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Abstract

Studies of the appropriation of technologies in everyday life show that user activities are critical to success or failure of innovation and diffusion. This text explores strategies of technology designers to deal with user agency presenting the results of an empirical study of architects and engineers working in the design of energy efficient buildings.

These experts advocate different roads to more energy efficiency, but they agree when it comes to the diagnosis that there is a problem with users. Two groups of architects and engineers with different professional self-conception and assumptions about the nature of the 'user problem' are distinguished. One tries to black-box actively non-technical aspects of their work, such as users and their agency, while another one is willing to engage with non-technicalities, but does not know how.

The paper shows that different representations of what users are and do are closely connected with conceptions of the expert's role and with technological choices. It also affects how successful interdisciplinary collaboration is imagined.

The text concludes presenting resulting options for user research from the social sciences to intervene productively in technology design.

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Introduction

More energy efficient design of basic building services like heating, lighting and ventilation is technically possible. Still, diffusion rates in this area are unexpectedly low. Given profitable reduction of operation costs, an ever-growing political interest in reduced dependency from fossil energy carriers, and other undeniable environmental benefits, there is no obvious reason why adoption of these technologies should happen as slowly as it does. Consequently, this 'energy efficiency paradox' prompted a search for what interferes with the successful implementation. Since the 1980s, political scientists, economists, psychologists, engineers, architects, sociologists, and even a few anthropologists have been searching for these barriers and ways to remove them. Not surprisingly they all identify hindrances in their respective field of study: policies, markets, the technology, attitudes, cultural practices, and behavior. When I – in my function as student of science and technology with a particular interest in technology use – started to work with the problem, I did something similar: I tried to identify barriers related to users. I first collected together with my colleagues what the social sciences know about energy use (Aune, Berker, and Sørensen 2002), which is not much. As expert on users, I understood non-diffusion of the technology as problem of usability. Users reject otherwise sound innovations, when they are badly designed. During technology design users are mainly present as representations created by the designers. So, I decided to study these user representations, following in the footsteps of Woolgar (1991) and Akrich (1995), in order to find out what goes wrong there. Conducting my empirical research, however, I discovered that representations of what users are and do cannot be separated from more general patterns, which additionally establish relations between the designer and the technology and between different groups of experts. Thus, the study of the role of users in technology design served as catalyst revealing more fundamental problems than just individual obstacles, which can be removed more or less easily.

Among the many extensions of scope, which Science and Technology Studies have undergone since their beginnings, extending the focus of study from laboratories and experts to the tinkering lay persons' agency has proven to be one of the most fruitful ones. It challenged fundamental analytic and descriptive categories like the distinction between production and consumption and linear models of innovation and diffusion. We know today that without the acknowledgment of the users' agency, accounts of how and why technologies become what they are remain incomplete.

In the next section I will briefly recapitulate the story of the discovery of user agency's role and elaborate on the consequences for the study of use und design of technologies. This sets the stage for the following empirical exploration of user representations in the design of energy efficient buildings and their context. The goal here is twofold: to develop user research within STS, but also to show how this kind of user research can contribute to the fostering of technological innovation and diffusion.

The Discovery of User Agency and Its Consequences

Shortly after World War II for the first time objections were voiced against simplistic assumptions about how media technology's agency influences the audience. Then, Paul Lazarsfeld and his colleagues (Lazarsfeld, Gaudet, and Berelson 1948) established that being exposed to (political) discussions – namely under presence of opinion leaders – is much more relevant to the explanation of how mass media influence voter's decision-making than these media themselves. Hence, the assumption of an one-way relation from media to audience was rejected, and the context of the use-act became object of study.

In terms of theory, the critique of simplistic one-way models was and still is one important point of departure for much of media studies. Stuart Hall's "encoding decoding" (Hall 1992) – first circulated in 1973 – which systematically includes the audience's ability to negotiate or reject what media and its technology does to them, inspired a new generation of research focussing on the active appropriation of media contents and its embedding into the recipients' context. Relying heavily on this tradition, but also referring to other sources of inspiration, such as E.P. Thompson's study of 'moral economies' in late 17^{th} Century England (Thompson 1971; Thompson 1991) and the sociology of everyday life (Lefebvre 1971; Schütz and Luckmann 1974), during the 1990s a group of scholars explored the domestic sphere as such a context into which technologies are 'domesticated' (Silverstone and Hirsch 1992; Lie and Sørensen 1996). They put 'consumer-users' at the centre of their conception of the relation between production/design and consumption/use.

By relating usage to consumption and to the domestic sphere, individual use-acts – the object of quantitative audience-studies – are reconnected to the user being not only user, but also consumer and household member. Domestication describes production and consumption as tied together in a system, in which domestic consumption on the one hand and the economic activities of production on the other transact. The technological artefact – belonging to the objective economy of capitalism and to public discourse – is crossing the border of the household and is transformed there according to the household's 'moral economy'. These activities, which begin with the actual acquisition of the artefact, are conceptualised as 'dimensions of consumption' (Silverstone and Haddon 1996, 63-65), which transcend the immediate content of the use-act.

These and similar efforts drawing on feminist theory and semiotics (see Pinch and Oudshoorn 2003 for an overview) and usability research (Norman and Draper 1986; Nielsen

1993) made a new kind of user research possible, which is sensitive to user activities and their context. The interest in what happens with an artefact after it has left the factory yielded new insights not only into technology use, but also into technological innovation and diffusion. It offers explanations for why users may be completely unpredictable in their use of an artefact: they may draw upon cultural resources only available to themselves and unknown to the designers of the artefact and the observer. Obstructing or circumventing the designers' intentions is not necessarily can cause problems, but it also can 'correct' wrong design in those cases when designers have no idea or erroneous assumptions about what users need or want.

This kind of active users comes in as many guises as there are cultural and social resources users have at their disposal. Some groups are in fact to co-designers, for instance the tinkering hobbyist whose crucial role was for instance described for the early history of the radio (Douglas 1986). Early adopters have generally a good chance to influence technology design directly, because the early phase of the marketing of an innovation is accompanied by frequent design adaptations (Hippel 1988). A close relation between design/er and use/r or when both roles are even united in one person, has a very productive potential as the success of the Internet has shown most recently. There, many of the services now used by millions were originally designed by users to achieve their own ends (Castells 2001). The opposite case is conflict between what designers 'inscribe' into the technology as proper use (Akrich 1992) and the users' 'anti-programs' (Latour 1992). This conflict may take the shape of designers frustrated about obstructive users (Hatling and Sørensen 1998) resulting in misunderstandings or open conflict. In these cases partial or complete failure of innovations is a likely outcome.

If the artefact is continuously shaped in function and meaning after it leaves the work bench, technological innovation can obviously be obstructed or supported by user agency (Rohracher 2003). On a more general note, this critique of linear models of innovation is maybe the most momentous insight gained from user studies in STS. Both, close relations between designers and users, and open conflict on the other, are extreme cases. Technology design involves usually very little personal contact between users and designers and both do not know much about each others' intentions and actions. Moreover, linear models are not only wrong because co-design happens in the use of the artefact, but also because there are always already notions of what users are and do present in the design phase.

The co-production of users, designers, and technology

Woolgar's (1991) and Akrich's research (1995) shows that and how users are present already in the design phase: as representation. In Woolgar's (1991) case study, users are actually present in persona during usability trials, which are taking place in the laboratory. He observes that these trials are not methods used to understand user needs and actions which eventually results in (more) user-friendly design. Instead, he describes the efforts to do the opposite, to adapt the test-users to the technology. Akrich (1995) encounters besides explicit methods of user representation, like user testing, surveys, and market research, a broad range of implicit methods by which designers come to assumptions about use/r/s: interaction with expert-users and user-experts, comparison with similar products, which are already on the market, and above all the referral to the designer's own use experiences. Thus, designers are users as well as users are designers. Akrich concludes that there is a low degree of coordination between heterogeneous sets of explicit and implicit methods, which often leads to contradictory outcomes and problems in the implementation. In this scenario the farce described by Woolgar could also be an expression of the designers' efforts to maintain a certain user representation, which was established using other explicit or implicit methods.

Akrich and Woolgar show how use and users are present during the design phase. However, the importance of processes where knowledge about a group is created, which does not (yet) exist, should neither be over- nor underestimated. Claiming that these representations are devices to shape the user through the technology forget the lessons learned from explorations into the inconspicuous power of user agency. Acknowledgement of this power, however, does not need to result in voluntarism. As Oudshoorn (et al. 2004) demonstrate, it is important to distinguish which kind of freedom for whom it is that gets inscribed in artefacts.

Here, I want to suggest a way which allows us to escape the need to lean either towards voluntarism or determinism. I show that and how user representations in technology design are not only about users and what they will be able to do with the artefact, but that they are part of a more fundamental co-production of the relation between user, designer, and technology. Ultimately, this means the deconstruction of *the* user as an entity, which is conceived as more or less powerful in relation to *the* designer or *the* technology.

This approach boroughs part of its inspiration from media studies. In the late 1980s a couple of scholars started to critically review media study's turn to ethnographic inquiries into the audience's everyday (see Alasuutari 1999, for an introduction). They questioned naïve notions of '*the* audience' and its 'resistance', instead they referred to audiences as constructions which are part of larger discourses about media and society (e.g. Grossberg 1988).

The same can be applied to technologies and their users. Most deliberations about designers and users and their mutual relation let one thing untouched: That there is such a thing as *the* users, which then either can unfold unforeseen powers of co-design or will be influenced by options inscribed into the artefacts. When we cease to presuppose to know where the line between users and designers lies, then only notions remain of what users and designers and technologies are and do, and what they should be and do. Neither the design of the technology, nor how use (and thus what an user is and does) is inscribed into the technology, or the users' appropriation of the technology, or the designer's self-conceptions can be analysed and understood independently. These aspects are mutually dependent, they are co-produced (Jasanoff 2004).

This co-production of design/er, use/r and technology is explored in the empirical study which will presented now.

The Smartbuild project

It is one consequence of some 20 years of standard research's failure to overcome the so-called energy efficiency paradox, that alternative approaches are sought. One of these is the Smartbuild project at the Norwegian University of Science and Technology (NTNU) and the largest Norwegian research institution SINTEF. In this project, about 20 scholars from architecture, engineering, and social sciences work together in order to find ways to construct and implement 'smart energy efficient buildings'. The acknowledgement of the fact that there is a problem with use/r/s is reflected through a strong commitment to user research within this project. Besides this research on "user needs, environmental criteria, facilities management, and implementation", three other approaches are present in the project.

First, there are project members working on 'building integrated design processes'. These question traditional approaches, which they claim to have

> "a mainly linear structure due to the successive contributions of the members of the design team. There is a limited possibility of optimization during the traditional process, while optimization in the later stages of the process is often troublesome or even impossible." (IEA 2002, 11)

Instead, it is suggested to gather all experts involved in the building process – mainly engineers and architects – at an early stage of the project. This is assumed to lead through synergy effects to a better overall performance and reduced operating costs. Such a collaboration across different disciplines and stages of the building process requires new levels of standardization and new tools, which are mainly sought in computer supported collaboration.

In the second approach present in the project, a group of engineers is working with 'continuous commissioning' (CC^{SM}). Again, a traditional way of doing things is blamed to diminish energy efficiency: Usually, commissioning is happening once at the beginning of a building's life cycle, when its performance is tested and if necessary mended to reach the expected specifications. To do this continuously becomes possible through the introduction of computer-based real-time measurement and control. Its implementation is typically thought as process, in which especially trained CC^{SM} engineers develop a detailed plan, which then is executed by CC^{SM} technicians (see below and DOE 2002, 2-12, for a more detailed account of the process).

Within and besides these two overarching approaches the Smartbuild project comprises research on virtually every aspect of building technology. There is for instance a group working on a new kind of heat pump, which is based on CO_2 as carrier, which has more efficient physical characteristics than its water or air based relatives. Others seek in a similar manner to optimise the in-door environment, solar panels, energy storage, and the use of daylight. Although these efforts are located in all parts of the project, they represent logically a third approach to the improvement of energy efficiency: the improvement of individual technologies.

All these approaches complement each other in theory. The main aim in 'building integrated design' is the improvement of the actual design and building process, whereas 'continuous commissioning' seeks to enhance energy performance in existing buildings. Advanced individual technologies ideally can be employed within both approaches. Nonetheless, discussions within the project revealed more fundamental differences, which afflicted the collaboration from its early beginnings. Above all, there is an opposition between those who tend to favour more 'natural', less machine-based solutions, often concerned with a sensible design of the building envelope, and those in favour of efficient machines, who are more interested in installations. Advocates of 'continuous commissioning' tend to endorse the latter view, while those working with 'building integrated design' are inclined to stress the importance of avoiding the need for "high performance systems" (IEA02, 11) through thoughtful design and the utilisation of natural resources like sun, climate or draught. A similar opposition can be found among the experts working with the improvement of individual technologies. Some of these, like for instance the CO_2 heat pump, are more similar to 'high performance systems', whereas for instance the more intelligent use of daylight is mainly connected to basic characteristics of the building envelope.

As member of the project's work package "User needs, environmental requirements and strategies for the implementation", my main responsibilities are users and implementation. In 2003 I interviewed 13 architects and engineers working in the project about their conception of and experiences with users of energy efficient buildings. Methodologically speaking, these interviews are expert interviews with narrative elements. The thematic interview guide comprised questions about the interviewees' background, their own use experiences, their experiences and attitudes concerning users, and finally their reasoning about possible measures to overcome the 'energy efficiency paradox'. Earlier versions of this paper were distributed within the project and discussed during a workshop at the end of 2003. The majority of architects had some kind of technical background mainly from building engineering. A common element in all interviewees' professional careers was the interest in research but only two had no recent experiences in practical work in the building industry.

The interviews were complemented with observations gained in two years of active participation in workshops, seminars, and conferences addressing the 'energy efficiency paradox' and ways to overcome it in the building sector.

The "User Problem"

Who are users according to the informants? Most interviewees equalled users with end-users. Here, the prevalent concern is about the degree of control over the building environment. To give end-users too much control over their surroundings was seen as problematic. Stories told here were for instance about end-users switching on the light in the morning when it is still dark and forgetting to switch it off later. Other interviewees expected that end-users would start 'war' if they would get too much control over their environment, because of their diverse individual needs. Some interviewees stated that users do not want too much control since they are easily confused by too many options. One of the interviewees lived herself in an energy efficient test building. Her assessment of this experience was that 'normal' people would not be able and willing to use this house correctly:

> "But it needs committed occupants. ... And I don't think there are many others that think that this is so interesting to deal with it as I do. I have to think, is it going to be much sun today, should I open the windows before I go, or ... Maybe I have to switch on ...? That is one of the cases where I am convinced that we need intelligent – but also comprehensible – control systems." (Kari) [1]

Another interviewee argued in a similar way with the complexity of certain technologies, assuming that simplicity is a deciding factor:

> "[With water based heat pumps] you are on the verge of what a normal person would accept. Most people are very satisfied with their electric space heaters[2]. Those you can switch on and off ... They are satisfied with it, when it doesn't work, you know what to do, you can repair it yourself." (Mikael)

These representations of end-users as not interested in energy efficiency and discouraged by to much complexity lead in all cases to a call for automatic controls that manage ventilation, light, and heating according to technically defined and optimized in- and output specifications.

Despite this call for technical control, though, it was appreciated that the complete exclusion of users cannot be achieved, both for technical and non-technical reasons. A typical *non-technical* argument was used by an engineer, when she said: "... some kind of control over your immediate surroundings is a human right" (Mari). Or it is taken as self-explanatory frame: "The end-user obviously has to be satisfied." (Mikael) *Technical* reasons were mostly connected to passive or active resistance of end-users – be it based on their lack of motivation or on legitimate needs. End-users were also seen as resource, as an architect said, "it is important to listen to users, because they have suggestions and they have expectations" (Lise). Therefore, in most of the cases a balance between automatic and individual control was suggested. This was concretized as "automatic, which has an user override" (Håkon) or as limited user controls because "sometimes it is sufficient to have three choices" (Lise).

In a scenario where automatic control is managing at least basic settings, facilities operation has an important role – every interviewee agreed on this. Facilities managers, technicians, janitors, and cleaning personnel are responsible for daily maintenance as well as for cyclic routine inspections and small repairs. This group's composition, however, is particularly heterogeneous, above all when it comes to the level of technical skills. One interviewee pointed to that, when he said that Trondheim's municipal workers responsible for the maintenance of public buildings partly were recruited from retrained ship engineers and former tram conductors. This poses problems for the representation of this kind of user. The maintenance personnel need not only technical skills – that "they have to understand what happens when they push a button" (Mari), as one interviewee put it – but also social skills. This group is the first contact-point, when end-users utter needs or when something goes wrong. One interviewee said that these user interventions are often ignored by the service staff: "More freedom for end-users, when they can control more, it can of course mean more work for janitors" (Anna). Losses of energy efficiency or inappropriate environmental parameters within the building can be the result. Thus, the service staff in its daily work has the demanding task to mediate between technology and user needs. This important and powerful position has often been overlooked in research. Here all interviewees agree.

Besides these descriptions of end-users and facilities management teams there was also a generic definition of users, which was present in almost every interview: users are those who are present – meaning constantly present – at the building. In turn, we can conclude that the expert is defined as someone who is *not* permanently present at the building. The spatial aspect of this 'presence' is obvious: usually the expert moves on to a new building exactly in the moment, when the ready-made one is taken into use. However, as we have seen above all in the description of end-users, presence is linked additionally to different degrees of competence. The apparent inability of users when it comes to controlling their indoor environment results in the call for automatic, machine-based control. With other words, the competent expert, who is not present at all times *delegates* control to machines, which are continuously present. This is of course exactly Latour's (92) point made about the door-closer. Far-reaching control may be desirable from the point of view of the expert, yet it is in conflict with the potential agency of users, which might obstruct the machine or at least lessen its efficiency. This means that the users' agency is acknowledged, resulting in the plea for as much individual control as necessary and as much automatic control as possible. The particular 'smartness' of this balance is expected to marry the non-efficient behaviour of users with the universal efficiency of the experts and their machines.

Here, the maintenance staff comes into the picture. They are present in the building, which makes it possible for them to exert control in lieu of the expert. According to the experts, they shall become bearer of the rationality of energy efficiency, which explains the unequivocal call for their new valorisation. However, janitors are not fully accepted as being true mediators between locally situated presence and universal rationality. They might lack the competence or they might try to avoid too much work. The result is the call for more and better education and more professionalism to transform them into 'real' experts.

I have used the notion of delegation, which is a well-known mechanism for the student of science and technology. Following the programme outlined in the beginning, I will follow this trail, but try to find out why experts think of user agency in terms of a technical problem.

Downey and Lucena (1995) introduce their handbook article on the study of what engineers do and know, with the statement that the position of engineering as located at the boundary of science is one of their most interesting traits.[3] There have been repeated attempts to locate engineering on one of both sides of the boundary. As *applied* science it is local application *and* universal science at the same time. However, the remaining question, is whether engineering generates and represents a distinct kind of knowledge or whether it is 'just' application of knowledge created somewhere else. Edwin Layton, one of the pioneers of engineering studies and an engineer himself, argued against the latter option. According to Layton's 'interactive model' of technology (1971) engineering is dealing with a distinct kind of knowledge, since it refers to technology, which he describes as 'mirror image twin' of science. In order to get rid of the reputation of being 'just' application of science, Layton and his followers stressed the universal, intersubjective, and cognitive aspects of engineering. In doing so they sketched an image of engineering practice which matches very well the implicit self-portrait of architects and engineers as it was presented in the previous section. Mikael Hård (1994) shows in a study of closure in the design of the Diesel engine how universal knowledge, common practices, and global orientations on the one hand and local networks, local habitus, and local practices on the other, are present in engineering work. He concludes that on the level of abstract design goals the degree of global similarity of engineering solutions is higher than on the level of resulting designs. Similarly, there is no doubt among the architects and engineers interviewed here that – theoretically – they have the knowledge at their disposal, which enables them to build energy efficient buildings – wherever and in whichever context these buildings will be located. The specific local conditions are not seen as problem, as long as they are measurable and controllable from a remote position. Energy efficiency – the global design goal – belongs to the universal world of the expert, whereas the local agency of those 'present at the building' is conceived as its opponent. User agency, besides other local conditions, introduces non-measurable and non-universal elements, hence a 'user-problem' emerges.

Engineering Heterogeneity or Engineering Technology?

As we have seen, limiting this problematic user agency through delegation of control to those machines or individuals, who are present, was the preferred option within the interviews. The basic logic that user activity necessarily diminishes energy efficiency was common among all interviewees. If we, however, have a closer look at the reasoning about *why* this is so, we encounter two different accounts. This begins with the evaluation of user agency. One group of interviewees described contact and communication with users (end-users, maintenance teams) as difficult and as something which one would preferably avoid. These experts rather wanted like to 'outsource' this – like other non-technical tasks, such as political or educational intervention. A second group of experts said that users are the actual goal of their engineering. A common statement here was that they would like to become better themselves in communicating with users and other non-technical aspects of their work. As one architect said:

> "I think it is very important that consultants in design get a role as an advocate, psychologist, teacher for the user. [It is important] that one is ready to supervise users or that one is critical towards what they come with. [...] That is the most interesting, professionally but also personally: trying to understand the user, or to understand the essence, which often is hidden... ." (Lars)

The definition of the expert's role in this statement differed fundamentally from accounts encountered in the first group. There the expert's responsibility was defined purely technical. This has its institutional equivalent in the case of one interviewee whose job it is to develop a certain component of CO_2 heat pumps. The implementation of the pump as a working whole is done in another work group at his department. Consequently, this interviewee's dominant interest in users was: "users are those, who decide not to have heat pumps in the building" (Ingmar). The actual users are were institutionally outside of his focus.

A topic brought up in every interview was about the lack of knowledge. Univocally a general lack of knowledge was stated for every group involved – colleagues, end-users, constructors, building owners, and facilities operators. Again, however, there was a division into two different groups: some interviewees saw it as responsibility of pedagogical experts to improve this situation, whereas others said that pedagogy is something they have and want to become better in themselves.

These differences between two groups of experts were not mentioned explicitly within the interviews, even though they describe two clearly distinct approaches. Instead, there was a lot of reasoning about the problems of *interdisciplinary* collaboration. This was even characterized by the project's leader as being the most important part of the project. The interviewees offered more often explanations for why interdisciplinary collaboration is so problematic than proposals to overcome these problems. The most common element within these accounts of failing interdisciplinary collaboration was about professional cultures. One interviewee said that already in his first years at university teachers had made fun about other (above all neighboring) disciplines. Another interviewee stressed that in her private life contacts with other engineers prevail and that even in her family a substantial amount of engineers can be encountered. Similarly another engineer told me that he is 3^{rd} generation engineer.

No interviewee claimed that these boundaries between the disciplines should be defended – quite the opposite. The interdisciplinary nature of the Smartbuild project acts as a filter, preferring those who already have experience in interdisciplinary work, or who at least do not rule out its overall possibility. Thus, it is not surprising that every interviewee called for transgression of interdisciplinary boundaries, for the sake of more energy efficiency. However, again there were differences in how this transgression was imagined. Within one group of experts the idea was more often present that coming together in informal situations ('with beer and pizza' as the engineer Jan depicted it), i.e. outside the professional work, can foster mutual understanding. Besides informal contacts, these experts wanted to have clearly defined roles.

In one interview I was addressed directly as the sociologist, who is involved in the project: "We need something from you which we can work with, which is oriented at what we, what engineers do" (Jan). Interdisciplinary collaboration then is seen as division of labor with good informal mutual understanding ('pizza and beer') and clearly defined 'interfaces'. But this perspective was not shared by all interviewees. The second group of experts was explicitly concerned with professional interdisciplinary collaboration as such and wants to learn more about it, in order to become better able to collaborate. One exemplary situation here was described by an interviewee:

> "For instance at Dragvoll it was very interesting when we measured lighting conditions in offices at the atrium, and there many offices had more than enough daylight. It was sufficient, but those who were there did not mean that. They had a different understanding whether it was daylight or something else, right? Because, when you are at the atrium as they are, there [they think that] you don't have daylight. We had ugly problems with definitions, there it was nice to discuss with [collaborating sociologists]." (Kari)

In this quote sociologists are described as experts, who are able to provide knowledge, which is necessary to come to reliable outcomes. Kari clearly accepts that end-users' notions about daylight – even though they might be 'wrong' in a technical sense – are relevant for these outcomes. Stories like this one were completely absent in the accounts of experts from the other group.

As we have seen, users of all kinds are seen as unreliable when it comes to energy efficiency. Now I have introduced a differentiation. There are engineers and architects, who strived to black-box those aspects of their work, which are non-technical or less tightly connected to their technical expertise – at least as far as this is possible. This is similar to how Vincenti (1990), referring to Layton and others, described 'what engineers know'. He acknowledged that a non-technical context is influencing engineering, however, he conceived this as restricted to design stages *outside* the actual engineering, for instance when the overall goals of the design are set, before the engineering begins. In a next step, in this group of experts as well as in Vincenti's account, the context got actively black-boxed and defined as other people's problem. What engineers know about the *use* of the technical 'artifices' does not appear at all in Vincenti's study.

The second group of engineers and architects differed in these respects considerably. They were more or less comfortable with being 'engineer-sociologists' (Law and Callon 1988, 284), who master both the technical as well as the non-technical aspects of technological design. This kind of engineering, which was also described as 'heterogeneous engineering' (Law 1986) is aware of the technical and non-technical content of every kind of technological design. In this account, engineering practice is always already situated and the marvel of engineering success is seen in the establishment of heterogeneous networks, which can reach out over long distances ordering humans and non-humans and even space itself (Law and Hetherington 2000).

Applied to the rather non-spectacular worlds of the design of ventilation and heating, this kind of engineering appeared less heroic. The experts interviewed here were far from describing themselves as mastering of heterogeneities. They were rather doubtful concerning their ability to do what they were not trained in and tried to catch up on their self-imposed curriculum. Here worlds can collide, like in Kuhn's (1998) study of engineering students who, after they had become aware of social aspects of engineering, complained about the twofold burden, of becoming a good engineer *and* a good social scientist.

Technological Choices: Active and Passive Black-Boxing of User Agency

The two groups with different user representations, which were distinguished in the previous section, correspond to the two main technological approaches present in the project, which were described briefly above. 'Continuous commissioning' (CC^{SM}) and 'building integrated design' treat end-users differently.

In the beginning of a CC^{SM} process, "any problem in the building, such as thermal comfort, indoor air quality, moisture, mildew" (DOE 2002, 4) is assessed. Comfort and air quality clearly allude to end-user experiences. However, in a second step an "experienced engineer should review this information and determine the potential of the CC^{SM} process to improve comfort and reduce energy cost." (DOE 2002, 4) The engineer's control over the definition of what quality and comfort mean is also expressed in the complete absence of end-user contact within the process. The methods suggested are consultations with the building owner and the assessment of comfort problems by the engineers themselves – "quantified using hand-held meters or portable data loggers." (DOE 2002, 6) It is stressed several times, however, that the other user group – facilities management teams – is crucial to the success of a CC^{SM} process. Above all the importance of training is stressed, but also the usefulness of achieving commitment, to get the "buy-in and approval" (DOE 2002, 9) Still, local technicians are seen as 'dubious delegates' (see above), which becomes particularly clear when the steps to be taken after the actual CC^{SM} process is finished are described:

> "The CC^{SM} engineer should provide follow-up phone consultation to the operating staff as needed, supplemented by site visits. This will allow the operating staff to make wise decisions and maintain the savings and comfort in years to come. If long term measured data are available, the CC^{SM} engineers should review the energy data quarterly to evaluate the need for a site visit. If the building energy consumption has increased, the CC^{SM} engineers determine possible reasons and verify with facility operating staff. Once the problem(s) is identified, the CC^{SM} engineer should visit the site, develop measures to restore the building performance, and supervise the facility staff in implementing the measures. If the CC^{SM} engineer can remotely log into the EMCS (Energy Management Control System, TB) system, the CC^{SM} engineer can check the existing system operation quarterly using the EMCS system." (DOE 2002, 11)

According to this quote, the engineer has two functions. He or she is intervening in cases, when 'problems' occur, i.e. when the automatic controls which are operated by local staff, fail. Second, there is the task of continuous monitoring of the system's performance and its potential tuning. Again, in both activities end-users are not directly involved, and local staff is only useful as complement, helping through 'verifying' the actual measurement, but not through being endowed with autonomous agency.

Like 'continuous commissioning', 'building integrated design' is from its outset very concerned with the occupants' comfort, for instance when the various problems of conventional, non-integrated approaches are listed: "Occupants may be exposed to severe discomfort, due to excessive local overheating in West-facing spaces or glare in areas without adequate shading." (IEA 2002, 12) However, there is far-reaching absence of end-users' notions of comfort and discomfort again. This is, however, less conspicuous than in CC$^{SM.}$ After all, in the design phase there is often no knowledge about who the actual occupants will be.

Consequently, the focus lies on "[i]nter-disciplinary work between architects, engineers, costing specialists, operations people ..." (IEA 2002, 13). This lists continues with a rest category "other relevant actors", which may also comprise end-users, depending on the definition of 'relevant'. The interviews with members of the Smartbuild project working with 'building integrated design' express clearly that they think of end-users as relevant, arguing against some of their colleagues who claim that user inclusion would make things too complicated. Yet, those experts who want to integrate end-users and 'operations people' into the 'integrated design process' are not supported by the methodology. There, three groups are constantly and explicitly addressed: the client, architect, and engineers. To get them to work together in new more integrated ways is considered to be complicated and arduous enough.

These choices of which path to follow leading to more energy efficiency correspond with the two types of user representations which were distinguished above. One group avoids contact with end-users relying on intermediaries, such as local facility managers and/or quantified data. With 'continuous commissioning' they rely on computer guided systems of measurement and control, which constantly adapt environmental parameters to the building's conditions. Even if, in advanced variants, intelligence is built into the machine, which then can react on user-actions learning what occupants want – the final goal is replacement of user agency: the machine should act. In 'building integrated design', advocated by the second group, the particular smartness of the technology is not any longer exclusively defined by measurable efficiency as outcome, but also by the process which leads to it. 'Building integrated design' leaves more room for user agency mainly through its far-reaching silence on this matter. It is tacitly assumed that a really well designed building serves its occupants so well in a fundamental way, that they do not want to change anything. Thus, eventually, user agency is liekly to get lost again. This outcome could be called passive black-boxing of user agency in analogy of the active black-boxing practiced within the other group.

Options for Social Science User Research

As we have seen, the most fundamental user representation defines users as problem because of their recalcitrant agency. Complete delegation of control to machines – the eradication of user agency – is not feasible; therefore other delegates have to be found. Unfortunately, all candidates appear to be dubious. It is at this point that the approach forks. One group of experts black-boxes actively the 'user problem', declaring it to be other peoples' problem, whereas the other group seeks to include non-technicalities into their work; they only appear somewhat stranded in how to accomplish this extra task. Thus, for both groups user agency in the wild is 'problematic', yet for different reasons.

The empirical material presented here proofs that the concern for user agency and how it relates to technology and the designers' inscribed intentions is present in the design activity itself. The interviewees acknowledge that users are co-designers of the technology, and they try to deal with this 'problem'. Their efforts to define what users are and should be allowed to do are strongly related to how they define what they themselves are and do, what they want the technology to be and do, and how the design should be done. To find 'smart' answers to these questions, social scientists were drawn into the Smartbuild project.

But what can the social sciences actually contribute here?

A first set of possible contributions seeks to contain the unreliability and unpredictability of user agency, so that it can become manageable. An option to achieve this would be to advise engineers and architects that users have to be involved in methodologically clearly defined ways at a limited number of occasions within the design process. User centred design as it was for instance practiced by Garrety and Badham (2004) does exactly that: it imports methods and experts on user agency from the outside, which then – in spatially and temporally bounded situations – inject some user agency into the design process. The authors themselves question whether and to which degree these interventions reach outside these limited occasions.

A second and much more common way to bound user agency through social science user research is to define a limited array of typical user groups. Typologies of use/r/s reintroduce at least some of the complexity, which is hidden behind the umbrella-term '*the* users'. It reminds the experts that there are many different users in different social and cultural settings doing many different things. But typologies and taxonomies always also simplify complexity, promising to establish control and predictability: 'Type A focuses on value X, behaves typically in way Y and should therefore addressed through measure Z, while types B, C, and D have to be treated in a different way, and so on.'

These limited forms of user participation in design and explicit design for different empirically established user groups bring about progress towards more realistic treatment of user agency in design. The appreciation of *some* user agency and *some* complexity among users is the price those interested in black-boxing use/r/s have to pay to keep user agency at bay.

Yet, opening the black box of user agency in technology design could also mean more than these bounded openings. It could allow the unpredictability and unreliability of forces external to the 'engineer's knowledge' to enter the design process, which then in turn becomes open-ended, insecure, unbound, and heterogeneous. This threatens the status of experts and disciplinary boundaries, particularly in the case of those experts, who seek to black-box user agency actively. Like in Marianne de Laet's and Annemarie Mol's (2000) account of a 'fluid technology' the engineer of these open processes is very different from what we encountered in the interviews. He or she considers the technology never as 'complete' or finished. Instead, it is constantly in flux being worked at by all kinds of people. This is good news, after all, for those experts who are willing to engage with users and other non-technicalities not knowing how to achieve this. Through the active opening of the process to a participation of users, which is not contained in methodologies, not only agency is distributed more broadly, but also the responsibility for the outcome. How much energy efficiency is possible then is not any longer defined solely technically and by the technologists' technical and social skills, but is the result of all parties' actions.

One engineer said in the interview that his greatest hope for the Smartbuild project would be "that we dare, that we think ambitiously, that we do not accept [when someone says:] 'that is not possible'" (Håvard). He is talking about reaching new levels of energy efficiency. To engage in design processes, which distribute agency and responsibility in new ways, looks like an exciting challenge to me.

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[1] The interviews were conducted in Norwegian and translated by me. Names were replaced by pseudonyms.

[2] Electric space heaters are the most common heating devices in Norway.

[3] The professional status of architects is interesting in another yet related respect. They are working at another boundary, the one between art and engineering (Ryghaug 2003). Since all but two architects in-

volved in this study have an additional background from engineering, this aspect is not touched upon here.