Energy consultants calculating sustainability for residential buildings

Introduction

The building sector accounts for approximately 40% of worldwide energy consumption (unep.org, 2015), and Norway's energy consumption in the building sector closely maps onto this average, with approximately 40% of national energy use. The building sector is defined, both globally (Janda and Parag, 2013; Shove and Walker, 2007) and locally (Aune, 2007; Solli and Ryghaug, 2014), as one of the most promising sectors for energy use mitigation. The challenge of reducing energy use in buildings has been approached by means of a wide range of policy measures. For instance, increased political attention towards the built environment and its relationship to climate change has resulted in regulatory measures in the form of stricter building codes and mandatory energy labeling of dwellings (Directives 2002/91/EU and 2010/31/EU).

Still, policymakers face a number of challenges in attempting to facilitate efficient measures. One such challenge relates to upgrading existing buildings (Vlasova and Gram-Hanssen, 2014). Renovation of existing buildings poses a particular challenge for policies, as it is not subject to regulation in the same way as new construction. In Norway, as many as 90% of dwellings are owned by the dwellers, themselves; the majority of these houses are detached and semi-detached. There are approximately 2.2 million houses that fall within this category (Enova, 2012), and renovation is often conducted by the homeowners, themselves, or by small contractors and builders. Taken as a whole, these houses comprise a complex mass of buildings and actors that is difficult for the government to reach.

This situation can be described as a certain *distance* – between the offices governing energy transition and the houses subject to this governance – that needs to be bridged (Fyhn, Solli and Søraa, forthcoming). Government representatives do not visit the houses, themselves; rather, they depend on intermediaries and systems for control. Recently, they have taken steps to engage actors who are already involved in home renovation, such as contractors, builders and craftspeople, by facilitating a more active role for these professionals as energy consultants. In order to enable efficient policies, the government has introduced new digital tools designed to support energy consultants and enhance the set of existing measures. How have such tools been designed? And how does their supporting role work in practice? This paper approaches these questions through a close examination of a specific tool – an energy calculator. Energy-calculators are used in a variety of countries when assessing energy-performance of buildings, and the calculation itself differ, partly based on the method on how house data is collected (Wang, Yan & Xia: 2012). Energy moduling programs has been critizised by Boyer et al. (1998) to be too profession oriented, and they suggest a multiple-model approach of building systems.

This paper investigates the Norwegian energy caclulator by drawing on data from qualitative, semi-structured interviews with both users and producers of an energy calculator that was commissioned by the Norwegian Energy Authorities to measure the energy efficiency of buildings. The tool, which is colloquially referred to as the "energy calculator," was developed for Enova, a public enterprise owned by the Ministry of Petroleum and Energy. Enova was established in 2001 in order to drive the changeover to more environmentally friendly consumption and energy generation in Norway. Enova's measures include full renovation support and support for energy saving measures, such as the implementation of heat pumps, solar energy utilization and balanced ventilation, as well as monetary support for energy consultation and renovation. Further, Enova, in collaboration with the building industry represented by "The Low-Energy Program," set up a course to educate and certify energy consultants. The certified energy consultants are meant to visit homeowners and thoroughly review their buildings in order to suggest concrete measures for increasing energy efficiency. In this work, they are required to use Enova's energy calculator to measure energy efficiency. The search for more efficient ways to reduce energy use can benefit from an assessment of how current policy measures are working in practice. Without grasping the way such tools and measures work and how they connect into larger assemblages, it is difficult to understand the way in which large transitions – such as a radical downsize in energy use – happen or fail to happen, in practice. This paper contributes to our understanding of this transition by investigating the way in which energy consultants use the energy calculator to measure sustainability in the built environment. Despite having a localized focus, the green shift is also globally most promising in the building sector, which is why this article could serve as inspiration for other countries implementing or planning to implement similar calculators and audit practises.

A tool for sustainable transitions

This article analyses the implementation of an energy calculator, drawing on the analytical strands of sustainable transition and domestication theory. Sustainable transition research focuses on the way in which societies adapt to the problems caused by climate change by transitioning to a more energy friendly society (Shove and Walker, 2007; Smith et al., 2005; Tukker and Butter, 2007). This article focuses on the role of sustainable transition actors who are implementing sustainable transition policies in literally a "hands on" manner. Monetary subsidies are a central tool in the implementation of energy efficiency policy, and they are also used actively in single projects. Åm (2015) and Jørgensen (2012) define niches in sustainable transitions as protected spheres in which certain technologies can "take bloom" before they are released on the wider market. Niches created through economic incentives are relevant to the focus of this article: energy consulting is dependent, in part, on protection from market forces through the monetary subsidies provided by policies. Scrutiny of both the design and the practical use of tools such as the energy calculator can produce knowledge about the nature and effect of seemingly modest entities and technologies. Historical and social scientific analyses of academic and bureaucratic practices have, for example, shown that tables, reports and surveys function as "little tools of knowledge" (Becker and Clark, 2001)). This may imply that tools shape practices and that bureaucratic or political technologies may influence or execute control (Callon, 2002) and potentially shape decision makers (Asdal, 2004). This paper investigates *the way in which users of sustainable transition tools make sense of and evaluate* the energy calculator as a tool that could potentially enable sustainable transitions.

Thus, as an analytical resource in this paper, sustainable transitions serve a general role, partly demarcating the field and object of research. Domestication theory, in contrast, provides specific concepts for the task of making sense of and evaluating the energy calculator. The domestication perspective underlines the significance of investigating what users do with new technologies, tools and knowledge. When a tool is domesticated, it is transformed from an unknown element to an aspect of social and cultural practice. This process has *practical*, *symbolic* and *cognitive* aspects (Lie and Sørensen, 1996; Sørensen et al., 2000; Berker et al., 2006; Aune, 2007). The practical aspect concerns users' actual physical manipulation of the material object or technology in question; the symbolic dimension focuses on the meaning that users put into the technology – what it symbolizes for them; and the cognitive aspect focuses on users' learning of the technology. An important feature of the domestication perspective lies in the opportunity to describe how something is *not* successfully domesticated (Sørensen, 2006). This paper asks whether the energy consultants domesticate the energy calculator tool, and, if so, how they do so. Another model that could have been used to understand the implementaion of technology is the "Technology Acceptance Model "and its later extensions (Venkatesh and Davis, 2000), but as this study focuses on a sociotechnical multifaceted usage of the tool, domestication theory was chosen as the main analytical theory.

To strengthen the analysis, a partial approach is adopted, providing accounts from the implementers and designers of the energy calculator. For this purpose, the concept of "script" is used; here, script refers to the user guidelines that are written into or inscribed in an object (Ackrich, 1992; Ainamo and Pantzar, 1999; Wilhite, 2013), based on the designers' beliefs and assessments of the end user. The concept of script is also used to focus on designers' attempts to control a technology's usage through its design. This is not necessarily straightforward, since the process of domestication described above involves finding new ways of using an object that were not originally intended by its creators. Aune and colleagues (2008) see the enrolment of different actors in the building process as key to the transition to a more energy efficient building sector. Although their article focuses on building operators, this article adds craftspeople engagement as an important element in the transition. In this paper we ask: What do designers expect from the use of the tool, and how do they describe its script? Is the tool domesticated by its users, and, if so, how? And how are the users included in the design and implementation process? From this, the paper investigates the tool's ability to contribute to sustainable transitions.

Method

We investigated the topic through qualitative, semi-structured interviews with actors involved in both making and using the energy calculator. A qualitative approach was chosen in order to present the energy calculator tool technology as a case study, and qualitative interviews are well suited for this purpose (McCracken, 1988; Rubin and Rubin, 2011; Seale et al., 2004). On the producer side, Enova ordered the calculator; the Norwegian Water Resources and Energy Directorate (NVE), owned by the Norwegian Ministry of Petroleum and Energy, developed the tool; and EVRY, Norway's largest IT company, developed it. Two employees from Enova were interviewed in person, for 70 minutes. These interviews were conducted, based on experiences from three previous in depth interviews with representatives from Enova, made by one of the authors in a previous project in 2012/13. These interviews also focused on energy refurbishment, but were conducted before the calculator was fully introduced (Fyhn and Baron 2017). Telephone interviews were conducted with an employee from NVE and an employee from EVRY, both key in the development of the calculator. These interviews lasted for 35-45 minutes, with follow-up questions emailed for clarification later on. All of these interviews were conducted in autumn 2015.

On the user side, 19 interviews were conducted with Enova-certified energy consultants in Norway. Seven of the energy consultants were interviewed in person in spring 2015, with the interviews lasting around one hour, conducted with an interview guide. Whilst the majority, five, of these consultants had a background in craftsmanship (primarily carpentry), three engineering and one had architectural backgrounds (some had dual backgrounds). A year and a half later, twelve interviews were done over telephone, in autumn 2016. The telephone interviews were conducted after the in-person interviews, and helped to confirm topics that emerged in the face-to-face interview round.

All interviews (n =22) were later transcribed verbatim, and as they had been conducted in Norwegian, they were translated to English by the authors. For a closer observation of the way in which policy activities aimed at energy use reduction were played out in practice, one of the authors participated in a course for energy consultants arranged by Enova. The authors also conducted tests of the energy calculator, as the tool is available for public use. In fact, when selling a house in Norway, one must use the energy calculator to energy mark the house.

A script for sustainable transitions

Energy marking a house requires a visit to Enova's website. On Enova.no's "Tool" page, one can find the energy mark calculator, with the following information:

> *Energy mark calculator: Give me an A! A green one. In our Energy mark calculator you can check what you can do to improve the energy mark for your dwelling […] The Energy mark calculator does not require logging in, or pre-knowledge, and gives you useful knowledge on energy renovation.*

When a user clicks the link to the energy calculator, he or she is redirected to the main page of the energy calculator. This page describes the energy mark of a building in Norway as a point that results from two values: energy efficiency (represented by a letter) and the share of delivered energy produced from fossil or green energy sources (represented by a colour). The page provides a choice between two modes of registration: (1) simple; and (2) detailed. (In this study, these are referred to as the "simple" and "advanced" calculators, respectively.) The choice is supported by the following information: "(1) Easy registration: It is based on standard values and has few choices. (2) Detailed registration: It is more comprehensive, but requires the registration of additions, changes, and actions taken for the building." Further, the page explains how everyone selling a building in Norway must calculate the building's energy mark. It also states that it is illegal for sellers to report an incorrect energy mark when selling, and that violation of this law can prompt prosecution.

In order to register an energy mark, a person must access Norway's "My ID-web," which is the log-in portal for public services for Norwegian citizens. The site provides information on taxes, student loans, moving and so forth, as well as energy marking a dwelling. It is emphasized that logging in is only required for energy marking a building. The information on this site is aimed at the homeowner. For the expert, there are two additional modes, beyond the "simple" and "advanced" described above: (3) experts can adjust the input data directly, in the form of calculation data, in order to represent the building as accurately as possible; or (4) they can import an XML file from an external calculation. In data provided by EVRY (as of 20 October 2015), the percentage of use of these four modes of registration, to nearest hundred, was:

[Insert table 3 here]

The simple method was utilized much more often than the other methods. This is probably due to the fact that methods (3) and (4) are only available to experts, and, along with (2), are used for providing energy advice for renovation projects. Method (1) – and to some extent (2) – can be used by homeowners who simply need an energy mark; for instance, when selling their building. Energy consultants use the more advanced versions as they are much more precise. The large number of simple mode users is likely due to the fact that everyone who sells a house must use the method to calculate the house's energy level. Because commercial buildings and all new dwellings must be marked by an expert, utilization of modes (2), (3) and (4) will necessarily increase in the future. The next section will analyze the calculator input more closely.

Calculator input and output

The image below shows the simple (1) mode to the left and the advanced mode (2) to the right (translated to English for this article). To use the simple mode, one must provide input data on several building categories: type, year, construction material, floor space, number of floors, basement type, heating source, ventilation and types of heating and ventilation. After these parameters are filled in (which only takes a few minutes if one has the information to hand), a summary is provided, resulting in an energy mark and information on how the energy mark can be improved.

[Insert table 1 and 2 here]

In the advanced mode, the input data is considerably more complex. In addition to requiring mode (1)'s general data, mode (2) goes into more depth, asking users to provide various details for different categories as the table shows. Each of these categories includes many sub-categories, for which users must provide further detail.

How did the calculator designers intend the tool to be used? From the information described, one can get a sense of what the designers expected, of both the way in which users would use the tool and what the calculator would produce: what is inscribed in the calculator as a tool and technology. When interviewing Enova about the intention behind the calculator, they responded: "It's really meant both for experts and for those homeowners with a little bit of knowledge." However, this "little bit of knowledge" seems rather extensive, and as demonstrated by the numbers above, the vast majority of users chose the simple calculation mode. However, as all commercial buildings and new dwellings must be energy marked, it might be interesting to see what incentives are provided (or not) to encourage advanced registration. When a person is building a new structure, he or she should know the numbers required by the advanced mode fairly well; but do such persons choose the simple or advanced registration mode? One of the input issues described to us by an architect energy consultant was that users were not required to enter the building's insulation *type* – only the insulation *thickness* (interview energy consultant January 15):

> *Choosing a material that is good for the environment is not rewarded, neither are you punished for choosing a bad one. For example, polyurea foam develops hydrogen cyanide gas when burning, but your score in the calculator is the same. You stand there dressed in a moon suit and foam the house, but the brochure says it's environmentally friendly and not dangerous.*

The energy consultant suggested that the calculator should include a warning when "bad" materials are used, but it does not currently do this. By not separating between different qualities of insulation, the calculator hides potentially relevan information form view. This creates a form of uncertainty, which is also described by Solli (2013), wherein building engineers must make ethical choices due to a lack of information and regulation. When all input data is processed, the energy calculator gives an output in the form of an energy report. This report states where the building falls on the energy mark scale, as indicated by a letter from A (best) to G (worst) vertically, and a colour from green (best) to red (worst) horizontally, as shown on the figure below:

[Insert figure 1 here]

Both the simple and advanced calculator modes lead to general advice on improving energy use in the building. Advice is given on actions that will affect the energy mark, such as insulating walls (such advice could be provided following the simple or advanced mode) or changing a leaky front door (such advice would only be given following the advanced mode). Advice is also provided on actions that will *not* affect the energy mark, such as using less energy and turning off lights. The advice is dependent on the data that is input (e.g. advice relating to changing a leaky front door would only be displayed if data had been input to indicate that an old door is present that could thus be improved). On energimerking.no, users can read about potential next steps:

> *Discuss the actions with a craftsperson or energy consultant [...] Let the output of the energy calculator be part of a thought process towards rehabilitation of the dwelling [...] Maybe some of the actions awakened your interest? It will always be most profitable if you already want to do something with the house. We recommend that you discuss options with a specialist who sees the actual cost and saving possibilities.*

While this recommendation takes into account that householders may have other reasons for renovation than energy efficiency, and thus encourage them to consider energy upgrading in combination with other works being done, it could also be read as somewhat passive or subdued, presenting it as a "thought process" that could "maybe" lead to action. On the professional side, the calculator generates the same report, but as the data required is normally much more extensive, the energy consultant typically has much more precise insight into the building to determine what can be done to upgrade its energy efficiency.

Domesticating energy calculators

Technological innovation can be described in the language of a push/pull (Chidamber and Kon, 1994; Horbach et al., 2012; Zmud, 1984), emphasizing the way in which technologies are imposed on the users (by "force") or requested by them in some way. Although this dichotomy is likely too simplistic to describe actual innovation processes, it is relatively clear that, in our case, a "push" tendency can be seen, as the energy calculator is a tool that working professionals in the building sector must adhere to in order to engage in (lawful) business. The central question, then, is: How do energy calculator users utilize the tool in their daily work life? In other words, how is the energy calculator *domesticated*?

In the previous section, the script and intended use of the energy calculator were described. During practical energy consulting sessions, use of the technology does not necessarily follow the script; rather, the calculator can be used for unintended purposes and thereby transformed. Aune and colleagues (2008) argue that energy efficiency is not primarily dependent on technical solutions; rather, the fulfilment of these technical solutions' potential when implemented in a building is of primary importance. Taking a closer look at the *practical* dimension of the domestication of the energy calculator, one can find that the tool is used in ways that differ from its original intention, as suggested by the quote from this energy consultant (interview energy consultant December 2014):

> *Where it is possible to write comments, I always write that I have deviated from the program because "this and that," so that one afterwards can see how I have thought. I think that is quite nice.*

This illustrates that some users engaged in constructive dialogue with the technology, bypassing the difficulties that were put upon them. This kind of bypassing proved to be quite common, as houses often did not match the pre-defined categories provided by the calculator. However, it did make for some "educated guesses" by the energy consultants, that did not know how much freedom was allowed in the calculator, and it was also more time consuming to write down a lot of comments. Much of these categorical misfits pertained to the shape of the building (interview energy consultant January 2015):

> *It is not possible to get it 100% right […] It is difficult to include extra space without having problems with the total space. It* [the calculator] *keeps calculating the total space […] It is very difficult, as you only have a few standard figures to use, and in a typical house built in the '80s there are a lot of extensions […] which are very difficult to include, and then you have to cheat when describing the with and length to get the total area right.*

On enova.no, users can read about the challenges of strange building components:

> *How can I energy mark my crow-castle (a big old house with many extensions, nooks and carneys) when it's put together by different parts with different standards? With detailed registration it is possible to get a long way with detailed information, putting in different standards on walls, etc. Many deviations from unitary constructions mean longer registration time. The most complex buildings will get the most accurate registrations by an expert. Experts have the opportunity to register in other ways, including using their own expert tools.*

In their study of consulting engineers, Hojem and Lagesen (2011) found that "the doing of environmental concerns predominantly was considered a very practical question." This doing was primarily the enforcement of climate policy regulations in action, similar to what the energy consultants were doing in this study. The attitude among many craftspeople towards the calculator was one of disapproval, but acceptance, as many of our interviewees told us "we have to use it if we want energy consultant jobs". In addition to contributing to the tool's practical dimension, the domestication of the tool also pertained to the way in which the users understood it – its *symbolic* dimension. It became quite clear during the interviews that the calculator was seen as a symbol of a "rule from above" that took little notice of how "the boys on the ground" had to relate to the technology.

Several reported an observation of a general shift towards more paperwork and bureaucracy, of which the calculator was seen as an agent. Whilst carpentry has traditionally been a very practical profession, the computerized world of numbers comprised an interesting and new field of focus. Many of the informants – especially the older craftspeople – described having difficulty with the increasingly digital work tasks. This was especially true for mandatory digital tasks such as reporting, for which the computer was the only possible tool. Tales of older craftspeople resigning from a profession that had turned to digital bureaucracy were not uncommon. Some companies had chosen to hire their own "computer specialist" to handle all of the documentation demands that had arisen. These findings are similar to those of Aune and Bye (2005), wherein building operators were "feeling more like office workers." This finding was also emphasized by Søraa (forthcoming), who discussed the phenomenon of craftspeople blurring the line between traditional blue-collar work of manual labour and white-collar document office handling work, thus creating a new form of green-collar workers, i.e. working hands-on with energy related problems.

Hojem and Lagesen (2011) found that legal codes and regulations seem to be the most effective instruments for shaping the environmental practices of consulting engineers. Looking at the *cognitive* dimension of the energy consultants' domestication of the energy calculator technology, the authors observed novel ways of thinking about energy and buildings and the emergence of new skills. This can be seen, for example, in an interview with an energy consultant, when asked if he would have preferred a different system (interview energy consultant January 2015):

> *No, there are really not that many ways to do that. I think Enova have come up with a decent solution. Maybe they should have provided a "general" category as well, where you can check off that you have to deviate, and describe why you've digressed. For it does not match the landscape, we can't fit it in. You must feel free to do some experimenting on you own.*

The user here expresses a desire for greater flexibility in the program, as he thinks that it lacks a "general" category. The world of the calculator and the world of the energy consultants – or the world of numbers and the world of materiality – did not always translate perfectly. As the users became familiar with the program, many told us that some "tweaking" was necessary to fit the material world they had traditionally worked in to this new world of the digital calculator. By doing so, some learned new ways of using the calculator.

One of the more tech-savvy energy consultants interviewed told us that he had developed several "mini programs" that he used to get input data for the energy calculator. These mini programs provided features that he felt the program was lacking, so he had made them himself. This might have given the energy consultant an advantage in the competitive landscape and might explain why he had not fed his criticism back to Enova: if the necessary technology was not provided by the producer, he could develop and use it himself and thus gain an advantage over those who were unable to access such technology. Sharing these innovative ways of dealing with problems could potentially benefit the larger community of energy consultants, but, at that time, suggestions for improvements do not seem to have been taken into consideration.

Designed without user enrolment

Good computer programs are dependent on user involvement in the development process (Olson, 1984; Pagana and Brügge, 2013). This is both to ensure that customers get what they pay for and to minimize the development of unnecessary bad user interfaces. A piece of commercial software requires customers who will buy and use the program, and explicit knowledge of the target consumer group is vital for successfully developing the software. However, during interviews with NVE, it became clear that the target customer group was never obvious. When designing the energy calculator, NVE did not target energy consultants as the primary user group. This led the developers to refer to normal homeowners as "the users," and they assumed that the calculator was primarily designed for this group. During the interviews, it was necessary to clarify what was meant by "the energy calculator," as it apparently meant different things to different actors (interview NVE October 2015):

> *To us, the calculator is the one you can use without logging in, where you can play around with the system. That is the calculator. The calculator that we are referring to, it exists for playing around with the energy mark – see which energy mark you get by choosing different measures. If you are talking about the kind of calculator that energy consultants say they want, then we have misunderstood each other.*

The relationship between the energy calculator used for "playing around" and the one used for creating an energy label was cleared up later in the interview:

> *Computationally, they are identical, they use the same background data, it's just that you do not log in, and then you cannot save a certificate. But, you can take data registrations over into the energy label system. You must, however, log in, and then you can create a certificate from it. [...] You get a code that you can take care of in order to find the data you have registered.*

The intentions that were scripted into the energy calculator by the programmers do not seem to target energy consultants; rather they target a user who wants to "play around" with the energy mark. How did this affect consultants' use of the tool? In the case of the energy calculator, neither the layperson nor the expert users seem to have been included in the design process. As the programmers told us: "No, we have not seen that Enova spoke to any craftspeople when they made the calculator in an interview"; "There has been no testing of users, and we have not been doing inquiries on user responses either" (interview EVRY October 2015).

Without performing user tests, how can developers know if their program is being used as intended or if a user group has any problems with it? Some of the problems reported with the calculator and deviations from its intended use (as described in the previous section) can be seen to have resulted from the omission of professional users from the development process. When asked why there had not been any user testing prior to the program's release, this answer was given:

> *I guess it's something you should do when you develop that kind of thing, but we actually had no money and time here at that time [...] Enova had some kind of milestone, they were to present the energy marking on a TV program, I think it was on the* Consumer Inspectors.

Ironically, it seems that Enova needed to produce the calculator quickly in order to reach a deadline to take part in a popular TV program, *Forbrukerinspektørene* [Consumer Inspectors], which highlights consumer-related issues. However, whilst the users were not included in the initial design phase, their experiences could be included in further development of the calculator. Some of the challenges that the energy consultants faced in using and domesticating the calculator seem to be problems that the programmers could fix without too much effort. Energy consultants who use the calculator are encouraged to leave user feedback. The feedback from energy consultants goes straight to Enova and can then be sent onwards to NVE and the programmers. According to the programmers, though, very little feedback reached them.

It seems, from our data, that the governmental actors did not consider the calculator to be something that should be improved. An employee from NVE told us: "After all, that is how it is built. It will take a lot to change it." This static view of the calculator also seems to be by poor communication within the network. Whilst some energy consultants might have desired certain changes in the calculator, they had to send their feedback to Enova, who had to then send it on to NVE, who had to then send it on to EVRY for eventual implementation. Somewhere along this network, requests seemed to get lost. NVE were quite firm in their claim that "the program was made that way"; that is, that the program would be difficult to change. Whether or not the program was actually difficult to change is unclear, as the programmers would be the ones to make any changes, in practice. In this specific situation, perhaps a direct link between "user" and "maker" would limit the frustration over program bugs and missing parts, but the flow of information has to be routed through the automatic passage points of Enova and NVE.

There seems to have been a mismatch between what the programmers perceived as easy fixes and what the developers believed would be too much trouble to fix. Taking the extra effort to include expert user feedback could benefit the transition to a more sustainable building sector. This is evident from the detailed descriptions in our interviews of the program being too cumbersome; in the informants' view, the program should be fixed by (for example) incorporating easier ways of navigating registration when having to recalculate or "lacking opportunities for categorizing different types/bodies of buildings." The accounts illustrate both the practical and the cognitive dimensions of domestication that were not built into the design process.

Playing the calculator?

The energy calculator is intended as a government tool for enhancing energy efficiency in existing homes. The tool is supposed to support homeowners and energy consultants visiting homes in documenting energy efficiency and suggesting optimal solutions. It was designed as a tool between the 2.2 million homes needing renovation and the government. This article has shown how these intentions are affected by differences between the script of the calculator and the way the calculator is used and domesticated by energy consultants. There is a striking lack of connection between the domestication and script due to a lack of user involvement in the design process and a lack of consideration of user feedback. Thus, the potential for social learning in a broad sense is not being exploited by the designers. The lack of user testing and effective feedback implies that, for the user, potential influence is limited to domestication rather than further development or real co-production of the tool for sustainable transitions. With the political goal of creating a static reporting tool, something was lost in translation, when it came down to the actual users. As the tool has gone through several stages of development, the dynamic nature of the hands on usage of it does not seem to have been included up to its potential.

The analysis of the energy calculator domestication illustrates that many users do not adhere to the expectations that are written into the technology's script. The energy calculator developers claimed that they expected the users to "play around with it" like a game. However, many of the advanced users – the energy consultants – did not want to be part of this game, and instead made practical adaptations to get their job done. Interestingly, these users took the intentions behind the calculator in new directions and potentially contributed to transforming these original intentions, similar to the way in which the consulting engineers tackled uncertainty in the study conducted by Solli (2013).

Risholt and Berker (2013) point out that craftspeople could play an important role as mediators between available products and a specific building requiring renovation, but that, "today, due to a lack of knowledge and incentives, craftsmen are an important barrier to energy efficiency." The responsibility for this incentive barrier does not rest on craftspeople, alone. This article has shown that the incentive barrier has a crucial pressure point in the energy calculator, itself, as well as its design process, which hinders craftspeople working as energy consultants from performing their job most efficiently. The enrolment of craftspeople as users of the energy calculator could have proven fruitful earlier in the design process, but it might also be useful now, by reducing later frustration and making the transition to a greener and more environmentally friendly building sector more efficient. This could also serve as inspiration for international and intersectional actors seeking to implement similar tools of sustainability.

References

Ackrich, M. (1992), "The de-scription of technical objects", in Bijker, W. and Law, J. (Eds.), *Shaping Technology/Building Society*, pp. 205–224.

Ainamo, A. and Pantzar, M. (1999), "Design for the information society: the research paradigm", paper presented at the *Design Cultures: Semiannual European Academy of Design* Conference.

Asdal, K. (2004), "Politikkens teknologier. Produksjoner av regjerlig natur", *Acta Humaniora*, Unipub.

Aune, M. and Bye, R. (2005), "Buildings that learn–the role of building operators", *ECEEE 2005 Summer Study,* http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2005c/Panel_2/2115aune (Accessed 13. February 2017).

Aune, M. (2007), "Energy comes home", *Energy Policy*, Vol. 35 No. 11, pp. 5457–5465.

Aune, M., Berker, T., and Bye, R. (2008), "The missing link which was already there: building operators and energy management in non-residential buildings", *Facilities*, Vol. 27 No. 1/2, pp. 44-55.

Becker, P. and Clark, W. (2001), *Little tools of knowledge: Historical essays on academic and bureaucratic practices*, University of Michigan Press.

Berker, T., Hartmann M., Punie, Y. and Ward, K. (2006) (Eds.), *Domestication of Media and Technology.* Maidenhead: Open University Press.

Boyer, H., Garde, F. Catina, J.C. and Brau, J. (1998) "A multimodel approach to building thermal simulation for design and research purposes" *Energy and Buildings* Vol 28 No 1, pp. 71-78.

Callon, M. (2002), Writing and (Re)writing Devices as Tools for Managing Complexity. I J. Law & A. Mol (Eds..), *Complexities – social studies of knowledge practices,* pp. 191-217). Durham: Duke University Press.

Chidamber, S.R. and Kon, H.B. (1994), "A research retrospective of innovation inception and success: the technology–push, demand–pull question", *International Journal of Technology Management*, Vol. 9 No. 1, pp. 94–112.

.Directive 2002/91/EU of the European parliament and the council on the energy performance of buildings (2003) *European Union Directives*.

Directive 2010/31/EU of the European parliament and the council on the energy performance of buildings (2010) *European Union Directives*.

Enova (2012), *Potensial- og barrierestudie: Energieffektivisering i norsk bygg*, Report, 2012:0.1.

Fyhn, H. and Baron, N. (2017), "The Nature of Decision Making in the Practice of Dwelling: A Practice Theoretical Approach to Understanding Maintenance and Retrofitting of Homes in the Context of Climate Change", *Society & Natural Resources,* Vol. 30. No 5, pp 555- 568.

Fyhn, H., Solli, J. and Søraa, R.A. (forthcoming), "Framing and reframing energy retrofitting by builders, homeowners and energy policies", submitted to *Energy Research & Social Science*.

Hojem, T.S.M. and Lagesen, V.A. (2011), "Doing environmental concerns in consulting engineering", *Engineering Studies*, Vol. 3 No. 2, pp. 123–143.

Horbach, J., Rammer, C. and Rennings, K. (2012), "Determinants of eco-innovations by type of environmental impact—the role of regulatory push/pull, technology push and market pull", *Ecological Economics*, Vol. 78, pp. 112–122.

Janda, K.B. and Parag, Y. (2013), "A middle-out approach for improving energy performance in buildings", *Building Research & Information*, Vol. 41 No. 1, pp. 39–50.

Jørgensen, U. (2012), "Mapping and navigating transitions—the multi-level perspective compared with arenas of development", *Research Policy*, Vol. 41 No. 6, pp. 996–1010.

Lie, M., and Sørensen, K. H. (1996). *Making technology our own?: domesticating technology into everyday life,* Scandinavian University Press Oslo.

McCracken, G. (1988), *The Long Interview* (Vol. 13), SAGE.

Olson, M.H. (1984), "User involvement and MIS success: a review of research", *Management Science.*

Pagana D. and Brügge, B. (2013), "User involvement in software evolution practice: a case study", *Software Engineering* (ICSE).

Risholt, B. and Berker, T. (2013), "Success for energy efficient renovation of dwellings—learning from private homeowners", *Energy Policy*, Vol. 61, pp. 1022–1030.

Rubin, H.J. and Rubin, I.S. (2011), *Qualitative Interviewing: The Art of Hearing Data*, SAGE.

Seale, C., Gobo, G., Gubrium, J.F. and Silverman, D. (2004), *Qualitative Research Practice*, SAGE.

Shove, E. and Walker, G. (2007), "CAUTION! Transitions ahead: politics, practice, and sustainable transition management", *Environment and Planning A*, Vol. 39 No. 4, pp. 763–770.

Smith, A., Stirling, A. and Berkhout, F. (2005), "The governance of sustainable socio-technical transitions", *Research Policy*, Vol. 34 No. 10, pp. 1491–1510.

Solli, J. (2013), "Navigating standards–constituting engineering practices–how do engineers in consulting environments deal with standards?", *Engineering Studies*, Vol. 5 No. 3, pp. 199–215.

Solli, J. and Ryghaug, M. (2014), "Assembling climate knowledge. The role of local expertise", *Nordic Journal of Science and Technology*, Vol. 2 No. 2, pp. 18–28.

Søraa, R.A. (forthcoming), "Becoming green-collar workers: practices of craftspeople working as energy consultants", submitted to *Craft Research*.

Sørensen, K. H., Aune, M. and Hatling, M. (2000), "Against Linearity: On the Cultural Appropriation of Science and Technology", in Dierkes, M. and Von Groete, C. (Eds.), *Between Understanding and Trust*, pp. 237–257. Amsterdam: Harwood academic publishers.

Sørensen, K. H. (2006), "Domestication: The enactment of technology", in T. Berker, M. Hartmann, Y. Punie and K. Ward (Eds..), *Domestication of Media and Technology*, pp. 40–61. Maidenhead: Open University Press.

Tukker, A. and Butter, M. (2007), "Governance of sustainable transitions: about the 4 (0) ways to change the world", *Journal of Cleaner Production*, Vol. 15 No. 1, pp. 94–103.

unep.org (2015), United Nations Environment Programme (UNEP), http://www.unep.org/sbci/AboutSBCI/Background.asp (Accessed 03. October 2017).

Venkatesh, V., and Davis, F. D. (2000), "A theoretical extension of the technology acceptance model: Four longitudinal field studies", *Management science*, Vol. 46 No 2, pp 186-204.

Vlasova, L. and Gram-Hanssen, K. (2014), "Incorporating inhabitants' everyday practices into domestic retrofits", *Building Research & Information, Vol. 42* No 4, pp. 512-524.

Wang, S., Yan, C. & Xia, F. (2012), "Quantitative energy performance assessment methods for existing buildings" *Energy and Buildings*, Vol. 55, pp. 873-888.

Wilhite, H. (2013), "New perspectives on the theory and policies of reducing energy consumption", in *Routledge International Handbook of Social and Environmental Change*.

Zmud, R.W. (1984), "An examination of 'push-pull' theory applied to process innovation in knowledge work", *Management Science*, Vol. 30 No. 6, pp. 727–738.

Åm, H. (2015), "The sun also rises in Norway: solar scientists as transition actors", *Environmental Innovation and Societal Transitions*.