagined with experimental governance. Indeed, the Active House standard is formulated with the input of the Active House Alliance members -- not least of all VELUX --, and its standardization activity reaches beyond a single documented standard.² While developing the standard, the Active House Alliance uses multiple *devices* (Callon, Méadel, & Rabeharisoa, 2002), including technical specifications, professional guidelines, internal communications strategies, marketing materials, lobbying activities, and more; but more importantly, the alliance's standard is ongoing and fluid, involving "constant learning and modification" (Slager, Gond, & Moon, 2012, p.767). Its development process engages not only others in the industry, but re-orientes towards the product (building) user, brushing against notions of deliberation in standards making. One standards researcher asked me: "When does the standardization process result in a standard? When is it finished?" Based on my investigations into Active House and knowledge of its kin (such as LEED, BREEAM, DGNB, and Passive House, described further in the background), the standard is born with a new concept and continues to build upon dynamic interactions among the standards makers, policy makers, homeowners, and other stakeholders.

This is a necessary furthering of sustainability and innovation research. As this process has been undergone with the developmental support of the Innovation for Sustainability (I4S) network (FP7 Marie Curie Initial Training Network Project), it became clear to me very early on that there are a multitude of perspectives on what constitutes valuable sustainability research. Part of this is due to sustainability's ambiguous meanings and friction among its many objectives (Geels, 2010; Manning & Reinecke, 2016). Given my background in environmental studies, biology, and environmental management and policy, I have developed a critical perspective on the positivist natural science and engineering approaches to sustainability, as well

² See more on standardization dynamics in Brunsson, Rasche, and Seidl (2012).

as of sustainability for sustainability's sake and preaching to the choir. Rather, I see that many of the barriers facing sustainability transitions are not based on a lack of desire for a better world, better well-being, etc., but that change is difficult to stimulate and toilsome to sustain. Just as this obliges some experimentation within the research approach, so too does this warrant experimentation within governance for sustainability transitions: "Solutions to such problems are not given, and purely analytical approaches will not suffice. The structural uncertainties surrounding future development necessitate more explorative, experimental, and reflexive approaches" (Loorbach, 2010, p.164). In this way, even though standards do not immediately evoke a connection to sustainability, I believe them to be at the core of change processes and the shifting of socio-technical landscapes (Rip & Kemp, 1998).

Given the ambiguity of many of these concepts (new governance, sustainability, innovation), this introductory cape (Part A: Kappe) is meant to drape over the dissertation's findings and place them in context. The kappe opens the stage with an introduction to the industry and research problems at hand. This is followed by a description of the research case and a presentation of the research objective. Subsequently I recount the research methodology before elaborating upon theoretical departure points. Finally, I present a summary of the three articles. The three articles can be found thereafter in Part B.

The Problem: Sustainability beyond energy

Although many of the issues examined in this thesis are relevant for building organizations in manifold corners of the globe, its geographical focus is upon the European Union. Lessons learned in the EU will likely prove useful for other geographies, in addition to international organizations touching upon multiple locales, as the nature of the problem is that it is intensifying and spreading. This is in line with the theorization of GXG as being based on revisions and lessons on the local level that extrapolate more broadly. The EU demarks the building industry from other areas of world in two main fashions: firstly, the member states are beholden to the scripture of the European Commission's EU directives for building (in large part informed by existing voluntary standards), and secondly, Europe is in the unique situation of being approximately 99% built, with new building representing only 1% of the market and the remainder necessitating maintenance and renovation (European Commission, 2013). This

section first describes the problem faced by the building industry, followed by the problem for research.

The Industry Problem

To begin with, the problem faced by the building industry in the EU is two-fold: (1) reshaping the built environment to reduce energy consumption (and thus CO₂ emissions), and (2) raising the bottom line of building quality, i.e. modernizing buildings, or even anticipatorily preparing them for the future, as is the mindset of sustainable builders. First let us take the problem of energy. In the European Union, buildings account for 40% of energy consumption and 36% of CO₂ emissions (European Commission, 2016). These figures have resulted in enormous pressure upon the industry from the European Commission (EC), mainly through the Energy Performance of Buildings Directive (2010/31/EU) and the Energy Efficiency Directive (2012/27/EU). Whereas the formation of these directives themselves involves an enormous amount of research and negotiation, the pathway to compliance is terribly opaque. What is worse is that in all likelihood, compliance is not even sufficient, as the EC will continuously advance these directives to improve the built environment -- as witnessed, for example, by the shift from pressure for nearly-zero energy buildings (NZEB) to plus energy buildings that produce enough energy to sell back to the grid system.

As such, policy-makers on the city, regional, and state levels tend to look to industry for framework guidance on how the required cuts can be technically and practically achieved. On the one hand, this requires demonstrated effectiveness, and on the other, it requires parameters for building that can be described in legal language. This is, in part, why the Passive House building standard has received so much attention. Passive House was born in Germany out of concern for energy security -- emerging after the Oil Shock of 1978-79 -- hinging on the idea that if we could just build in such a way as to minimize energy demands, the built environment would no longer be subject to such crises, or to the volatile political relations between energy-producing versus -demanding countries. Thus, Passive House is especially popular in countries hit the hardest by the former crisis (Austria is a good example). To the benefit of policy-makers, it has been an approach to construction for decades, giving it a grandfathering advantage over more recent, experimental standards. It is also a standard

focusing only on energy savings and therefore well-represented by numerical parameters easily codified into law.

The overall result has been that energy has become an *idée fixe*, in turn affecting the other problem of quality. Energy is the primary focus both technically and politically, where other building qualities fall to the wayside. Cities and regions around Europe (including Hamburg city, and the Brussels region) are adopting Passive House as the main framework for their legal compliance to the EU directives. Whereas Passive House can deliver excellent energy performance in buildings, particularly in colder regions where heating energy is the main consumption culprit, it does not account for any other sustainability concerns, such as toxins in building materials, sustainable sourcing of wood products, recyclability, water usage, life cycle impacts, or the inhabitants' health and well-being. In other words, policies developed around Passive House address building energy, but not building quality. From an actor-network perspective (Latour, 2005), energy has become a powerful actant at the center of a network of buildings, their inhabitants, their designers, and standards and policy makers; whereas designing around the inhabitants, instead of energy, could justify quality and a more holistic sustainability. And in the context of the semi-permanency of the built environment, transformation based solely on energy orientation is especially dangerous -- the effects of this basis of regulation may continue to impact society 20 years, 50 years, or even longer down the line.

Yet, there are no settled definitions or firm parameters for building quality; and this is exactly what alliances like Active House are grappling with. Whereas we are learning evermore about the dynamics of *adaptive thermal comfort* (wherein people make adaptive adjustments to their environments and behaviours in order to feel comfortable in a space) (see Nicol and Humphreys, 2002) and *circadian rhythms*, health based on aspects like light, view, temperatures, and fresh air inherent in daily cycles (for example light penetration as discussed in Holzer and Hammer, 2010), the calculable holism of indoor wellbeing is just beyond reach. Phrased another way, numbers representing the total quality of building are elusive, as the total is lost in breaking apart the qualities. This is not to say that the industry does not have standards for quality; indeed, much of the skill in architecture involves an intuitive expression of quality through building design. Rather, it is to say that commensurative processes, in which qualities are converted into quantities, and user-centred innovation, wherein design based on the experiences of building inhabitants, gain more significance. Likewise, the application of

networked and communication technologies is increasingly prevalent in building experimentation. And these advancements emerge not from governments alone, but in combination with new approaches to governance by industry partners, as well as research institutions. Indeed experimental governance can be seen as a strategy for addressing such increasingly complex sustainability issues (Sabel & Moore, 2011). And yet, there are research challenges to this as well.

The Research Problem

This dissertation contributes to research problems in sustainability transitions and experimental governance, and the problem is likewise two-fold. The main research problem relates to *intersections*: (1) In sustainability transitions, we know very little about what happens at the intersection of the local and international scales, and (2) in experimental governance, we do not know how to organize the intersection of governance by non-governmental organizations and by private citizens.

When it comes to sustainability transitions, we know that transitions are contingent upon different histories and thus have diverging pathways (Loorbach, 2010; Smith, Voß & Grin, 2010). A prerequisite is that developments at different scales must converge, scales referring to local as *niches* (which have unique innovation characteristics) and large scale or international as *regimes* (systems of dominant structures, rules and practices) (Loorbach, 2002 & 2010).³ We also know that existing regimes interact in the formation of new socio-technical landscapes -- that these are not isolated pathways (Smith, Voß & Grin, 2010; Manning & Reinecke, 2016). Rather, they are distributed. As well illustrated in Manning and Reinecke (2016), experiments on a niche level are important for standards that in turn reshape the regime, forming a “modular architecture” or overall structure supported by local dynamics; and successful experiments need to be interconnected and legitimated in different contexts in order to construct the architecture. These are significant first steps; but we still know very little about this intersection of local niches and this architecture, in particular how organizational activity affects the field level (Ferraro, Etzion & Gehman, 2015). For example, we need to know how organizations translate the meaning making of experimentation into quantifiables that can be used in standards. And

³ For an excellent explanation of the dynamics and embeddedness of niches and regimes, and how they relate to innovation, see Geels (2014).

although we see that this experimentation opens up sustainability transitions to reflexivity, we need to better understand why this reflexivity is important for organizations working to furthering transitions.

In the case of experimental governance, we know that when organizations govern industry practice through standards, they can be used as a form of regulatory power – over or together with other organizations in the sector (Levy, 2011; Slager, Gond & Moon, 2012; Arnold & Hasse, 2012). Yet we know that top-down approaches to sustainability, alone, are ineffective (Rotmans & Kemp, 2008) and that we are developing towards governance (and standards) formulated in a deliberative, experimental, reflexive way (Loorbach, 2010; Manning & Reinecke, 2016; Scherer, Rasche, Palazzo & Spicer, 2016). We do not know how innovations function when governance is driven by primarily private actors (Rotmans & Kemp, 2008), including large-scale design experimentation. And we do not know how to engage citizens or the public, in the experiments, the resultant innovations, nor the governance itself (Scherer, Rasche, Palazzo & Spicer, 2016; Markard, Raven & Truffer, 2012). We know that framing is significant (Reinecke & Ansari, 2016), but face particular challenges in the area of sustainable consumption, wherein the correlation between values and action is unclear (McMeekin & Southern, 2012). Therefore we need to better understand the potential dynamics of experimental governance involving both private organizations and the public.

The main problems are that: (1) there is a need for understanding how to bring international organizations and their sustainability ideas on the ground, in practice, and also how to bring learnings from sustainability experiments back into organizations on a larger scale. Without this, there is a lack of connectivity and progress in transitioning organizations (despite even the best intentions for sustainability), and investment in experiments fails to pay back with innovative business practice. This is a problem that the first paper, in part, addresses. And (2) as experimental governance advances, how the deliberative, bottom-up aspect can best further sustainability is poorly understood. Without better grasping how consumers become oriented towards sustainability, interact with sustainability-furthering technologies, and provide deliberative input for standards, experimental governance runs the risk of similar failures as

“command and control (CAC)” policies⁴. These are aspects addressed in the second and third papers. This dissertation builds upon the standards literature to further our understanding of these challenges. It shows the significance of organizational commensuration and the significance of reflexivity in the commensurative legitimization process; pivotal contrasts in designing default rules into experiments for sustainable consumption; and interactive design dynamics in co-developing sustainable technological standards between organizations and end-users. To lend perspective on the case setting from which these findings are drawn, the following section presents a description of the case.

Case Description

In attempting to grasp the ongoing discourses and the activities for sustainability transitions in this sector, it has become clear that standards are where the change starts and how the messages of sustainability are spread. This can readily be seen with the development of such voluntary building certifications as LEED (Leadership in Energy and Environmental Design) out of the USA, BREEAM (Building Research Establishment Environmental Assessment Methodology) out of the United Kingdom, DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen, or Germany Building Council) and Passive House out of Germany. These standards, with the exception of Passive House, have all been initiated by the national building councils of these countries, reflecting culturally relevant approaches to sustainable building. They are based on earning points, divided into categories such as energy and materials, which qualify the building or neighborhood for a certain certification status (such as LEED Platinum at the highest, or Gold the next step down). Passive House is based on complying with strict parameters for the building’s design for energy consumption in kilowatt hours (kWh). All of these standards seek to alter traditional, high carbon building practice through voluntary measures, and together represent the modern multiplicity of sustainability standards (Reinecke, Manning, & von Hagen, 2012) in building.

The case studied herein is that of the Active House building standard. And in order to explain the relationship between VELUX and Active House, I will first introduce the Model

⁴ Command and control policies dictate what is and is not allowed, in contrast to more reflexive development such as with economic incentive or non-prescriptive policies. See more in Harrington and Morgenstern (2007).

Home 2020 project, referring to a cluster of research buildings VELUX initiated from 2009-2011 in the wake of the 15th Conference of the Parties (COP15) held January 2009 in Copenhagen. Although widely considered the landmark failure of governments to secure action against climate change, this conference became the stimulus for a broader exploration of the intertwining of governments, industry, and finance in our shared future. As could already be seen from COP16 in Cancun in 2010, the self-organization of proactive industry and the furthering of the Green Climate Fund (expansion beyond government pledges) represent movement into collaborative projects.⁵ Inspired by the social energy of COP15 and their potential role in the sustainable building industry, VELUX began Model Home 2020 as a way of demonstrating the feasibility of healthy, environmentally friendly, and energetically performing buildings already in today's world. These demonstration buildings were planned, constructed, and then monitored, both pre- and post-occupation, with post-occupancy monitoring with test families lasting one or more years. Two of the demonstration projects researched, Sunlight House and LichtAktiv Haus, were originally part of the program and have likewise been technically and sociologically evaluated in this grouping (see Foldbjerg, Asmussen, Plesner, & Christoffersen, 2015).

Nonetheless, the United Nations', transnational industries', and VELUX's perspectives expanded in these years to incorporate the significance of collaborations -- be it through the UN Global Compact, the World Business Council for Sustainable Development (WBCSD), or Active House. In bringing together industry partners, such as researchers from the Danish Technical University (DTU) or insulation manufacturers from Rockwool, the Model Home 2020 project laid the groundwork for an alliance. Thus VELUX became one of the co-founders of the Active House Alliance, an alliance bringing together actors in the building industry interested in holistic building that aims to balance human, environmental, and energetic considerations.⁶ Rather than fighting as a competitive entity against the aforementioned sustainable building standards, the Active House Alliance seeks to ensure that these principles are reflected across industry practice. The AHA is managed by a Board Advisory Committee and a Board of Directors and is coordinated by a secretariat, currently hosted by Cabinet DN

⁵ See a more in-depth reflection on the Copenhagen Accord and Cancun Agreements in Ayalew and Mulugetta (2012) and statements concerning industry and finance, such as in the World Climate Summit (2010) press release.

⁶ For a list of current Active House members, see <http://www.activehouse.info/about/alliance-partners/>

consulting and based in Brussels. There have been 27 projects around the world thus far, not including those influenced by the concept, and experimentation is ongoing.

Both the development of the alliance and of the different projects connect back to innovation. Whereas some see innovation as the stage-gate organizational processes of creating a new product or service, I see innovation as more abstract, incorporating the creation of new modes of being, new institutions and societies of the future. Luckily for the progress of my research, VELUX also tends to take a broader perspective on innovation. This helped to narrow the scope of the project -- from very early on we decided that given my research interests and topic, Active House would be an interesting subject (as opposed to VELUX as an organization). Active House is a project that itself envisioned sustainable building innovation as rooted in the larger landscape of the building field, international business, and legislation. The idea is: experiment. When the experimentation with tomorrow's buildings can be done today, the innovation rolls out, and we can see our way into a more imaginative future in a practical, substantiated way. This is interesting in terms of the different challenges and opportunities laid out by the industrial and legislative contexts of the projects, as well as the organization gone into coordinated alliance members in order to adapt and fine tune the Active House standard in accordance with the project learnings. This project-based innovation has been pivotal in reorienting attention to building users; simultaneously further socializing the organization of the built environment. The following sections present the research objective and research methodology.

Research Objective

As laid out in the problem section, the singular focus on energy issues in buildings threatens to undermine the holistic approaches needed for sustainability transitions. And as described in the case description, the Active House standard offers an alternative sustainability approach based on energy, environment, and comfort. It is experimented with through an ongoing program of multiple building demonstration projects. Yet there is little research explaining how transitions branch across local projects like the demonstrations and international regimes like the building industry, or how experimental governance can better connect non-governmental organizations and citizens, such as in a more deliberative process of

standardization. The aim of this project is to study the Active House Alliance in cooperation with VELUX in order to illuminate how experimentation with the Active House standard through projects tackles these issues and drives sustainability transitions. The overarching research question is:

How does the production and adoption of experimental standards unfold governance effects, and how do they contribute to sustainability transitions?

The three papers represent three subquestions that contribute to different levels (macro and meso) of answering the research question:

- 1. How can user comfort be legitimately represented in standards specifications?*
- 2. How can default rules in building standards serve as a starting point for sustainable consumption?*
- 3. Why is user focus significant in standards for technological design?*

In lieu of the research problems described above, these questions are a meaningful investigation into the functioning of experimental standards. The first question addresses the problem of the intersection between niche experiments and transitions on a field level, while also highlighting issues of commensuration and reflexivity in sustainability standards. The second question addresses the both the former problem, as well as the problem of the intersection between experimental governance by private organizations and private citizens, using experimental green default rules in sustainable building standards to examine the relationship between defaults and sustainable consumption by building users. In this second question, the concern is moving from consumption experiments in buildings to higher-level sustainable consumption, while the focus is upon what private organizations can do with these standards to engage private citizens in sustainable consumption. Lastly, the third question relates to the intersection of private organizations' standards and private citizens, examining the dynamics amongst the design standard, the building technologies, and the building users. It investigates the significance of user deliberation in experimentation with these technological design standards.

Overall the research objective is to navigate the interwoven threads of qualities and quantities; design, architecture, and engineering; private organizations, governments, the public,

and alliances; automation and participation; and demonstration buildings and durable infrastructure, all forming the fabric of the sustainability movement in the built environment. It is to detangle some of these lines in order to better understand how experimental standards can contribute to sustainability transitions and, based on the findings, identify lineages of further needed research.

Research Methodology

My ontological stance in approaching the research is that of critical realism. In other words, I take the position that although there is a true reality, it cannot be perfectly apprehended, and therefore knowledge is imperfect (see more on postpositivism in Carlo & Gelo, 2012). Rather, attempts to gather knowledge to more adaptively interpret reality should both question the foundations of knowledge and investigate with more natural, observational procedures (as opposed to the notion of controls and confounding variables). Following from this and the nature of the aforementioned research questions, I used qualitative methodology, specifically naturalistic methods embodied in a case-study examination. The case study approach allowed for detailed examination of process, interrelation of actors, and context. There are indeed limitations to this approach, what Adrian Currie refers to as “the curse of the case study” (Currie, 2015) -- namely, the difficulty of generalizing case studies (no two cases are exactly alike). Rather, the usefulness of case studies is in their richness and ability to capture elements of institutionalization and change (Yin, 2009; Jacobs, 2010). They can even serve to “counter the deficiencies of abstract investigations” (Jacobs, 2010, p.680), such as in the building field, where a great deal of quantitative research is undergone, with little qualitative contextualization to assist sense making of the data. Hence, this case study research contributes to a larger body of more quantitative research, which together can be used to make a more complete picture of the field.

In order to investigate these questions, I had to first narrow down which building demonstration projects I would study. Firstly, the top priority of Active House is to influence the content of building regulations on the EU-level, as this sets the baseline for nation-level legislation. Thus it made sense to study the demonstration projects within the EU. In order to capture the breadth of building differences, I selected projects in three different countries:

Austria, Germany, and Belgium, each with a built environment uniquely molded by their histories, but bound together under the European agenda. In the hopes of following developmental trends in the Active House standard, these three projects represent a new-build single-family home, a part new-build and part renovation single family home, and a unit renovation of a social housing owned duplex, respectively. The direction is already tangible: for the standard to make sense, it must be affordable and scalable. The last of these projects, the RenovActive project in Brussels embodies just that. The project had to work within the budgetary constraints of Foyer Anderlechtois, the social housing company; and if successful, the company plans to apply the design to the other 200 units owned in the same garden house community (about 40% of the neighborhood).

Following from this, scaling and cost are two issues that arose regularly throughout the research. On the other hand, the standard had already developed to quite a sophisticated level of specification, guidance, and evaluation even before these questions entered new projects. The nuances, the rich detail of the processes leading up to this point, the history of the demonstration projects, and the dynamics of the building cultures in the different regions were effectively tangled out using the case study methodology, treating the Active House standard as the unit of analysis and the demonstration projects as three examples of its application. As Yin (2009) points out, the case study approach is best when “the boundaries between phenomenon and context are not clearly evident” (p. 18), such as the entanglement of the buildings, the building laws, and the national and regional cultures. Although I interpreted early on that I would be relying most heavily on the interviews to disentangle these, I further kept detailed notes during my research stays at VELUX and visits to the project sites and audio recorded segments of the workshops and conferences. Yin anticipates the need for this as well, urging triangulation of sources due to the disparity between concepts and data points (Yin, 2009). As such, I used ethnographic techniques in the case study research, appropriate for studying processes of change and continual construction and reconstruction (O’Reilly, 2005). I will first describe the data sources and then the approach to analyzing the data.

Data Collection

Launching from a critical realist epistemology wherein physical and social realities intertwine (see Maxwell, 2012), I sought out data on both the projects on site and the

stakeholders related to their manifestation. The data is drawn from five sources: interviews; research stays; event attendance; visits to the three sites; and secondary sources, as summarized in Table 1. A research timeline is found in Figure 1. I conducted 30 semi-structured interviews from a number of professional backgrounds, each lasting between 60 and 90 minutes, and audio recorded them with the permission of the interviewees (none declined). I developed an interview guide to steer the direction of inquiry during the otherwise quite open interviews (Appendix A), tested its functionality with three pilot interviews, and, pleased with the resulting flows and explorative interviewing, utilized the guide in all subsequent interviews. I enlisted a professional service to have the recordings transcribed, reviewed these transcripts myself, and then fact checked them with the interviewees via email. I uploaded matching audio recordings and transcriptions into my data analysis software for analysis.

Data Type	Structure	Detail
Interviews	Semi-structured, voice-recorded, transcribed, fact-checked	Professions: architects, building engineers, building scientists, policy-makers, social-housing workers, home owners, standards makers.
Research Stays	Two three-month research stays	Sharing office space with VELUX employees, including those working on Active House, at the headquarters in Hørsholm, Denmark. Joining for lunches, meetings, and company events.
Events	Conferences and workshop attendance, observation and notes	Titles: Passive House 2014 Exhibition in Brussels, Zebau Northern Germany Passive House Conference in Neumünster, Bauz! Vienna Congress for Sustainable Building, Active House Guidelines Workshop in Brussels
Site visits	Tour, inquiry, notes, photos	Visit to the three different sites, including the dilapidated unit in Brussels. Site visit in Hamburg did not include entry.
Secondary sources	Following communication materials released around demonstration projects (Model Home 2020 and Active House).	Reading and tracking development of communication materials such as specifications versions, guidelines, reports, and conference presentations.

Table 1: Data Sources.

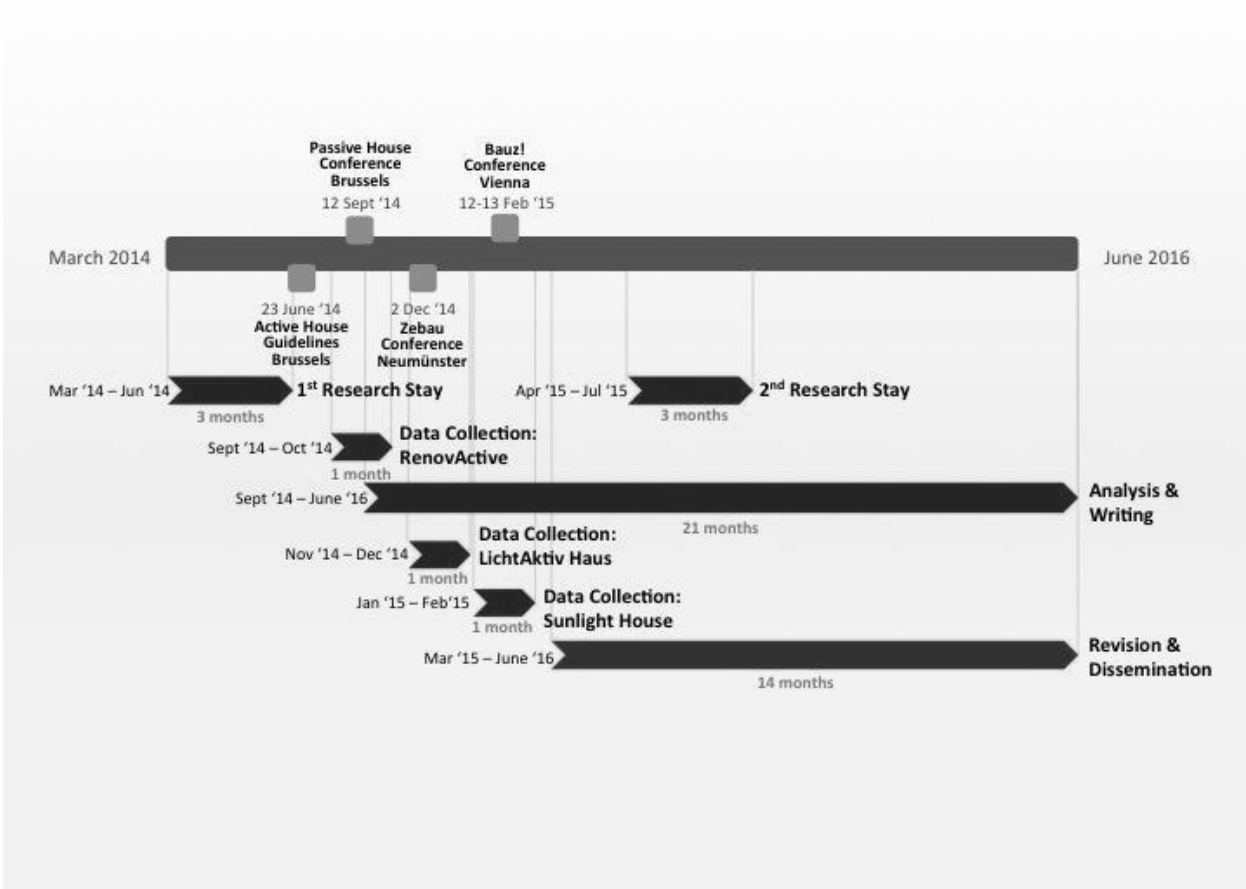


Figure 1: Research timeline.

I held two three-month research stays at VELUX headquarters in Hørsholm, Denmark: the first from March to June 2014, and the second April to July 2015. During the first research stay, my interactions were within a subsection focusing on corporate social responsibility (CSR) and sustainability. I was provided a desk in the “project room” (on the first, instead of second floor, apart from the group); socialized during lunches; attended meetings regarding advancing the science, evaluating and planning for the demonstration projects, developments within Active House, and other integration and greening programs within VELUX; and joined more generalized strategy meetings. During this time, my office mate, a student intern, proved pivotal in providing me access to company documents and updating me on and inviting me to office events. However, dramatic changes altered the second research stay experience. First, in a year’s time, VELUX had restructured departments into a more holistic strategic unit, combining sustainability, CSR, communications, and market strategy. And second, my VELUX supervisor arranged to relocate my provided desk into an open working

space shared with the main sustainability group. Whereas the nature of interaction was similar to the first research stay, the feeling of connection and ease of inquiry and engagement was far improved. During the research stays I kept notes (digital memos in NVivo) on activities, people met, and reflections.

VELUX was also key to informing me of and inviting me to relevant events in the sustainable building industry. The events used for this research are: the Passive House 2014 Exhibition in Brussels, which included presentations, industry booths, and a guided tour of the new Passive House certified headquarters for the Brussels Ministry of the Environment; the aforementioned Northern Germany Passive House Conference in Neumünster, attended by some of the main politicians and architects driving the sustainable building movement in Germany; Bauz! 2015 Vienna Congress for Sustainable Building, representing the cutting edge of sustainable building experimentation in Austria; and the Active House Guidelines workshop, during which I participated in the roundtable development of the guidelines for applying the Active House concept and specifications. I took notes and photos at all of these events. As the Northern Germany Passive House Conference was held in German, I audio recorded and had transcribed and translated the introductory presentations. Further, beyond my participation in the Active House Guidelines workshop, I audio recorded and had transcribed first the general assembly, and then the environmental subgroup (concurrent with the comfort and energy subgroups) in which I took part. This event was fundamental to my understanding the Active House Alliance interactions among the secretariat and a diversity of member organization representatives, as well as networking with some of the other organizations involved besides VELUX, such as Saint Gobain and Renson, high-end glass and ventilation system producers, respectively.

Likewise fundamental in terms of understanding the processes underwent with the projects and development of the standard were the three site visits, specifically to the RenovActive renovation site in Anderlecht, Brussels, Belgium; LichtAktiv Haus in Willendorf, Hamburg, Germany; and Sunlight House in Pressbaum, Vienna, Austria. The visits to each region lasted three weeks, during which I conducted interviews, attended events, attempted to better understand the building culture (through history museums, memorials, and casual conversation with local residents), and visited the demonstration projects. At each demonstration building, I documented the visit with photos and took note of the surrounding neighborhood and

city context. For RenovActive, the project manager gave me a guided tour of the garden city in Anderlecht and the unit targeted for renovation. This was remarkable in terms of experiencing the utter dilapidation of the unit, including visual and olfactory remnants of squatters. One of the interviewees from Foyer Anderlechtois, the social housing organization owning the unit, gave me a tour of a nearby historical garden city, likewise targeted for scalable renovation, but under even stricter historical preservation rules. Likewise, the owner of Sunlight House gave me an inside tour, opening up her family home to me and describing their living experiences in such a specially designed house. These site visits were important for both identifying specific details of the projects (lighting, air quality, technological installations, design nuances) and the overall contexts in which they are imbedded. For example, I documented opposition signs posted just one block from LichtAktiv Haus protesting the construction of a major industrial transport highway being planned to cut through the neighborhood, representing a contrasting political push to industrialize, rather than sustainably develop Willendorf.

Finally, the interviews, research stays, events, and site visits were supplemented with secondary sources. These were composed mainly of news articles and publications, both public and internal, obtained by following news sources in general and the development Active House and VELUX specifically. These include articles such as “Commission hamstringing Brussels renovation drive” (Calderbank, 2013), “Glasgow study reveals pollutant dangers within airtight homes” (The Scotsman, 2016), and “Design Thinking for Media that Matters” (Ording, 2016), publications such as “Post-Occupancy Evaluation by the test families in five Model Home 2020 across Europe” (Christoffersen, Feifer, Foldbjerg, Raben Steenstrup Hannibal, & Gylling Olesen, 2014), “The psychophysics of well-being: Methodological approach of the socio-psychological monitoring of the VELUX LichtAktiv Haus” (Wegener, Fedkenheuer, & Scheller, 2013), and confidential documents on internal evaluations and strategies. Tracking the news and the issuing of publications gave a particular sense of process over time and developments in strategy and trajectory that informed the interpretation of the primary data, especially in terms of giving a broader world view of changes in the sustainable building industry and opening the boundaries of perspective locked in by the geographical and case limitations of primary data collection.

Data Analysis

The data analysis process was thematic and open and often involved revisiting the data to reconsider new information from the field (Strauss & Corbin, 1990), especially between the two research stays at VELUX headquarters. The process closely follows the steps proposed for ethnographic data analysis: describing the context; noting key individuals; activities and events; chronology of research; description; identifying themes; and developing theoretical categorizations (Brewer, 2000). The first phase of analysis following from a semi-analytical data collection was to identify main themes, and then structure these into coding groups. The primary coding themes, their reference occurrences, and number of sources wherein the theme occurs can be seen in Table 2. These themes can be seen as representative of the main realms of contention during sustainability transition in the building field, aligning with the research problem. In order of references, the top four are: institution, technology, cost, and measurement; and these themes served as the reorientation of thematic coding in the second cycle.

Theme	Total No. of References	No. of Sources found within
Technology	175	21
Cities	55	19
Cost	142	24
Daylight	46	13
Demonstration	78	21
Institution	192	24
Legitimacy	46	12
Measurement	121	23
Scale	50	17
System	94	20

Table 2: First coding cycle.

The second cycle involved delving deeper into the main themes, which included reexamination of the primary data and further informal inquiry. An example would be during the Northern Germany Passive House Conference, during which I made note of introductory speech disparities between the German Federal Minister of Construction and Active Plus proponent, Hans Dieter Hegner, and the founder of the Passive House Institute, Wolfgang Fiest. On the one hand, Hegner proposes the focus on understanding the user, a sister- and brotherhood of

buildings in neighborhoods, and an increase in available, sustainable social housing; whereas on the other hand, Fiest urges the bottom line of total energy, the behavioural restriction of building inhabitants, and building in a cost competitive way with commercial building. Namely, the second cycle was a time of analyzing branching discourses in terms of how actors seek to orient demonstration and standardization and on what basis. Such friction opened up the research into topics like paternalistic libertarianism and building user focus. The third cycle involved aggregating these in the construction of theoretically-informed paper topics, while coding sub-themes identified as holding some weight or interrelationality with the topic, as exemplified for the third paper on interaction design in Table 3.

Theme	Total No. of References	No. of Sources found within
Proliferation	6	3
<i>Subthemes: general, sensing, beyond sensing</i>		
Interaction	18	8
<i>Subthemes: altogether, automation, adaptation & time, interference, overkill</i>		
User focus	11	7
<i>Subthemes: control as positive, control as negative, change over time, beyond control</i>		
Social monitoring	2	2
<i>Subthemes: none</i>		
Monitoring & standards	12	7
<i>Subthemes: monitoring for standards, nudging, what standards do for people</i>		

Table 3: Second & third coding cycles.

Analyzing the material often involved dramatic swings between micro-scale details and macro-scale organization. I believe that this breadth is reflected in the papers herein: I attempt to follow the standard from its wider application and influence to its smaller components and interrelationality. Although I am cautious about combining scales, I am also inspired by authors who successfully place a lens over the small in order to interpret the large, such as the work on practice, materiality, and comfort being carried out in the UK (i.e. Chappells & Shove, 2005; Shove, Watson, & Ingram, 2007; and Ingram, Shove, & Watson, 2007), or those who write specifically about multi-level research on organizational ecosystems for sustainability transitions (i.e. Geels, 2010 and 2014). After all, this is how the built environment plays out: the few buildings become many, the many become the cities, and the

cities become the character of nations and of the world. The whole while, this *becoming* is first guided by standards and then dictated by law. And so standards serve as the experimental realm that builds the (scaling) pathway between good ideas and new norms. The following section introduces the theoretical perspectives adopted in the research.

Theoretical Points of Departure

This section presents a theoretical background of first the new governance paradigm and experimental governance and then standards in transition and standards for transition. This background is meant to be a literature review and explication of the theoretical framing of the overall dissertation. The subsequent subsection then delineates how different theoretical perspectives shaped the dissertation's three articles.

The New Governance Paradigm and Experimental Governance

Before delving into the specific theories used in the dissertation papers, I would like to first lend more depth to the area of experimental governance and standards that interconnects them. First is the matter of *new governance*, a reconceptualization emerging from the past few decades of traditional governmental approaches to solving societal issues. Van der Heijden (2013b) points to new governance as a contested concept, lacking a singular definition with consensus of opinion, but describes it as “a novel paradigm building on collaboration between state and non-state stakeholders to address public problems through experimental forms of decision making and policy implementation” (p.2). Another definition is “the planning and implementation of activities backed by the shared goals of citizens and organizations, who may or may not have formal authority and policing power” (Avril & Zumello, 2013, p. 6). In contrast to previous forms of governance, it is considered less hierarchical and controlling and more flexible and inclusive (Van der Heijden, 2013b). Lee (2003) describes how this collective pattern of governance evokes (1) a decentering of governance mechanisms (to also include organizational and citizen participation), (2) a redefinition of systems of rules for societal problem solving (including norms and non-regulatory rules such as standards), and (3) characteristics of social networks, including negotiation, fluidity, and shifting memberships. The new governance paradigm relates to globalization in that it often involves inter-organization and intergovernmental projects concerning global issues, i.e. human rights and climate change. It is the result of seeking alternatives to the systems of command and control regulation and market

mechanisms, but it also reflects “divergent norms”, “substantial problem diversity, conflicting interests, and uncertainty regarding risks, gains, and losses” (Ruggie, 2014, p.6).

Global experimental governance (GXG) is part of the new governance paradigm, likewise characterized by confluences of governmental demands, industrial solutions, and citizen participation. Namely, experimental governance is conducted collaboratively by diverse actors, including governments, industry, universities, non-profit organizations, direct democracy of citizens, alliances, networks, and so on. As formerly presented in the introduction section, global experimental governance (GXG) is “an institutionalized process of participatory and multi-level collective problem-solving, where the problems and the means of addressing them are framed in an open-ended way, and subjected to periodic revision by various forms of peer review in the light of locally generated knowledge” (DeBurca, Keohane, & Sabel, 2014, p.477). Van der Heijden (2016) points to the origins of GXG in the flexible social governance work of John Dewey (1991 [1927]) and Donald Campbell (1969). Yet, there is certainly a *newness* in experimental governance at the moment, including regarding sustainability, as Hoffman (2011) emphasizes: “The first quality of the experimental world that stands out is how recent experimentation is. While climate change has been the focus of international governance efforts since the late 1980s, experimentation was slow to develop” (p.29). The vague territory between shared goals and authority sets the stage for an ongoing debate on the nature of organizational governance, especially in relation to sustainability. On the one hand, it is driven by policy instruments motivating a wider sense of societal responsibility, including corporate social responsibility (CSR) (Steurer, 2011), and on the other hand, corporations are mobilized to partake in the definition and redefinition of societal rules, including through standards.

On the social responsibility side, this illuminated further within works on corporate citizenship and CSR. For example, Moon, Crane, and Matten (2005) investigate the multifaceted nature of corporations’ participation in governance. Further, Gong, Kang and Moon (2011) elaborate how although private organizations are powerful agents, they are simultaneously embedded in institutional frameworks that influence their activities. They present how this is expressed through CSR partnerships between governments and private organizations, while highlighting the significance of involving civil society organizations that “bring their close understanding of social expectations and of social problems as well as legitimatization to the partnerships” (pp. 649-650) -- thus opening up the multi-faceted

composition of responsible action in governance. On the corporate influence over societal rules side, there is expanding investigation into the workings of political CSR. This points more to the strategic, political drive for CSR partnerships, wherein private organizations co-create the very institutional rules and settings that they are subject to through lobbying, deliberations, engagement in public discourse, and providing of public goods, as “their impact reaches beyond their immediate contract partners and affects others” (Scherer, Rasche, Palazzo & Spicer, 2016, p. 276). This is also mobilized through the creation of standards. As Pies et al. (2011) highlight: “Corporations participate in public-private partnerships with the purpose of jointly providing public goods. They engage in forms of cross-sector cooperation for settling disputes and creating commonly accepted rules” (p. 172).

As in the case of the Forest Stewardship Council (Hollenhorst & Johnson, 2005), these governance activities are tied to globalization -- be it forest conservation through certified forest products, or the development of building design standards that incorporate particular approaches to sustainability. Whereas states are limited in their geographical scope, corporate and NGO networks spread across borders and oceans, tempting influence in far reaches of the world. The new governance is thus most certainly shaded by market economics, but the nature of directing influence from afar also implies ethical dimensions (Roman, Roman, & Boghiu, 2012). In other words, the new governance expresses particular organizations’ normative stances (Pies et al., 2011), perhaps more forwardly and strategically than could be interpreted in former governance modes. With sustainability standards: “In the absence of overarching authority, multiple, private standard-setters, such as Fairtrade and Rainforest Alliance, take governance roles by translating expectations from the global sustainability discourse and experiences from local producer contexts into adoptable standards of ‘sustainable practice’ across sectors and national boundaries” (Manning & Reinecke, 2016, p.619). From my perspective, this cannot be disaggregated from quality. What is considered high quality and what is considered an acceptable standard are informed by these norms, and in turn feed into the development of the aforementioned social rules that motivate the cooperation of public and private forces.

Nor are these norms disaggregated from innovation. The means to mold markets through technological design innovations puts industry in a unique position to influence governance approaches, one of the key aspects of the new governance paradigm that shifts democratic involvement. Avril and Zumello (2013) describe how as the formerly rigid structures

of institutions are liquefied in the new governance, access to decision making is restructured in a more dynamic, holistic way -- in part driving the popularity of using systems-thinking to describe phenomena in this paradigm. This includes how innovation -- both *of* organizations and *by* organizations -- is undertaken. Innovation is the starting point of sustainability transitions, the bridge from former societal states to the new ones: “Indeed, a certain representation from the existing regime is necessary, also with an eye to the legitimacy and financing of the process of innovation. But a transition arena is not an administrative platform, or a consultative body, but a societal network of innovation” (Loorbach, 2010, p.174). This societal network substantiates the democratization of standards making, i.e. an incorporation of the individual experience into innovative standards, often through tinkering and experimentation (Sabel & Zeitlin, 2008; Sabel & Moore, 2011). Through experimental governance, democratic innovations (say, in a modified standard) are scaled back up internationally (Manning & von Hagen, 2010). As the dynamics of governance change, so too do the sources of technological inspiration, the subjects of science, and the aims of international standards.

Standards in Transition and Standards for Transition

Experimental standards present a double-sided coin: sustainability standards in transition, and sustainability transitions through standards. Part of the change in these new standards is their fluidity, their ability to absorb non-rigid ideologies. However, this shift creates tension at the intersection with traditional governance approaches, i.e. legal regulations. On the one hand, standards makers seek to make use of law: “While virtually all experiments are voluntary, some experimental designs look to harness the political authority of various governmental actors to implement voluntary measures in an authoritative manner” (Hoffman, 2011, p.37). On the other hand, the intertwining of voluntary governance modes and regulatory systems alters both (de Burca, Keohane, & Sabel, 2014), and the lines between objective law and subjective standards blur. Centuries of applying laws have instilled the necessity of strictly interpretable language, the most certain being numerical. Yet, as any lawyer will attest, this is an impossible task, as all language (even numerical) is interpretable, and not all qualities can be commensurated⁷ (see also Rasche, 2010, on aporias in CSR standards). Rather the certainty comes from belief in authority rather than objectivity of regulatory language. Just as *justice* is

⁷ *Commensuration* refers to the comparison of different qualities using a common metric (Espeland and Stevens, 1998), often expressed in numbers.

incalculable and non-deconstructible, complicating the generation of laws that serve justice (Rasche, 2010), *sustainability* is similarly incalculable and contestable, challenging the development of sustainability standards (Reinecke, Manning, & von Hagen, 2012). The resulting commensurative issues are in fact a fundamental driver of advancing the new experimentalist approach: “[The experimental governance] shift went hand in hand with an increasing emphasis on measurement, and the constant adjustment of measures to experience” (Dorf & Sabel, 1998, p.466). Indeed, the redefinition of measurement and meaning in the new governance paradigm appears to be a major arena of contestation in sustainability transitions.

There is palpable tension herein: as standards comply with measurement expectations, standards have historically been part of defining what those measurements are. For example, Kindleberger (1983) refers to the cloth guild of Middle Ages Florence controlling the standard yardstick measurement.⁸ Similarly, Peter Holzer of the Institute of Building Research & Innovation, recently presenting at Healthy Buildings Day in Brussels, pointed out several widely accepted measurements of health in buildings that have been developed without any rooting in science (Holzer, 2016). These standards gain footing because of an assumption that if a value is represented in numerical form, then it must be rational and right. This can be traced back as far as Plato, who embraced the study of mathematics and numerical relations as being the pathway to understanding the idea of good, as versus evil (Anglin & Lambek, 1995); or later Euclid, who promoted accounting in the modern sense of disengaging objects from their qualities and instead expressing them as comparable units, i.e. numbers without meaning or distinction (Burnyeat, 2000). Technological development also represents such efforts at objective disengagement, although fraught with social phenomena such as bias and control, as Foucault (1975) and Rip and Kemp (1998) discuss at length. Thus, measurement processes are an underlying meter of the values embedded in a standard, and the ensuing legitimization is the topic of the dissertation’s first paper. And the dynamics of measurement and standards design for the combination of technology and the end-user are examined in the dissertation’s third paper.

Another assumption is that new governance arrangements will be more effective at overcoming barriers that traditional policies have faced, such as the lethargy of government

⁸ Kindleberger (1983) points to the political power of the guilds to set the standard measurement, as well as the standard’s significance for ensuring quality.

bureaucracy or the restrictiveness of prescriptive laws. It is not yet clear whether or not this is the case, but research in the building sector is indicating that early new governance experiments are not necessarily more effective at expanding low-carbon buildings (Van der Heijden, 2013a and 2016). However, Van der Heijden (2016) points out that this may in part be because the industry has aimed at showcasing and has thus limited the effect to the high-end, new build portion of the sector. This research project indicates the same, although witnesses a shift in the European building industry to focus on scalability and affordability, beyond showcasing. It also suggests, as expounded in the second article concerning *default rules* (rules for the default setting in contracts or technologies, unless users choose other settings), that the new experimental standards work in part through influence, which may be slower and less predictable than with regulations. Steurer (2011) likewise argues that evaluations of new governance tools have underestimated persuasion as a steering mechanism. Thus, the current changes underway may spell out different outcomes than we have yet been able to evaluate. Porat and Strahilevitz (2013), for example, detail how Big Data is enabling a personalization of default rules that may make them more influential. We need a better understanding of the complexities and systemic mechanisms of these new standards before being able to evaluate the new governance paradigm, and this research seeks to contribute to this understanding.

So standards are both in transition and part of sustainability transitions. We do not yet know how to use them to undertake sustainability transitions. As Raymond Cole, Professor of Architecture and former Director member of the Canadian Green Building Council, underlines, “We have a lot of information on how we’re doing, but very little idea how we got there” (2016). Rather, standards are massive machines of societal experimentation. Insert technical expertise, public interest, economic considerations, natural resources, and government politics; and they churn out...Surprises! This also means they may not work as intended (Brunsson & Jacobsson, 2000; Kerwer, 2005; de Burca, Keohane, & Sabel, 2014). But it is clear that experimental governance is a major machine of transition; and it is well established that these processes are endowed with systems characteristics, including the unpredictability of outcomes borne of complexity, synergy, and feedbacks, which justify the categorization of sustainability issues as “grand challenges” (Ferraro et al., 2015). Indeed one of the robust strategies Ferraro et al. (2015) identify is distributed experimentation. As opposed to finding total disorder, when examining GXG for climate change transitions, Hoffman (2011) asserts, “Yet, further examination of what experiments do reveals that there is some method to the

experimental madness and that there is reason to suspect that experiments can have collective relevance for how climate change is governed. It turns out that the experimental world is significantly patterned and organized, even in the absence of conscious planning to make it that way” (p.36).

Standards making is one of the arenas where the paradox of unpredictable chaos and patterned organization plays out, and it is an intention of this dissertation to highlight a new experimental standards paradigm that parallels the new governance paradigm. Standards have expanded beyond the compatibility of devices and metrics definition to raising quality levels, inherent in sustainability, such as was the initial aim of the International Standards Organization (ISO). I daresay that organizations are picking up on the synthesis quickly, or more accurately, that they are already doing it. For example, Lubin and Esty (2010) identify sustainability as a business megatrend and anticipate an inevitability of integrating sustainability as a quality metric in business processes. We can see that this is emerging in both supply chain sustainability and consumer-targeted campaigns in, for example, the fashion industry with the popularization of eco-fashion and post-growth fashion (Rose, 2015). Technology again plays a role with the vastly improved ability to formulate resource contracting structures and track resource transactions, as enabled by open-source database technologies like Blockchain⁹. Yet there may be complications with too much reliance on technology as a means in and of itself to make sustainable practice a reality, an issue taken up in this dissertation’s third article.

We cannot see the action of standards within these transitions’ black boxes -- and so this work contributes to the illumination of the role of experimental standards in sustainability transitions, utilizing the following theoretical perspectives.

Theoretical Perspectives

I daresay it would have been simpler to apply the same theory consistently across the dissertation papers; but I took an inductive approach to the research, seeking explanations in theory based on analysis of the data. My original starting point for delving into explanations within one type of theory was Institutional Theory (see Meyer & Rowan, 1977 as a starting

⁹ *Forbes*, *The Guardian*, and *The Economist* have all issued articles suggesting that Blockchain technology will completely overhaul the structure of financial markets. Read more at <https://www.blockchain.com/>

point). It is clear to me that the role of institutions is powerful, and learning about Institutional Theory helped me to understand the significance of legitimacy (Suchman, 1995; Botzem & Dobusch, 2012), particularly in the context of standards and technologies (i.e. Hoffman, 1999; Greenwood & Suddaby, 2006; Garud, Jain, & Kumaraswamy, 2002). However, it has taken the doctoral research period for me to better understand that when aspiring after goals (such as sustainable institutions), it is the processes that we must better understand (experimentation and sustainability transitions). And whereas some neo-institutionalists are able to embrace the classic paradox of agency and embeddedness plaguing Institutional Theory (for example Seo & Creed's 2002 work on contradictions, praxis, and change), the often rigid structuration and path-dependency perspectives can overwhelm the nuances of multi-level processes and uncertainty and fluidity found in sustainability transitions. As Lawrence, Suddaby, and Leca (2010) reflect in their argument for a refocusing of institutional studies of organizations, "Missing from such grand accounts of institutions and agency are the myriad, day-to-day equivocal instances of agency that, although aimed at affecting the institutional order, represent a complex *mélange* of forms of agency— successful and not, simultaneously radical and conservative, strategic and emotional, full of compromises, and rife with unintended consequences" (pp. 52-53).

I needed further theoretical perspectives to help me shape my understandings of what was happening with Active House, leading to alternative approaches to organizational research, especially in terms of standards and experimentation. Research on standards in the context of the new governance paradigm is fairly new, revealing interesting dimensions such as institutional entrepreneurship in the sponsorship of standards (Garud, Jain, & Kumaraswamy, 2002), rational myths furthering standardization (Boiral, 2007), and the negotiation of standards as institutional work (Helfen & Sydow, 2013). Even more recently, we are gaining a better understanding of how standards are used to govern transnational sustainability transitions (Manning & Reinecke, 2015), and also now how they can be used experimentally as new governance tools (Sabel & Moore, 2011; Overdevest & Zeitlin, 2014). I strive to bring build upon these bodies of research, to better understand how experimental standards further sustainability transitions. Altogether, I contribute theoretically to the research problem of intersections (intersections between scales and between organizations and citizens) with articles analyzing sustainability innovation processes within commensuration, sustainable consumption, and technological standards design. These connect back to the earlier discussion of tensions within experimental standards, namely: increasing demand for measurement in experimental

governance, uncertainty around influencing sustainable consumption, and issues role of technology-driven sustainability.

For this dissertation's article "Commensuration and legitimacy in standards: The case of Active House", institutional theory informed the perspectives on legitimacy; and commensuration research supported an examination of the relationship between legitimizing standardization of qualities (like comfort). First and foremost, this article builds upon the model of the "recursive cycle of transnational standardization" set forth in Botzem and Dobusch's (2012) paper on standardization cycles. They highlight that the process of standardization is reciprocal and utilizes different kinds of legitimacy depending on the stage, writing that "If mastered convincingly, private standard setters fill the transnational regulatory void – but only in conjunction with other actors needed to (re-)contextualize standards according to local requirements" (p.756). From this, I then refer to the literature on commensuration, which analyzes the organizational work gone into such "contextualizations" - or more specifically the interpretation of qualities into comparable information, often numeric. I especially benefitted from the views presented in Espeland and Stevens (1998), Levin and Espeland (2002), and Espeland and Stevens (2009).¹⁰ Connecting and building upon these literatures is important for understanding experimental standards because, as Brunsson et al. (2012) underline, standards are built upon processes of legitimization and commensuration. And further, Espeland and Stevens (1998) point to Weber's notion of calculation in order to manage uncertainty, uncertainty which increases with experimentation.

At the intersection of Structuration Theory (Giddens, 1984) and Science and Technology Studies (STS), I came to a synthesis between the agency of socially composed structures and the agency of physical structures. Namely, this brought me to paternal libertarianism and default rules, the main theoretical concepts studied in this dissertation's second article "At home with sustainability: From default rules to sustainable consumption". Paternal libertarianism is an approach to choice structuration (how choices are presented) that suggests that whereas freedom (of the citizen, of the consumer) should be prioritized, choices should be framed in such a way as to encourage decisions that make others better off (Thaler &

¹⁰ See also Déjean, Gond, and Leca (2004); Kolk, Levy, and Pinske (2008); and Van Bommel (2013).

Sunstein, 2003).¹¹ The dissertation's article examines how the choice structuration of homes -- namely designing green default rules, default rules which orient choices towards sustainability decisions (Sunstein & Reisch, 2013), such as thermostat settings and natural lighting -- could orient consumers towards sustainable consumption. This is one of the main questions underlying experimental standards: how does application of the standard change norms in society, i.e. consumption norms? Given that appeal to conscious sustainability choices has largely failed to motivate sustainable consumption (known as "the green gap") (Dolan et al. 2011; Barbarossa & Pastore 2015), theoretical development of alternate approaches to change on a consumer level is key to better understanding how to bridge organizations and consumers in sustainability transitions.

Exploring further into STS led me to the concept of *socio-technical landscapes* (Rip & Kemp, 1998), a way of describing the world in terms of complex social and technological interrelations and histories. This is the foundation of the third paper herein, "Anthropocentric design: Human significance in technological building standards". Within these landscapes, *interaction design* is the iterative process of design between designer and designee in order to realize a product or process with which the designee would interact, i.e. consulting with the social in order to improve technical standards. This design approach resonates strongly with the experimentation of scaling sensor technologies within the Active House demonstration projects; and concepts such as *appropriation* and *scripting* [the designees seizing ownership of the purpose of objects and writing of their own purposes onto these objects (Shove, 2003)] well reflect many of the responses witnessed with the test families during post-occupancy monitoring. Using this lens helps to interpret the standard's changes over time, and more importantly, the interdependencies of humans and objects (social worlds and technological standards innovation), especially how these changes affect not just the objects (!), but also the people interacting with them. This article is fundamental to the thesis in terms of understanding human-technological interactions in sustainable technologies standards. More specifically, technological optimism (the belief that technology will inherently improve the lives of humans) will not drive sustainability in and of itself; but rather there is a need to understand the dynamic

¹¹ This is also related to *nudging*, wherein small structurations signal a choice (Thaler & Sunstein, 2008), for example posting a sign by the elevator spelling out the number of calories you might burn by taking the stairs. However, default rules regard what choice organizers set for when an active choice is *not* made.

development between humans and technologies, as they affect each other and, ultimately, development of standards for sustainability transitions.

Just as the nature of sustainability is multifaceted, likewise are experimental standards for sustainability transitions. Indeed, I am of the belief that in the next generation of research, there will be a greater matrix spanning these multitudes. Although I tinkered with writing about innovation through actor-networks (Latour, 2005; Latour & Yaneva, 2008) and boundary objects (Star & Griesemer, 1989; Star, 2010) in standards for sustainable building, I found difficulty succinctly describing (or visualizing, for that matter) a theoretical universe that combines governance, materiality, and transition. The papers became bogged down with terminology, definitions, and explanations that distracted from observations of interesting discovery and change. I believe that there is promising opportunity for future maturation of this theoretical arena, perhaps under the auspice of embracing the paradox of unpredictable agency and fatalistic change. For the time being, I hope that these articles can contribute to unraveling some of the theoretically shrouded intersections amongst sustainability and standards concepts, and even more so, that these unravelings can shed light on the practical way forward in sustainability work. In the next brief section, before the articles themselves, I summarize the article topics, approaches used, and findings.

Summary of Papers

The three articles herein represent the investigation of the three research subquestions:

1. How can user comfort be legitimately represented in specifications?
2. How can default rules for building users serve as a starting point for sustainable consumption?
3. Why is user focus significant in the design of technological systems?

In the first article, launching from a standards research perspective and building upon Botzem and Dobusch's (2012) model of standardization cycles, I find that commensurative processes are recursively tied to input and output legitimization in the development of standards. Especially wherein it is challenging to commensurate -- as in from comfort or well-being to numerical values -- organizations must work to legitimate with both professionals on the input

side and policy makers and consumers on the output side. The more secured the legitimacy on either side, the more it furthers the likelihood of legitimacy on the other.

The second article, examining the application of default rules in sustainable building, reveals that contrary to previous assumptions about defaults and consciousness, building inhabitants must experience an awareness of contrast between sustainable and non-sustainable residences before appreciating their value. In this way, even though their behaviour may shift with the defaults -- namely, consuming fewer resources -- it is their awareness of the pleasure of doing so, the health and quality of life aspects, that serve as the starting point for sustainable consumption of their own volition. The research indicates that this awareness may arise from first experiencing a sustainable building and then living elsewhere, implying complications for sustainable builders to more predictably see a change in inhabitants' behaviour.

In the third article, I argue against a total departure from anthropocentrism in lieu of technocentrism. I use Science and Technology Studies to analyze the interactive design process between designers of automation and measurement technologies (biometric sensor technologies) in sustainable buildings and the building users. I find that too little automation relies too heavily on the sustainability motivations of the inhabitants; too much automation disturbs their daily lives; and that the comfortable balance involves close attention to the users and providing them with the opportunity to adapt with their home environments. This suggests that the trend away from anthropocentrism and towards full automation in sustainability transitions could undermine the development of technologies for a desirable sustainable future -- both for supporting quality of life and the development of sustainability conscientiousness.

Paper	Title	Unit of Analysis	Analytical Focus	Main Finding	Main Implication
1	Commensuration and legitimacy in standards: The case of Active House	International standards (Macro)	Commensuration and legitimization processes	Commensuration is recursively linked with legitimacy in standards processes.	Experimentation can be used to connect international knowledge and local areas and thus further refinement and acceptance of quantifying sustainability aspects.
2	At home with sustainability: From green default rules to sustainable consumption	Choice architecture (Meso)	Default rules for sustainable consumption	Awareness of contrast to the default is necessary for motivating sustainable consumption.	Consumers need exposure to the contrast between status quo and quality sustainability. This could involve more of a "trial" approach for the average citizen.

3	Anthropocentric design: Human significance in building systems design	Technological standards design (Meso)	Human interaction during building systems design	Human input in design leads to socialized technologies better able to address sustainability challenges.	Technology can support sustainability objectives, but must be oriented to people using them, and developed with their feedback. The co-development unfolds over time.
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Table 4: Papers summary.

Closing

The main message of the dissertation is this: the benefit of experimental governance for sustainability transitions is that it seeks out viable pathways into an unclear future. Experimental governance works through a broader dynamic of interaction with and input from manifold actors that necessitates a greater focus on legitimizing measurement and validating the end-user, making the many alternatives for sustainability more concrete and relatable. The experimental standardization activities draw on knowledge and resources from multiple scales to nurture a learning and adaptation process for the standard, making it resilient to societal, economic, and environmental changes, akin to the resilience needed in our physical environments. Yet, despite being resilient, experimental standards still behave as rules, influencing perspectives and norms. This does not comprehensively answer the research question of “How does the production and adoption of experimental standards unfold governance effects?”, but it explicates tangible examples connecting these standards to their effects and offers a starting point for answering “How do they contribute to sustainability transitions?”. In other words, this dissertation exposes relationships among experiments, standards, and change for sustainability – specifically amongst the experimental challenges of measurement and citizen engagement.

Pointedly, in order to justify sustainability transitions under current regimes, organizations need legitimized measurements for creating a sharable platform for standardizing the means to transition. For Active House this means legitimating the incorporation of comfort into technical building considerations. The expansion of focusing organizational activities on measurement can especially be seen in the realm of ecosystem services, wherein the question is posed: What does nature do for us *measurably*, and how much is it worth? Systems ripe with qualities that formerly benefited society without being commensurated – for example coastal wetland zones or prairie grasslands – were historically issued zero economic value. Now society

is pressured into commensurating for the sake of considering their value in political and organizational decision making. The same can be said of building, wherein the failure to value comfort has resulted in poor air quality, low light, lack of views, bombardment of noise, etc. But now to have it including in building specifications, it must be commensurated. Further, though in part the increasing demand for quantifiables can be ascribed to the merger of globalization and market capitalism, financial commensuration is not the only driver. Commensuration has also become a pillar of organizational practice in order to reduce uncertainty and risk. Numbers – representing costs, key performance indicators (KPIs), resource movements and transactions – make organizational developments visible, scripting comparable histories that can be used to strategize into the future. For experimental governance, having metrics attached to qualities like comfort enable organizations to compare results across space and time and identify the standard aspects that give the best sustainability outcomes; but it is as important to know how to go about doing this legitimately.

In order to further reduce the uncertainty of governance experiments, organizations need to better understand and cater to the subjects of interest, in this case the people living in and using sustainable buildings. Consumption accounts for sustainability transitions as much as production: without the demand for unsustainable products and services, there is no market for them, and with stronger demand for sustainable products and services, they will flourish. The green gap in sustainable consumption – the disparity between how consumers say they will act and what they actually do – has raised frustrating questions of how to inspire consumers to bridge the gap. Given the fickleness of human beings and our tendency to behave differently than we say (or even believe) we will, it is tempting for organizations to try and “bypass” engaging people actively in the sustainability transitions of their own societies. Choice architecture has lent fascinating perspectives on how the framing of our decision making can indeed contribute to this; with an especially great attraction to default rules, where the influence is passive. But can organizations truly passively inspire sustainable consumption? The building experiments so far suggest that whereas installing green default rules across the whole of society is impractical if not impossible, providing consumers with a quality sustainability experience that then contrasts with the status quo can inspire a *conscious* shift of mindset and, ultimately, consumption decisions.

Along these same lines, organizations need to know how to build architectures (real, digital, and metaphorical) and utilize technologies more democratically, in cooperation with people. In the case of technology, it is also tempting to let technologies do the sustainability work for people; and indeed, this can happen to some extent. But technologies embody decisions from afar determining when and how they do what, which detracts from the benefits of democratically developing solutions and may overlook innovative technological design from the bottom-up. In other words, for lasting *social* sustainability transitions rather than just physical, technical transitions, technological standards should be developed in a manner akin to open source technologies, with their fundamentals open to citizens to view and edit based on their needs or experiences. Traditional standards might have well led down the path of pushing default rules and highly automated technologies onto building users, while either misled about or ignoring the long-term consequences; but experimental standards exhibit a greater organizational concern for the effectiveness of these approaches -- not just as binary as whether or not they work, but also as an exploration into *how they might work*. In other words, experiments have altered the way organizations approach not only other organizations in legitimacy-seeking, but also how they approach people: curiously, interpretively, and recursively. Learning and adapting gain greater significance with the need to improve upon subsequent experiments and reduce uncertainty.

The new horizons of governance and standards warrant further investigation; and as the urgency for sustainability transitions ever increases, the fields and geographies demanding said viable pathways will surely expand. The built environment is particularly interesting due to its paradox of simultaneous rapid change and permanency, and I hope to further partake in further research alongside other scholars targeting governance amongst building organizations. That said, the relevance of experimental standards in sustainability transitions extends well beyond buildings, as already noted, to the fashion industry, as well as to transportation and food systems, to name a few. It is difficult to reach definitive conclusions in this form of research, as the experiments carry on, well beyond most feasible research brackets, but the fundamental processes can be captured, and the trajectories can be estimated. Altogether, researching experimental governance is an experiment itself, and like other forms of research and experimentation, the furthering of a community that shares their insights can lend society a systemically synergetic perspective, and perhaps even some illumination down shaded paths ahead.

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Part B: Articles

Commensuration and legitimacy in standards: The case of Active House

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ABSTRACT

This paper argues that commensuration is crucial for the legitimacy of standards. It is thus far poorly understood how standards are constructed in a legitimate manner, let alone the role of *commensuration*, the micro-process of converting qualities into measurable quantities for the purpose of comparison. In order to study this, the lens is placed upon the relationship between the commensuration processes and input and output legitimacies. Research on the Active House sustainable building standard reveals that this activity involves navigating deeply interrelated qualities and attempting to formulate their new measurable meanings in a legitimate way. It also shows that those involved in the standard's processes utilize commensuration in order to secure input and output legitimacy in different stages, either technical for the standard's specifications or contextual for the standard's implementation. The paper claims that commensuration is recursively linked to legitimization in the standards creation process.

Keywords:

Standards; commensuration; legitimacy

Introduction

Standards are fundamental to shaping modern institutions, not least of all in the building field. As society faces increasing pressure to reduce carbon emissions, the shift to sustainable building is increasingly guided by standards. Yet the adoption and diffusion of such standards is reliant (among other things) on their legitimacy. Standards are an interesting subject of study because they are an increasingly significant governance tool (Brunsson & Jacobsson, 2002; Brunsson, Rasche, & Seidl, 2012). Underlying standard developments are micro-processes of *commensuration*, the conversion of qualities into measurable quantities for the purpose of comparison (Espeland & Stevens, 1998); and understanding how these processes function, especially in relation to legitimacy, is key to opening up standards' dynamics. This research takes up the case of Active House, a building standard that seeks to standardize sustainable building in such a way as to include comfort. Many of the details of standardizing energy and environment in building standards are already taken for granted; but the addition of comfort poses new legitimacy challenges. This opens up the process of *how* a new addition is standardized and legitimated. This paper claims that the commensuration of introduced qualities is recursively linked within a standard's legitimization process.

How standards are arrived at, and how to further them in the future is poorly understood. The organizational processes underlying standards development constitute a black box. Whereas there has been much attention to taken-for-grantedness of institutions, less has been paid to the processes of how they become (Lounsbury & Crumley, 2007), which is also true of standards. We know that standards are used for governance (Brunsson & Jacobsson, 2002), and we know that the social connections and institutional intersections involved in their development and diffusion are complex (Brunsson & Jacobsson, 2000). But we know very little about the inherent commensuration; and we know very little about the interplay with legitimacy. Yet, there has been a recent increase of theoretical interest in social processes like standardization and commensuration (Lamont, 2012), and Botzem and Dobusch (2012) further our understandings of recursivity in standards legitimization.

Although there is discussion of how commensuration underlies legitimacy in modern day society (i.e. Espeland & Stevens, 1998; Levin & Espeland, 2002; Slager, Gond, & Moon, 2012; Taupin, 2012; Timmermans & Epstein, 2010), how the two interrelate in the standardization process needs to be unpacked. As commensuration is an unobvious, seemingly natural way of trying to navigate a world of qualities with quantitative tools, many of those involved in commensurating are unaware of their own roles. When we name and describe commensuration, we begin to see an undercurrent of subconscious agency affecting governance. Standards are rooted in commensuration (Brunsson et al., 2012; Levin & Espeland, 2002) when they are based on quantitative conversions of contextual, experiential qualities (Espeland & Stevens, 1998). Grasping the relationship between commensuration and legitimacy in standards is particularly challenging given the subsurface nature of commensuration; but understanding it is essential for exploring the black box of standards and the issues they encounter. Further, understanding the interplay between commensuration and legitimacy can help to formulate better standards and possibly improve the likelihood of professional and societal acceptability.

This paper postulates that commensuration embodies organizational work that is critical to standards makers' legitimacy seeking. It uses the case of commensurating comfort in the Active House sustainable building standard to show that commensuration and legitimacy in the diffusion of standards can be recursively related, and that drawing out commensuration processes from under the surface of standards opens up the black box of their workings. It then proposes a model of this cycle – building upon a theorized standardization cycle – and argues a standard's process is dependent on the commensuration undergone in therein. This research applies qualitative methodology to investigating how this is done. The research consists of three demonstration-building cases that adhere to the Active House standard in Austria, Germany, and Belgium. A total of 30 semi-structured interviews were conducted between June 2014 and June 2015. The emergent patterns indicate a recursive relationship between commensuration and legitimacy. Input legitimacy is closely linked with technical commensuration and output legitimacy closely linked with cognitive commensuration in a cycle.

The paper proceeds as follows: it tours the relevant theory; introduces building standards; describes the case setting for commensuration of comfort in building and the background of the Active House sustainable building standard; presents the methodology of the

research; goes in detail through the findings; and discusses the implications of these findings before concluding.

Theoretical Framing

Standards

Researchers have recently been shedding the light onto standards and their implications for organizational processes (Brunsson et al., 2012; Slager et al., 2012; Timmermans & Epstein, 2010). This arises from observations of standards' increasingly widespread use for governance at multiple scales and their deepening collaborative nature (Fransen & Kolk, 2007), as well as the socio-technical nature of standards-setting (Dokko, Nigam, & Rosenkopf, 2012). This paper draws on the work of Brunsson et al. (2012) and their definition of standards as a "rule for common and voluntary use, decided by one or several people or organizations" (Brunsson et al., 2012: 616). Brunsson et al. (2012) bridge the governance understanding between standardization by organizations and regulations, while highlighting the inherent multiplicity and tension arising from standards. They in turn describe Slager et al. (2012) as offering "several good examples of the dynamics that arise from this type of tension and of the elements that complement standards in order to reinforce their regulatory impact" (Brunsson et al., 2012: 625); and Slager et al. (2012) at one point refer to standards as "distributed regulation" (784) – so that these two works reinforce each other.

Legitimacy and Standards-Setting

Through these standards-focused papers, and others (Boiral, 2007; Boxenbaum, Georg, Reijonen, & Garza de Linde, 2013; Déjean, Gond, & Leca, 2004; Garud, Jain, & Kumaraswamy, 2002; Kerwer, 2005; Reinecke, Manning, & von Hagen, 2012; Jones & Massa, 2013), the connection between standards and legitimacy has been established, though not yet deeply investigated. Legitimacy is important for organizations in a three-fold manner: it leads to the accruing of resources and strategic advantages; reduces ambiguity, allowing for easier social signals in decision-making; and it helps to protect against selection pressures, moving organizations towards reduced competition (Durand & McGuire, 2005). Within organizational research, there is a tendency to adopt Suchman's (1995) framework for interpreting legitimacy. I likewise adopt the overarching definition of legitimacy as "a generalized perception or

assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions” (Suchman, 1995: 574). As Suchman acknowledges, however, his legitimacy categories of moral, cognitive, and pragmatic co-exist in most circumstances, and this can be limiting when trying to model real-world processes. He also points out that the main challenge of gaining legitimacy (as is the aim in standards making) is usually divided into the two categories of gaining legitimacy with practitioners and gaining legitimacy generally with new audiences. This pointed me towards Botzem and Dobusch’s (2012) work on standards from a process perspective and their employment of the concepts of input and output legitimacies, which focus on professional and societal validations, respectively.

In Botzem and Dobusch’s (2012) study on Windows software and International Accounting Standards, they delineate the holistic nature of standards and their dependency on the work of multiple actors interconnected in a complex network process. They argue that this process is defined by recursive standard formation and diffusion, and that it pivots around legitimacies (Botzem & Dobusch, 2012). They refer to these as *recursive standardization cycles* (Botzem & Dobusch, 2012). The cycle model (reproduced in Figure 1) utilizes the concepts of input and output legitimacies, drawn from systems thinking and first applied to organizational processes in the 1950’s and 1960’s (Thompson, 1967) (while also giving due credit to Suchman’s open systems take on legitimation).¹² The model supports their core argument that “effective standardization – the setting, diffusing, and implementing of rules – depends on the reciprocal linkage of the formation and diffusion of standards” (Botzem & Dobusch, 2012: 738).

¹² The systems perspective also includes *throughput* legitimacy (Thompson, 1967). Given that this legitimacy concerns internal behaviors, it is probably better suited to analysis within an organization than to field-level analyses. Researching this additional dynamic could yield fruitful findings.

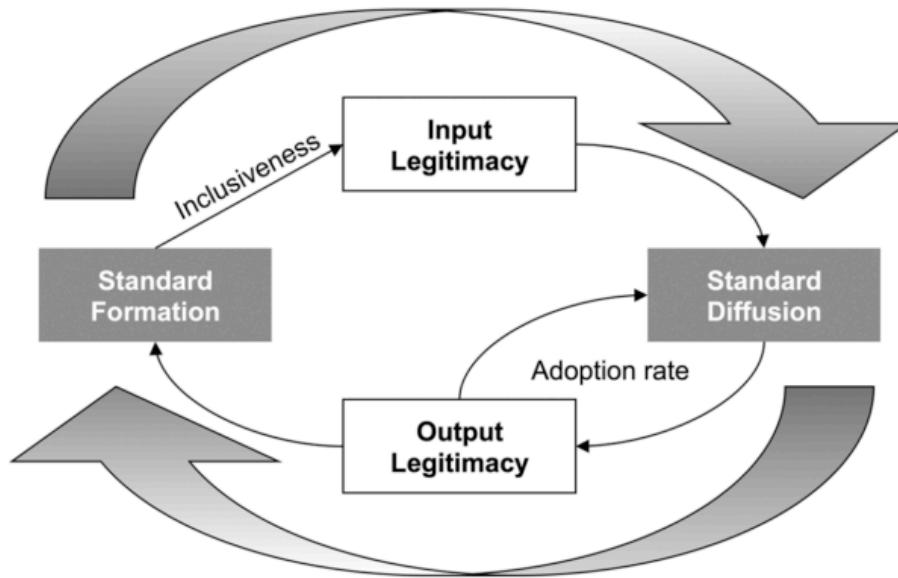


Figure 1: Recursive cycle of transnational standardization. Source: Botzem and Dobusch (2012).

Their use of the input and output legitimacies indicates a more political interpretation of standardization. The political orientation of legitimacy in institutional research has received little attention in recent years (Stryker, 2000); but the social conflict (Stryker, 2000) involved in standards creation and the inability of standards-making organizations to fall back on regulatory authority (Black, Law, & Papers, 2008) makes legitimization of standards inherently political. From this perspective, legitimacy is based on *input* – the credibility and justification of the standards –, and *output* – how well the standard addresses the issue at hand (Mena & Palazzo, 2012). Input legitimacy is defined by the quality of input and is “derived from the consent of those being asked to agree to the rules” (Cadman, 2013: 8), whereas output legitimacy is based on how effective it is, i.e. how well the standard matches its outcomes (Cadman, 2013; Thompson, 1967). I find this model very useful and straightforward. It is especially valuable in how well it highlights the interplay between legitimacy and standards and takes a process approach, and I build upon these foundations in order to reflect the commensurative dimensions revealed in my research.

Commensuration

Botzem and Dobusch’s (2012) recursive standardization cycle model using input and output legitimacies is thus expanded herein with detail on the phases of standards processes and

the significance of commensuration. Commensuration is ubiquitous (yet unseen) not only in standards processes, but in organizational processes across society, underlying such diverse areas as law school rankings (Sauder & Espeland, 2009), weather risk (Hualt & Rainelli-Weiss, 2011), pollution credits (Levin & Espeland, 2002), and flood management (Samiolo, 2012). In other words, in order to make (any kind of) decisions, we compare the weights of our options; and to enable this, aspects of those options are *made similar and then measured* by assigning them quantitative value.¹³

Yet, the dynamics of translation are not as straightforward as this and carry political influence. They are seeping with crafted meaning that then infuse standards, and in turn, organizational processes. Kolk, Levy, and Pinkse (2008) in their work on climate reporting, point out that in addition to the difficulty of commensurating carbon sequestering because of questions of effectiveness, there is also a social dimension: “[These] are also political questions, involving an asymmetric distribution of costs and benefits across actors” (Kolk et al., 2008: 728). This social dimension can manifest as exertions of power and conflict of interests (Garud et al., 2002), and it can be pointedly seen in the case of rankings (which can also be seen as a standard), wherein a singular number expresses a level of “good” (Bermiss, Zajac, & King, 2014; Sauder & Espeland, 2009).

Somewhere in between the commensuration and the taken-for-grantedness is the social process that sets a standard. Such a social process perspective can likewise be found in Johnson et al. (2006); and Slager et al. (2012) also hint at organizational work of commensuration in standards, defining commensuration as the first phase of a four-stage process of calculative framing. Not only is commensuration simultaneously ubiquitous and subsurface, but the acceleration of technological development drives an increase in the unseen “legitimacy of quantification” (Espeland & Sauder, 2007: 4), further shading the nuances of how these taken-for-granted quantities drive standards. Altogether, the theory converges at legitimacy and commensuration as micro-processes that shape the development of standards. And this can be seen in the building industry, especially as the subsector of sustainable building seeks to become better established.

¹³ Commensuration is more than comparison. Commensuration additionally involves quantification and measurement (Boyle, 2002).

Case Setting

Building Standards

In lieu of the pressure to build more sustainably, a number of sustainable building standards are on the rise (Boxenbaum et al., 2013). Institutionalizing sustainable building is one of today's most pressing issues, relating to many concerns such as carbon emissions, health, and social equality. Not only does the building field account for a sizeable chunk of the economy (Averjanoviené et al., 2008), but it also represents one of the largest energy consuming sectors worldwide, responsible for 31% of energy use and 33% of energy-based carbon emissions worldwide (Kiss, 2013). At the same time, buildings are essential to the quality of our lives: we sleep in some, work in others, gather and organize, pass time with our families. Yet, the building field is notoriously difficult to change, and sustainability standards still represent a mere fragment of building practice (Henn & Hoffman, 2013). Yet standards have been key to integrating sustainability considerations into the building field (Boxenbaum et al., 2013; Henn & Hoffman, 2013). Commensuration explains, in part, how these considerations are worked into the norms of the field.

Comensurating Comfort: A Primer

Standards – even the most widely adopted – can be flawed, only partially reflecting the concepts they set out to guide; and this is in part due to the commensuration process. Take the example of the current building industry standard for measuring comfort: the Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD), or the *Fanger Method*. P.O. Fanger, a professor at Danish Technical University and Syracuse University, developed these measures of comfort in the late 1960's at a time when very little was known about the body's responses to changes in indoor temperature, humidity, and airflow. His aim was to develop solutions for designing indoor environments in which as many people as possible would feel comfortable, an optimal environment (van Hoof, 2008). Fanger theorized about comfort based on laboratory experiments, usually involving college students who were requested to identify conditions of neutral comfort prior to being exposed to alterations in individual parameters (Fanger, 1967; Fanger, 1970). The PMV, which is meant to represent the optimal conditions for indoor comfort, is considered achieved when the PPD, the portion of the indoor population experiencing discomfort, reaches 10% (Fanger, 1970). Testing based on this measure of comfort

continued in the following decades and in some cases shifted from experimenting on humans to using mannequins rigged with sensors (Madsen, Olesen, & Kristensen, 1984; Nilsson, 2004).

This way of commensurating comfort was considered a dramatic advancement at the time, being the first integration of multiple parameters into measuring comfort, and it became ingrained into the practice of designing heating, ventilation, and air-conditioning (HVAC) systems and, ultimately, building standards used the world over (Bundegaard, 2010; Solomon, 2011; van Hoof, 2008). Not only has the research since made leaps, but also technology has advanced: mannequins now resemble androids, and sensors have become far more sensitive, complex, and affordable (Nilsson, 2004). The Fanger Model even serves as the basis for the International Standards Organization's "Ergonomics of the Thermal Environment" (ISO 7730), the European Committee for Standardization's (CEN) "Ventilation for Buildings: Design Criteria for the Indoor Environment" (CR 1752), and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers' (ASHRAE) "Thermal Environmental Conditions for Human Occupancy" (Standard 55), which are hugely influential in the building industry (Dall'O', 2013; van Hoof, 2008; Yau & Chew, 2012). In other words, the industry has largely accepted that the Fanger Model is a legitimate commensuration of comfort, and it now permeates practice.

However, using this model as the industry standard now harries human comfort in buildings with its disparities between prediction and reality.¹⁴ How is it that a method specifically targeting optimal comfort could now be getting in the way of designing for comfort? This can be explained by how comfort was commensurated in the Fanger Model – namely, that the technical representation of comfort did not account entirely for the complexity of people's comfort in buildings: their different clothing, psychology, behaviors, level of activity, adaptive capacity, etc. (Solomon, 2011). Nor did it consider that people might not want to feel *neutral* (Yau & Chew, 2012). These gaps make sense given the limitations of researching with small sets of students and sensors within laboratory or climate chamber settings (van Hoof, 2008).

It is difficult to change using the Fanger Model as the basis of comfort now that it is, in essence, institutionalized. For example, the more recent Adaptive Thermal Comfort model

¹⁴ Under some circumstances the Fanger Model can be validated, and under others it is debunked. See van Hoof (2008) for more detail.

incorporates people as active participants in shaping their own comfort and whose indoor preferences respond to the outdoor environment, at least in naturally ventilated conditions (Nicol & Humphreys, 2002). But this model is only minimally recommended as an alternative to the Fanger Model in standards revisions: “Fanger’s PMV model is almost 40 years old and still used as the number one method for evaluating thermal comfort. Even the incorporation of an adaptive model in ASHRAE Standard 55 did little harm to the status of the PMV model, as it is still recognized as valid for all buildings types” (van Hoof, 2008: 198). For now, the Fanger Model is the default approach, but the friction between sticking with what we know and investigating an improved commensuration of comfort opens doorways for a re-commensurating comfort. Further, the endurance of the Fanger Model exemplifies the power of commensuration amidst lack of more convincing quantitative measures.

The Active House Standard

The Active House demonstration projects, to date totaling 21 buildings in 12 countries, are rooted in VELUX’s Model Home 2020 program. VELUX, as a prominent roof-top windows manufacturer headquartered in Denmark with branches across Europe, noted recent sustainability standards’ tendency to reduce daylight and fresh air (features embedded in the company’s motto), and ultimately extended Model Home to act as co-founder of the Active House Alliance. The vision of Model Home was to build the kind of houses that people would want to inhabit in year 2020; and this vision serves as inspiration for the expansion of both collaboration and building design that Active House now embraces. Thus, two of the three demonstrations studies herein – Sunlight House and LichtAktiv Haus – were originally part of Model Home 2020.

One of the difficulties of creating a standard is ensuring that it embodies all the significant components of the practices it guides. Whereas sustainable building standards to date frame their specifications around environmental and energy factors, they largely omit building users. The Active House Alliance was formed in order to expand sustainable building practices to additionally incorporate consideration of the people spending time in buildings. Specifications commensurating environmental and energy performance are fairly well established and implemented through a multitude of building standards. However, commensurating a user-related factor like comfort into standardizable specifications is a new

venture, an innovation of sorts. And although Active House has worked amongst its members to develop a standard intended to enable design for comfort, the challenge becomes building belief in others – in particular, other builders, consumers, and the policy-makers – that this is doable.

Methodology

This research project is aimed at better understanding institutional change in the building field. The intent was to gather detail-rich data that might shed light on multi-level processes ongoing in Active House's efforts to spread its message. Through the project structure, I have an established academic relationship with VELUX, one of the founding partners of the Active House Alliance. This partnership facilitated access to the demonstration projects on-site, as well as communication with the Active House Alliance's members and other building industry connections. As such, the snowball sampling technique (Goodman, 1961) was used, wherein contacts would recommend others to interview and events to attend. Ultimately, the categories into which the findings are organized emerged from an inductive data collection and analysis process.

I use qualitative methodology to build three cases of Active House demonstration projects and obtain enriched perspectives on meaning and contextual conditions (Yin, 2011). These three cases (out of 21 demonstration projects) reflect the diversity of projects and the direction of the standard's formation. Only cases of residential buildings were studied to enable comparison. Sunlight House in Vienna, Austria, was selected as an example of former sustainable building standards' targets: it is new-build, suburban and luxurious. LichtAktiv Haus in Hamburg, Germany, was chosen as a small, but significant shift: it is part renovation, part new build (i.e. the old house was renovated and then extended) and fairly central in the Hamburg region, having public transportation connection to the city center. It was also part of the Hamburg International Building Exhibition. RenovActive (monitoring phase) in Brussels, Belgium was chosen to represent the a new direction: it is one unit of a duplex, owned by a social housing company, currently in very poor condition, planned for renovation, and part of a garden city community quite central in Brussels. Together, these cases paint an elaborate picture of the processes involved in this standard.

The data is based on semi-structured interviews, research stays, events, and site visits. A total of thirty interviews were conducted (anonymously to encourage openness), audio recorded, transcribed, and fact-checked with the interviewees. I also engaged in two three-month long research stays at the VELUX headquarters in Hørsholm, Denmark, during which I kept a digital diary. This allowed me to better understand the development of the Active House standard and the different interests at hand. Events played a role, as well -- of particular significance was the Active House Guidelines Workshop wherein the opportunities and limitations of the standard were discussed among various stakeholders. Some parts (the Active House Guidelines Workshop and the Northern Germany Passive House Conference) were audio recorded and transcribed, and for the other events I kept written notes. And finally, site visits gave a physical context to the manifestation of the standard in practice, and I also noted my reflections at the time.

I collected the data as follows: the digital diary from the research stays were kept in memo form in Nvivo; the interview audio tracks and transcriptions, as well as documents highlighted by VELUX, were loaded into Nvivo; and my notes from the site visits and events were transposed into a digital notebook. After the first project visit, data was reviewed for an initial coding round, in which major themes were identified. The flexibility in this early phase made room for conceptual discovery (Miller, Dingwall, & Murphy, 2004). Subsequently, I went through a second round of coding, adjusting to focus on whole segments (from sentences to paragraphs) relating to these major concepts and iteratively re-visiting the cases, as is usual in inductive analysis (Patton, 2014); and this was followed by a third, refining round, wherein I pulled the concepts into specific research questions and then restructured the order and nesting of the coding segments to relate back to theory.

Data Type	Structure	Detail
Interviews	Semi-structured, voice-recorded, transcribed, fact-checked	Professions: architects, building engineers, building scientists, policy-makers, social-housing workers, homeowners, standards makers. The interviews were recorded by a mobile application with permission of the interviewees. These audio files were then sent for professional transcription. The transcriptions were reviewed and then sent to the interviewees for fact-checking and any additional privacy concerns.
Research Stays	Two three-month research stays	Sharing office space with VELUX employees, including those working on Active House, at the headquarters in Hørsholm, Denmark.
Events	Conferences and workshop attendance, observation and notes	Titles: Passive House 2014 Exhibition in Brussels, Northern Germany Passive House Conference in Neumünster, Bauz! Vienna Congress for Sustainable Building, Active House Guidelines Workshop in Brussels
Site visits	Tour, inquiry, notes, photos	Visit to the three different sites, including the dilapidated unit in Brussels. Site visit in Hamburg did not include entry.

Table 1: Data description (source: own).

Findings

The making of standards is often a process of uniting and building upon prior standards (Timmermans & Epstein, 2010). This can be seen, for example, in the global standardization of shipping containers (*containerization*), which drew upon and expanded standards for horse-drawn and train-transported containers (World Shipping Council, 2014). It can also be seen in sustainable building standards, which draw together building standards for energy performance (primary, electrical, and heating/cooling energies) and environmental performance (materials, water usage, and recycling, to name just a few). These are added on top of a plethora of building regulations concerning principal aspects such as structural stability, ventilation, and plumbing and electrical compatibility, most of which vary in detail across regions and even townships. Active House contributes a standard including user comfort, as well, leading to a triangulation of energy, environment, and building occupant. As pointed out earlier, the incorporation of

comfort poses new commensurative challenges that are affected by and in turn influence the legitimacy of the standard.

This research finds that input is key to the legitimacy of technical commensuration, which drives standardization; cognitive commensuration drives output legitimacy, which is key to a standard's diffusion; and evaluation is an important, but optional recursivity link between the technical basis of a standard and the context of its diffusion. It shows that commensurative work is integral to the recursive standardization cycle; but that this recursivity only perpetuates with the feedback of evaluation.

Proposed Model

The model in Figure 1 represents the cycle observed in the research. Following the selection of a quality or qualities, the process is divided into phases: 1) *technical commensuration*, the commensuration of desired qualities into the standard's technical specifications, 2) *cognitive commensuration*, the interpretation of the specifications given a specific context, 3) *implementation*, the application of the adapted specifications to a project on the ground, and optionally, 4) *evaluation*, the assessment of the product of implementation. Commensuration is divided into two spheres: technical and contextual; and these relate to input and output legitimacies, respectively. The product of standardization, in this case the specifications, connects the two spheres. They may also be connected through evaluation. However, evaluation is not necessarily undertaken in the technical sphere (represented by dashed arrows). The following sections go through the findings in further depth, walking step by step through each technical sphere and its contents, and closing with evaluation.

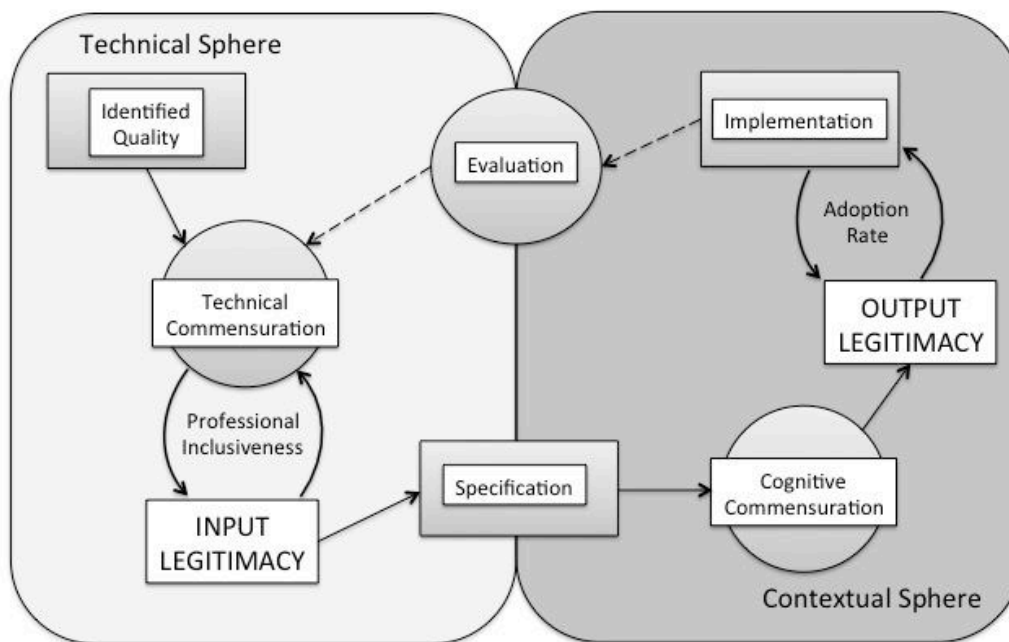


Figure 2: Recursive standardization with commensuration and legitimacy (source: own).

Technical Sphere

In order for a standard to be formulated, it must be shaped and defined by professionals. This article refers to the *technical sphere*, the realm in which those who are trained in the necessities of the work manifest their knowledge in a particular, technical format, in this case in specifications (delineated ranges of quantitative measurements, i.e. temperature and water demand, that if followed produce a certain quality of building). It is distinct from the contextual sphere in that input legitimacy, to which it is linked, is based on the professional assessment of technical accuracy of commensuration (which is represented by “professional inclusiveness”). In Active House, professionals have mainly consisted of architects and construction engineers; but, depending on the scale and needs of a project, it can also involve architectural engineers, building scientists, life-cycle assessment (LCA) specialists, and more recently, sociologists. Each of these professions brings with it a set of perspectives, approaches, assumptions, and

(sometimes conflicting) priorities. Since VELUX is selecting sites and funding the demonstration projects, they are able to organize cooperation in the technical sphere among their own professionals and those of the Active House Alliance. This has included, for example, reaching out to engineering consultants at Grontmij and daylight researchers from the Institute of Building Research & Innovation in Austria. All of these actors have been involved in shaping the meaning of comfort as commensurated in the Active House standard, and the higher their level of involvement in the commensuration, the higher the input legitimacy.

Technical Commensuration

The *technical commensuration* of comfort is done by composing a definition based on measurable indicators, all of which must be believably combined into an aggregate measure of comfort. Technical commensuration is the attempt to accurately express the technical measurement of a quality (Levin & Espeland, 2002). Comfort is the crux of Active House: “If you look at the certifications like LEED or BREEAM, they definitely have a focus on health aspects; but it’s not as much in focus as when it comes to the Active House” (Interview 28 May 2014). The indicators that Active House refers to composing comfort are daylight, thermal environment, air quality, and acoustics; features that are measurable, but complicated in and of themselves. For example, in the case of daylight, daylight factor (DF) is still calculated with a rather simplistic, UK-centric protractor method developed by the UK Building Research Establishment (BRE) in 1975 (Building Research Establishment, Ne’eman, & Light, 1975). Reminiscent of the Fanger Method, not only does this method fall short of international application, but it does not connect to the human experience of daylight. What Active House does to tie these indicators together is relate them to the senses and to health: they reflect our sight, touch, and hearing, and even echo our well being, as our bodies respond to our environments on an unconscious level. As in the case of sense and health, one finds holism in the connection among qualities.

One of the main findings is the significance of the interrelatedness of qualities in the process of technical commensuration. What I mean by this is: qualities are not only defined by relating to other qualities; but qualities are tied to one another in objects of perception. Interestingly, one interviewee refers to such phenomenon in architectural design, referring to it as “positive boundaries [that are] a more or less negative precondition” (Interview 19 November

2014). It likewise relates to Hegel's concept of *sense-certainty* of a thing as a community of interpenetrating qualities that do not affect one another (Ellis, 2005). Even though Active House commensurates comfort through sense-based indicators, the process is particularly challenging because of comfort's interconnectivity with other (already commensurated) features. Not only is the commensuration of comfort based on the indicators difficult to technically justify, but attempting to do so opens up the commensurative basis of the other features, as well. For example:

Energy

Although energy use measurement and comparison in buildings is an institutionalized aspect of sustainable building, when one considers its relationship to comfort, its security is unfastened. As one interviewee explains, Passive House building parameters since the 1980's have been determined with the aim of promoting heat energy derived independently from the grid (to avoid politically contested energy sources such as nuclear, and more modernly, natural gas): "they decided to make a technical set up, which meant that you could avoid having external heating supply into your house" (Interview 2 July 2014). As these political aims seek energy outcomes unrelated to human comfort, the current application of energy use standards is based on modeling, simulations that do not yield results consistent with actual energy use (see related research, i.e. Hoes, Hensen, Loomans, de Vries, & Bourgeois, 2009; Karlsson, Rohdin, & Persson, 2007) -- a phenomenon that is explained not by the inaccuracies of these programs, but by the behavior building users adopt in order to feel comfortable (i.e., opening windows that the simulation kept closed, or turning up the thermostat above what the simulations use as the baseline for comfortable temperature). Rather, this misalignment between energy performance and comfort is driving a new technical commensuration: "We have to not only talk about this one figure and energy for heating anymore. It's too narrow" (Interview 2 July 2014). But it's important also to note that the recommensuration does not necessarily dispose of the previous commensuration approach. As one of the standard makers remarks: "For quite some time there was a conflict between the Passivhaus people and, 'What are you guys doing, stealing it away and making it Active House? And why are you opposing what we are doing?' We spent a lot of time saying, well, actually we are not opposing. We are adding" (Interview 15 June 2015).

Materials and Space

Similarly, when attention is paid to comfort, one must also question the basis of material selection – for reflectivity, texture of fibers, even scent -- as well as spatial specifications in sustainable building standards. One standards maker and architect explains her perspective on comfort's interrelatedness: "Comfort is everything that surrounds me: it's the space, it's the colors, it's the materials. It's basically what I see with my eyes and how can I use the space. So it's not only in regard to the aspect that you cannot grasp, like daylight and fresh air, the things you feel, but also the things you touch and see" (Interview 28 May 2014). Similarly, another architect points out the difference between how she designs for comfort (clean and open design, white colors, simple) and how she experiences comfort herself at home (chaotic and cluttered, historical details, colors) (Interview 23 November 2014) -- a contrast that evokes the subjectivity of comfort commensuration. Comfort design also relies on acoustics, which are likewise tied to materials and spatial layout. Yet in terms of technical commensuration of acoustics for comfort, this has so far proved out of reach: "Should you measure how the building is performing inside, for example, if you have an office building – what's the acoustic resistance of the materials there? Or should you always reflect it to the outside environment? It was very difficult to measure so we dropped that. But then we include it as a thing to consider in the qualitative terms [...] It's about the design of the buildings, the orientation of the openings, the process of the plan" (Interview 28 May 2014).

And still, technical commensuration separates these qualities. Hegel would argue that unraveling qualities renders them meaningless, as they do not have an object to which they relate (Ellis, 2005). However, with technical commensuration in standards: the quality is separated out, measured, and compared; and altogether it is tied back to other qualities within the standard and in relation to the standardized object (i.e. buildings). Still, the separation must be done in a legitimate manner for the standard to be accepted by the professionals involved. In essence, technical commensuration demands legitimacy not only for the newly commensurated quality, but also a re-commensuration of the relevant, connected qualities also represented in the standard.

How comfort is technically commensurated is scrutinized insofar as it matters to the professionals who will be applying the specifications, thus relating it to input legitimacy. The main source of conflict in input-legitimacy-seeking is comfort's relation to energy. Social circumstances have led to energy being one of the most heavily commensurated units of building standards (Interview 10 November 2014). If the measurement process is not driven down to a nano level, it is not considered scientific or appropriate for the progression of the industry (Interview 13 February 2015). The situation has also led to a proliferation and tightening of building-related energy regulations, not least of all the European Union's Energy Performance of Buildings Directive 2010/31/EU¹⁵, which requires that all new buildings in the member states must be nearly zero-energy buildings (NZEBs) by the close of 2020 (EUR-Lex, 2014). This explains why Active House is usually discussed in comparison with Passive House rather than LEED or BREEAM, which do not require par excellence energy performance. However, attention is starting to reorient. As one interviewee describes the shift: "[Energy] is the first thing, the first driver. Now more and more people who talk to us say 'you can't lose the user living inside, energy efficiency is not everything'" (Interview 2 December 2014).

The significance of commensuration for input legitimacy is that professionals in the building industry may determine that expanding the conceptualization of energy to incorporate comfort is important, but they cannot work with it unless tangible guidance for implementing building design for this has been developed by other professionals, in the form of specifications, building codes etc. "Even in the EU, everybody knows, 'No, you cannot just talk about energy and not just part of the energy consumption.' It's well respected. But we haven't got the hard scales for it. And then people will go into regress[sic] and do what they already know and what's already there" (Interview 2 July 2014). They will not legitimate this guidance unless it is developed with diverse participation of building professionals and insofar as the guidance will close the performance gap. An EU policy maker notes these expectations: "If you see a building, whatever it is, and you calculate the energy performance certificate, you have then the real building with occupancy and the real consumption. And so you expect that there is some degree of correlation" (Interview 15 June 2015). For VELUX alone, they needed the input of other building professionals: "When we are going in these standard situations, where I know it's a bit

¹⁵ The directive expresses the necessity of targeting the building sector in order for member states to comply with the Renewable Energy Directive 2009/28/EU, which stipulates that renewable energy sources must account for at least 20% of total Union energy consumption by 2020.

more of a pragmatic target group, they build their houses according to whatever norms and actual standards. And they, in my opinion, they don't trust or they don't want to hear those generic and scientific abstract statements from a window supplier” (Interview 19 November 2014). Thus the wide membership in Active House and the professional participation in the technical commensuration process legitimates the Active House standard.

Active House has developed the Active House specifications to deal with this input legitimacy conflict in three ways. First, they conform to the established measure of energy demand, or energy use intensity (EUI) (kWh/m² per year) and offer four rankings in a relatively low, well-performing range. Passive House certification requires less energy demand; but this is only calculated through heating or cooling energy demand (Passive House Institute, 2012), whereas Active House additionally incorporates water heating, ventilation, appliances, and electricity for lighting. This latter method calculation is becoming ever more relevant, as total energy consumption is on the rise, despite massive strides in building and appliance efficiencies, due mainly to the multiplication of energy-demanding devices.

Second, the specifications adopt a broad approach to calculating primary energy, based on energy from the extraction source (energy plant, wind farm, etc.) in order to distinguish transmission losses and ratio of renewables. It is typical to have different standards for calculating primary energy in non-comparable ways (Wittchen, Thomsen, & EuroACE, 2008); but calculating it from the extraction source aligns with the EU directives for building and renewable energy targets for 2020. Active House’s standard for primary energy ranges from less than 0 kWh/m² (plus-energy) to over 30 kWh/m² per year, whereas Passive House’s (calculated only on-site) must be under 120 kWh/m². By applying better foresight, Active House gained a sort of front-runner advantage; especially reflected in that Passive House has now established a standard (so far only in Germany) based on this way of calculating, calling it instead “final energy”.

Third, the Active House specifications leave room for adaptability by including a section called “Qualitative Parameters” in which comfort, energy, environment, and building management are considered more qualitatively, with bullet-point criteria and areas for filling in argumentation. On the one hand, this is advantageous, as it allows for more flexibility and creativity and is less prescriptive in total. Flexibility can impact the building outcome in relation

to comfort: “I think that in the way of making the spaces you need flexibility for people to use those spaces, [...] they're completely different and people use it differently, and that person will have comfort, personal comfort in the end” (Interview A 8 September 2014). On the other hand, this non-technical section renders the specifications difficult to transform into regulative action. And it can be the basis of doubt: “So the results: is this sharp enough or is it too...some kind of smooth sentences or quotes done; or some interdependency of outdoor temperature and user behavior? Is it scientifically sharp enough to bring something really new?” (Interview 19 November 2014).

Altogether, these three strategies seek to secure input legitimacy by speaking the professionals’ language, while bringing taken-for-granted measurements up to par with standards of the future. As they were developed through the input of diverse professionals, the specifications are input legitimated from different angles by the different professionals involved. For example: engineers and building compliance specialists legitimate the approach to energy demand because, as the European Committee for Standardization (CEN) indicated at the World Sustainable Building Congress in 2014, energy standards will soon be meeting consumption standards in forthcoming EU redefinition of nearly-zero energy and plus energy buildings. Urbanist architects and planners embrace the primary energy specifications as they reflect the movement towards opening up calculations based on neighborhood and city scales. And architects and sociologists resonate with the necessity for quality aspects, even within qualitative specifications, an opening that leaves room for creativity, innovation, and long-term thinking. Further, the latter qualitative section is crucial, despite its drawbacks, in that it allows for interpretation and argumentation, something that sets Active House apart from building certification systems and enables proactivity in the contextual sphere.

Contextual Sphere

Whereas the technical sphere refers to the professional formulation of standards, the *contextual sphere* refers to the environment to which a standard is adapted. As opposed to the technical sphere, the linked output legitimacy is based on the acceptance of those subject to the standard in context. This division between technical and contextual was reflected in the interviews:

[This] project was cut into two pieces for me. Because first it was starting architecture-wise: everybody was focused on the house, on the design, on the technical part in it, on the energy concepts, and all these things. And then families came in, and we researched them here in Germany by a normal PR [public relations] story. So I gave the text to the newspapers – we are searching for families – and we had 38 families that wrote to me, ‘Oh, we want to test the house.’ And I thought, wow! That’s a new kind of work. I must say I’m gaining a family now. (Interview 2 December 2014)

Although standards are associated with uniformity and sameness (Brunsson et al., 2012; Timmermans & Epstein, 2010), they also involve dynamic processes (Brunsson et al., 2012; Paradeise & Thoenig, 2013; Sandholtz, 2012; van den Ende, van de Kaa, den Uijl, & de Vries, 2012) and serve as a collective platform from which to launch all the innovation and creativity borne of diversity. This allows for interpretation and reconfiguration that leads to the multiplicity of standards. It is also this source of deviation that results in narratives for diffusion, as discussed in Haack, Schoeneborn, & Wickert (2012), and necessitates coordinating standards, as discussed in Reinecke et al. (2012).

For Active House, this adaptation is considered on the nation-level, but it can on other levels as well. Each of the three nations studied have different historical framing and modern politics shaping their approach to sustainable building. It should be noted that for the sake of simplicity, this research approaches these nations as homogenous, even though they encapsulate vast diversity, as well. The context of buildings can affect anything from the sizing of housing plots to preferences for single-family or collective living to the assumed arrangement of rooms within a given space (Interview B 8 September 2014). Further, the context is shaped from both bottom-up, through consumer preferences, and top-down, through policy. This paper uses the example of Belgium’s context in order to give the reader a sense of the uniqueness of place. This is important for understanding the following discussion of cognitive commensuration, and how context can disrupt the efforts to commensurate qualities into singularities, an aspect essential for assigning them price values (Lamont, 2012).¹⁶

Belgium’s Context

¹⁶ A third form of commensuration is *value commensuration*, wherein a price value is assigned to the quality (Espeland & Stevens, 2002).

In Belgium, the building stock performs poorly, as most of the structures are made of old, uninsulated stone. This exacerbates the pressure for leadership that stems from hosting the European Commission headquarters, as it comes off as inauthentic to receive directives from a place with low standards itself. Brussels region has taken the helm and, following a series of inspiring government-sponsored demonstrations with *Bâtiments Exemplaires* (Exemplary Buildings), imposed an adapted version of the Passive House standard as its requirement for all new build from January 2014. Antwerp announced in the Summer 2014 that it would follow suit. Further, the destruction of history and edification of streamline buildings was so reckless in the 1980's and 1990's that this kind of urban development is termed *Brusselization*. In reaction, Belgium now has a most restrictive approach to historical preservation. As of January 2015, all major renovations in Brussels (and in the future in Antwerp) will also be subject to the new building regulations, possibly running into direct conflict the historical preservation requirements. "And that's what's so strange about the legislation, because up to now we've been focusing so much on new build, and it's 1% of the market. And renovation, I mean you can see" (Interview B 8 September 2014).

A specific example concerning the Belgian context regards collectively owned renewable energy production. An interviewee describes why, despite desire for such a system in RenovActive, they did not design for it: "[We] cannot even do it in the legislation in Belgium because we have another project with townhouse renovation [...], and they wanted to have a collective energy system but by law you have to, there's such strict guidelines to be an energy provider, so she had to sell it again because it was too difficult, she had to sell the energy back to the grid and then the grid sold that again to the people living in the towns, so she said this investment for me, is not worth it, [...] and they sat together for the project, and they went back together to other politicians to try to get the laws changed about that" (Interview A 8 September 2014). Or on why they chose a local project manager: "[We will] just sit at the meetings without actually having any inputs because we don't know the legislation in Belgium, we don't have the tradition for building. We don't know the products...we know the Danish market; we can see the manufacturers selling different products in Belgium. [...] I think it's more convenient for the whole process" (Interview 29 September 2014).

Cognitive Commensuration

The process of cognitive commensuration is wholly dependent on these contexts. *Cognitive commensuration* refers to what is paid attention to in a given context, what we focus in on, what unquantified phenomena fall by the wayside, and how we cognitively reimagine the subject of commensuration in application (adapted from Levin & Espeland, 2002). In other words, cognitive commensuration is about interpreting the meaning -- whether it be through placing in categories or other constructs -- of the technically commensurated, in this case the specifications and comfort. The result is the creation of new objects of classification. Active House is identified as a sustainable building alliance that standardizes comfort and that develops specifications that may or may not improve comfort in sustainable buildings (outcome is more related to output legitimacy, to be discussed). And just as technical commensuration changes if handled by different technical professionals, the outcome of cognitive commensuration is subject to the various actors of the contextual sphere (be they policy makers, those living in buildings, contractors, realtors, or others). Cognitive commensuration serves to translate the context into the specific framework needed to judge the outcome of a standard.

The research finds much organizational work that goes into supporting how the meaning is interpreted, how cognitive commensuration is undergone in context. This work is identified as establishment of: interest, understanding, and compatibility. In order to generate interest in sustainable building for comfort, Active House has worked to maintain a simple, attractive message, embodied in the triad, overlap spheres of energy, environment, and comfort. This is furthered with the specifications' radar tool, displaying building performance within these three spheres in relation to the radar of an average house in the area. They have set up workshops in various countries, wherein they promote this message, and they invite architecture and engineering firms, as well as, relevant building product companies (ventilation systems, vertical windows, etc.). For example, along with their members VELUX, Rockwool (stone wool insulation suppliers), and Politecnico di Milano (Polytechnic University of Milan), Active House conducted a touring workshop in June 2014, making new contacts in 19 cities around Italy. And the 2014 Active House Symposium, as a sustainable building standard event, was integrated into the World Sustainable Building Congress, a massive convening of professionals

working with sustainable building held in Barcelona, Spain. This interest encourages enough questions to work on the understanding.

Understanding, a general grasping of the purpose of incorporating comfort, in this case usually involves training architects and engineers on how the Active House radar works and how to use the Active House specifications when designing a new build or renovation. But more specifically, Active House has approached cognitive commensuration differently depending on the country and their own learning experiences. For example, in Germany Active House held an architectural competition. The selected architect, a student from Technical University of Darmstadt, was then transitioned from university and trained how to adapt her design to better fit both the realities of architectural practice and the Active House values. In this way, Hamburg's International Building Exhibition (IBA) could make sense of the project as a localized German approach to sustainable comfort, and they chose to integrate it into the IBA portfolio. By the time the Belgian project was initiated with more of an eye on gaining understanding in the European Commission, Active House contracted an architectural and engineering firm, but kept final decision-making in-house. As one architect pointed out, this project was less about an immutable idea of a building in the early stages: "It's more of a lobbying. It's more of a big discussion thing" (Interview 8 September 2014). Rather, cognitive commensuration of comfort was furthered through the Brussels region's building commission (responsible for issuing the building permit) involvement in the design decisions, a negotiated process: "We want to also show them what we're building, to make changes to it. We say, for example, 'We would like to increase the windows -- not everywhere but some parts -- because the windows are quite high in some points.' [...] And if we say, 'Okay, we can drop this. For example, if we can enlarge them in the back, just not visible from the street'" (Interview A 8 September 2014). This is largely because of the progression of the demonstration projects towards renovation, inviting tension at standards for historical preservation, a serious issue for compatibility.

Compatibility, the acceptance that a standard suits the framework of the regional or national society, is arguably the most challenging area of organizing in cognitive commensuration. It is also the most ambiguous: on the one hand the social framework for comfort is influenced by the very technical professionals shaping the technical commensuration, and on the other, the unique contexts leave trace nuances that can prove to deeply influence

acceptance of externally developed standards for comfort. It involves the activity of drawing common threads together between standard and place. A contextual understanding through design negotiation is one thing, but contextual compatibility is needed for a replicable, diffusible standard that Belgians (and the European Commission) categorize as a potential large-scale solution. In Belgium with the RenovActive project, Active House charged the project manager (Belgian herself) with the task of aligning the project with relevant culture, codes, and legislation. It has been this alignment effort that has enabled the project workers to engage municipal councils about their historical preservation concerns. This does not guarantee that the project will be replicated, even on the other units owned by Foyer Anderlechtois, but it does allow for communication. Further, collaboration contributes to compatibility. When discussing the relationship between Active House and the social housing company that owns the RenovActive building, an interviewee says, “[We] also want to do with the house what we want, but we want to do something that they can use. So there’s this confidence that they need to build up, but we have a very good contact with them from the beginning. [...] So now, it’s like friends or colleagues, let’s say. So it’s a very good collaboration” (Interview A 8 September 2014).

Cognitive commensuration is needed for output legitimacy in that the commensuration gives meaning to the classification within which *comfortable* sustainable building can be legitimized. In other words, before people can judge whether or not the standard functions, they first have to interpret comfort as a reasonable category within classifications for sustainable building. While cognitive commensuration is about how to make sense of the combination of comfort, energy and environment in the standard, output legitimacy is about acceptance (within this defined meaning) from those utilizing its output in context, i.e. those using the buildings. So on the one hand there is the intellectual experiment of commensurating comfort, and this is inseparably tied to the physical experiment of building something based on commensuration. As one building researcher describes the transition: “You can't really persuade somebody or impress [a person] by just logical arguments, by intellect, by thinking. You can only change his way of thinking and doing by giving him [or her] real experience, a strong experience: experiments, testing buildings, living” (Interview 13 February 2015).

To better understand the move from thinking to experiencing in output legitimacy, take the example of waste incineration in the United States in the late 1800’s: American engineers and urban planners were interested, the technology (mainly coming out of Europe) made sense,

and it was compatible with the cultural and legal situation at the time. But as the projects failed, so did the output legitimacy:

The introduction of incinerators in the United States, however, involved a series of bad choices and eventual failures. Problems of faulty design and construction, in addition to inadequate preliminary studies, contributed to a widespread malfunctioning of these systems. Often the U.S. incinerators were used only to burn wet garbage without the inorganic materials that the European incinerators relied upon to maintain combustion. As a result, of the 180 incinerators built in the United States between 1885 and 1908, 102 had been abandoned by 1909. (Blumberg & Gottlieb, 1989: 8)

A change to the technology, a new generation of incinerators, largely relieved the technical problems and added the benefit of energy extraction (Blumberg & Gottlieb, 1989); but its output legitimacy never recovered. As a result, United States has had over one hundred years of landfill dependency. When New York City's last waste incinerator closed in 1999, one politician even announced, "We have ushered out the era of incineration. It's gone and un lamented" (Martin, 1999). Gaining or damaging output legitimacy therefore has serious consequences for the diffusion of a standard, and the processes of technical and social commensuration preceding it -- while providing essential priming -- do not guarantee acceptance.

Overall the research finds that legitimacies are not binary, but rather advance as gradients – so that the acceptance is gradual rather than absolute. The Active House specifications are used to cognitively commensurate a sustainable building standard with a comfort aspect, and the Active House demonstrations are used to generate output legitimacy, essentially as evidence that the standard works in practice and in context. This is based on a kind of informal evaluation (as opposed to the formal evaluation discussed below), the outcome of which is reflected in public media and engagement of policy makers, consumers, and local building professionals. The reception of the two studied completed demonstrations in Germany and Austria has been positive; but there are complications of replicability. Specifically, these projects have been quite expensive, to the extent that the standard is not considered practical for general adoption. When asked if the LichtAktiv Haus demonstrated a potential renovation solution for use around Germany, an interviewee responded: "If we don't talk about costs of LichtAktiv Haus, then it is" (Interview 25 November 2014). On the other hand, experiments precede scale and are thus more expensive: "[The] prototype is always more expensive than the series" (Interview 24 November 2014). This brushes against the debate in standards about

bringing up the bottom line versus raising the ceiling – whether standards should focus on improving the worst or inspiring the best. Further, when considering output legitimacy as a gradient, some legitimacy is given for what is accomplished beyond cost: “[LichtAktiv Haus] didn't directly attract clients but it was good for the company background [...] so we can say or we can show what we've been working with and what complex situations we can master” (Interview 24 November 2014). Such issues of scaling, cost, and reputation emerge during early implementation.

Implementation

Implementation is the utilization of a standard in context. It may vary how much the spirit of the standard is altered to suit local application. As one interviewee pointed out, the Passive House standard is based on designing for energy independence, but in Brussels' conceptualization of Passive House, it is acceptable to use imported natural gas (Interview 2 July 2014). How implementation is stretched is based on negotiations of cognitive commensuration between the standard makers and the standard users. For Active House, the leniency of this interpretation is improved by the lack of a certification system. Certification has advantages, including name recognition (Boxenbaum et al., 2013), but it also makes a standard more rigid. Instead of taking the route of certification, Active House promotes implementation in the form of demonstration buildings.

In order to be built, these houses must first comply with regulations, assuring the legal compliance of the standard in context; and then these demonstrations are further used as “lobby tools” (Interview B 8 September 2014). To give an idea of the actors involved in a building demonstration project, one interviewee briefly describes participation in LichtAktiv Haus:

And obviously this project, being an experiment, tried to work out all the [sic], tried to take everything to the limit, we had lots of engineers working with it not only as the coordinators in charge of the building fabric and the integration of all technical stuff, but also we had service engineers from Munich, we had structural engineers from Darmstadt and we had a lot of people from Denmark who also were accompanying the project with their computer simulations of how the building would perform, I don't remember all the names, but there were [sic] an engineering company from Aarhus and obviously the VELUX people [...], they were all involved and we had meetings in Copenhagen and

meetings in Hamburg and meetings in Copenhagen again for getting all this special knowledge incorporated in the project. (Interview 24 November 2014)

Thus, the demonstrations incorporate a large number of actors and large amount of information that serve as the basis of output legitimacy. Further, the extent of implementation (reflective of the “adoption rate”) is recursively related to the output legitimacy – the more acceptance from those using the buildings, the more extensive the standard’s diffusion. However, the diffusion process only reconnects to the technical sphere through evaluation.

Evaluation: Coming Full Circle

Evaluation is the assessment of value – it does not affect value, but “updates a value present in the good” (Vatin, 2013: 33). The research finds that in order for commensuration to be recursive in the standardization cycle, evaluation is needed so that the assessment feeds back into and potentially alters the commensuration process. In other words, evaluation is key to standard makers’ organizational learning and adaptation. It is through this link that the contextual sphere can shape the technical sphere. Demonstrations are becoming a more popular tool for formal evaluation, as well. As Lamont (2012) describes, “[Demonstrations] are employed for effectiveness and as evidence of competence and have come to define parameters of evaluation in a range of sites” (2113). It may seem obvious to use demonstrations for evaluation in addition to promotion, but this is not necessarily so and cannot be assumed.

Rather, the research finds that evaluation is a learning process itself – organizations learn *how* to evaluate: how to structure, interpret, and communicate evaluation. Early on, Active House did not have a formal evaluation process in place; but over time, it became apparent that it was needed. At first, they were unsure how to proceed: “The first time I had to figure out how to [conduct an evaluation] because they had the specifications and then I’m thinking okay how do we actually...What do they mean writing this, and they were not clear on all the topics [...] We had to do it in some way” (Interview 29 September, 2014) They undertook an effort to evaluate the demonstration projects, called “The Learnings Consultation”, based on surveys and interviews around the building field. They also incorporated the results of technical monitoring and the interviews with the inhabiting families (each of the test families lived in the house two

years during monitoring and also maintained a blog detailing their experiences with the house). That said, Active House is still very much in a learning process regarding evaluation (Interview 28 May 2014).

Several issues were identified from The Learnings Consultation. One was the need more calculation tools (such as the daylight tool VELUX has since developed), but also the need to keep calculation simple – if it becomes too complex, then it also becomes inaccessible. Another learning was that they should remove the auditory factor from measuring comfort, as it is too complicated and expensive to implement (for the time being). Active House also learned from a life-cycle assessment (LCA) evaluation: “They were not aware at the beginning that it’s much more eco-friendly and efficient to do a renovation, even in such a small house. And when we talk about upgrading this house it was really like there was a bottom slab and the walls” (Interview 25 November 2014). They adapted what kind of buildings to target, shifting from single-family homes to duplex and apartment buildings nested in urban neighborhoods. This has included a shift from newly built to renovation projects. The criteria now for RenovActive are meeting the Active House standard, affordability, and reproducibility (Interview A 8 September, 2014). However, they have also found that the specifications are not designed for renovations (Interview A 8 September, 2014); and now this means an adjustment of the technical commensuration or else a set of specifications aimed at renovations separately from new buildings.

Whereas Active House has previously focused on raising the ceiling in building practice, the aforementioned legitimacy outcomes have influenced its direction, and it aims now more towards excellent improvement of more widely relevant buildings (as reflected in the RenovActive project). It was the evaluation process that made this possible. The evaluations now feed back into the technical commensuration, affecting the specification tools, the aspects included in the definition of comfort, and work on specifications appropriate for renovation projects in addition to new buildings.

Summary Findings

- Technical commensuration involves an attempt to separate out qualities that are interlocked around an object. This separation involves attaching the standard makers' meaning before re-attaching it to the object of standardization.
- Technical commensuration affects input legitimacy in that it must adapt technical measurements to better reflect the input of the multiple actors informing and using the standard, a balancing act of technical rigor and professional interpretation.
- Cognitive commensuration is the process of giving meaning to and classifying the aspect of commensuration in context; and it affects output legitimacy by making sense of the standard in the time and place, priming it for trials; though it does not guarantee output legitimacy (the output still must function to some degree).
- Output legitimacy proceeds along gradients of acceptance. It is not something that is completed, but rather is recursive with implementation, increasing with a standard's diffusion.
- Evaluation cannot be assumed and is itself a learning process, and evaluation is needed in order to feed learning back into the technical sphere.

Discussion

The work of commensuration in standards affects legitimacy, and this legitimacy in turn informs the commensuration when bridged through the work of *evaluation*. Whereas some details of this paper are particular to the building field (such as standards that are composed of specifications and large physical infrastructure as outcomes), the insights on commensuration and legitimacy are generalizable. One can imagine that it is all the more relevant in fields with a stronger the relationship between numerical representation and legitimacy; but standards in general are enabled by the same value comparability as economic exchange (Vatin, 2013). Thus, we can see the significance of commensurative processes for legitimate standards in fields ranging from art dealing to financial markets (Lamont, 2012).

One implication of these findings is regarding the relation between values and quantification. Whereas standards, rules, and norms are perceived as tools for defining quantification (a singular value representation) (Styrhe, 2013), this research shows that the relationship goes both ways. Standards inform technical commensuration, but cognitive commensuration can also impact standards and even the revision of technical commensuration. The significance of evaluation in the cycle of commensuration and legitimation is paramount. The linkage back to technical commensuration describes, in part, the dynamics of how standards-making organizations can respond to “conflicts of interest and value” (Stryker, 2000: 182) and trade-offs among legitimizing entities (Durand & McGuire, 2005; Black et al., 2008) in the field. This also furthers the understanding of “social becoming” – how a totality of actions can feed into the repair or concealment of contradictions driving institutional continuation, furthering such standards while adapting them (Sztompka, 1991; Sminia, 2011).

Finally, the findings have implications for the meaning of that which is commensurated – comfort. Is comfort truly reducible to these measurements? What could it mean for us to assume that it is? At the very least, the research suggests that if comfort is not commensurated in a new way, that building standards and regulations will proceed regardless, applying instead the Fanger Model. As a former student of ecological economics, this reminds me an adage my professors emphasized: if you do not assign something value, then the value assigned to it is zero. It may sound overly simplistic and tragic; but rather, I would say it is important work to give value to comfort, a quality that has significant meaning for the well-being of society. The research also suggests that even though comfort’s commensuration subsequently alters its general understanding, comfort does not necessarily lose the richness of its qualitative meaning. Several interviewees responded that yes, they believe comfort can be represented quantitatively; and yet, many continued to describe comfort more holistically, underlining the significance of experiencing details that make comfort ephemeral and unique (i.e. Interview 28 May 2014; Interview A 8 September 2014; Interview 23 November 2014).

This may relate to the fundamentally personal (even emotional) nature of ascribing meaning to qualities and experiences. The German sociologist Georg Simmel notes “how extraordinarily difficult it is for three people to attain a really uniform mood—when visiting a museum, for instance, or looking at a landscape— and how much more easily such a mood emerges between two” (Zuckerman, 2010: 3). If this uniqueness is indeed maintained (which,

again, warrants further study), it has implications for the ubiquity of commensuration in society at large. The consequences of quantification might be overstated, as society may still allow for the incommensurability even of the commensurated. The quantities may be used to legitimate standards, the standards used to alter mindsets, but especially in the realm of sustainability, the totality is still a composition more elegant in its living complexities and holisms than can be calculated.

Conclusion

Standards are often connected to earlier standards, and commensuration is often born of prior processes of commensuration. Exploring the dynamics of commensuration within standards helps to open the black box of standards to better conceptualize their interrelatedness with meaning making. It underlines the significance of organization in shaping standards, and the impact of commensuration on legitimacy-seeking, in terms of both input and output legitimacies. Understanding standardization processes and how some standards diffuse, whereas others get stuck, has important implications for standards in a plethora of fields. It also highlights the significance of evaluation processes in the adaptability and evolution of standards. As an increasingly significant segment of global governance, international standards are pivotal in these fields' processes of innovation and shifting to sustainable practice. In the building field, governance through standards is fundamental to energy usage, health, and the very ways by which we envision and organize the spaces of our everyday lives.

In order to further these findings, it would be beneficial to investigate how these findings are reflected in commensuration processes in other fields, such as low-energy electronics or ecological food labeling. Of particular relevance to sustainability practice are fields in which multiple organizational types – both private and public – are involved in the shaping and diffusion of standards, as this complexity better reflects the dearth of issues arising from sustainability challenges. The potential relationship between value commensuration and institutionalization of standards, focusing on a quality that has been commensurated and then assigned a price value, warrants further research. On an organizational level, future research could additionally explore the nature of throughput legitimacy. Researchers could also investigate whether a similar standardization cycle ensues when dealing with qualities that have

not yet been commensurated or are considered incommensurable. If designed to be facilitate evaluation and learning in their own processes, standards can be part of adapting practice to complex situations. And if done legitimately, they can be part of stabilizing the consolidation of shared values across society.

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At home with sustainability: From green default rules to sustainable consumption

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ABSTRACT

Although it is often assumed that default rules affect change without awareness, this paper suggests that conscious decisions are needed to establish long-term changes in consumer behaviour. *Green default rules* offer interesting prospects for sidestepping the drawbacks of direct marketing to individuals. Under green default rules, behaviour is guided by a default, such as utilities automatically sending customers renewables-sourced instead of fossil fuel-based energy. To act otherwise requires additional effort and is less likely. In this paper, I investigate how organizational processes lead from green default rules to standards that facilitate sustainable consumption. This paper examines the Active House sustainable building demonstrations in order to understand how (1) communications and market creation and (2) user-centered experimentation, are organized to move from defaults to sustainable consumption. Despite the rooting of default rules in subconscious decision-making, this research finds that ultimately awareness drives the demand necessary for the creation of sustainable consumption.

Keywords: green default rules; sustainable consumption; sustainable building; standardization

Setting an example is not the main means of influencing others, it is the only means.

Albert Einstein

Introduction

Historically, natural resources (air, water, energy) flowed virtually unrestricted in and out of the home space; but modern environmentalism is now changing the attention paid to the environmental impact of residential housing (Michael and Gaver 2009). Yet as institutional change around climate change is slow, policy-makers are putting increasing pressure on behavioural change, including in the home (Shove 2003). However awareness and marketing campaigns targeting individuals' sustainable consumption have proven to be largely ineffectual (Dolan et al. 2011), largely because there is a gap ("green gap") between what consumers express as their intention of behaving and how they behave (Barbarossa and Pastore 2015). Rather, research suggests that long-term sustainability behaviour is driven by a collective conservation context (Fields et al. 2012; Nair and Little 2016). But how is that collective sustainable consumerism created in the first place? This is important for us to understand, as sustainability transitions and natural resource conservation rely on the proliferation of such a conservation culture. If individual consumers cannot be directly motivated, what processes underlie wider conservation cultures? In building, the choices in design can affect individual consumption, resulting in homes that are designed in such a way as living a more sustainable life becomes automatic -- conveniently swerving around questions of individual values and motivation. The prospect is attractive, and as such, *green default rules*, rules that determine sustainability-oriented default behaviour (Sunstein and Reisch 2013) are increasingly designed into homes. Yet, there is something between these experiences and the creation of a wider community supporting conservation. I argue that there is an organizational standardization process between the inception of default rules and large-scale behavioural change towards sustainability. This paper explores how such rules are standardized and, ultimately, used to create the culture of conservation that furthers sustainable consumption.

As the study of *choice architecture*, 'organizing the context in which people make decisions' (Thaler and Sunstein 2008, 3), is blossoming, we know from Thaler and Sunstein's seminal book - *Nudge: Improving Decisions About Health, Wealth, and Happiness* - that nudging is about designing choice architecture in such a way as to encourage small behavioural changes (Thaler and Sunstein 2008). Default rules are a form of nudging, the design of which particular choice is automatic; or green default rules, designing the default choice to be environmentally- or sustainability-oriented (Sunstein and Reisch 2013). To act otherwise, consumers would have to consciously choose to *not* act in this fashion -- a much less likely scenario (Sunstein and Reisch 2013; Johnson and Goldstein 2013). For example, Brown et al. (2013) studied how reducing the default thermostat setting in office buildings by 1 °C affected workers' willingness to work in slightly cooler temperatures. They found that, given some of the workers' thermostat interventions, the thermostat would not stay at this reduction; but it would still be set lower than previously by an average of 0.38 °C. Examples of how these defaults can affect your home consumption include: it does not occur to you to turn on the kitchen lights before dark because the design allows for natural daylight in this space; or the taps just run on a low water pressure and low temperature setting without your consideration of the resources being saved. Similar outcomes have been studied in areas such as environmentally-friendly household electricity supply (Pichert and Katsikopoulos 2008; Kaenzig, Heinzle, and Wüstenhagen, 2013), healthy food (Cioffi et al. 2015), and proper waste disposal (Wu, DiGiacomo, and Kingstone 2013), among others. Green default rules are promoted as valuable because of their higher effectiveness compared to awareness campaigns. On the other hand, Fields et al. (2012) indicate that one of the most influential aspects of a household's resource use is the family's shared conservation values. Their research points towards support for policies that facilitate long-term change in attitudes.

This paper shows that there is a process leading from experimentation with an industry's sustainability products or services -- such as occurs with the implementation of green default rules -- to industry standards that promote sustainable consumption. The research also finds that a key aspect of this process is the building inhabitants' consciousness of the value of the green defaults, indicating a more nuanced process in moving from lack of awareness to decisive choice than established in the default rules literature thus far. It shows how Active House, a strategic alliance, organizes the standardization of green default rules in sustainable building using building experiments. The term *standardization*, as used here, refers to the process of

using models and/or scripts to establish an infrastructure of voluntary rules. Active House has developed (and continues to develop) a sustainable building standard and has experimented with its application since its conceptual beginning in 2009¹⁷ across 26 building demonstration projects. Examples of how default rules in the building standard can affect home consumption include: it does not occur to the inhabitants to turn on the kitchen lights before dark because the design allows for natural daylight in this space; or the taps just run on a low water pressure and low temperature setting without the inhabitants' consideration of the resources being saved. Experimentation with green default rules affects redrafting of the standard, and ultimately with market demand for the standard, the kinds of sustainable buildings and inhabitant behaviour it yields. Based on qualitative methodology with Active House as the case study, this paper proposes a preliminary model of this process. As organizations are deeply involved in the experimental governance surrounding international sustainability efforts, particularly through voluntary measures like standards (Hoffman, 2011), they are invested in advancing the effectiveness of green default rules. The more organizations grasp these rules' breadth and impacts, the more important it becomes to understand how these rules can stimulate larger-scale change in consumption.

The paper proceeds through the following sections: the theoretical concepts used in the study; the method of study; background of the case; an analysis of the case; and discussion of the implications for behavioral campaigns and the development of green default rules.

Default rules and standardization

By guiding behaviour through setting the starting choice, default rules work through status quo bias (Kaenzig, Heinzle, and Wüstenhagen 2013; Samuelson and Zeckhauser 1988). This means that individuals are most likely to choose to do nothing when faced with new options (Samuelson and Zeckhauser 1988; Kahneman, Knetsch, and Thaler 1991). One difference between the foci of status quo bias and default rules is the role of awareness. Whereas research on the status quo bias shows an individual will consciously select to stick with what has been previously chosen, default rules research explores the impact of an outside entity choosing

¹⁷ The Active House is rooted in VELUX's Model Home 2020 programme, spurred by Conference of the Parties (COP) 15 held in Copenhagen, Denmark in 2009. Upon identifying collaboration opportunities with like-minded organizations, VELUX co-founded the Active House Alliance.

the status quo without the individual's awareness. Default rules thus come in contrast to direct attempts to influence behaviour through, for example, marketing and incentives -- attempts subject to the green gap. They arise from research demonstrating that awareness is ineffective at encouraging change. For example: 'Numerous studies however demonstrate that providing information does not necessarily lead to changes in behaviour [...] More than four out of five Nordic citizens are concerned about the environment, yet only about 10–15% state they buy green products on regular basis, while the actual market for green products remains at only 3,6% in Sweden (Ekoweb 2013)' (Mont, Lehner, and Heiskanen 2014, 14). Rather green default rules are a way of setting a default that *influences* behaviour by taking advantage of the status quo bias: an individual engages enters a new situation or infrastructure, the default aims at sustainability, and this default becomes (or at least nudges) the reference point for the individual. Ideally, it becomes their status quo.

The literature is in agreement that this initial effect of default rules falls in the realm of un- or subconsciousness. Some of the earliest references to this unawareness come from the legal field, in relation to contract law. Barnett (1992) refers to default rules as being based on *tacit assumptions* which unfold without occurring to a person, and which remain unexpressed. He further points to Heald and Heald (1991), who describe how defaults affect behaviour: "The process occurs in a mindless, nonconscious manner, and once invoked, the script provides a map for subsequent behavior" (p. 1151). More recent works from policy and sociology research uphold the role of unawareness in default rules' influence on behaviour. Van Benthem et al. (2010) argue that defaults work through a gradual revision of beliefs, with no role for knowledge or awareness, and Dhingra et al. (2012), when exploring the dynamics of default pull (similar to status quo bias) remark: "Additionally, we have shown evidence that the default pull happens outside of the decision maker's awareness; almost all of our subjects denied that they were affected by the presence of a default despite statistical evidence to the contrary, and a sizeable portion of our subjects reported not even noticing the presence of defaults" (p. 75). Smith et al. (2013), in their appropriately named article "Choice without Awareness" place default rules in a category of tools that work under the auspice of unawareness, including measurement, framing, and placebo effects.

I argue that standards work to make visible and script these invisible default rules, enabling diffusion for the establishment of widespread behavioural change. If a set of actors

standardize their intentions in the form of green default rules and integrate them into a standard (such as building specifications), the standard will do the influential work from thereon out (Rip and Groen 2001). This is to distinguish between standardization, as defined above, and *standards*. Standards are a form of rules similar to laws, likewise written or documented in some way, but they are distinguished by their voluntary nature (Brunsson and Jacobsson 2000), moving them from the realm of authority to the realm of legitimacy (Kerwer 2005). Despite their voluntary nature, they are in fact significant governance mechanisms (Brunsson, Rasche, and Seidl 2012; Thévenot 2009; Brunsson and Jacobsson 2000). As Brunsson et al. (2012, 620) describe, standards 'are a powerful tool for challenging and altering institutionalized behaviour and identities.' From this view, standardization and standards are pivotal in networks that work to institutionalize behavioural change (Higgins and Hallström 2007), especially since addressing norms and habits is considered fundamental to choice architecture (Mont, Lehner, and Heiskanen 2014; Thaler and Sunstein 2008; Sunstein and Reisch 2013). To be clear about the terms as used herein, default rules are voluntary, undocumented rules that set the status quo, standardizing is the process of establishing an infrastructure for such rules, and standards are documented (materialized) voluntary rules (Table 1). These exist along a continuum of awareness, with default rules influencing without consciousness; standardization processes starting to experiment with awareness levels; and standards being open and communicated. In other words, this paper takes the stance that default rules become embedded in standards through a process of increased awareness, usually by experiencing a contrast to the default (i.e. moving from a house with natural daylight to a dark house).

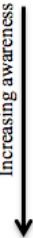
	Rule Category	Form	Mode of Influence	Examples
Increasing awareness 	Default rules	Status quo setting, starting point when individuals make no changes. Not necessarily written, but in example of energy, this is a documented choice by utility companies.	Status quo bias, psychological barrier to making changes.	Thermostat temperature setting, type of utilities energy used by a household (renewables vs. fossil fuels).
	Standardization	Activity of using models, scripts, language to make a shared infrastructure for a process or outcome.	Experimentation and consensus among stakeholders about how interests are incorporated into infrastructure.	Development of the FTSE4Good responsible investment index (Slager, Gond, & Moon, 2012), the formation of technological platforms such as Java (Garud, Jain, & Kumaraswamy, 2002).
	Standards	Written or otherwise documented voluntary rules that can be communicated.	Legitimacy, rational myths, and power of communicative technologies.	Fair Trade certification, International Standards Organization (ISO) standards, LEED green building standard.

Table 1: Rule forms and mechanisms (source: own).

The study of standardization of green default rules in the built environment touches upon many overlapping dimensions rife with tension: the mixed interests of different standards-makers, the architectural versus engineering design of buildings, desired behaviour in the home against the free will of individuals. In their article 'Assembling Asturias,' Slater and Ariztia paint a nuanced picture of how culture centers are *cultural boxes* that interconnect and act as scaling devices in order to transport and stabilize a network of culture across time and space (Slater and Ariztia 2010). One can similarly see demonstration homes as experimental boxes, an embodiment of default rules on trial for standardization, while serving as a physical space for working out the tensions in the creation of a culture of conservation. This perspective is especially useful given that much of the research on choice architecture details influencing consumers, while emphasizing that success relies on information *about* the consumer (Mont, Lehner, and Heiskanen 2014). In other words, building experiments work simultaneously to influence the consumer while learning about consumer behaviour. This is important to note because a culture of conservation cannot be made without being based on people -- the standardization must be user-centered. This is because of the market-driven, demand nature of both the cultures of consumerism and conservation, two sides of the same coin.

The building field is an interesting arena in which to study how defaults relate to larger scale sustainable consumption. As Thaler and Sunstein describe: 'A crucial parallel [with traditional architecture] is that there is no such thing as a 'neutral' design. [...] As good architects know, seemingly arbitrary decisions, such as where to locate the bathrooms, will have subtle influences on how the people who use the building interact' (2008, 3). In other words, there exist critical interdependencies between infrastructures -- be they physical or virtual -- and behaviour. Standardization is a form of infrastructure-building, and indeed, standardization of interest-driven design into material objects is fundamental to choice architecture. Instead of directly standardizing behaviour, a choice architect standardizes the design of the infrastructure within which daily life is carried out. In the case of default green rules, the idea is to design the infrastructure in such a way as instead of expecting consumers to choose to sustainable behaviour, it is the default action, making other selections more challenging (Sunstein and Reisch 2013). Thus, default rules are similar to standards in that they are voluntary and make nonadherence difficult (Kerwer 2005), yet they differ by their invisibility, the lack of awareness surrounding them. How these building experiments are set up, who the standards-makers are, and so on, are discussed in the following case description.

VELUX and Active House Defaults

The issue of resource consumption in buildings - or otherwise put, the need for a culture of conservation in the built environment - is a pressing sustainability challenge for both European governments and industry. Energy consumption is a major factor, with households accounting for 27% of Europe's total energy consumption (Building Performance Institute Europe 2011). And around 9% of all European freshwater goes to the operational use of buildings, with 72% of that being consumed in residential buildings for purposes such as showers, toilet water, and laundry (Ecorys 2014). On the Europe-wide regulatory side, resource consumption in buildings has driven such EU directives as the 2010 Directive on Energy Performance of Buildings (EPBD) [Directive 2010/31/EU] and the 2012 Energy Efficiency Directive [Directive 2012/27/EU]; yet industry initiatives are essential for compliance with these directives within member states. Alliances, certification schemes, and whole neighborhood-scale projects have been emerging in an effort to reimagine building practice. And yet, building modeling and simulation fail to anticipate actual building performance, which is subject to consumer behaviour (Gilani, O'Brien, Gunay, & Carrizo 2016). As both public and private sectors appeal to consumers to change their consumption patterns, citing ethical imperatives and the benefits of lower costs, the focus on the technically perfect, resource-efficient building overshadows the human.

In 2009, on the heels of the UN Congress of the Parties (COP) 15 climate summit in Copenhagen, VELUX, a rooftop windows manufacturer, launched Model Home 2020. The idea was straightforward: use existing knowledge and technologies to demonstrate that we are able to build human-centered sustainable homes with natural light and fresh air to the standard anticipated for 2020. It swiftly became apparent that their efforts would leave them on their own -- and as there were many others (for example Rockwool and Danish Technical University) interested in human-centered sustainable building, VELUX became the principal founder of the Active House Alliance, a strategic alliance aiming to bring the principles of health and comfort into stipulations for sustainable building. Their three design foci, represented by three concentric circles, are environment, energy, and comfort, thus establishing the Model Home 2020 projects as the first demonstrations of the Active House principles. These foci are portrayed for

simplicity's sake, in order to say that in addition to the energy and environmental aspects that many certification schemes address, comfort must also be addressed. The standard is composed of building specifications, primarily technical (i.e. thermal environment or energy demand ranges) but also qualitative (i.e. design solutions or appliance selection), and is supported by pointed access to tools for composing calculation vs. performance radars, visualizing daylight layout, and calculating life-cycle assessments (LCAs). On the one hand, incorporating design for comfort into building specifications fashions a more desirable vision for sustainable building, but it also poses a challenge: could human-centered standards influence consumer behaviour in the home?

In order to explore this question (among others), VELUX and Active House have showcased 21 demonstration projects, mostly in Europe and with more under development. These have mainly been residences, but also public buildings such as schools. The Active House Alliance is herein considered the standards-maker, with 37 membership organizations and a secretariat -- though it is worth noting that VELUX plays a leadership role in the alliance and is often the primary organizer of the demonstration projects. The three experiments studied here are Sunlight House in Vienna, Austria, LichtAktiv Haus in Hamburg, Germany, and RenovActive in Brussels, Belgium. Many of the demonstration projects, including the three focused upon herein, undergo thorough monitoring and evaluation. Post-construction, they are monitored without inhabitants and acted as design experimentation (to compare with the virtual model) and open houses. Then, a test family is selected to live in the house for a one-year period, rent free, in exchange for participation in what the industry calls *post-occupancy monitoring*¹⁸, including sensor systems, resource use, and sociological (in the form of interviews and blog-writing) monitoring. These families are selected based on a competition and evaluation of the most typical family (usually not particularly green-oriented) -- with the exception of RenovActive, which follows the queuing procedures of the social housing company. Thereafter, the family has priority option for buying the home, or it is put on the market. All of the technical and sociological data are assembled, analyzed, and put together in an evaluation report. These evaluations are then shared with the Active House Alliance, and ultimately shape future project designs and priorities, i.e. the demonstrations are both showcases and experiments, the outcomes of which feed into future experimentation.

¹⁸ Many organizations in the building field seek to move beyond terms like 'occupant' to more humane terms like 'inhabitant' or 'dweller'.

In this case, the demonstrations serve as the foundational fabric of choice architecture, facilitating standardized “green” decision-making at home and the design of defaults across multiple homes. One example of a default rule is: *You will not turn on lights until natural daylight is unavailable*. Using architectural expertise and design tools with a focus on natural daylight as a parameter, the demonstrations are constructed to optimize natural daylight levels, say by using light tunnels and windows and orienting daytime activity rooms to be the most light rich. The rule sets the status quo as carrying out activities -- reading, cooking, playing with children -- in a natural light environment, which in contrast to low-lit or artificially-lit environments is both healthier and saves electricity. Another example is: *Your space will be cooled with natural ventilation when too warm or stuffy for comfort*. Utilizing temperature and carbon dioxide sensors, the building’s combined natural and mechanical ventilation system will open windows automatically to cool a room when it is becoming too warm or the carbon dioxide levels are too high (the latter being a danger we cannot usually sense ourselves). This rule sets the status quo as ventilating space with fresh air, which again, in contrast to electrical ventilation systems is both healthier and saves electricity. These are just a few of the default rules designed into the demonstrations, none of which are explicit, and all of which leave open possibilities for acting otherwise (i.e. turning on the lights during the day, or shutting the windows manually). This leads into the presentation of how default green rules are standardized for scaling, but first the following section briefly describes the method of study.

Methodology

As the concepts and processes studied herein are inherently social (i.e. design, monitoring, communication), this research takes a qualitative approach. I use the case study method in order to assemble a rich description of surrounding phenomena and to - in the spirit of studying processes - “retain the holistic and meaningful characteristics of real-life events” (Yin 2009, 4). In referring to the *case*, I’m thus referring to the collective outcome of the research on Active House standardization with a focus on VELUX as the principal founder, whereas the objects of study are the three demonstration projects individually. The projects studied herein are residential buildings in three different countries. They were selected in order to represent the diversity of new build, part-new/part-renovation, and renovation projects, as well as differences

in the conceptualization of home across regions. At the same time, they are all single-family homes at the cutting edge of sustainability design in the residential building sector. Sunlight House, located in Pressbaum, Austria (on the outskirts of Vienna), is Austria's first zero-energy house, and is in fact often operating as a plus-energy house, one which feeds electricity back into the grid system. LichtActivHaus is a part-new build and part-renovation project that is part of the International Building Exhibition (IBA)¹⁹ in Hamburg, Germany. And RenovActive is a budget renovation project underway in cooperation with a social housing company in Anderlecht, Brussels, Belgium. The first two were both part of VELUX's Model2020 project, whereas the latter is the newest development under the Active House Alliance. All three of these countries are in the process of reshaping their building standards (and regulations); and all three projects have received attention from policy-makers. Thus, these cases represent a trend towards collaboration (moving under the umbrella of an alliance), renovation (it is anticipated Europe of 2050 is mostly built already, but requires renovation) and accessibility (economically affordable for an average family) in countries actively seeking to address sustainability issues in building by codifying standards into law.

The most informative data in regards to studying default rules were the VELUX and Active House communication materials. These were particularly important for identifying the emergence of an interest in consumer behaviour within the home. Most of the materials are VELUX-sourced, as they are a primary co-founder of Active House and my research partner, but the materials also reflect the activity of the alliance, cooperation among diverse stakeholders in order to shift building practice. An example would be the overall Model Home 2020 evaluation, which was conducted by Grontmij and largely influenced the second generation of the Active House specifications. The documents utilized herein include the Active House specifications, guidelines, brochures, reports, and public presentations. Major early reports on the demonstration projects included: the aforementioned overall alliance cooperation and technical building performance evaluation of the Model Home 2020 projects; a comparison of energy performance across the projects; a study of automation and control of indoor climate systems; and a report on the socio-psychological monitoring results -- though this last focuses on the parameters and characterization of well-being in the home, rather than consumer behaviour. However, in an Active House Workshop presentation in Budapest, Hungary in

¹⁹ <http://www.iba-hamburg.de/en/iba-in-english.html>

November 2014, the director of VELUX's Sustainable Living in Buildings program pointed towards a growing interest in how the demonstration projects have affected the test families' consumption patterns and attitudes towards sustainability. Exploration into this emerging topic was furthered in the interviews.

I conducted visits to each of the demonstration project cities, and through cooperation with the VELUX headquarters in Denmark, I was introduced to each of the local VELUX offices and given an overview of the projects before delving into interviews. As the Active House Alliance is well-networked throughout these places, VELUX was able to give me initial contacts to invite for interviews, as well as invite me to relevant sustainable building events in the area. From this point, I used the *snowball sampling* technique (Atkinson and Flint 2004), asking interviewees for further contacts or persons who might be interesting based on what we had discussed. This technique was especially useful in terms of following emerging conversations within the field and gaining perspective on the demonstrations from experts not necessarily employed by VELUX or only indirectly involved in their design and construction. The interview guide I employed for all interviews included general introductions, as well as more targeted questions such as *What do you think the purpose of the demonstrations is?* or *What are the most important qualities in a building to you?*; though exploration beyond the guide was often most informative. The logic was to investigate the interviewees' relationships with building, sustainability, design, and standardization. In most cases, these open questions triggered particular interest areas in the interviewees (e.g. local materials in building, international project management), which we then explored in relation to the demonstration projects. In total, I conducted 30 semi-structured interviews with a variety of actors, including architects, engineers, home-owners, and policy-makers.

I visited the homes, and in the case of the Sunlight House the homeowner also gave me a tour of inside the home. I was also given a tour inside the uninhabitable, pre-renovation state of the RenovActive building, and I have taken a self-tour during its post-construction (completed June 2016), but pre-occupation monitoring phase. The site visits enabled me to witness the manifestation of the building design and observe how people relate to and behave in the buildings. The events I attended were: the Active House Guidelines Workshop in Brussels, the Passive House 2014 Exhibition in Brussels (including a tour of the new Brussels Regional Environmental Offices, Passive House certified), the 2014 Northern Germany Passive House

Conference in Neumünster, the 2015 Bauz! Vienna Congress for Sustainable Building, and the 2015 VELUX Daylight Symposium in London. These events enabled me to: position the interviews amidst the larger European building field; understand the advancement of building design; get a sense of the significance of the demonstration projects and their locations; and witness how building demonstrations are used to communicate and influence. These reflections were kept in mind while reviewing VELUX and Active House communications material, both internal and externally aimed at different sales, marketing, and policy-making audiences. The data is thus composed of communication materials, semi-structured interviews, and notes and transcribed recordings from industry events and visits, allowing for triangulation (Yin 2009).

First Coding Cycle			Second Coding Cycle		
Theme	References	Sources	Theme	References	Sources
Technology	175	21	Proliferation	6	3
Cities	55	19	<i>Subthemes: general, sensing, beyond sensing</i>		
Cost	142	24	Interaction	18	8
Daylight	46	13	<i>Subthemes: altogether, automation, adaptation & time, interference, overkill</i>		
Demonstration	78	21	User focus	11	7
Institution	192	24	<i>Subthemes: control as positive, control as negative, change over time, beyond control</i>		
Legitimacy	46	12	Social monitoring	2	2
Measurement	121	23	<i>Subthemes: none</i>		
Scale	50	17	Monitoring & standards	12	7
System	94	20	<i>Subthemes: monitoring for standards, nudging, what standards do for people</i>		

Table 2: Data themes and coding process (source: own).

The interview data and notes from the events and site visits were then loaded into data analysis software (NVivo) in order to better organize and track surfacing patterns (Table 2). The first cycle of interview data coding was an open coding process, identifying and grouping segments of text (from half a sentence to one paragraph in length) into coding themes -- mainly identified and noted during the initial review and transcribing of the data. I consider this stage pivotal in the overall coding process, a dimension of analysis that helps deepen reflections (Miles, Huberman, and Saldana 2013). “Technology” was a main theme in this cycle, including references to both technological design and monitoring. After recognizing the technology theme, I revisited the pertinent references, and upon revision, found a number of other inter-related themes, highlighted by topics brought up in both my research stay and events data. The second cycle consisted of condensing these segments and organizing them based on persistent patterns; and these segments of data were further organized into sub-themes. Two of these patterns -- concerning user focus and monitoring & standards -- became the foundation of this paper. It must be noted that default rules was not originally a focus, but blossomed as the standard’s

evaluative emphasis on consumer behaviour took root, especially relating to the data on *change over time* and *nudging*. In order to understand how the demonstrations were being used in this regard, the communication materials and field notes proved to be the most useful for making sense of the green default rules in the building sector and the standardization process. As such, the analysis utilizes these, with support from interview data. Borne out of these materials, an analysis of how green default rules move through standardization to kindle a conservation culture is presented in the next section.

Standardization: Awakening the defaults

The analysis herein attempts to answer the question of how sustainable consumption can be created from green default rules by elucidating the organizational processes of bringing awareness to the value of sustainable consumption. It shows how experimental green default rules are standardized towards multitudinous audiences (including policy-makers, practitioners, researchers, and consumers) to establish a market for sustainable consumption, along an increasing awareness gradient, as outlined in Figure 1. The circle represents an opaque construct, whereas the squares represent observables. It is fundamental that green default rules are *not explicit*, but that they are embedded in specifications for building design. Further, the connection between green default rules and sustainable consumption is uncertain. These processes do not necessarily directly link the rules and sustainable consumption, but rather organize towards this connection. Thus this analysis is exploratory -- the subsurface nature of green default rules, and the emergent, surprising nature of experimentation converge in an industry open to innovation, and embracing new interests and strategies as they arise.

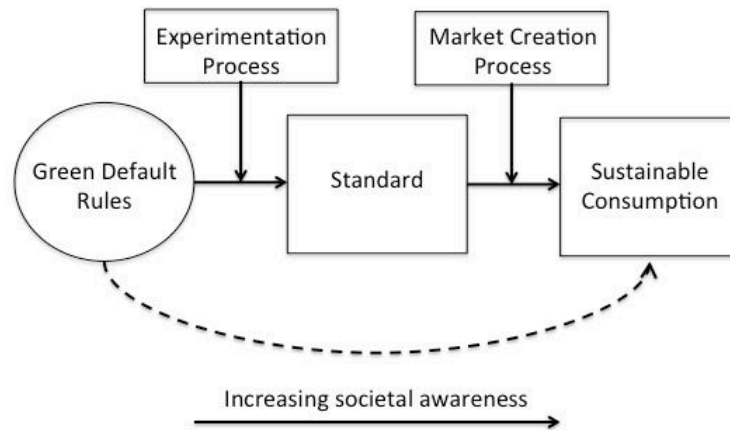


Figure 1: From green default rules to sustainable consumption through standards (source: own).

First, I highlight aspects of three forms -- representing just a few of many -- of standardizing the Active House default rules and the experimental demonstrations: the Sustainable Living in Buildings platform, the Circadian House Report, and the Active House Guidelines. Each, in some way, adapts the green default rules built into the demonstrations and standardizes them for a different audience, driving one side of market creation in industry and policy. As on the one hand, there are markets spurred by industrial norms, and on the other there are markets inspired by social movements, I then give a brief glimpse of how the standardization of green default rules furthers awareness that drives society towards sustainable consumption through both legislators and consumers.

Sustainable Living in Buildings Communicative Platform

The Sustainable Living in Buildings (SLiB) Communicative Platform is VELUX's main platform for communicating the company's sustainability activities, interests, and materials. It embodies the company's "onion model" which embeds from the outer layer inwards: the global level through the UN Global Compact²⁰, society level through Active House, business level through VELUX products, and household level through Healthy Homes²¹. The purpose is to centralize information and serve as a resource to any VELUX employee when communicating sustainability to stakeholders, including specifiers, end-users, and policy makers. An example of how it use used to lobby is the involvement of key Brussels policy makers in VELUX's Healthy

²⁰ <https://www.unglobalcompact.org/>

²¹ http://www.velux.dk/~media/marketing/master/documents/pdf/brochures/velux_hhb_18032015.pdf

Buildings Day, the annual one-day conference centered around SLiB. The second tier placement of Active House implicates the demonstration projects as the key lever for influencing sustainability on a societal level and interacting with other key stakeholders. When summarizing activities on the societal level, the platform states:

Among other things:

- We are discovering new solutions through full-scale building experiments and research, establishing in-depth knowledge and applicable solutions.
- We are engaging in dialogue with politicians and stake-holders in the building industry, initiating experiments and sharing knowledge.
- We are influencing the agenda of sustainable buildings via cooperation and argumentation.” (VELUX 2014)

Packaging these activities together reveals how the design aspects of the demonstration projects, including green default rules, are standardized in the building field: a combination of experimentation, dialogue, joint projects, knowledge-sharing, and lobbying.

Likewise, it is through these activities that the green default rules can be conveyed into other projects. The platform encourages using the projects as a main argumentation and design modeling tool, and presents photos, quotes from residents, and measurement data in one place: “One of the most effective ways of communicating SLiB is through cases from real life proving the advantages of the Active House principles in action. During the last decade, the VELUX Group has participated in a large number of projects that we now make available as easy-to-use case stories as part of the communication platform. [...] The case stories collect the information, facts and photos that you need to tell the story of the buildings in brochures, newsletters, websites, presentations, trade shows, PR activities, etc.” (VELUX 2014). Thus, the SLiB platform is the best compiled, succinct resource for standardizing the default rules in Active House across multiple audiences. It makes the outcomes of experimentation with the standard visible, inviting consciousness on the part of the building inhabitants, advancing the process from default rules development to experimentation to standardization to a presentation form that primes market creation, as presented in Figure 1. The platform represents a progression through the phases depicted in the model and involves adapting internal learnings from within VELUX and the test families’ lives to graspable data and stories for a wider market. It is these packaged solutions and open engagements that, in part, encourage a consciousness of the contrast between

the sustainable and non-sustainable default experiences and a conscientiousness about demand. In the next example, on the other hand, a particular feature (circadian-related design) is made explicit.

Circadian House principles and guidelines

The Circadian House principles and guidelines report, released in November 2013, was developed with the aim of standardizing how health (as related to circadian rhythms) is considered in building design. The report was compiled through workshops, with the support of multiple stakeholders external to VELUX: “The workshops were carried out by scientists and consultants specialized in healthy buildings, indoor environment, architecture and planning from November 2012 to August 2013” (VELUX 2013, 2). As the report points out, there is not currently an official definition of healthy housing; but the report can be used “to guide and improve the design of residential buildings of all types, including apartment buildings, and are applicable to both new and existing dwellings” (VELUX 2013, 2). This, in part, relates to the previous example of green default rules light -- as much in relation to natural daylight during activity as to darkness during rest. It structures the standardization of default rules in the form of key performance indicators (KPIs) that can be benchmarked, including: building site and orientation; contact to nature; view to the outside; healthy light; healthy indoor air; elimination of emissions from building materials and consumer products; healthy thermal environment; good acoustics; and building controls.

The report first refers to the definition of circadian rhythms as found in ISO 16817: 2012, the International Organization for Standardization’s standard covering building environment design, indoor environment, and design process for visual environment, indicating the standardization direction of the report. It then hints at the role of default rules in building design: “Being physically active is a big part of a healthy lifestyle and this is where the home should promote the occupants to be active, without putting additional stress on their lives. A nice, inviting staircase and an easily accessible garden are examples” (VELUX 2013, 5). Note the emphasis on not disturbing the awareness of the occupants. Through these examples and the KPIs, the report presents what reads like ingredients in a design recipe for working default rules into circadian design, where the green default rules are the design input, and the KPIs measure their effectiveness against other design formulations.

Finally, it draws on the Active House homes, referring to benchmarks established through demonstrations and pointing to the Active House specifications for further reading. The evaluations of these homes serves as an example of how one can verify whether or not the green default rules designed into the building are effective. In relation to the model in Figure 1, it relates to the process phase between green default rules and the standard, wherein experimentation with various rules have enabled the development of specific design KPIs for circadian health. The combination of the circadian KPIs and the Active House specifications provides a guidance package that (on the market creation side) can be requested by consumers seeking a more sustainable, healthy lifestyle. As one interviewee describes the development of livability for consumer awareness and demand creation: “So if you go and buy a house, you can put, for instance, the indoor comfort on a formula and say that it all amounts up to 7.7 in this house because it has sufficient daylight, it’s good conditions for changing the air, you will not feel too warm or too cold when you don’t have to. And that means that you will have a livability – the right volumes, the right flow, configuration of rooms – you’ll have a livability of 7.7” (Interview 2 July 2014). Guiding in this fashion with a mix of argumentation and quantification appears to be a significant aspect of the standardization process, as seen in the next example, as well.

Active House Guidelines

Over the course of the projects, it became apparent to the their stakeholders that the Active House specifications, due to their technical nature, face limitations in communicating the Active House principles beyond architects and engineers. In this way, we can imagine that the default green rule is made not just of specifics, but also of principles. As described on their webpage, the vision for these principles is the foundation, and the specifications are the vision’s manifestation (Active House 2016). The alliance decided to explicate the relationship between the principles and the specifications in the Active House Guidelines, and conducted several workshops in order to refine the professional input. This has been an important tool for transitioning the default rules from concept to market, as the principles can be conveyed to Professional House Builders (PHBs) (Interview 4 June 2014), and salespeople and installers are geared to pose further questions to customers: “We have brought them together, trained them to understand a little bit about climate renovation, and we have trained them to cross-sell. So, if

you were a carpenter normally installing roof windows, you will also go into the basement and say, well, you probably could get a new circulation pump than this one, or, have you considered changing your oil furnace heat installation, or whatever it is” (Interview 15 June 2015). Simultaneously, the guidelines themselves emphasize the importance of using the outcomes from the experiments: “The ambition and the performance of an Active House is based on calculation, including pre-defined values and expectations of user behaviour. In order to secure that the final project meets the expected levels and ambitions, it is strongly recommended to include monitoring of the project” (Active House 2015, 5). This data is used not only to standardize the green default rules, but also enables evaluation that can describe their impacts.

During the final Active House Guidelines workshop on June 23, 2014, a Belgian ventilation systems expert highlights the significance of technical systems for ensuring the green default rules: “Demand-control ventilation is applicable for all types of ventilation and really aims at monitoring air quality in the house and managing it. If there’s a CO₂ increase in the bedroom, it will monitor that and react correspondingly. [...] That kind of evolution is crucial because we say in the specifications we need demand for CO₂ levels, and the best way to do that is with demand-control systems. [...] Because once you start monitoring air quality, you can very easily monitor temperature and all the rest and link it to building management.” In other words, this monitoring and automation in buildings allows for adjustments to the default rules without disturbing the inhabitants. Thus, the technological advancement in demonstration projects drives the advancement of green default rules as well, furthering their effectiveness. Also during this workshop, a Danish daylight expert points out that “if the user is not comfortable, he will take action to achieve this comfort, which will have impact on the energy performance or his well-being if he cannot improve it. So there’s a strong relation between the two.” Designing for comfort is fundamental to the implementation of green default rules in building design, as discomfort can drive inhabitants to act against the default. The next segment examines what actually happens amidst the process towards sustainable consumption.

Awakening sustainable consumption

There is a great deal of organizational work, including the outputs described above, that goes into linking the defaults rules to a greater social movement, from both top-down and bottom-up. In my early meetings with VELUX, they expressed to me that the term *standard*

represents something else to them than what I was describing (and what is defined herein) from an academic perspective, but we could understand one another in regards to the Active House building specifications. Now, given the multitude forms of Active House demonstration learnings I have come across in researching with them, I can appreciate the misnomer. The specifications themselves may be the standard at face value, but the whole is less cut and dried. The process of *standardizing* involves the development of the unseen green default rules, as design rules, into various communication materials to different stakeholders, i.e. whereas the specifications are accessible to architects and engineers, many other actors must be reached. Expressed in the presented model, the standard is developed along a pathway, augmented by experimentation and market adaptation. As Michael K. Rasmussen, Chief Marketing Officer of VELUX, emphasized in an in-house presentation on March 10, 2016, “You cannot just say something to politicians, media, and industry. You need to have consistency because they all speak with each other.” As these rules slide towards awareness, they need to be consistent to building professionals, policy-makers, and consumers. In other words, supply and demand must be aligned.

The first point on awakening default rules is that standards anticipate building legislation that reshapes society.²² Demonstrations work as experiments that “prove” the practicality of regulating to a higher level by matching technology and coding with the most advanced insights into social responsiveness. In the Northern Germany Passive House Conference in 2014, Hans Dieter Hegner, Head of Division at the German Federal Ministry of Transport, Building and Urban Development, points out, “I am responsible for sustainable construction, but also for the construction research.” He carries on to describe how the German government’s demonstration project partnerships (highlighting Effizienzhaus Plus in Berlin) rely on measurements (“We have 256 measurement points. So we want to know everything.”) and work to refine specifications based on building experimentation. In his presentation, Hegner refers mostly to the Active Plus specifications (following a similar ideology as Active House); and he praises how successful they have been at advancing the standardization of sustainable building: “Also an important element, we need to make good architecture to convince.” At the same conference, renowned architect Manfred Hegger reflected on Active House’s Licht Aktivhaus project as being a starting point for shifting focus to the wellbeing of residents in sustainable building in

²² See BINE (2015) and the graph showing the learning curve for energy-efficient construction, wherein German building demonstration projects precede matching legislative changes.

Germany. This is not in the least part due to the outcomes of post-occupancy monitoring and the reported experiences of families thereafter.

We can see that the standardization of green default rules is a highly relational process. The described forms of reaching policy-makers and consumers were just a few of many.²³ At this point, the standardization process has been well underway: the design principles for the green default rules (tried and tested in the experiments) are standardized into several forms of communicative guidelines that inform and negotiate amongst stakeholders, such as architects and policy-makers; and the rules are then expressed in new building experiments, which serve as both further diffusion and a widening of the breadth of knowledge about social effectiveness. But once accepted, as by key figures like Mr. Hegner, is it not enough that perhaps these rules may become mandatory? We know that the desired sustainability behaviour may not previously have been the status quo at home, but that the green default rule can be, at least, part of making it so. Yet, as Lone Feifer, Programme Director for Sustainable Living in Buildings at VELUX, underlined during an in-house presentation on March 10, 2016, “You cannot have a new building, ask people to do what they were doing yesterday, and expect something new. That's not how innovation works.” Eventually, what can be seen is the contrast that the tests families experience between their old homes and the demonstration homes, an awakening that drives both political support and consumer demand.

Taking the example of the green default rule relating to homes with more natural light (from windows, light tunnels, orientation, etc.) reducing the use of electricity for artificial light, we can see that, ultimately, a little awareness might go a long way for moving from the standard to sustainable consumption. Two building experts, identified here as Expert 1 (E1) and Expert 2 (E2), describe:

E1: What he did was build the kind of terrace houses [...] So everybody had really contact to the sun and to light as one of those ideas. And he said, he put the people out of their homes they had before, and brought them to the new homes. And then he made evaluation, asked 1,000 questions. One: where is the light situation better? And they said, “It has been good before. It's good now.” Okay. And then he puts them back. And then - only then - they said... What? “It's dark.”

²³ See also: Active House radars, VELUX and Grontmij Model Home 2020 evaluations, VELUX Healthy Homes Barometer.

E2: And that has been the experience with the VELUX experiment too, when the VELUX test families moved back to other homes, then they asked for different light situation. They chose their new home according to light needs. Before they said there's no problem.

E1: They didn't even recognise it.

E2: And this is, for me, a very strong example for the situation where you do not know what you need before you...if you are not really trained to question your feelings.
(Interview 13 February 2015)

There are other examples of this, as well, such as with Ismaël, the younger son of the Pastour family who lived in the Maison Air et Lumiere during the test period, 2012-2013. He had been suffering from asthma; but stopped being affected once in the Active House and was even able to cease preventative medication. However, once the family moved to a flat within the same region, the attacks recommenced (Pastour 2013). Only after moving out were they able to appreciate how dramatically his health is affected by the environmental materials and ventilation design of the home. Though in some cases, it is enough to gradual become aware of changes that have extended over a long enough period of time. The owner of the Sunlight House professes: “My husband always says now, he realizes how bad the air quality is in offices when he has meetings. Yes, so now [...] he always opens the windows, and because here it's normal to have fresh air” (Interview 10 February 2015). Likewise, the Oldendorf family of LichtAktiv Haus describes how the alteration in building design affected their lighting use: “In our old flat, my first reaction was always to reach for the light switch. In the beginning, I didn't even know where they were in the LichtAktiv Haus – even when it's overcast outside, it's always bright enough inside” (VELUX, 2015). One can imagine multiple scenarios compounding the awareness: a visiting guest notes the difference; a reading book stays open late into the evening; the utility bills plummet. In any case, their awareness of the contrast was enough to motivate them to mobilize their finances to purchase the home after the monitoring period, making them

the first family to buy their tested Active House, though prohibitively expensive for an average family.²⁴

Examining this phenomenon, the effect of the default rules in sustainable building appears to concern relativity and, surprisingly, awareness. This is not to say that the literature concerning the subconsciousness of default rules is incorrect. Rather, it is to further our understanding of the importance of moving default rules into consciousness as part of the process of creating sustainable consumption. The demonstration experimentation plays a role in this: “It's the performance of people. But you have to make them aware. It's the next step to show them [...] because you never meet the objective, you don't meet the standards. You're talking about it and you're convinced. And for them, I show that, look at that, look at the results. You can demonstrate it easily” (Interview 12 February 2015). Although, as theorized, default rules work on tacit assumptions and the status quo bias, the wider social effect arises from awareness following a period of having experienced the new status quo. This awareness pairs with professional, policy, and market developments to shift the overall field. The following section discusses the implications of these findings.

Discussion

Sustainability consumption is the flipside of the same sustainability coin as production. The significance of standards for sustainable building lies just as much in what kind of buildings are demanded and how these buildings are used as in how buildings are produced. In other words, both the standardization and the effect on sustainable consumption are important for shifting the built environment. The first aspect, the standardization of default green rules, paints an intriguing picture of a sustainability future wherein the home is no longer a black box, but an innovation stage for acting out green default rules that alter what we take for granted. As depicted in the model, the green default rules are altered based on experimentation in a standardization process that then opens up a market aligning technical approaches and policies. That experimentation is part of the standardization process is important to recognize, as the overlapping interests, especially of those living in the homes, must be allowed to experience

²⁴ It should be noted that though other families had wanted to purchase an Active House after testing, historically the price has been out of reach for an average family. The trajectory towards affordability of experimental homes like RenovActive in Brussels may change this, a key factor in linking supply and demand.

friction and negotiate a meaningful, desirable reality in practice. Certainly, learnings across the demonstrations contribute to adjustments in design that improve green default rules' effectiveness; and this kind of adoption and adaptation is a form of innovation itself (Rip and Kemp 1998). One point is that the engagement of multiple experts from different fields in the standardization and communication of the default rules' effectiveness is essential. In this way, the standardization outcomes garner creativity from diverse inputs, as well as legitimacy.

But industry and policy change efforts are not in and of themselves enough for societal change. This underlines the importance of understanding how default rules work in practice and how active choice is the starting point of sustainable consumption. The literature on default rules collectively suggests that these rules effectively influence behaviour under design conditions. Yet, as Barnett (1992) points out, the designs (and outcomes) of default rules are only as good as the broad assumptions about the communities involved. Hypothetically, then, the better the knowledge of the communities in which default rules are applied, the better the outcomes for society overall. In contemplating the motivation for either industry or consumers to participate in such *smart defaults* -- default rules that are welfare-oriented and market-targeting, Smith et al. (2013) ask: “[Can] we assume in the first place that the incentives are sufficiently strong for marketers to create consumer welfare-enhancing smart defaults? Are the rewards so evident if the (smart) default effect occurs without awareness?” (p. 168). In response to these questions, this research suggests that so long as this awareness *is* awakening and creating demand, there may indeed be very interesting incentives for both parties. At least ideally, organizations may proceed more swiftly towards lower impact or cradle-to-cradle markets, and consumers may benefit from a raised basic standard of living, as well as healthier, more value-aligned lifestyles.

However, given the prospects of bringing awareness to the value of green default rules, I suggest treading with care into the so-called smartness of default rules. Amidst the choice architecture community, the phenomenon of personalized default rules is gaining ground. Porat and Strahilevitz (2013) map the way from active choice toward personalized rules, pointing out that although the concept is not new (as opposed to impersonal default rules), technological advancement has changed the practicality of personalization. They argue that Big Data now enables effective personalized default rules while simultaneously minimizing transaction costs. The Internet of Things (IoT) compiles mass matrices of data on our preferences and behaviour that can be used to structure default rules particular to us as individuals, all without us ever

having to know. Based on this paper, I caution against too much personalization on two points. First, I echo Selinger and Whyte's (2011) ethical concerns that the more accustomed we become to having default rules set for us, the less realistic the opt-out option becomes and more vulnerable we are to manipulation: "The main point, then, is that the more we become habituated to being nudged the less we may be bothered by the incremental introduction of more controlling tactics" (p. 929). Second, the apparent inseparability of market and consumer in this research implies that for default rules for broader social change, such as moving in the model from the standard to sustainable consumption, shared social values are needed. This is the difference between the power of increased individual awareness and societal awareness.

Further along the lines of interconnection between market and consumer, if these changes to design are not appreciated in society unless first experienced and then noted of their absence, it implies the need for a double-edged sword of political and societal change. Kopelman (2011) points to successful choice architecture as being dependent on intervention that is both across policy and legitimate. And at the same time, the status quo bias also applies to policy reform (Fernandez and Rodrik 1991), making the prospect of broad policy change unappealing without awareness of something better. Default rules thus lie in the uncomfortable space in between individuals and the makers of society: the communication is key for organizational reach and policy development, and the awareness through experience is key for household change and demand. Their diffusion across households, organizations, and political bodies alike is paramount for large-scale change. As green default rules are applied more widely, the insufficiency and undesirability of previous designs become apparent; and we become the embodiment of these rules by preference instead. In other words, perhaps the idea of default rules is not to remove awareness, but to pair it with policy and markets in a more socially sensitive, sophisticated manner. The key message is that both standardization and consumption benefit from experimentation that teaches producers *and* consumers where the benefits of sustainability lie, so that there are both production and demand forces at work for change.

Conclusion

All in all, we now have a better idea of how default rules are standardized and encroach the realm of awareness. We also have some indication that green default rules need to

simultaneously target different parts of society to have a larger scale impact. Still, this research is an early attempt to shed light on the meeting point of green default rules, standardization, and sustainable consumption. It is hoped that further research can build upon the proposed model of this process. For example, there is need for greater evidence in order to solidify the dashed-line questioning whether sustainable consumption can reinforce the green default rules to make the process a cycle. With Active House, efforts to establish sustainable consumption for both new and renovated buildings are still in their early stages. As research around choice architecture develops, and pressures on sustainability transitions grow, homes will likely be increasingly targeted for their effects on lifestyles and carbon dioxide emissions alike, and we will need to understand more about what are the important design aspects of default rules and how to organize them for society-wide (as opposed to purely personalized) sustainability transitions. But of great importance in these developments is the involvement of the user, and the significance of leaning towards an active, worldview motivated choice to participate in sustainability transitions, i.e. co-developed transitions.

There is likely much to be learned from other fields, especially those similar to building that combine choice architecture with physical architecture; but this also means that these findings may not extend to less literal infrastructures -- for example the default rule design of product labels. Therefore, I recommend that research should explore how default rules are standardized in contexts with a diminished role of product or architectural design. Also further research is needed to explore the role of subconscious (unaware/impulsive) versus conscious (aware/comparative) decision-making in the formation of worldviews that support sustainable consumption. For example, does the awareness-spurred demand for sustainability-oriented buildings entail ripple effects, demand for other sustainability-oriented products or lifestyle changes? Can multiple industries collaborate to shift worldviews from different pressure points, in a more systems-thinking approach? This research is a starting point for delving into the resetting of status quos that spur both personal and societal change and will hopefully inspire other organizational researchers. It serves as one contribution to the burning question of how we can live better, more sustainable lives and still feel at home.

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Anthropocentric design: Human significance in technological building standards

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ABSTRACT

As sustainability transitions in the building sector rely 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 *anthropocentrism* -- the centric focus on humans -- can be just as erroneous, leading instead to technocentrism. Using concepts from Science & Technology Studies (STS), this paper uses Active House building demonstration projects to illustrate how building users' interactions with technology serve to shape technological standards design bidirectionally with users, driving design that is relevant for and meaningful in society. It presents a model of how experimental, interactive design within developing systems proceeds through stages of piloting, automation, overshoot, and then balance. Simultaneous attention to technology and people in design experiments ultimately changes the technologies and the people in a dynamic relationship that produces building and technological design that better facilitates democratic design and sustainability transitions. This paper advances the discussion of anthropocentrism in that it: a) distinguishes between anthropocentrism and technocentrism, b) argues that a combination of the two is needed for sustainability-oriented technological standards, and c) presents a model of interactive design between humans and technologies.

Keywords: sustainable building; anthropocentrism; biometric systems; interactive design; post-occupancy monitoring

Introduction

In the current sustainability discourse, the coining of the modern epoch as the “Anthropocene,” that of planetary dominance by humans (Davies, 2016), has resulted in *anthropocentrism* -- societal focus on human interests -- as being viewed as the root of environmental destruction. At the same time, *technocentrism* -- 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. Whereas both developments offer promises of improving the lives of people in quite different ways -- for example, high tech life hacking²⁵ versus the sustainability of living more simply and thus consuming fewer resources -- the intersection of the two is ever-increasing. In the building field, 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 the physical world threatens to bypass co-development with the building inhabitants, potentially leading to non-democratic self-learning systems that do not “consult” humans. “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 in standards, but rather to caution against drifting too far into technocentrism, wherein technology becomes both the tool

²⁵ The improvement (or “hacking”) of life through better management of life data, also connected to the Getting Things Done (GTD) movement (Thomas, 2006).

and the purpose. Attention to ecological consequences is fundamental in sustainability transitions; however, this paper focuses on the relationship between humans and technologies while solving sustainability problems. It also draws attention to a historical lack of distinction between anthropocentrism and technocentrism, such 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 and 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).²⁶ 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).²⁷ It has long been suspect of resulting from variations in behaviour and can often be closed with post-occupancy monitoring (Bordass, Cohen, & Field, 2004; Menezes et al., 2012; Sunikka-Blank & Galvin, 2012; Fedoruk, et al. 2015). The main failures are a non-consideration of building inhabitants, lack of an integrated design process, and lack of real-time data (Frankel, Edelson, & Colker, 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 sustainable buildings that the very people who are meant to inhabit them 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 (AIA, 2012).

²⁶ 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).

²⁷ Actual energy use in buildings can be as much as double the modeled predictions (Frankel, Edelson, & Colker, 2015).

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 anthropocentrism in technology standards and, ultimately, sustainability transitions. Engineering determinism paired with the trend towards “post-human” design (Fry, 2000) argue for a decentering of anthropocentrism (McIntyre-Mills, 2013) and a greater focus on technological objects in standards for systems design (Qvortrup, 1996; Fry 2000). 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. The theoretical approach is inspired by Rip and Kemp’s (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. 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 an STS perspective, I use the case of measurement and evaluation in Active House demonstration building projects to a) distinguish between anthropocentrism and technocentrism, b) improve understanding how aspects of each are dynamically used to develop technological standards, and c) develop a model of interactive design. The paper is structured as follows: I first give a background on biometric technologies; then introduce theoretical aspects of Science and Technology Studies; followed by a description of the Active House case and the research methodology; presentation and analysis of the data; and finally a discussion of the implications in the building field and beyond.

Technology: Advances in technological interrelation

As society seeks solutions to modern sustainability challenges, technological fixes have great appeal, with smaller sized devices, lower prices with scaling, 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 termed the Internet of Things (IoT), in which

technologies and other objects gather and communicate. Size and cost have had no small role to play in this rapid realization: “Most dramatically [at the beginning of the 21st 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.

The current pervasiveness, the connectivity between humans and the objects of fused sensor networks, is literal: “In general, any self-contained device that detects a property and produces a signal is a sensor that I can connect to a network and use to extend my powers of observation and surveillance” (Mitchell, 2004, p.26). Further, the access to the data these technologies generate is essentially unregulated (Hall, 2014), opening up the internal network of the home to the outside: “Today, as more and more devices get embedded intelligence and IP

addresses, access control lists are extending their power into the everyday physical world. They have accomplished a species jump, from cyberspace to architecture. [...] Thus your domestic access control lists begin to define who, physically or telepresently, is welcome in your house” (Mitchell, 2004, p.191). This gives a glimpse into potential openings for humans’ democratic involvement (or dis-involvement) in determining the extent of and the traffic within the IoT bridging their homes, i.e. programming parameters for sensor communication or altering the settings on access control lists. In other words, in lieu of human control, the expanded systems can make decisions for whether or not to trigger security alarms, change indoor temperatures, open doors, or allow system settings to be changed.

Yet, the trend is to shift the design of networks towards no longer involving the people they measure and serve (Thomas, 2006; Jethani, 2015). 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 framework for self-organizing systems (Qvortrup, 1996).²⁸ As these network systems advance, it is proposed that the IoT will remove the necessity of conscientious input from people: “It promises to create a smart world where all the objects around us are connected to the Internet and communicate with each other with *minimum human intervention*” (Wang et al., 2015, p. 15, emphasis added). Thomas (2006) goes so far as to anticipate the collapse of cyberspace as a place virtually inhabited by humans. She suggests that the trend of technological networks is to work seamlessly without humans, so that we can better inhabit the real world while technologies manage the virtual one on our behalf. The urge for technological fixes that bypass the messiness of social change is strong. In his book on organizational transformation, Oden (1999) points to the frequency, but error of believing that applying technologies to problems will solve them: “Certainly technology is a key *enabler* of transformation. But technology is not transformation. [...] Perhaps one reason that many practitioners fall into the error of technocentrism is that technical change is easier to implement than social change” (p. 17, original emphasis).

The downside of standards for technological systems operating without humans is that this approach also implies the removal of human input, the extinguishment of technological deliberations. This is important on a number of different levels: 1) humans are imperfectly

²⁸ These objections perpetuate despite consistent system failures when designing out human interconnectivity (Maguire, 2014).

represented as data -- these systems cannot qualitatively “know” us and make appropriate decisions in our stead; 2) technologies are prone to errors in their design and programming, potentially subjecting whole building systems to issues if not checked by humans, and 3) technologies are ultimately *made by humans* and thus need the insight of humans to work well in an ongoing development process. These issues can readily be seen emerging in the performance gap problem in the building field: the data does formulate models that accurately represent how people behave in buildings; as building inhabitants are not acquainted with the technological systems, they are rendered helpless when they break down (with potential health and/or environmental consequences); and standards for technological building systems have only improved upon further sociological study, developed with a better understanding of such phenomena as adaptive thermal comfort (wherein people are most comfortable when they are not at one set temperature, but experience variation and adapt to it). The next section introduces aspects of Science and Technology Studies (STS) in order to theorize these technological developments.

Theorizing Technological Standards Design

Since the role of technologies is often taken for granted (Law, 1991; Lawson, 2007), Science and Technology Studies (STS) is useful for illuminating their agency. As STS is a broad theoretical field, this research draws mainly upon socio-technical infrastructures and the design of objects and systems therein (see Rip and Kemp, 1998; Fry, 2000; Bergman, Lyytinen, & Mark, 2007; Maguire, 2014; and so forth). The technologies studied here (biometric systems) are action-infused technologies of power that enable governing from a distance (Foucault, 1988; Rose, 1999), but are also active in an object-oriented sense as physical actants in a network (Latour, 1991). The dynamics of such distant governance and its objects are key to understanding how building projects are mobilized, and how technologies can be granted decision-making responsibilities in lieu of humans. Technologies serve as entry *and* exit points with the outside, but once settled into a stable design, operate as black boxes, including home technologies: “The material aspect of black boxing in modern household appliances is evident in the sleek surfaces that hide from view how the appliances work. The cultural aspect is exemplified by the absence of any need to inquire into the world behind the electrical outlet”

(Rip and Kemp, 1998, p. 329). They may be capable of making decisions for the buildings and their inhabitants, but do so behind the scenes.

STS is particularly useful for this paper, as it has as much to contribute concerning social development as that of technology. It describes how with the introduction of technologies, before this disappearance from awareness, people go through processes of *technological appropriation* and *scripting* -- possession of, repurposing, and shifting the functions of technology into new scripts of interaction (Shove, 2003). As such, design is thought to require both social and technical considerations (Maguire, 2014). Research in the building field likewise evokes the significance of design through interaction: whereas not involving users in the shaping of design and technologies can be a barrier to comfort in buildings, too much involvement can confuse and frustrate them (Cole et al., 2008). Thus the interactions go through processes of pushing *and* pushing back, a concept brought forth in Akrich's (1992) book chapter on scripting and *descripting*. Mattozzi (1987) likewise focuses on this dynamic exchange, but emphasizes the involvement of more actors than just designer and user, including sales-persons, marketers, etc. Rip and Kemp (1998) refer to this collectively as *socioware*: "For some technologies, such as nuclear technology and modern biotechnology, public reactions have forced developers to redesign their systems. Learning from these experiences, they sometimes anticipate public acceptability actively; in other words, they include socioware in the design and development of their technology" (p. 331). These theoretical perspectives laid the groundwork for connecting the research data to theoretical concepts in the formation of the process model herein.

An area of STS that this article contributes to is the significance of the human role in systems and its distinction from the role of technology, even in the post-modern era of describing interrelations. Indeed the intertwining is important. As Fry (2000) describes of design interrelations in the built environment: "What it actually opens up reveals numerous and complex ways to think and engage the causal agency and diverse effects of the designer and the designed. More than this, the question also begs to be grounded in time and space, as well as within the framing of contemporary imperatives" (p. 48). Yet the theory would benefit from a consideration of holistic interdependencies paired with conceptual distinction. In his chapter taking critical perspective on political ecology in the Anthropocene, Horborg (2015) points out that STS has tended to aim at breaking down the distinctions between nature and society and society and technology (in an attempt to illuminate their interfusions); and I support his

assertion that these categories are essential for analytical distinction. He gives the example: “[T]he future of fossil-fuel capitalism no doubt hinges upon the relation between the market price of oil and the Second Law of Thermodynamics, but I cannot imagine that we have anything to gain from dissolving the analytical distinction between the logic of the world market and the laws of thermodynamics” (p. 59). This paper argues that anthropocentrism and technocentrism should be distinguished to better understand how these different foci influence one another dynamically. Because of the entanglement of designers, objects, and social worlds, attention to humans appears essential -- to the extent that systems may not function without it; and there must be distinctive concepts with which to analyze this.

On the other hand, there is support from the STS literature that human orientation is critical for the development of sustainable systems. Maguire (2014), in describing the relevance of socio-technical systems, points to a lack of input from people using systems in designing systems as a primary reason for system failures and inefficiencies. It is also because of this entanglement that design without a human focus can be seen as stuck in the structures of past design, which in building has largely focused on engineering priorities (Fry, 2000), contributing to the persistence of the performance gap and construction of buildings without consideration of their inhabitants. This highlights interactive design as a crux of sustainability transitions in the built environment: “Design is therefore deeply embedded in the creation of sustainment, but equally in the proliferation of unsustainability” (Fry, 2000, p. 50). Humans and technology may be inextricably intertwined (in a depth that is arguably deepening), but they are certainly different entities that in their own rights shape each other, and improve upon one another for sustainable change. The next section introduces Active House demonstration projects as a case of building and technological standards experimentation, specifically aiming at sustainability transition.

Case: Active House Demonstrations

A *demonstration building* is used by industry, organizations, and governments alike in a similar fashion as a typical product demonstration: it is “a method that (1) shows the performance of a product in actual use conditions, or (2) encourages trial purchase and use of the product for evaluation by the customer” (Business Dictionary, 2015). At the forefront of the

demonstration is its illustration of design approaches, including standards technological design. One example is that of the Solar Decathlon held biannually by the U.S. Department of Energy, a competition for university teams to showcase the best small-scale building design for cost and energy efficiency. Another is Les Bâtiments Exemplaires (The Exemplary Buildings), which was the Brussels Capital Region's program that supported 243 building projects demonstrating design for affordable environmental and energetic performance. The results of these demonstrations often lead to the adoption of design parameters in both standards and regulations.

Active House was selected as a case study because of its aim of incorporating *comfort* into sustainable building. As comfort is an inherently social phenomenon, the Active House demonstration buildings have been a fascinating test bed wherein the focus on a human aspect meets the application of building technologies, including biometric systems. It is an especially interesting case in that the resultant standard is then applied to the design of new projects (in an ongoing process) and contributes to a social movement for new sustainability approaches across the building industry and construction politics.²⁹ The Active House Alliance is an alliance formed around the Active House building standard, with the possibility of applying an Active House label to construction projects. The alliance was inspired by (and could even be considered an extension of) a program called Model Home 2020 initiated in 2009 by VELUX, a roof-top windows manufacturer. The program aimed to demonstrate that the buildings society would desire in 2020 - in terms of energetic, environmental, and comfort performance - could be built today. The Active House Alliance, composed of industry, university, governmental, and NGO partners, continuously develops the Active House standard to reflect learnings from both the process of making building demonstrations (of which there are 26 with more underway) and post-occupancy evaluations. As with much sustainable development, there is a distinctive focus on the energy aspect (after all, the main root of the greenhouse effect); but given the issues described above about the performance gap, Active House seeks to broaden design concepts to include environmental and social considerations, as well, for a more holistic (and effective) approach to sustainability.

²⁹ For example, these demonstration projects are featured at Healthy Buildings Day, an annual VELUX event held in Brussels, involving practitioners and policy makers at the forefront of European decision-making.

One of the interesting aspects of Active House is its use of measurement -- both qualitative and quantitative -- through a number of devices. A test family -- the more “average” in terms of ecological or technological lifestyles, the better -- is invited to live in the house for two years, during which time they undergo measurement in numerical terms by meters and sensors (biometric devices such as carbon dioxide sensors, motion sensors, temperature and humidity sensors, and so on) and in sociological terms by interviews, blogging, and regular interaction with researchers, altogether termed *post-occupancy monitoring*, monitoring done once people already inhabit a building. The designers of the technological systems work together with the building architects and engineers. For example, WindowMaster, the producer of a building management system that connects sensors and windows in order to respond to building inhabitants and environmental conditions, collaborates with VELUX, the windows manufacturer, in order to integrate the building material and the technological material in a communicative measurement system. This opens a Pandora’s box of information on home behaviour that we previously did not know. The social measurement aspect is important to acknowledge, as the demonstration building concept is not new, but the combination with social information is. The introduction of affordable biometric technologies has made this extent of measurement possible; and the sociological work supports this data, allowing for interpretation and inquisitiveness from both the demonstration project researchers and the families. It is also a window of time during which the activity of building technologies is observable and malleable. The following section explains the methodological approach to studying these demonstration buildings and the design experiences.

Methodology

The qualitative methodology herein suits the social and processual nature of the study. I take a case study approach to studying Active House, which is important for shedding light into the black box of biometric technologies, as the explorative nature of the data collection gives those in the case an opportunity to reflect on their own socio-technical relations. As Flyvbjerg (2006) points out, the case study “is important for the development of a nuanced view of reality, including the view that human behavior cannot be meaningfully understood as simply the rule-governed acts found at the lowest levels of the learning process and in much theory” (p. 223), and Yin (2009) further notes its ability to “retain the holistic and meaningful

characteristics of real-life events” (p. 4). Whereas Active House serves as the case, the objects of the study are the demonstration projects, their experimental building automation systems and inhabitants.

The projects covered in the research include Active House’s 26 demonstration buildings, as well as some of the interviewee’s personal experiences with smart homes. Whereas three demonstration projects served as the main focus, the interviewees, speakers at events, and Active House and VELUX materials consistently made reference to additional projects across the board. The three main Active House demonstration buildings are located in three different countries and were selected for their representativeness as technified single-family residential buildings, but also for their diversity as new-built, part-renovation, and full renovation projects. Sunlight House, located in Pressbaum, Austria (on the outskirts of Vienna), is Austria’s first zero-energy house, and is in fact often operating as a plus-energy house, one which includes a charging station for an electric vehicle and feeds electricity back into the grid system. LichtActivHaus is a part-new build and part-renovation project that is part of the International Building Exhibition (IBA)³⁰ in Hamburg, Germany, and it features solar arrays that “harvest” the sunlight in a fashion similar to the original post-war garden neighborhood home. And RenovActive is a budget renovation project underway in cooperation with a social housing company in Anderlecht, Brussels, Belgium, which faces new challenges of system design based on the low cost requirements and the unpredictability of residents’ familiarity with technologies. All three of these countries are in the process of reshaping their building standards (and regulations); and all three projects have received attention from architects, engineers, and policy-makers.

I conducted visits to each of the three demonstration project cities. Through cooperation with the VELUX headquarters in Denmark, I was introduced to each of the local VELUX offices and given an overview of the projects before delving into interviews. As the Active House Alliance is well-networked throughout these places, VELUX was able to give me initial contacts to invite for interviews, as well as invite me to relevant sustainable building events in the area. From this point, I used the *snowball sampling* technique (Atkinson & Flint, 2004), asking interviewees for further contacts or persons who might be interesting based on

³⁰ <http://www.iba-hamburg.de/en/iba-in-english.html>

what we had discussed. I visited the sites of the projects, and in the case of the Sunlight House the homeowner also gave me a tour of inside the home. I was also given a tour inside the uninhabitable, pre-renovation state of the RenovActive unit (construction completed in June 2016). The site visits enabled me to envision the manifestation of the building projects and observe how people relate to and behave in the buildings.

Altogether I conducted 30 semi-structured interviews with interviewees from different backgrounds, including standards-making, architecture, engineering, and policy-making (as well as the home owners). Interview questions were explorative and open-ended. For example: *How do you regard the effect of the demonstrations on the building inhabitants?* Or *What does comfort in a building mean to you?* followed by *How do you think this comfort experience might be reflected in measurements?* Many of the responses regarding technology and building systems followed from extensive exploration of trends in sustainable building -- particularly in regard to increasing automation and the high-tech approach of mechanized design under a type of energy-efficiency building certification called Passive House. The six events in which I partook were: the Active House Guidelines Workshop in Brussels, the Passive House 2014 Exhibition in Brussels (including a tour of the new, highly technified Brussels Regional Environmental Offices), the Northern Germany Passive House Conference in Neumünster, the Bauz! Vienna Congress for Sustainable Building, the VELUX Daylight Symposium in London, and Healthy Buildings Day 2016 in Brussels. These events gave contextualization to the overall European building field, the use and evaluation of building technologies, and future trends in sustainable building design. The data is thus composed of interviews, notes and transcribed recordings from the aforementioned events, and notes from site visits, enabling triangulation (Yin, 2009).

I continuously collected data in data management and analysis software (NVivo10) in order to better track emergent patterns and note ideas and questions. During the first coding cycle, I reviewed large segments of data (ranging from half sentences to whole paragraphs) for recurrent themes (Table 1). In the second cycle, these primary themes were broken down into secondary themes, deeper within which sub-themes could be seen to both tightly interweave and serve as independent concepts. I consider this stage pivotal in the overall coding process, a dimension of analysis that helps deepen reflections (Miles, Huberman, & Saldana 2013). It was also the stage during which the research questions resounded with the

objects of study and their constructs. For example, when asking about the role of user focus (anthropocentricism), I found coded answers in the data referring to the nature of human control over technology and human response to automation of technological systems. Gioia, Corley, and Hamilton (2012) describe this relationship: “Put simply, in our way of thinking, concepts are precursors to constructs in making sense of organizational worlds” (p. 16). Once these clusters of answers were organized, I could identify a process developing over time, which became the foundation for this paper’s process model. I could then connect the models different “stages” to the theoretical STS concepts of appropriation, scripting, redesign, and re-appropriation.

First Coding Cycle			Second Coding Cycle		
Theme	References	Sources	Theme	References	Sources
Technology	175	21	Proliferation	6	3
Cities	55	19	<i>Subthemes: general, sensing, beyond sensing</i>		
Cost	142	24	Interaction	18	8
Daylight	46	13	<i>Subthemes: altogether, automation, adaptation & time, interference, overkill</i>		
Demonstration	78	21	User focus	11	7
Institution	192	24	<i>Subthemes: control as positive, control as negative, change over time, beyond control</i>		
Legitimacy	46	12	Social monitoring	2	2
Measurement	121	23	<i>Subthemes: none</i>		
Scale	50	17	Monitoring & standards	12	7
System	94	20	<i>Subthemes: monitoring for standards, nudging, what standards do for people</i>		

Table 3: Data themes and coding process (source: own).

Following these coding cycles and the formulation of the process model, I experimented with this series of suggestive answers in what Gioia and Chittipeddi (1991) refer to as “gestalt analysis,” leading to a re-synthesis of themes into “aggregate dimensions” (Gioia, Corley, & Hamilton, 2012). The tentative answers and aggregation of the secondary themes of proliferation, interaction, and user focus resulted in this paper: the proliferation theme helped me to use the data to make sense of the distinction between the Anthropocene and the Technocene; the interaction theme helped to structure the process model itself; and the user focus theme helped to elucidate the significance of anthropocentricism in the interactive dynamic. In order to understand how technologies were being used and humans responded, the interviews proved to be the most useful at revealing the nature of interaction; whereas notes from the research stays and events proved more useful for relating to the designing process. A limitation of this methodology is that whereas it can depict nuances in the reflections on the human experience, it is not a direct representation of the experiences themselves. It is hoped, however, that this perspective counters the limitations of quantitative measurement (all numbers and no reflection) by painting in the richness of interpretation. The following section presents the findings

concerning the nature of interaction between the building inhabitants and the biometric technologies.

Human and technological relationships: A process model

The findings show a pattern of development of interaction and design between homeowners and the home-based biometric devices, stages that emerged from the data under examination. The stage-model presented herein is the main contribution of this paper. Overall, the model shows how the biometric technologies' settings in the home shift from a pilot design to being designed as automated, in some cases going into the overshoot stage and dominating the users, but then leading into a scaled-back design with more balanced interaction (Figure 1). Note that there can be overlap between stages as the interaction develops. Along the design process, the technologies exert agency, and the users exert back. The learnings from the design process, consultations with the inhabitants, and the measured data shape the Active House Specifications and Guidelines and thus the future application of technologies in Active House projects. In this section, I present the stages that this process proceeds through, based on the demonstration projects: pilot design and increased automation (this is presented in one section, showing the change in time from pilot to increased automation), overshoot, and then balance.

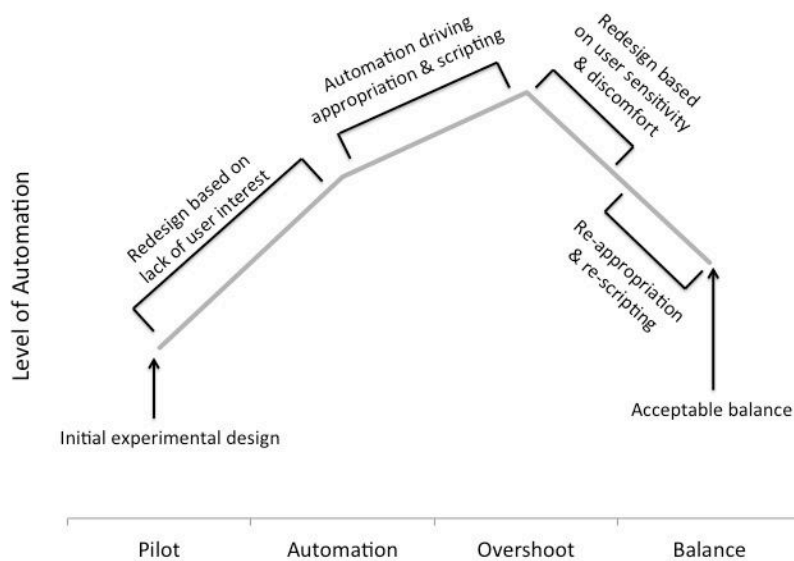


Figure 2: Stages of interaction in design (source: own).

Pilot Design to Increased Automation

The earliest part of the introductory phase does not highly automate new technology; but failures and complications of users trying to make sense of them quickly shift design to boost automation. The idea is that the users do not understand how the technology works and are not motivated to put in the effort to learn how, especially if their ownership status disenfranchises them from a sense of responsibility with their home.

It's too complicated for most consumers or most homeowners to bother about. I have geothermal heating in my house. I struggle to change from winter to summer setting and back from summer to winter setting two times a year because I basically don't remember what to do. So I have to understand my notes, but if you have to do that on a daily basis, then it will never work. You have to make the house do it on your behalf. Once you make the settings and it's working, then it should be automatic and we will go in that direction. (Standard maker, Hørsholm, Denmark, Interview 15 June 2015)

The people who are living in the house don't have to...They don't have to think about how does it work. And that's really important because if you are an owner and that's your house and you are going to build it with an architect and with an engineer, to think about these technologies. You are going to think about and you are going to take care about all

those things. But if you are not an owner and that when we explained to you, “You have to change the filter, you have to push this button, and if you do that you have to open the door.” The people...it's not the way of living for them and then they are not going to do the effort to keep it. Because they don't see the benefits. (Architect and social worker, Brussels, Interview 17 September 2014)

Yet, despite reservations about user capacity to handle technologies, over time it becomes clear that some level of interaction is needed. Otherwise, people feel alienated from what is happening in their own homes, and they do not understand the reason for these happenings. This can be interpreted that the *script* is not readily understandable or perhaps overwhelming to the people using the buildings. In the following statement, it is possible to relate to the discomfort the people in the buildings must feel:

The most [sic] complaint that was very frequent was like at a certain moment the windows go open, and they don't know why. That feels a bit awkward if you don't see on the screen. It's because the CO2 level in the room is increasing, and it's outside not cold - so we will now have the natural ventilation. But they don't like it if they don't understand something, or if they want to open the window, and it doesn't open. Then you feel something goes wrong, but maybe it's just outside too hot, and otherwise you will have overheating in your room. (Building engineer, Brussels, Interview 19 September 2014)

However, regular interaction, though awkward and unfamiliar at first, can lead to *appropriation* (re-adjusting the use of technology to feel ownership of it) and *scripting* (reinterpreting the instructive use of the technology) and become a feeling of connectivity. As an architect in Hamburg described one of the families in a demonstration house who had adapted to the system over time: “They love steering and monitoring and checking out how well they can do with it. And if you have people who are interested, I think it is a good idea to incorporate this type of technology” (Interview 24 November 2014). Yet, perhaps the interest is not even necessary. One of the homeowners of another house describes herself as not being very technologically sophisticated; but when she showed me how her network of technologies functions and what her family can observe, she operated the system with ease and spoke with both excitement and pride. Rather, she had adjusted her interaction with the technological system to understand particular aspects and only attempted to influence functions she understood:

There's the weather station - so you always have the temperature and the wind, how fast the wind is. So we are here in the kitchen, and you can see here the CO². It's in ppm [parts per million]. So if this is higher...I will show you. It's the information here. So this is...it was in the night so everybody slept upstairs. And here we had breakfast. We are four people so the CO² value is higher, and if there is a special order, so it will open the windows, yes. (Interview 10 February 2015)

The introduction of interaction with the technologies can often be characterized by heightened awareness and can even be emotional, as people can in fact feel as though their selves are extended through the devices. As the technologies are sensing the people, the people are likewise making sense of the technology with their own adjustments to function and script. This is in part possible because so many of us are becoming accustomed to technology. As a building engineer in Brussels phrases it, "It's not that it's something that nobody knows. Everybody uses it" (19 September 2014). But even the technologies we know and grasp can go too far, exerting too much agency.

Overshoot

On the far end of automation, biometric technologies can push too far into the home life, into what I refer to as *overshoot*, a disruption to a human's sense of normality and self. In some cases, the expectation of human input is too much, and in others, the automation has given technologies an independence that overwhelms human agency. One building scientist in Darmstadt cautions that such highly technological buildings can demand too much attention and response:

Before we had the high performance buildings, we, as user, just didn't care about it. We just used the building, and the building itself somehow worked it out. [...] When it was too cold we just turned it, twisted a little bit on the heater, and hopefully it got warmer. But now we've got this complete interaction, and the building wants to be - in my opinion - it's like the building is saying all the time, 'Here, look at me, look at me! I have some information for you,' and it's stealing your time. (Interview 25 November 2014)

Though excessive focus on humans can lead to these perturbations, swinging away from anthropocentrism can lead to just as disturbing outcomes. In the next example, the network

tipped out of balance and the agency of the technologies was granted more value than the homeowner's own. He does *not* feel *uncomfortable*, but the biometric system is insisting that something is out of order, that the humidity is too low. Confused by his own sensation versus the software's conclusions, he reaches out to VELUX to check which interpretation is the right one:

The interesting thing was that this monitoring software had some kind of a smiley and that was saying, "It's too dry here." We were asked, and we said, "Okay, what's the value?" He said, "It's around 40." That's okay. I think it was in winter - so it's definitely not dangerous. That's what we were telling him. And we were asking, "Do you feel uncomfortable?" "No, but the sign is saying it's too dry." [...] And I thought, okay, so the people do not heed to the self anymore; they just start believing in this monitor. (Interview 25 November 2014)

In the second example, after extensive interaction with the biometric system and developing a sensitivity to energy consumption, a family struggled to keep the performance of the building *plus energy*, i.e. producing more energy than they are consuming. Yet their understanding of how to accomplish this and their willingness to put themselves out of comfort in order to try did not match; while the system was expected to function without their knowledge or interaction:

One important thing was at one certain time they found out, "Okay, we're consuming too much electricity, and the house is not producing that much electricity." And then they switched off all the lights because they wanted to save more electricity. But those were LED [light emitting diode] lights - so they almost consumed no electricity. And so the saving was almost nothing, but they were sitting in the dark. (Interview 25 November 2014)

It may seem odd that design for automation would actually end up further disturbing people, but allowing for appropriations and scriptings comes against the ideal of not having to *cope* with technology, romanticizing technological systems as just working as intended: "The indoor climate of your car is really advanced and it's actually working most of the time without you having to touch anything. Imagine how little time you spend in the car. Why don't we do the same in the house?" (Standards maker, Hørsholm, Denmark, 15 June 2015). So on the one end there are designers attempting to demand too much interaction, and on the other technological

control is supreme. However, to the people at home, either case feels as if they are being forced to change. The following describes these divergent reactions to automation issues in building technology design, driven by energy consumption concerns:

A lot of the technology that's now going into energy efficient buildings is taking away from the occupant the control. For example you have automatic blinds or you can't open the window because if you did you would let out the heat from the building so you have building like this where you can't open the windows. And then on the other hand there other ways [...] where we're trying to or where projects are trying to give more power to the occupant, more control. So smart meters enable them to monitor better their energy use or to see how their occupancy is affecting the energy use. So occupants are becoming much more important and getting the right behaviour amongst the occupants is getting more important. As the energy use goes down in buildings the impact that the occupant has on what's left is more important. (Policy maker, Brussels, Interview 10 November 2014)

Balance

The pendulum can push too far in the direction of human intervention, and it can push too far in the direction of automation. But as this pressure has a tendency to backfire -- so that people break or reprogram (rescript) these technologies, and the resource savings are no longer realized (Active House Guidelines Workshop, 23 June 2014) -- anthropocentric co-design reorients for some automation, while allowing for people to exercise control over their environment. In other words, the pendulum can also settle into a balance between the extremes, as long as the human response is incorporated into the design. One of the Active House standard makers in Belgium recounts arguing that the design should be a balance between technological action and refraining from interference:

I remember we had a discussion in the design group about the monitoring, because we want to have some kind of audit monitoring for the inhabitants so they can follow their consumption. [...] And I was telling them in the situation of the inhabitants, I would be enraged if each time I'm using my clothes drier you tell me, "RED, RED, RED, RED. You're using electricity." When you have the case you need...I mean, if you need to dry clothes, you need to. [...] There must be attempts to try and educate and promote and support without the paternalistic. (Interview 8 September 2014)

Certainly the design of the technology's levels of automation impact this balance; but so to does the process itself, the involvement of people -- so that people are also changing.

As an example of balanced socio-technical home system, one interviewee, a policy-maker in Brussels, excitedly demonstrated his home sensor system through his mobile phone while we were interviewing in an office building.

I don't know if you know the system NetAtmo. [...] It is really fantastic. I have it at home. [...] But it is basically very cheap. Well, it always costs money, but let me just see here. The basic set is 169 Euro for one indoor sensor and one outdoor, and then I have three more, but it is 69 Euro per sensor. But what is fantastic is so the outdoor sensor measures temperature, humidity, but then the indoor sensor measures temperature, CO2, noise level, humidity level. That's my home, the measurement at my home. And so I can see that we are here now in my office so you see it gives an indication of comfort. You see temperature but you see also the evolution function of time, humidity, atmospheric pressure, CO2, noise. And the same outside for 169 Euro. And it is wireless so it is storage in the cloud. I get it on my iPhone. So you see here? And so there is no subscription fee. I paid it once and I can export everything free of charge to Excel with the frequency I want. (Interview 1 June 2015)

He expressed that prior to using NetAtmo, he would have been neither concerned nor aware of his house's humidity levels. His interest in the details of his environment, even when his home environment is at a distance, has changed; and his engagement with the system underlies its functionality.

Even though the design for focus on humans is key to developing such a balanced socio-technical interaction, humans themselves also need to work on their self-design, their awareness of and integration into their own environment. While designing technology to be anthropocentric, people too can learn how to use technology to improve themselves. In other words, people too need to be anthropocentric: interested in themselves, their welfare, and their wellbeing. As an example of when this dynamic fails, another standard maker (at the forefront of transitioning sustainable building in Austria) told me a story of how his team made a visit to discuss the possibility of renovating an elementary school to the Active House Specifications. This visit revealed that the teachers were spending the full day in classrooms with their students with all the windows and doors shut (there was no possibility for opening the windows). There

was a teacher and some twenty-five-odd students at a time in each classroom; and so, naturally, when they tested the air quality, the carbon dioxide levels were at a poisonous level.

So many kids and no awareness in that, and especially not the teachers. No awareness. And they said, “No, we don't have controlled ventilation, and we don't want to have it.” So this, to me, is: we have developed the standards so we have to use them. But we have to introduce them and we have to encourage them to use them. (Interview 12 February 2015)

In the case of Active House, they have come much closer to this middle ground between high automation and conscientious residents; though it is still under experimentation (Interview 19 January 2015), yet to be tried with the Belgian social housing project RenovActive. The learnings from the demonstrations thus far are especially well illustrated in the Building Controls section of the VELUX Circadian House report: 'It is important that the functioning of control systems is transparent and comprehensible for the occupants and they can easily adjust the interior daylight levels, electric lighting, temperature, fresh air supply etc. according to their personal needs. Automatic systems are often of advantage, but always see to it that easy-to-use options to override the systems are available. Feedback indicators on e.g. indoor air quality and temperatures (telling you that the systems have understood that you want some kind of change and giving you information about the current status of e.g. temperature, CO₂-levels, etc.) are a plus as they help occupants to use the building service systems ‘as intended’ (VELUX, 2013). In this way, the co-designed technologies and their scripts become inscribed in the next generation of building guidelines. The following section discusses the implications of this interactive process and its perpetuation.

Discussion

The interactive design process model highlights that focus on humans, anthropocentrism, is an essential element in the codevelopment of technological standards for furthering sustainability transitions. The model is significant for: appreciating the bidirectionality of technological development and social change; better understanding how design processes affect sustainability transitions, wherein the whole *and* the sum of parts matter; and nurturing a positive sense of responsibility for sustainability in the Anthropocene. The

model also evokes the power of experimentation. As Rip and Kemp (1998) point out: “Individual behavior, organizations, and society have to rearrange themselves to adopt, and adapt to, innovation. In this sense, the introduction of a new technology is an unstructured social experiment” (p. 338); except that with building demonstrations experimentation, the application of new technologies becomes a *structured* social experiment. As the experiments are carefully crafted, the outcomes are evaluated, and the learnings feed back into the future orientation of development trajectories, this experimentation is indeed a powerful engine of transformative innovation in society. And perhaps the most significant relevance of innovation to society is its ability to improve the human experience.

A benefit of the experiment is to be able to better delineate focus on humans versus technology, but more importantly it sheds light on the interplay. The trend towards technocentrism has its own societal appeal: one can imagine that these systems are more fluid, less costly, and more convenient (Maguire, 2014). Perhaps they would be faster, cleverer, and better able to apply synergistic reasoning to complex problems. But as Maguire (2014) pointedly inquires: how would a systems designer make “appropriate” modifications to them? (p. 169) Appropriateness can be seen as a repercussion of appropriation. When we take ownership of the things we use, they become appropriate for us. Clark (2003) supports the model’s implication that the development of suitability to the human experience is a result of bi-directional learning: “All the *fitting*, the adaptation of the technology to the needs and capacities of the biological user, is done by the slow cultural process of design and redesign; the final dovetailing of biology and technology is achieved courtesy of individual human learning” (Clark, 2003, p.57, original emphasis). And if it was not for human learning, how could there be technological learning that reflected our interests, growth, and maturation? Just as the overshoot example with the LED lighting portrays what happens without learning about a building’s energy consumption, the balance example with the NetAtmo app shows how learning can bring a comfort and cohesiveness to change.

This bi-directional learning process could be the hinge swinging forward sustainability transitions. The process stages hint at the folds in socio-technical systems functioning that Latour (1991) delineates as *wanting to do* [vouloir faire] and *being able to do*

[pouvoir faire].³¹ In terms of social appropriateness, he gives the example of Saint-Exupéry's *The Little Prince* Turkish astronomer's inability to convince his colleagues of the existence of Asteroid B 612 until he is dressed like them, a factor assumed to be meaningless under the auspice of mathematics and science (Latour, 1991). And yet, humans take for granted their own influence on technological systems: "We see neither resistance to, nor opening of, nor acceptance of, nor refusal of technical progress. Instead we see millions of people, held by an innovation that they themselves hold" (Latour, 1991, p. 117). Altogether, anthropocentric design for sustainability transitions most likely does involve disposing of belief in true dualisms, but does remove analytical distinction between the roles of humans and technology. McIntyre-Mills (2014) suggests: "Dualist thinking pervades our consciousness and is reflected in socially just and environmentally sustainable designs for society. Designs need to be supported by constitutions, based on a priori *norms*, and consequentialist or a posteriori *approaches*, based on testing out ideas within context and with future generations in mind." (p.145, original emphases). Again, technology is a means, not an end. The challenge is that to be able to productively experiment demands social and technical literacy, the learning imperative at the heart of the sustainability transitions paradigm.

The silver lining of this model and the distinction of anthropocentrism is that it demands a conscientiousness about the influence and power embedded within and exerted by the resultant technologies. This is a shared responsibility among many actors: regulators, standards makers, systems designers, and the users of technology. Rather than responsibility for engagement and interaction in technological systems being interpreted as a burden, it should be seen as an opportunity for learning, development, and constructive social movements: "Speaking broadly, and somewhat optimistically, critical engagement with the objects, processes, behaviors and relations that are involved in producing the various types of body-awareness involved in decision-making and personal development can stimulate political action and social change" (Jethani, 2015, p. 41). While Jethani continues to describe how engagement can change how biometric technologies are introduced into homes, his arguments are just as applicable to sustainability discourse in the Anthropocene. Fry (2000) reinforces: "The crucial move open to us is not towards the impossibility of liberation from anthropocentrism but, in contrast, the embracing of an affirmative recognition of it with an extended and critically

³¹ Mattozzi (2010) adds that these eventually become *having to do* [devoir faire].

reflective sense of responsibility for it” (Fry, 2000, p. 51). Rather, in alignment with transition theory’s arguments (i.e. Hall, 1993), we have a responsibility to ensure that the way we design for sustainability transitions’ policies and frameworks (and from a socio-technical landscape perspective, also technologies) incorporates social attitudes and values.

Technologies regulate both through their technological scripts and through their representation in social scripts, like standards. Rip and Kemp (1998) caution that regulatory standardization involves locking in aspects of design, and that the most robust technologies leave the least flexibility. Nonetheless, this research suggests that standardizing co-developed technologies after experimental, dynamic learning processes furthers anthropocentric design by negotiating system functionality and better balancing with technological control. I particularly enjoy the way Lisa Nelson describes the import of technological values in her book on the advancement of biometric technologies used for identification, *America Identified: Biometric Technology and Society*: “In evaluations of the structural and substantive consequences of information technologies, including biometric technologies, it is not enough to ask whether the action taken reaches the desired regulatory effect or whether the use of the technology is efficient or reliable. The greater question is whether the regulating effects of technology respect the fundamental values, norms, and expectations of society. The question is not only about preventing the regulatory effect of technologies, but, in certain circumstances, using the regulatory effect of technologies as a tool to protect the moral community” (Nelson, 2010, p.182). To go one step further, I point to value-driven anthropocentric design as a potential route for improving upon the interconnective dynamics between technological development and “the moral community”, an optimistic take on the Anthropocene and arguably the only way forward in designing for sustainability transitions.

Conclusion

With the advancement and proliferation of biometric technologies and the pervasiveness of the Internet of Things, disinvolvement of humans in a movement from the Anthropocene to the Technocene becomes more feasible. The question of why designers should bother to integrate humans into the process becomes ever more poignant. Yet given technological developments’ intersection with the pressure for sustainability transitions, how

technology relates to sustainability likewise becomes more poignant. Anthropocentric design, the focus on humans in the process, is important because technology and humans are inseparable, and because conscientious engagement with technology is a means for humans to co-develop, co-learn, and ultimately exercise a form of design deliberation that can represent social values. This research identifies four phases of interactive design: pilot design, automation, overshoot, and balance. These phases give some idea of the pushing and pushing back in the scripting, appropriation, and re-design of socio-technological systems. Like the continuous unfolding of dialectics towards the truth, codevelopment of humans, technologies, and their embedded meanings unfold over time in a dynamic process.

This is not to say that technocentric design will not continue to trend anyway, but I argue for the importance of anthropocentricism and conscientiousness in design. The reformation of society during sustainability transitions is far from preordained, and these processes should be undergone democratically. Arguably -- a perspective stretching as far back as the Brundtland Report -- it is not sustainable development if it is not inclusive; and that inclusivity refers also to the relationship between humans and their systems. Although the built environment is an excellent representation of the interchanges and integration between people and technologies, the findings concerning technological design are more broadly applicable, such as IT systems or industrial design. Research into interactive design would benefit from further investigation, for example into the nature of synthesized, fused networks and their ability to model social values, as well as research into the communicative potential of biometric technologies in sustainability as a social movement. In particular these findings could be built upon with a deeper look into how designers use social information. Further, given the ontological approach herein, such research can offer more comprehensive insight when paired with quantitative research. Ultimately our ability to learn about ourselves improves our designs, but it also can improve the theories and frameworks shaping design for sustainability.

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APPENDIX A: Interview Guide

General

What do you do? In relation to...(projects, daylight, communications, etc.)?

Active House

What stands out to you as the most defining feature of the Active House approach?

What is your relationship to the Active House Alliance?

Demonstrations

What is your involvement in the demonstration projects?

Have you been inside one of the demonstration buildings? If so, what was your experience like?

What do you think is the purpose of the demonstrations?

How do you regard the effect of the demonstrations on...

- the government?
- other building stakeholders, i.e. constructors, architecture firms?
- the general public?

Qualities

What are the most important qualities in a building to you? (Explore those that come up, even if not connected to daylight or comfort)

What does daylight in a building mean to you?

How do you think this daylight experience might be reflected in measurements?

What does comfort in a building mean to you?

How do you think this comfort experience might be reflected in measurements?

What have been your learning experiences in working with these concepts in the AH specifications, and what does this imply for possible changes in the future?

Who else should I talk to about this?

Clarifying questions:

- Can you expand a little on this?
- Can you tell me anything else?
- Can you give me some examples?

APPENDIX B: List of Sources

Primary

Semi-structured interviews

- 30 anonymous interviews
 - 6 in Denmark
 - 7 in Germany
 - 9 in Belgium
 - 8 in Austria
- Professions: architecture, engineering, building science, policy making, sociology
- 60-90 minutes each
- Audio-recorded, transcribed, and checked
- Transcriptions fact-checked with interviewees
- Audio files paired with transcriptions and loaded into software for coding

Research stays

- VELUX headquarters in Hørsholm, Denmark
- Two stays of 3 months each
- March – June 2014 and May – July 2015
- First stay desk in project room, and second stay within department office
- Attended department project and strategy meetings
- Attended department and company events
- Maintained observational notes in journal, saved as memos in software

Event participation

- Four main events: Passive House 2014 Exhibition in Brussels; Northern Germany Passive House Conference in Neumünster; Bauz! 2015 Vienna Congress for Sustainable Building; Active House Guidelines workshop in Brussels
- Accompanied by one or more interviewees
- German conference introduction recorded, transcribed, and translated

- Active House Guidelines workshop general discussion and environmental aspect breakout recorded and transcribed
- Notes taken at all events
- Other noteworthy events include the 2015 6th VELUX Daylight Symposium in London and the 2016 2nd Healthy Buildings Day in Brussels

Secondary

Documents and Books

Served as sources for organizational development, standards, and projects. This list is partial.

- Active House Specifications v.1
- Active House Specifications v.2
- Active House Guidelines
- Circadian House: Principles and guidelines for healthy homes
- VELUX Model Home 2020: The buildings of tomorrow. Today. (Brochure)
- VELUX Healthy Homes Barometer 2015
- VELUX Healthy Homes Barometer 2016
- VELUX Group Daylight and Architecture Magazine (D/A) 2013-2016
- Edwards, B. W., and Naboni, E. (2013). *Green Buildings Pay: Design, Productivity, and Ecology*. 3rd ed, London, UK: Routledge.
- Sustainia. (2012). *Buildings: Exploring the sustainable buildings of tomorrow*. Morten Jastrup and Marie Drique (Eds.). Copenhagen, DK: Sustainia Sector Guide.
- Henn, R. L., and Hoffman, A. J. (Eds.) (2013). *Constructing Green: The Social Structures of Sustainability*. Cambridge, MA: MIT Press.

Internal Documents

These are not public documents and are here for reference only. Details are confidential.

- The VELUX Customer Journey Map 2014
- VELUX Strategy 2014
- VELUX Strategy 2015
- Grontmij evaluation of VELUX demonstration projects

News Publications

Articles read on housing development, sustainable building design, urban sustainability, sensor technologies, building management systems, life-hacking, and more. This list is partial.

- *The New York Times*
 - Ex. “The Monitored Man” (http://well.blogs.nytimes.com/2014/03/10/the-monitored-man/?_php=true&_type=blogs&ref=science&_r=1), “The Stormy Politics of Building”
http://www.nytimes.com/2013/10/23/opinion/international/the-stormy-politics-of-building.html?hp&_r=0, “Design Thinking for Media that Matters” (<http://open.blogs.nytimes.com/2016/08/05/design-thinking-for-media-that-matters/?ref=technology>)
- *The Guardian*
 - Ex. “A new calculator aims to make business sustainability choices simpler” (<https://www.theguardian.com/sustainable-business/2015/may/15/coclear-greenhouse-gas-emissions-climate-change>), “When did houses stop being homes?” (https://www.theguardian.com/lifeandstyle/2015/jun/07/when-did-houses-stop-being-homes-eva-wiseman?CMP=fb_gu), “Is sustainability the new total quality management?” (<https://www.theguardian.com/sustainable-business/sustainability-with-john-elkington/sustainability-new-total-quality-management>)
- *Politiken*
 - “Rum stresser os – eller det modsatte” (“Space stresses us – or the opposite”) (<http://politiken.dk/magasinet/feature/premium/ECE2477707/rum-stresser-os---eller-det-modsatte/>)
- *The Journal of the American Institute of Architects*
 - “Three Ways Neuroscience Can Inform and Improve Architecture” (http://www.architectmagazine.com/technology/three-ways-neuroscience-can-inform-and-improve-architecture_o)
- *Building*
 - “The True Cost of Sustainable Homes” (<http://www.building.co.uk/analysis/features/true-cost-of-sustainable-homes/5074632.article?origin=facebook#>)
- *Forbes*

- “Google’s Nest Will Track You Closely To Make Its Thermostat More Efficient”
(<http://www.forbes.com/sites/aarontilley/2014/11/04/googles-nest-will-track-you-closely-to-make-its-thermostat-more-efficient/#3189f78f7361>)
- *National Geographic*
 - “The Race to Save Architecture in Myanmar’s Biggest City”
(http://news.nationalgeographic.com/news/2014/11/141112-myanmar-burma-yangon-rangoon-heritage-architecture/?utm_source=Facebook&utm_medium=Social&utm_content=link_fb20141112news-myanmar&utm_campaign=Content&sf5734965=1)
- *Building Green*
 - “Are FSC and LEED Killing American Jobs? A Look at the Evidence”
(<https://www.buildinggreen.com/news-article/are-fsc-and-leed-killing-american-jobs-look-evidence>)
- *Foreign Policy*
 - “Big Data: A Short History” (<http://foreignpolicy.com/2012/10/08/big-data-a-short-history/>)
- *The Times of India*
 - “Tech inter-operability standards vital for smart cities”
(<http://timesofindia.indiatimes.com/city/ahmedabad/Tech-inter-operability-standards-vital-for-smart-cities/articleshow/47373590.cms>)

TITLER I PH.D.SERIEN:

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Internet-based Electronic Marketplaces and Supply Chain Management
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A Philosophical Investigation*
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En systemteoretisk analyse af moderniseringen af et amtskommunalt sundhedsvæsen 1980-2000*
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A product development strategy that is based on online communities and allows some firms to benefit from a distributed process of innovation by consumers*
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