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A future challenge for energy savings?

Jensen, Jesper Ole; Gram-Hanssen, Kirsten; Røpke, Inge; Christensen, Toke Haunstrup

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Jesper Ole Jensen,
Danish Building Research Institute, Aalborg University
Dr. Neergardsvej 15
DK-2970 Hørsholm
joj@sbi.dk

Kirsten Gram-Hanssen,
Danish Building Research Institute, Aalborg University
Dr. Neergardsvej 15
DK-2970 Hørsholm
kgh@sbi.dk

Inge Røpke
Department of Management Engineering
Produktionstorvet, DTU – Building 424
DK- 2800 Kgs. Lyngby
ir@ipl.dtu.dk

Toke Haunstrup Christensen
Danish Building Research Institute, Aalborg University
Dr. Neergardsvej 15
DK-2970 Hørsholm
thc@sbi.dk

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Abstract

Increasing consumption of electricity due to a growing number of information and communication technology (ICT) appliances in households is a major challenge to reducing energy consumption. Several studies have predicted escalating ICT-related energy consumption, but relatively little has been said and done about possible initiatives to curb this increase.

This paper presents results of a research project focusing on how dynamics of consumption influence household energy consumption on ICT. Results of the project include scenarios on how electricity consumption on ICT is expected to grow, suggesting that in a few years on average ICT will make up half of household electricity consumption. Recent initiatives from various actors to prevent this development are presented and discussed, and difficulties in regulating this area, as compared to other parts of household electricity consumption are highlighted. Through presentation and discussion of qualitative interviews with families having extensive ICT use in their everyday lives, the interviews illustrate how users domesticate and use technologies in many different ways. The interviews reveal a variety of practices and dynamics in different aspects of everyday life, including sport, shopping, entertainment and different hobbies. The growing electricity consumption related to ICT is thus as dependent on the consumers' use and domestication of the technologies as on the energy efficiency of the appliances. By analysing the interviews with the use of theories of domestication of technologies, it is argued that aspects such as consumers' creativity in technology

use and their non-adaption are relevant aspects to include in policy and regulation discussions on how to limit the escalating electricity consumption from household ICT use.

Introduction

In recent years the amount of ICT in households has risen dramatically, and as a consequence we have also seen growing electricity consumption for these types of consumer electronics. Even though we know that ICT is having an important impact on energy consumption, there is still quite scarce knowledge on this aspect of households' electricity consumption. As stated by the British Energy Saving Trust: "To conclude, consumer electronics is the most under-represented sector in terms of data and information held. It is also the fastest moving sector which makes it very difficult to monitor and forecast. Priority should be given to improve the evidence and knowledge base, especially on consumer behaviour" (Owen, 2006). New knowledge is needed, as well as new policy and strategies to handle this growing challenge.

On the background of this insight a research project has been put together, which on the one hand focuses on the estimation of electricity consumption related to household ICT use and on the other hand focuses on understanding consumers' use of the technologies to give recommendations on how to regulate it. In this project we define ICT as including information and communications technologies (computers, laptops, monitors etc.), as well as consumer technologies (TVs, DVDs etc.). When estimating electricity consumption, electricity consumed directly in the home as well as energy used indirectly to maintain the communication channels and produce the hardware was investigated. For direct electricity consumption in the homes, the project built scenarios to quantify different possible futures of ICT-related electricity consumption in households. Questions have been raised, such as how future household electricity consumption can be influenced by further expansion in the number of ICT appliances and in the use of the ICTs, combined with more efficient ICTs. The study of consumers' use of ICT builds on qualitative studies with people who have extensive ICT use; people who can be seen as pioneers in the use of ICT and who can possibly indicate the directions ICT will take in the near future. The purpose of these qualitative interviews is firstly to give input to the quantitative scenarios of how electricity consumption related to ICT might expand, and secondly, and perhaps more importantly, to reveal how and why consumers adopt these technologies and the different ways in which it happens. Most efforts in policy and regulation of ICTs focus on the technologies and on how they can be made more efficient. One idea in this project is that knowledge of consumers' use and domestication of technologies has to be incorporated into the efforts to regulate the electricity consumption related to ICT use, and for this purpose knowledge revealed in the qualitative interviews is relevant. Finally as a last element in the project, main actors within policy issues have been invited to a workshop to discuss the results of the project and contribute their viewpoints on how to regulate, or in other ways prevent the escalating electricity consumption from ICTs.

The following sections of this paper first introduce the methodologies of the different parts of the project. They are followed by the results from the scenarios on how ICTs are expected to consume half of all electricity in households in the near future. The following section is an introduction to the kinds of policy instruments and initiatives that are currently in use or being discussed in relation to ICT and household electricity consumption. One of the conclusions here is that the main focus is on more efficient technologies. This discussion points towards the conclusion that consumers and their use of ICT are not really seen as part of either the problem or the solution. Taking this as a challenge, the rest of the article focuses on how different consumers use and domesticate technologies in very different ways. Theories of domestication are introduced and the qualitative interviews are analysed within this theoretical framework. The insights are used to point towards how, for instance, the creative or the resistant consumer has to be seen as part of a political regulation of household ICT use.

Methodology

The project consisted of four parallel parts:

- An extensive literature study to quantify the indirect energy required for households' use of ICT. This includes the energy consumption related to the manufacturing, transport and disposal of residential ICT appliances and the energy consumption related to the ICT infrastructure related to residential ICT application (Willum, 2008).
- Scenarios for households' ICT-related electricity consumption. This part is based on the forecast model "Elmodel Bolig" developed and owned by the Danish energy authorities and major energy suppliers. The model contains a large volume of data on households' use and ownership of energy-consuming appliances (including ICT) based on survey data combined with data on the energy efficiency of the products. On the basis of this model, it can be estimated how present household electricity consumption is used in different types of product. With input on

possible future ownership and patterns of use, the model can correspondingly estimate future electricity consumption.

- Qualitative interviews with ICT users: 14 in-depth interviews with ICT users. The interviews lasted from 1½ hours to 3 hours, and took place in the informants' homes. The informant's were aged between 25 and 75 years, and in three cases included their partners. Potential informants were asked to fill in a short questionnaire concerning their ICT use (we wanted people who were interested in ICT, but not people who were experts). The themes of the interviews were the use of different ICTs, and the practices related to them. Energy use was not a central issue, although informants were asked about their experiences and practices in relation to energy consumption and the ICT equipment.
- Workshops with relevant policy actors: A workshop on possible ways to reduce ICT-related energy use in households was held with representatives from different parts of the sector – producers, interest groups, policy makers, practitioners etc. Here, different themes were discussed: producer-consumer regulation, TV replacements, regulation of the indirect energy use for ICT and intelligent home control.

Scenarios

Purpose, method and assumptions

The purpose of these scenarios is not to predict the future, but rather to raise substantive debate about possible future developments – what is likely to happen if no action is taken? The scenarios are based on standard assumptions from Elmodel-bolig forecasting model, complemented by the project's own assumptions on growth in use and ownership of PCs and TVs in the coming eight years compared to the previous seven years. When comparing the present with the previous years and when predicting the future development, the total number of households and the mean size of households are taken into account. An increasing number of households only consist of one person, meaning that even with a steady population we will see a growth in the number of households, and this is also part of the explanation for the growing number of ICTs. However, in the scenarios we have not taken account of how the international financial situation will influence consumer behaviour. There are two scenarios, a low and a high, for the year 2015, with different assumptions in number and use of TVs and PCs respectively. Assumptions related to ownership and use of technologies in the scenarios are shown in Table 1. The low scenario is based on the assumption that we will see continued growth, but with lower growth rates in the future compared to what we have seen up till now, both related to number and use of TVs as well as PCs. Whereas in the high scenario we assume escalating growth rates in the number of TVs and a stable growth rate in the number of PCs. Furthermore in the high scenario the time of use per appliance is expected to have a higher growth rate for TVs, whereas for the PC we expect the growth rate to be a little more modest than the very high rate we saw in the previous period.

Table 1. Calculation base for ICT scenarios. Columns "2000" and "2007" show actual stock and use of ICT on average per household in Denmark. For 2007 the actual growth in percent between 2000 and 2007 is shown. Column "2015, low" and "2015, high" show the assumptions for respectively the low and high scenario, and the predicted growth compared with 2007 is shown in percent.

	2000	2007		2015, low		2015, high	
			% growth		% growth		% growth
TV, number per household	1.4	1.9	35%	2.1	10%	3.1	63%
TV, time of use per appliance? (hours)	3.5	4.6	31%	5.2	13%	6.2	35%
PC, number per household	0.8	1.6	100%	2.4	50%	3.3	106%
PC, time of use per appliance? (hours)	2.4	5.4	125%	7.0	30%	8.0	48%

The arguments for these trends are found partly in the qualitative interviews, where there are different examples of what extensive ICT use might look like, and partly in the literature on ICT use.

The arguments for continued growth in the number of TVs are that new types of TV on the market, including digitalisation, will increase households' need and desire to buy new TVs. When households buy a new TV, experience shows that they usually use the old TV in a secondary room rather than dispose of it. Arguments for continued growth in the use of TV are that TVs can be used as radios and that the big TV screens can be used as picture frames when not actually being used for watching TV (Crosbie, 2008). Arguments against a continued high growth rate are that computers may take over some of the roles of TV as a channel for news, information and entertainment. This might influence the number of TVs as well as the use of TVs. The total number of TVs may be reaching a saturation point as

many families already have TV in most of their rooms including living room, kitchen, bedroom and children's rooms, though TVs in bathrooms may be a new area for expansion.

The arguments for continued high growth rate of computers in the scenarios are based on the premise that individualisation in the household makes it normal for every person in a household have their own PC, including older citizens and young children. Furthermore we will see more specialisation in the use of computers, making it normal for each person have several computers for different purposes as computers become more integrated in still more everyday activities (one for IP telephone, one for games, etc). Arguments for a continued growth in the use of PCs derive from evidence that we see still more activities and hobbies requiring computers as an integrated part.

Other assumptions for the scenarios are formed from the belief that technologies, such as DVD and set top boxes, will follow the development of TVs, that printers etc. will follow the development of PCs, and that all households will have Internet connection, two electronic photo-frames and a mobile hard disk. For wireless telephones no further development is expected, for clock radios and Hi-fis, the hitherto development is expected to continue. Technology type (for TV: CRT, LCD or plasma screen, and for PC: laptop or stationary) are based on present sales figures which are extrapolated and combined with assumptions of average lifetime per appliance. Energy efficiency of technologies is based on knowledge of the hitherto development of energy efficiency per appliance type and this development is predicted to continue both in relation to standby and on modes.

There may be many arguments for and against all these assumptions, however, the purpose here is not to predict how the future will actually be, but rather to exemplify that there is likely to be a form of continued growth in ICT use and ownership, and then to quantify the likely consequences for electricity consumption.

Findings and interpretations

With these assumptions the scenarios show an increase in ICT-related electricity consumption in Denmark from approximately 2,200 GWh per year in 2007 to almost double (4,200 GWh per year) in the 'low' scenario, and 5,100 GWh in the high scenario, per year in 2015. In Figure 1 this is shown for an average Danish household, where we also see that ICT-related electricity consumption will be between 45 and 50% of households' electricity consumption in 2015, compared to around 20% today. The scenario for "Non ICT" follows the standard prognoses from EL-Model Bolig.

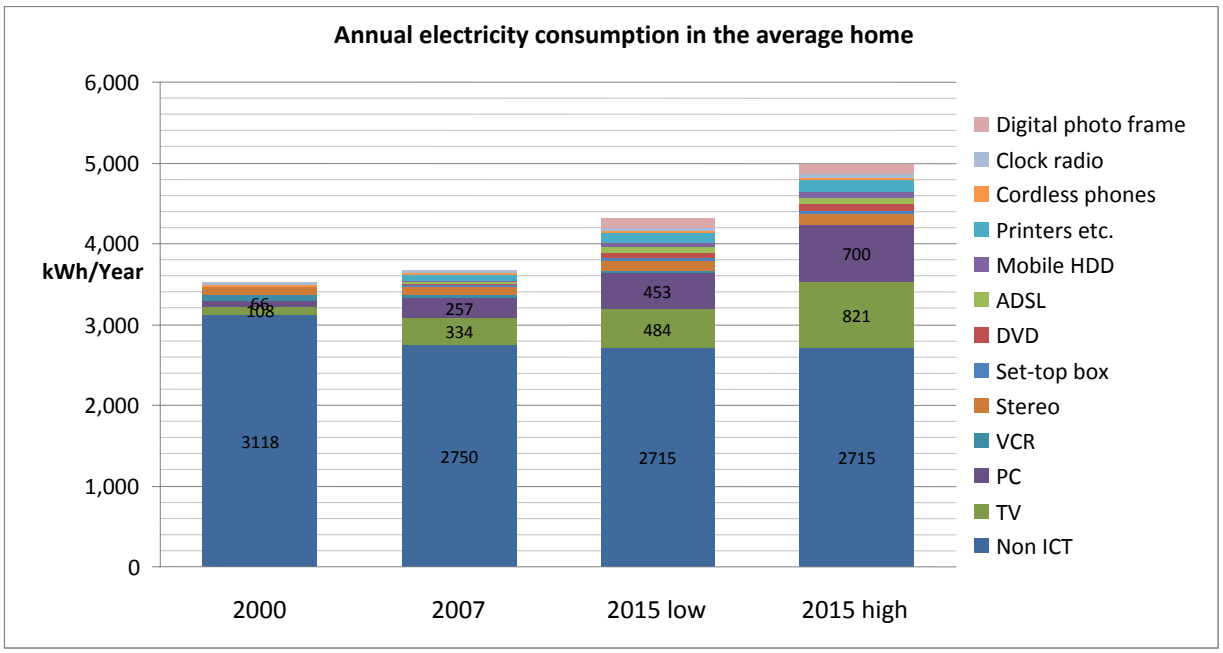

Figure 1. Scenario calculations "high" and "low" for ICT-related electricity consumption in households. *The scenarios are for 2015 together with actual ICT consumption in 2000 and 2007 and are shown as a proportion of households' total electricity consumption.*

These scenarios show that if nothing is done to prevent it, it is very likely that household's ICT-related electricity consumption will expand in the future even though standard assumptions of more efficient technologies are included in the calculations. This means the expansions we are predicting follow primarily from a growing number of technologies in households, together with growing use of these technologies. The scenarios highlight that strong focus on the consumer behaviour related to ICT is needed. In the following section we will continue with a description of the type of initiatives that are already in place or are being discussed as means to prevent this escalating electricity consumption from household ICT use.

Initiatives and challenges for ICT energy efficiency

In the following section we will give a short review of current international and Danish activities to reduce environmental impacts from the use of ICT, and some of the challenges for these initiatives, especially related to the role of the consumer.

It has taken some time to realise what impacts the emergence of ICT technologies might have on electricity consumption and other environmental impacts. As early as in the 1990s, literature included headlines such as "Dig more coal – the PC's are coming", "IT and the $8 Billion Electric Bill", "The Internet: the most important driver for future electricity demand in households", and "Future shock: Challenges from a new generation of appliances", all of these raising the issue of electricity consumption related to the emerging number of ICT appliances in households. Although this caused the International Energy Agency (IEA) in 2002 to label this development as one of the main challenges for future energy policy (IEA, 2002), it has taken time for national and international regulation to tackle this challenge. In recent years a number of political initiatives to reduce ICT-related energy consumption have been launched, but it is clear that these initiatives also face various challenges.

Our workshop with representatives from different parts of the sector (producers, interest groups, policy makers, practitioners etc.) on possible ways to reduce the ICT-related energy use in households, showed that several actors see energy efficiency of products and environmental labelling as the primary tools. A main initiative is the EU Eco-design Directive, which is expected to have a great influence on the efficiency of ICT equipment. The Eco-design Directive aims at establishing minimum standards for ICT equipment in order to keep the poorest products (in relation to the energy efficiency) out of the market, as well as to develop energy labels for ICT and abandon certain technologies (for instance the incandescent light bulb). So far standards for two groups of products have been established (external power suppliers and simple digital signal converter TV boxes). Also, a standard on maximum standby consumption for all equipment has been established. As production and trade of ICT products are global, it is obvious that possibilities for establishing environmental labelling of ICT products at national level are very difficult. There have been national initiatives in Denmark to establish an energy label for TVs, but these stranded after resistance from members of The Consumer Electronics Association[1] and discussions concerning different standards to measure energy consumption. The international approach however means that there are many different opinions amongst producers on how the labelling should be arranged, with a slower ensuing decision-making process. Consequently, international regulation such as the Eco- design Directive reacts relatively slowly compared to the speed of the market and the development of new products. It has been argued that new low-energy TV screens (OLED and FED) could have been developed much faster with public support, and could possibly have been on the market by the time of the digital shift, at the end of 2008 (Crosbie, 2008).

Another shortcoming of the present labelling system is that it does not include the indirect energy consumption related to the use of ICT technology. It requires energy to manufacture and dispose of appliances and objects, and it requires energy to ensure that the infrastructure is in place. A study conducted as part of the project shows that for each kWh used at home, it takes roughly 1 kWh to produce, transport and dispose of the hardware, and ½ kWh to operate the Internet and related facilities (Willum, 2008). This consumption is largely driven by consumer demand and usage of ICT technology, but it has not been addressed at all in existing policies. Therefore, energy labelling as we know it might not be able to include all environmental aspects of the product.

Moreover, it has proven difficult to involve the retailers in energy questions, and therefore relevant information on the energy qualities of ICT products does not often reach consumers. An acknowledgment of this barrier is that the private Consumer Electronics Association have launched a campaign towards retailers to make them promote 'green IT', with a competition and a prize for the salesmen who are best at selling green IT products.

[1] The Consumer Electronics Association (in Danish 'Branchen Forbruger Elektronik, BFE) is an umbrella organisation for various interest organisations amongst producers, manufacturers and providers within consumer electronics.

At national level, in 2007 the Danish government launched their 'Green IT' action plan. This plan includes a number of different initiatives towards industry and private consumers. For instance, industries are encouraged to launch their 'good stories' on how they have reduced their power consumption by using intelligent IT, as well as a 'knowledge bank' to illuminate and visualise the ICT-related power consumption. Several members of the Consumer Electronics Association and IT Business[2] have taken an active part in the campaign. Initiatives towards consumers include an information campaign targeting the young 'digital natives' through Arto and Facebook. However, it is difficult to see how this will seriously engage consumers in energy savings on a wider scale, and the campaign has also been criticised for being too unambitious.

The ICT-theme is also being increasingly integrated into existing policies for energy reductions in homes. The Electricity Saving Trust that was established in 1997 to promote electricity reductions in households, industries and institutions, carries out a number of activities to reduce ICT-related electricity consumption, including advice provided on their homepage, and in campaigns, directed towards ICT producers as well as consumers. They also engage in energy-related discussions on topics such as remote sensing in households, and launch tools to monitor and control consumption in the home. Such ‘intelligent home management’ is seen by the Energy Saving Trust as an important opportunity for saving electricity and energy. As a consequence, the concept of 'the intelligent home' is increasingly being linked with concepts of 'sustainability' and 'energy-savings'. The Energy Saving Trust sees a large potential for intelligent management and operation of the home and has launched a web-based control unit ('MyHome') that enables intelligent control of equipment in the home, including ICT-related equipment, lighting, white goods, and heating etc. The Trust optimistically estimates that it is possible to save up to one-third of the domestic energy consumption by using intelligent control. However, this is not without problems. Those of our informants who had established such control systems also see large potentials in this type of solutions, but they also points out a number of barriers. One is the different standards – for instance, the preferred control system (Lauritz Knudsens’ programmable system, ‘LK IHC’) is not compatible with the system that the Electricity Saving Fund promotes (Z-wave technology). Another problem is the lack of user-friendliness in the ‘LK IHC’ control board; it is very difficult to program and thereby adapt the system to the individual family.

The ICT theme is also increasingly being raised in the Danish ‘energy-saving centres’, where independent energy consultants can take initiatives for energy savings into private households, industries etc., as well as advising consumers who are seeking information on energy savings. A survey of energy consultants carried out as part of the project showed that ICT-related issues were raised regularly in questions from consumers, but also that the energy consultants felt they lacked information on these issues.

In generally, one of the big challenges in the TV market is the pending digitalisation of TV services and the shift from CTR screens to digital screens (mainly LCD of plasma), which implies a large technological shift in household ICT equipment. On the one hand, this can be seen as a possibility to increase energy efficiency, but on the other hand it contains risks for more energy-consuming ICT equipment and, due to complex and changing standards, a short lifetime for the equipment, leading to large indirect energy use (in production and disposal). This also gives the consumers a number of new types of screens and new ways to combine TV, PC and the Internet. Today, TV can be used for other purposes, for instance showing pictures (photographs) or listen to the radio. However, it requires more energy to listen to the radio on TV compared to digital radio – and apparently many consumers prefer to listen to the radio over the TV, as they find the sound quality better (Crosbie, 2008). The complexity of the ICT , and the many different ways ICT can be combined and used by consumers, makes it difficult to give simple and concrete advice to consumers on how to make the best energy choice. Our workshop with central actors involved in energy savings related to ICT shows that there is a lack of information for consumers on energy-efficient ICT solutions for the home, for instance on which type of TV to choose. Largely, consumers are left to themselves to find ways to reduce ICT-related energy-consumption. Moreover, it is debatable whether the traditional consumer approach, with information, advice on limiting consumption etc. is a feasible way to gain energy savings from consumers, especially since household ICT technologies include many small sources, each one with limited power consumption. Traditional advice to reduce standby consumption can be problematic for much ICT equipment. For instance, data information stored on DVD and set-top boxes are lost if they are turned off. Set-top boxes are updated continuously as the suppliers require, and therefore it is recommended not to turn them off (Crosbie, 2008). Therefore we can conclude that there is a void in current ICT and energy-saving

[2] The Danish IT Industry Association (ITB) is the largest and leading independent representative for the IT business community in Denmark, and counts more than 500 IT member companies.

policies on how to approach the consumers. We argue that an important problem in the existing policies for reducing ICT-related energy consumption is the understanding of the consumer. The intended role of the consumer in existing policies is roughly to buy (the coming) eco-labelled ICT products, to use 'intelligent home control' and to avoid standby consumption from the ICT-equipment. As we have indicated above, and as our interviews with consumers show, questions of energy savings are more complex and strongly interwoven with the general use of the ICT equipment. We therefore advocate for a better understanding of consumers' rationales and use of ICT equipment, by applying a domestication perspective to the subject as described in the next section.

Domestication: understanding consumers in the home

Domestication theory and research on ICT development in households

Using the domestication perspective on ICT integration in households is a way of understanding energy behaviour and energy consumption by consumers in their homes. Domestication is a concept that largely originates from anthropology and consumption studies (Haddon, 2006).It represents "a shift away from models which assume adaptation to new innovations to be rational, linear, mono-causal and technologically determined" and it provides "a theoretical framework and research approach, which considers the complexity of everyday life and technology's place within its dynamics, rituals, rules, routines and patterns" (Berker at al., 2006). In other words, a domestication approach offers a way to understand ICT in the context of everyday life and the home. There are different roles at stake for the home, and different ways that the meaning of home motivates the purchase and use of technologies (Aune, 2007), as well as the understanding of 'energy savings'. Applying a domestication perspective to the use and development of technology will allow a more detailed understanding of consumers, and the dynamics behind consumption and savings.

Two of the first to use the domestication approach to study households' adaptation of ICT were Silverstone and Hirst (1992). They emphasised the domestication process in relation to the symbolic and cultural environment of the household, including for instance the family structure and the 'moral economy' of the household (an approach that has later been discussed, see Berker et al, 2006). Studies of household use of ICT have moved from a work-focus in the 1980s, to a mixture of home-based utilities and entertainment in the 1990s, and to more advanced social networking and household automation in the 21st century (Brown, 2008). Several studies are on impacts related to household adaptation of ICT, intentional as well as unintentional (Brown, 2008). Examples are studies that identified negative social impacts on family life, reduced communication with other household members, and increasing social isolation (Brown, 2008). Different groups of users have been studied according to their family situation (nuclear families, singles etc.), their work situation, social class etc. In addition studies have concerned single ICTs or have taken a holistic view of ICTs as an entire ensemble (Haddon, 2006). But there is also research showing that users struggle with the technology and find new ways of adopting it in the household, leading to new ways of using the ICTs. The lesson is that researchers "should keep an open mind and avoid pre-assigning or pre-defining use" (Brown, 2008; 399). The domestication approach has also been combined with other theories, for instance ethnology and in 'netnography' studies. Also the social consequences of ICT have been partly studied through comparisons of adaptation and use in relation to 'time rich – money poor' and 'money rich – time poor', as well as discussions on the 'digital divide' (Haddon, 2006). It is obvious that the physical context, for instance different uses and understandings of 'home' has a large influence on the domestication process (see Aune, 2007). In cross-cultural studies the context also becomes highly relevant for domestication of ICT, for instance sizes of apartments, use of rooms in different cultures and other subjects. In the light of the ICT nature, others have argued for studies of domestication beyond the home, for instance in game-halls, education centres, or other places where portable ICT (mobile phone, PC etc.) might be used (Haddon, 2006).

In spite of several studies pointing to increasing ICT-related energy consumption in the home (for instance Aebischer and Huser, 2000; Cremer et al, 2003; Baer et al, 2003; Owen, 2006; Erdmann et al, 2004), energy consumption has been absent in most domestication studies of ICT (for instanced based on the review papers by Brown (2008), Dwivedi et. al. (2008) and Haddon (2006)). However, recent studies on ICT and electricity consumption (for instance Crosbie (2008) and Røpke et al (forthcoming), as well as several papers from the recent EASST conference) might indicate that the picture is about to change.

There are several ways to use domestication theory and several examples of overlaps between domestication theory and other research traditions (Haddon, 2006). One approach that has been especially relevant for our research is evident in studies by Lie and Sørensen and others, who have tried to link the domestication approach to the Social Construction of Technology approach, emphasising that social shaping continues after the products have left the shelf at the retailer. The 'Norwegian approach' to domestication theory (Berker at al, 2006) emphasises the creativity of consumers, and their ability to form the product. This is parallel to the decline of technological determinism in SST theory. It is inspired by Latour's use of 'script' as the producers' intention and vision about the product, contrasted with the consumer's use and

appropriation of the commodity. However, as Latour has never tested the concepts in practice, there is a need for a concept such as 'domestication' to establish a link between action, meaning and materiality (Aune, 1998).

In relation to the model developed by Silverstone et al, suggesting four phases in the domestication process: 'appropriation', 'objectification', 'incorporation' and 'conversion', Lie and Sørensen's approach uses three of the same phases, and adds a cognitive dimension (Aune, 1998; 54). In contrast Silverstone's model, the 'appropriation' phase is toned down, as the most important aspect for Lie and Sørensen is to understand the learning process in domestication. Several authors, for instance Lie and Sørensen, have noted that the appropriation phase might not be relevant, for instance in non-domestic situations where the purchaser and the user are not the same, or in domestic situations where one family member decides the acquisition of a technology that all members of the household will use (Hynes and Rommes, 2006; 128). Creativity in the domestication process of ICT is, however, not the only theme we will focus on. Former studies of ICT have suggested certain characteristics of the domestication process (Haddon, 2006), which we will discuss in relation to the findings from the interviews with ICT users:

- ICT implies evolutionary (not revolutionary) changes in households
- ICT is domesticated in a personal and creative way
- Non-adaptation of ICT is widely expressed amongst users

Although these themes are strongly intertwined, and have several sub-themes, we will use them to structure our findings. The following section presents some of our findings from the interviews with ICT users.

Findings from interviews: consumers' use and understanding of ICT technologies

Evolution rather than revolution

Domestication theory generally suggests that changes due to ICT adaptation in the home are more evolutionary than revolutionary in nature, and the use of ICT equipment is often built upon existing practices. This contrasts with the utopian visions envisaged by some earlier writers for the integration of ICT in households (Haddon, 2006). Several statements from our informants confirm this and suggest that typically, ICT technologies are carefully integrated into every-day life and built upon existing practises, rather than changing them radically. Also, the motives for acquiring ICT appliances are often to carry out different practices easier and faster, not to establish entirely new routines. For instance, one informant was asked about the main difference between today, where he has got much more internet capacity (cable), compared to the situation before, when he had a more restricted modem access. He stated that the main difference is that today it is easier to send large files, although the practice remains the same, i.e. working from home and sending large data files to the workplace. In another example, concerning the reason for desiring a new digital video-camera, instead of an existing VHS-based camera, a female informant stated that using the digital camera is simply much easier, faster and more flexible. , although the camera fulfils the same basic purpose (recording horse-riding and watching it afterwards for instruction).

> *"It's easier to get into the box. I want one with a DVD in it, so you just put it over in the DVD player… in our old one, Video 8, you had to plug into the video, and then over to DVD. It's too inconvenient".*

Even for an informant in a household with massive use of ICT, both in relation to entertainment, work, intelligent control of light and heating, safety and other features, the informant's main experience was that: "It's so much easier to shut down all lighting and appliances when you go out the door." In this example, as a part of establishing the 'intelligent home', the informant had installed a comprehensive IT-based management system that controls the entire electric system in the house, as well as the heating.

These small examples illustrate that ICT often allows users to carry out certain routines in a simple, faster, easier or smarter way, rather than establishing entirely new practices. From an energy perspective, it is therefore difficult to pinpoint the changes in activity patterns in households, but easier to quantify the energy consumption by the technologies. However, the way the practices are being carried out involves an increasing use of ICT, and especially the internet. It is evident that ICT can be characterised as a 'pervasive' technology, i.e. that it is being used in relation to almost all kinds of activities, and ICT is increasingly integrating with other domestic technologies (Røpke et al, 2008). In a longer perspective, however, domestication of ICT, and the adaptation of existing practices, might lead to changing consumption patterns, but in a shorter time-scale it will lead to surprisingly few new practices.

In parallel with this, other studies of users' selection of ICT emphasise the technology's ability to fit into the design of the home and everyday life, including the aesthetic of the home (Crosbie, 2008). The ability to fit into existing practices and the design of the home is central for selecting ICT. In our interviews we have also found that a main driver for new

and smarter ICT is a strong desire amongst informants to establish order amongst the various ICT medias and technologies (wires, plugs, routers, DVDs, CDs etc.), and to avoid mess in the home. This, for instance, includes wireless LAN to avoid mess with the cables to the laptop, or establishing a central server in the home to collect CDs and DVDs in one place, which several of the interviewed users had done. The desire for more control of time and space has also been highlighted as a strong motivation for acquiring and developing ICT solutions in the home in former studies (Silverstone, 1993).

This can, however, mean that certain ICT solutions are rejected. For example, one informant had deliberately chosen to abandon digital TV in order to avoid multiple boxes, hubs and remote controls, which in his eyes would be the consequence of a future change in image standards for TV (it has been decided to change the digital TV-format to mpeg 4 in 2012, and only a few of today's TVs are prepared for this). This person had established a central server in the house with TV, DVDs, pictures etc., connected to all TVs in the house. With the analogue TV signal it is possible to distribute to several TVs, whereas the digital signal will require a separate top-set box for each TV.

> *"Another box means more power plugs and more cables to be connected. What I want is solutions that are integrated in the same unit. Why do I need a hub, a broadband, a router and perhaps an extra hub to make it all work, if I could get just one box with it all, and with a sufficient number of connections in it?"*

Therefore, as digital TV would require top-set boxes, cables and remote controls for all six TVs in the house, this user made sure that his present TV-provider would continue to deliver an analogue TV signal, enabling him to continue with an analogue TV solution. In general, we see that users often balance technical qualities against aesthetic qualities. For instance, the wireless LAN solution for the PC has an aesthetic quality (avoiding cables), but might not have enough bandwidth for image transfer, which one of our interviewees explained. She had therefore dismissed this solution.

Personal meaning and creativity

Some of the first domestication studies demonstrated that users often impose their own personal meaning on the technologies, even though these meanings differed from the meanings of the designers, dealers and others (Haddon, 2006). A general observation is that the technologies need to fit into everyday life and the design of the context. However, in the long term the interaction might change, and later studies have focused on this. The conclusion is that the domestication of ICT is an ongoing process, more than a one-off event (Haddon, 2006). Adding a personal meaning to the technology as a part of the domestication process, includes different aspects.

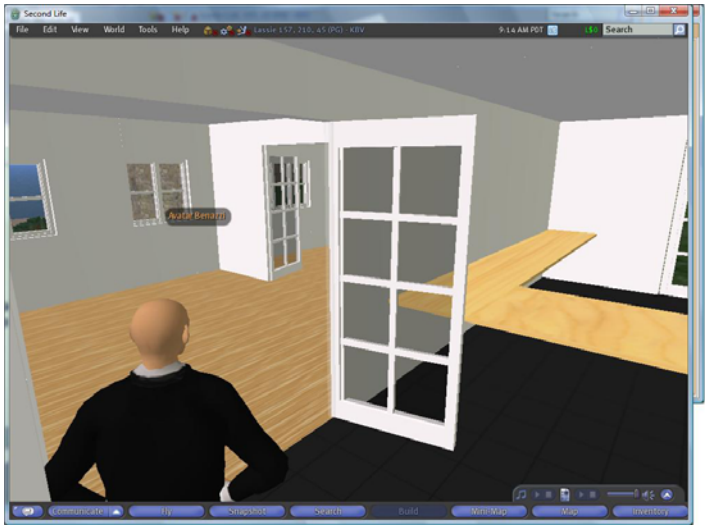

Figure 2. The Second Life avatar as an example on ICT creativity. *The avatar enters a copy of the real home, where he is able to turn the light in the real home on and off.*

An evident characteristic of ICT use and domestication that came out of our interviews was the creativity amongst consumers. ICT has become a new area where you can be very creative in projects at home. Many acquisitions and applications are driven by creativity, where it is not necessarily close functional needs that are met, but more a desire to test and develop the technology. This applies both to the more 'geeky' informants, and the 'normal' consumers, since there are many opportunities for choice and combination of technologies, while there are few standard options and few

places to get advice. This does not necessarily mean that new functions or practices are developed, but often new ways to carry out relatively simple functions using ICT in a very creative way.

One example is the user who from his ‘Second Life’-home – a perfect copy on his ‘real-world’ home – had made it possible for his avatar (his alter ego in Second Life) to turn a light in his ‘real’ home on and off (see Figure 2). While in Second Life he is able to take his avatar into his virtual house and touch the virtual light switch – a few seconds later, the light in his ‘real world’ living room would turn off. This implies several complicated ICT operations and technologies, in Second Life as well as in the real world, that go way beyond any conceived or conventional use of ICT. The communication between Second Life and his real home is based on mail correspondence between various mail servers, controlled by a piece of software developed by the informant himself. He has tried to make it work the other way as well, but this is more complicated. In the real world, his home is under reconstruction to an ‘intelligent home’, enabling -based power control of all sockets and switches in the home. This function has involved a massive investment of creative energy from the informant, although turning lights on and off from Second Life has few practical implications in the short run.

> *"Naturally, it's great to be able to control your own house in Second Life. I can decide to turn on a light, when I'm on holiday, for instance."*

In the long run, the idea is to develop the concept to build an entire copy of the house in Second Life, allowing control of all sockets in the real house. This will also allow a differentiated access for different members of the family to the various functions in the house.

As a part of a rebuilding project, one informant has designed his own version of 'the future home' based on extensive ICT use for house management, information and entertainment. This includes intelligent management of all lighting, heating and door locks in the house. For instance, the lighting automatically turns on when someone enters the room, switches have been programmed for different types of lighting, the heating can be controlled from a touch-screen in the kitchen and there are other facilities. For TV and entertainment a central server in the house has been set up to manage all DVDs and CDs, so that films and music are collected in one place. An Apple TV box that combines TV and video on demand has been installed, and the basement has been designed as a cinema-like room for watching films with blue-ray and a projector, or for playing with the X-box.

A number of more special features have been made, for instance for the children's rooms on the first floor. From a screen one can 'see' when the bathroom on is free, and if the children don’t come down when dinner is served, they can be 'motivated' by cutting off all power on the first floor, which has proven very efficient. Also, to prevent long showers, the light automatically starts to shut down gradually after 7 minutes, leaving the shower in darkness a few minutes later. These features have been designed and developed in collaboration with the other members of the household, in a process of 'no-tolerance'. If the technology (typically selected by our informant) did not work immediately and without problems for the other members of the household, it was not accepted by them, and he would have to start over again. Here, the creative part of the domestication process has been in the initiating phases (getting the idea on how to design certain solutions) as well as in the following phases (discussions and adaptation amongst the different family members). The domestication process involves not just the ICT appliances, but also the use and design of the whole house. For instance, the family has decided to establish an 'acoustic' corner in the living room, for activities that do not involve ICT. The creativity was apparently a strong motivation for the planning, design, implementation and development of these solutions, although the respondent retrospectively related the work process to improving control of the home, and all the appliances:

> *"...The thing is about leaving the house and pushing a button, knowing that no unnecessary power is turned on …(and)...all the plugs that are turned off. All the standby-equipment shuts down… Generally, the knowledge that here we have got something comfortable and at the same time we have reduced our electricity consumption to a minimum"*

Also in other interviews we have found a large amount of creativity in the domestication process of ICT. For example, one informant was using a software program designed for route diagrams to draw up suggestions for interior decoration and housing design in the rebuilding process she was working on at the time of the interview. Using this program had enabled her to draw up a number of different solutions for the internal design of the house to discuss with friends and relatives, and this had already given her valuable feedback and good ideas. The same interviewee also had plans to set up web-cameras in the horse stables in order to watch her horses from the laptop – both at home and at work – which again would allow smoother and more optimal planning of her every-day life.

> *"So I can see how the horse is doing, so I don't have to go out there at night……I hope I can also use it when I'm at work….If it's bad weather and they get uneasy, I can go home half an hour earlier"*

The creativity amongst our interviewees runs from smaller solutions (for instance, installing PCs in the ceiling of the car, to allow the children to watch DVDs and take the PCs on holiday) to larger solutions, for instance rebuilding an old house with the most up-to-date type of ICT control and intelligent management. The desire to use new technology ranges from dealing with well-known challenges (for instance children's long showers), imagined challenges (for instance web-monitoring of the house to improve security and avoid possible crime), and even non-challenges, such as the avatar turning the light in the living room on and off. We argue that this creativity characterises the ICT more than other types of domestic technologies, and therefore makes the intended use and domestication process more unpredictable. In an energy perspective, on the one hand this raises a challenge in designing energy-saving solutions and providing advice to the users, but on the other hand we argue that the creativity can be seen as a resource for energy savings, and that advanced users should be involved in designing energy-saving solutions for the home. Several of the creative ICT users we have interviewed, for instance users creating their own version of an intelligent home, had energy savings as one of their main reasons for establishing intelligent power control systems, and their experience could serve as valuable input for future energy-saving campaigns.

Non-adaptation

Many domestication studies have been concerned with the lack of adoption of certain technologies (Haddon, 2006). Besides reasons such as lack of social networks and limited financial resources, identity and managing the image of the home can be seen as parameters for rejecting ICT. Other studies show that there are different motives for not purchasing or using certain technologies, for instance lack of resources (Hynes and Rommes, 2006; 127), suspiciousness toward new technologies, or a desire to control the impulse to buy it (Lehtonen, 2003). However, the adaptation can also relate to the relations between household members (for instance teenagers and parents), and strategies for controlling the medias (Haddon, 2006).

The interviews revealed several examples on non-adaptation and a number of different reasons for this. Some of these are closely related to creativity, where consumers are able to say "no" to certain products or technologies, but instead design similar solutions based on other ICT products. ICT consumers are not passive recipients and users of the ICT solutions that are sold and promoted on the market, but they are critical recipients, developers and users. Several informants expressed practices and reflections that reflect both positive and critical attitudes to ICT, and these affect both their acquisition and use of ICT solutions. The consumer has to be selective, partly due to the many technological options available, and partly because of the uncertain future of technological development and standards in the near future. This selectivity includes financial, aesthetic, functional, social and environmental considerations. The non-adaption of certain technologies is often linked to creative solutions that give the users the same function by using other technologies.

One informant (and his family) does not use a traditional TV or media centre. Instead, they use PCs to watch TV, primarily based on the internet, where different TV channels are available. Their rationale is that PCs are able to deliver the same service as a traditional TV and a media centre, and with less costs:

> *"Why should we pay so much when we can buy a laptop for DKK 4500 (app. 600 Euro). …It's got a CD and DVD player as well, and it uses much less power. It has been designed not to use power. …. The largest problem (with the media centres) is the noise, because they have to be cooled, as they normally dump a huge graphic card into it, which is not necessary…the laptop here, it says nothing".*

Another informant has turned down the offer of having a fibre-based TV connection established to his home, which would have given him 100 MB of broadband. Instead he has decided to keep his old cable connection. His argument is that the 100 MB broadband is just sufficient for 5-6 TVs watching different channels, but no more, and this would reduce the flexibility of the connection. Due to the changing standards of the digital TV format, the new cable would mean that they would probably have to buy set-top boxes at some time, and as each TV needs its own box, this would, according to the informant, lead to a mess of boxes and cables (see quotation p. 9). He and his family have therefore decided to keep their 'old' analogue cable connection for TV, having ensured that they will still be able to get the analogue signals from their TV operator, although the TV signal in general will go digital in 2009. This shows how the uncertainty of the future standards, combined with aesthetic and practical considerations of the technology, might lead to technological non-adoption, although maintaining a functional adoption by using other technologies.

However, there are also examples of households who are simply not interested in the technology, for different reasons. One informant (from a single-person household) lived with a boyfriend who brought a lot of ICT equipment into their home. After they split up, she misses very few of the ICT facilities he brought into the home.

> *"I actually think it became a bit clumsy. I can see that it was very smart with a large flat-screen TV, as the picture and sound quality were so much better and we could sit here in the dark. It was very*

cinema-like and fun, but I was falling over it all the time in such a small flat I have here. …What he did to connect the computer and the TV was very clever, but it's just so clumsy… with my wants I don't need all kind of things that can be connected…. He spent so much time putting it together, but he thought it was fun. But I don't think it's fun, I don't know how to do it and it doesn't interest me very much"

The critical and non-adaptive approach to ICT-technology is widespread amongst our informants. This does not necessarily mean that they reject the service delivered by a certain technology, but instead get the service from other ICT products. With the huge number and types of ICT products for the home, a critical approach is simply a necessity for the consumer.

Implications for future energy policy

The different themes on ICT in households, emphasised by domestication, can be illustrated by changes in how certain practices are carried out in the household. One example is the practice of watching TV; an interesting aspect in an energy context. Firstly, TV represents the major energy consumer amongst the ICT, but our analysis shows that there is an absence of consumer guidance on this area. Even amongst experts it is very difficult to find the 'right' solution to basic answers on energy savings for TVs. Secondly, the TV media is currently undergoing radical development. This development includes new hardware (from CRT to LCD and other types of screens), digitalisation of the transmission signals, integration into other media (computer, mobile phones etc.) and the general organisation of the production and distribution of TV. This development opens up the potential for new interpretations and practices related to TV use, where the understanding of 'traditional TV use' (watching the telly!) is challenged.

In our interviews we have found several examples of changing practices in the use of TV. Watching TV is taking on new forms, in terms of the social contest (who watches, when and where?). There are social, spatial and temporal changes compared to 'traditional' TV-watching practices (if there ever was such a thing). Also, we see that TV is increasingly being integrated into other medias, and conversely other medias are being integrated into the use of TVs (see Crosbie, 2008), and TV programmes are today being produced from many different sources – national companies, private companies, amateurs, friends etc. Finally, watching TV is under competition from other medias; the Internet and other ICT are increasingly substituting TV as the only medium for news and entertainment. Our interviews demonstrate a wide variety in consumers' choices on TV strategies, for instance to substitute traditional TV screens and TV signals with PC and Internet-based TV, to use new types of TV services (such as Apple's Internet-based TV-box), or to maintain a traditional analogue signal.

Another example is the intelligent home. Two of our informants were in a process of designing their own intelligent home, based on intelligent management of all electricity (sockets/switches) and other features with implications for energy consumption in the home. Using intelligent management for to control energy consumption was highly relevant for these people, as they had already several ICT components in their homes, and were interested in reducing the energy consumption of their homes. For these informants it is important to note that the high level of ICT in their homes also reflects an everyday life where the home is used extensively for work (for all adults in the household), which – along with the extensive use of ICT – is probably the main reason for a relatively high electricity consumption. Therefore it is difficult to assess the potential energy savings with intelligent home control from these examples, as it is connected to a certain way of using the home. However, these informants' lifestyles could be a picture of a future everyday life for many people, where intelligent home control could be highly relevant. For others, such solutions would be highly irrelevant.

The creativity in the process of domestication is characteristic of households' use of ICT. In our interviews there are several examples of users developing creative solutions and raising relevant questions related to energy savings. This makes it difficult to design general energy-saving advice on the basis of a traditional expert-based top-down approach which, as described previously, is how the existing energy-saving policy can be characterised. Instead, energy efficiency related to ICT calls for much more user involvement in defining and developing energy-saving strategies. To prevent the escalating electricity consumption related to ICT use, which has been demonstrated through the scenarios, we therefore suggest a combination of a top-down and bottom-up approach, where users' experience and solutions are discussed and developed with experts on ICT and energy savings.

An example parallel to this argument has already been seen through one of our informants, who has established an intelligent home in which his wife and children have acted as users with 'non-tolerance' towards the new technologies introduced in the home. This means that technical ICT solutions that did not work were abandoned immediately. The potential of exploiting the experience gained by this informant has already been identified by one of the main TV operators in the market. As, due to forthcoming digitalisation, this operator is about to send out thousands of set-top

boxes, they are very interested in learning about how to deal with 'non-tolerance' from users. They have therefore hired our informant to teach them about this issue on the basis of his own experience in establishing the intelligent home.

We have seen many examples of ‘user-driven innovation’ in domestic ICT use, including initiatives to reduce energy consumption in the home. We also need to see technical ICT knowledge and energy-efficient ICT as two integrated parts; it makes little sense to talk about energy efficiency without having the general technical competence to understand the technologies. Therefore, initiatives for energy savings should be designed and carried out with the 'traditional ICT experts', i.e. by trying to involve traditional ICT experts in identifying and developing energy-saving solutions for consumers, instead of operating with energy-saving experts on ICT. Compared to other consumer goods, ICT too complicated for 'laymen' to give meaningful advice on how to save energy. Therefore, energy savings related to ICT require new ways of collaborating between users, producers, experts and energy-saving agents, and therefore they represent a break with past policies for energy savings in households.

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