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Information and communication technologies – A new round of household electrification

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ABSTRACT

Information and communication technologies (ICTs) increasingly permeate everyday life in industrialized societies. The aim of this paper is to explore ICT-related transformations of everyday practices and discuss the implications, particularly for residential electricity consumption. The present socio-technical changes are seen in a historical perspective, and it is argued that the integration of ICT into everyday practices can be seen as a new round of household electrification, comparable to earlier rounds that also led to higher electricity consumption. A case study carried out in Denmark in 2007–2008 explores the present changes in everyday life. Based on qualitative interviews, the study focuses on people's ways of integrating ICTs into their everyday practices, on any significant changes in these practices, and on the influence of the changed practices on electricity consumption. The paper concludes with a discussion on the implications for energy policy.

Introduction

Information and communication technology (ICT) increasingly permeates everyday life in industrialized societies. Computers, the Internet, mobile phones and many other related technologies have become standard devices that most people take for granted. Like many previous technologies, ICTs are involved in transforming everyday practices, and like previous transformations, the present processes are reflected in changing energy consumption. ICT use thus has impacts on both direct electricity consumption in the home and indirect energy consumption related to providing ICT-devices and operating ICT-infrastructure. The aim of this paper is to explore the processes of ICT integration in everyday life and discuss especially the implications for residential electricity consumption. The present socio-technical changes are seen in a historical perspective, and it is argued that the integration of ICT into everyday practices can be seen as a new round of household electrification, comparable to earlier rounds that also led to higher electricity consumption.

Until recently, few studies have focused on the energy impacts of ICT in households, but the political relevance of this issue is increasingly acknowledged. Various scenario-studies indicate that the share of residential electricity consumption related to ICT (including consumer electronics) may rise to about 50 percent within the next one or two decades unless preventive action is taken. Thus, Owen (2007, p. 3) concludes that by 2020, "entertainment, computers and gadgets will account for an extraordinary 45 percent of electricity used in the home" (see also Jensen et al., 2009; Market Transformation Programme, 2008, p. 14). The International Energy Agency also issues warnings: "electronic devices have made a major contribution to the recent growth in total residential electricity use and will become one of the largest end-use categories in years to come" (IEA, 2009, p. 3).

The paper is based on a case study in Denmark, which provides a useful example for two reasons. First, elaborate material on the historical development of electrification in Denmark is available (Wistoft et al., 1991, 1992), which makes it possible to place present changes in a historical perspective. Second, ICTs have diffused widely in Denmark, making it relevant to study emerging energy impacts in this country. By 2008, 88 percent of the Danish population had at least one personal computer at home, 85 percent had access to the Internet, and 90 percent of this group had a broadband connection such as ADSL, optical fibre access, etc. (Statistics Denmark, 2008). With 37 broadband subscribers per 100 inhabitants, Denmark had the highest penetration of high-speed Internet connection in the OECD in 2008. With regard to bandwidth, however, Denmark is lagging behind such countries as Korea, Japan and Finland, and prices per Mbit/s are relatively high (OECD, 2009a). Electricity consumption reflects the diffusion of ICTs: the share of residential electricity consumption used for

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consumer electronics, computers and related equipment has increased from 17 percent in 1997 to 26 percent in 2006 (Gram-Hanssen et al., 2009). While total residential electricity consumption has been stable since the early 1990s, the growing electricity use for ICTs constitutes a serious challenge.

Traditionally, ICTs are distinguished from consumer electronics, which include equipment for entertainment such as radio, television and music players. But this distinction becomes increasingly blurred and irrelevant as computers, for example, are used to watch television, and televisions are combined with hard disk recorders. Still, to delimit our study, we have chosen to focus mainly on practices that integrate the computer, Internet and related devices, although we are well aware that some of the most immediate energy-consuming trends are related to the development of television (Crosbie, 2008).

The paper starts by outlining the history of household electrification based on an interpretation of available historical studies. Then, the present socio-technical changes related to ICT are analysed, based on an empirical case study carried out in 2007–2008. Based on qualitative interviews, the study focuses on how people integrate ICTs into their everyday practices, whether these practices are changing in significant ways, and how changes in practice influence electricity consumption. The presentation includes an outline of the theoretical and methodological approach, the findings regarding changing everyday practices, and the immediate implications for electricity consumption. The paper concludes with a discussion of the implications for energy policy.

The history of household electrification

The history of the first hundred years of electrification in Denmark is presented in two large volumes (Wistoft et al., 1991, 1992), which are the main source for this section (the page references in this section refer to these publications unless otherwise stated). The work covers production, distribution and consumption in all sectors, but this paper concentrates on household electrification.

The development of *total residential electricity consumption* started, when the first electric light was turned on in 1891, but the real jump in electricity supply took place from 1905 to 1920, when 80–90 percent of households in cities and larger towns acquired electricity (1991, p. 134). During the period between the world wars, electricity diffused into the countryside, and in 1939, 75 percent of the population in the countryside and 98 percent of the population in the cities had electricity (1991, p. 213). After the Second World War, growth was resumed, first moderately, and then at a fast pace from the late 1950s. The energy crises in 1972–1973 and 1979–1982 motivated serious efforts to save energy, but electricity consumption continued to grow. Whereas the government succeeded in keeping the level of total energy consumption constant from 1972 to 1991 (through improved insulation, co-generation of heat and electricity, and other measures), household electricity consumption grew by 53 percent from 1976 to 1991 (1992, p. 244). The long-term trend towards ever-increasing residential electricity consumption was not broken until the early 1990s. Since then, household electricity consumption has been virtually constant (Energistyrelsen, 2008).

Over time, the *composition of residential electricity use* changed dramatically, as electricity became used for an ever-increasing range of purposes. From a *consumer perspective*, electricity is used to obtain services – directly in the form of lighting, or more indirectly as input to the processes of preparing food, for example, or washing clothes. The history of household electrification is the story of electricity as a condition for using the various artefacts involved in meaningful domestic practices. But the 'invisible' input of electricity received little attention from consumers, except in the very beginning when electricity was synonymous with light.

Viewing electrification from a *technical perspective* highlights a different aspect of the story. Electricity is used for such basic functions as providing light, transmitting sound, heating, powering mechanical devices, and processing data. The introduction of these basic functions into the domestic sphere was usually based on a technological breakthrough, materialized in new basic technologies such as the electric bulb, the small electromotor, the vacuum tube and the transistor. Sometimes the basic technology was a product that could be applied directly in households, like the telephone and the light bulb. In other cases, the basic technology was applied in many different consumer products, like the electromotor built into many appliances. Basic technologies were also combined – in the washing machine, for example, which combined an electromotor and a heating element and, more recently, data-processing technology as well. In addition to the infrastructure used to provide electricity, some new basic technologies depended on the development of supplementary infrastructure – radio and television broadcasting networks, or more recently mobile telephone networks and infrastructures to provide Internet, such as cables, fibre net and Wimax.

The following account of electrification views the history from a combination of the consumer and technical perspectives. The traditional story, as well as the statistics, is based on the consumer perspective, while priority in our account is given to the technical perspective. Our point is that new rounds of household electrification tend to emerge in connection with the introduction of new basic functions.

The introduction of the telephone is usually not considered to be part of household electrification, because it came with its own dedicated net, integrating power supply and transmission. From a technical perspective, however, the telephone was the first use of electricity in homes and thus deserves brief mention. In Denmark, the telephone net was established at a rapid pace, starting in the early 1880s and covering the whole country before 1920 (Wistoft, 2007). Thus, the first basic function of domestic electricity use was the *transmission of sound*, which is related to the first important member of the ICT family of devices.

Considering the telephone to be a separate system, electricity was basically synonymous with *light* during the first decades. Lighting can thus be said to constitute the first round of household electrification. This application was so dominant that light still constituted 97 percent of residential electricity consumption in 1950 (see Table 1 and Fig. 1). The exclusive use of electricity for lighting was problematic for power plants, because of the large fluctuations in demand throughout the day, and starting in the 1920s, other uses were actively promoted (1991, p. 222; Forty, 1986, reports on the same situation in Britain). These uses can be seen as the first seeds or signs of later rounds of household electrification. The first real success was the electric iron, owned by as many as 28 percent of households in 1938 (1991, p. 236). The iron uses electricity for *heating*, and many other heating devices became available (such as electric cookers, electric heaters, toasters and warming pans), but few people could afford such luxuries. The second successful device during the period between the world wars was the vacuum cleaner, owned by 15 percent of households in 1938 (1991, p. 236). The vacuum cleaner uses electricity to replace manual *power* through the application of a small electromotor. Other power devices such as potato peelers and dishwashers became available (1991, pp. 86–87), and when very small motors entered the market, they were combined with or integrated into products

like sewing machines (1991, p. 264), but again such products were reserved for the few. The most successful device before World War II was the radio, which needed no motivation from electricity companies. From the establishment of the state *broadcasting* service in 1926, the radio diffused rapidly, and within a few years it was the most common device in the home, owned by 37 percent of households in 1938. The radio did not consume much energy, but it kept people awake, and they used light until later in the evening (1991, pp. 236–237).

The second round of household electrification took off in the late 1950s and was based on the use of electricity for power and heating, which were integrated into rapidly diffusing appliances meant to ease household chores. Refrigerators replaced larders and iceboxes, first in cities and later in the countryside, and in 1971, 80 percent of all households had a refrigerator (1992, p. 124). While refrigerators were difficult to share, both freezers and washing machines had a long history with different kinds of collective arrangements before they ended up being privately owned (many people in housing blocks still rely on shared laundries). Around 40 percent of households owned washing machines and freezers in 1970 (1992, pp. 124, 127), followed by the dishwasher and the tumble dryer (Olesen and Thorndahl, 2004, p. 305). Also electric cookers and water heaters diffused in the 1960s, and electric space heating was installed in some new houses (1992, p. 131). In addition, a wide range of smaller kitchen appliances gained a footing, as well as equipment for body care. The resulting composition of household electricity consumption is shown in Table 1 and Fig. 1: lighting was reduced to 27 percent, while appliances based on small electromotors and/or heating elements amounted to 66 percent of electricity consumption in 1970.

Table 1
The composition of household electricity consumption in percent, 1950–2006.

	1950	1970	1990	2006
Light	**97**	**27**	**18**	**11**
Heating and power	**3**	**66**	**68**	**59**
Cooking	3	6	8	8
Heating	0	20	23	18
Cooling	0	30	24	18
Laundry	0	9	13	15
Miscellaneous	**0**	**7**	**14**	**30**
TV, video, stereo	0	6	10	12
PC	–	–	1	8
Total	**100**	**100**	**100**	**100**
Total energy consumption (GWh)	**522**	**3341**	**8841**	**9401**

Note: "Heating" includes electrical heating panels, electrical water heaters and electricity consumed by central heating systems (circulation pumps, etc.). "Laundry" includes washing machines, tumble dryers and dishwashers. "Miscellaneous" includes many different small appliances, including the television set, VCR, stereo and personal computer.
Source: ELMODEL-bolig. ELMODEL-bolig is an extensive software model that can be used to calculate total electricity consumption in Danish households by different types of appliances (ELMODEL-bolig includes about 30 different types of appliances). The model includes historical data about the stock of appliances in Danish households and the average time of use per appliance (a representative survey including about 2000 households is conducted every second year). This data set is combined with information about the average efficiency (measured in Watt) of each type of appliance in order to calculate the total yearly electricity consumption for each type of household appliance. The results for 1974–2006 are estimated to have high validity, whereas the figures for 1946–1973 are more uncertain. However, as this paper focuses on electricity consumption related to modern ICT, this does not affect the overall picture shown in Table 1 and Fig. 1, since the real take-off of new ICTs did not occur before the late 1980s and early 1990s. For further information, see the website of ELMODEL-bolig (only in Danish): http://www.elmodelbolig.dk/ – or see Larsen et al., 2003. The figures used in Table 1 and Fig. 1 are calculated and provided by Troels Fjordbak Larsen as part of the project on which this paper is based.

Also during this round of electrification, seeds were sown for the next round, first of all in relation to television, which achieved the quickest diffusion ever (1992, p. 134). Regular TV broadcasting started in 1951 but could be received only in Copenhagen. In 1960, TV signals were available to everybody, and already in 1965, 75 percent of households had a TV set. In spite of this popularity and the high energy consumption of the first TV sets (3–400 Watt, 1992, p. 135), television and other entertainment technologies still constituted a relatively small part of electricity consumption in 1970.

The technological background for the third round of household electrification was the emergence of the transistor and later the microchip, which made it possible to install an ever-increasing number of transistors in a very limited space. This miniaturization enabled the inclusion of advanced *data-processing* facilities for monitoring, management and manipulation in a multitude of products, as well as development of the general-purpose personal computer. Advanced data processing can thus be considered a new general household application of electricity, constituting a third round of electrification. The first implications for electricity consumption became visible in relation to standby consumption. When teletext services emerged in the late 1970s, they gave rise to the development of more advanced wireless remote controls for televisions, later followed by remote controls for many other electronic appliances. Since remote controls only work when appliances are (partly) turned on, this development implied a massive increase in standby electricity consumption.

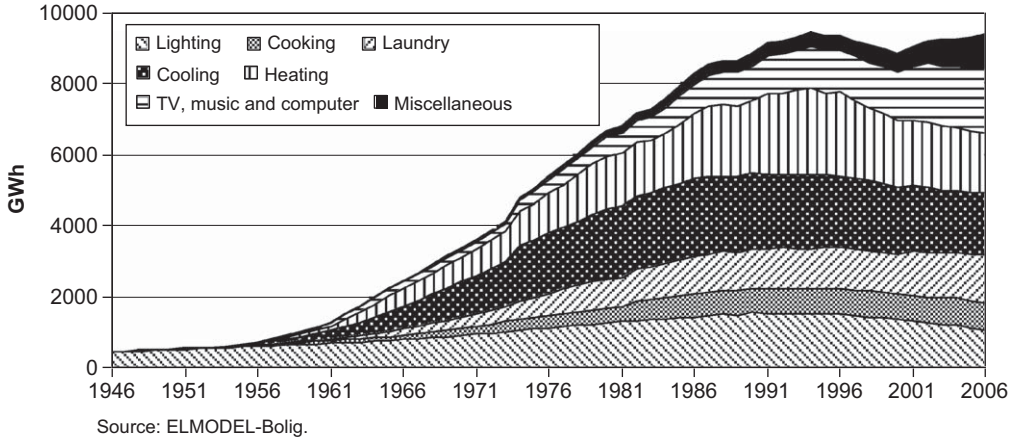

Fig. 1. Danish household electricity consumption distributed by final use (GWh), 1946–2006. *Source*: ELMODEL-Bolig.

The home computer was first introduced in the 1980s as a special-purpose machine that could be used to play games, replace the typewriter and calculator, and run various special-interest programmes. In the mid-1990s, however, the introduction of the Internet changed this situation completely, since the new infrastructure opened up a whole new range of possibilities. With the development of laptops, other mobile devices and mobile access to the Internet, the number of applications is escalating.

The impetus from the third round of electrification is reflected in the rapid growth of the "Miscellaneous" group seen in Table 1 and Fig. 1 – from 14 percent in 1990 to 30 percent in 2006. In addition to the electricity consumption for TV, video, stereo and PC that is specified in the table, the "Miscellaneous" group includes other ICTs. In total, 26 percent of residential electricity consumption in 2006 relates to ICT. It should be noted that the growing share of electricity consumption for ICTs also reflects the effectiveness of policies in other fields, causing the use of electricity for space heating to decrease considerably (see Fig. 1), and the energy efficiency of white goods to improve (effectively counterbalanced, however, by continued growth in the stock of white goods, see Fig. 1). Without the growth in ICT, residential electricity consumption would have fallen in recent years. Electricity consumption from 2000 to 2007 for non-ICT fell by nearly 10 percent, while electricity consumption for ICT increased by an impressive 135 percent (Gram-Hanssen et al., 2009).

Previous rounds of household electrification co-evolved with radical changes in everyday practices. Electric lighting opened for changes in daily rhythms and the experience of space, which involved many cultural changes (Garnert, 1994), and the use of household appliances based on heating and powering co-evolved with profound transformations in family life, household chores and women's participation in the labour market (Cowan, 1983; Olesen and Thorndahl, 2004). The present round of electrification may involve similar radical changes in everyday life. These changes are important to study in order to understand the dynamics and drivers involved and to develop a pro-active approach to the energy impacts that may follow.

Theoretical and methodological approach in the empirical study

The theoretical framework for the empirical study is based on practice theory. Basically, this means that the focus is on the practices that make sense to people in their everyday lives and on the co-evolution of new technologies and changing everyday practices. Practice theories have a long and heterogeneous history, developing as responses to classical dualisms like the structure–actor opposition in social theory. More recently, the work of the philosophers, Schatzki (1996, 2002) and Reckwitz (2002), has contributed to the formulation of a more coherent approach to the analysis of practice, and this work is increasingly reflected in a variety of fields. Warde (2005) has brought the approach into consumption studies, and Shove and her collaborators have operationalized the approach in empirical studies on consumption and technological change (Shove et al., 2007; Shove and Pantzar, 2005). Having elaborated in detail on the practice theory approach elsewhere (Røpke, 2009; Christensen and Røpke, 2010), we make only a few necessary points here, as background to the empirical study.

In brief, the point of departure is that people in their everyday lives are engaged in meaningful practices – cooking, eating, sleeping, visiting friends, and watching television. A practice is seen as a cluster of bodily–mental activities, linked together in a meaningful entity that is recognizable across time and space. The entity only exists when people carry out the activities involved, and the enactment of these activities transforms the entity over time. Individuals thus meet practices-as-entities as these are formed historically, and through their own performance of these practices, they reproduce and change these entities over time. When performing the practice, practitioners integrate the elements of material, meaning and competence involved in the practice (Shove and Pantzar, 2005): watching television, for instance, involves the television, the competences related to its use (e.g. selecting programmes), and the meanings people attach to the activity (e.g. relaxation). Over time, this configuration of elements co-evolves – for instance with the emergence of new technologies and new social discourses concerning the meaning of the activity. This perspective informs the way we have asked questions in the empirical study and the way we have interpreted the results.

As the aim of the study is to uncover emerging trends in the use of ICTs rather than to document present energy consumption, the qualitative interview method was chosen due to its explorative qualities with regard to identifying and describing new and not yet stabilized practices related to ICT use. The focus on emerging trends led us to choose informants with long experience in the use of ICTs and with competence to take up new applications. The study is thus based on interviews with persons whose use of ICTs is likely to indicate the direction of ICT applications in the near future. Although a few of them can be characterized as lead users in von Hippel's sense (Von Hippel, 1988), or as early adopters who are fascinated by new technologies and interested in playing with them, most informants are just skilful users of diverse forms of ICT but with little or no fascination with the technology as such. Thus, they resemble the majority of the population and, at the same time, are a little ahead of the majority with regard to use patterns.

Use patterns differ according to age, gender, education, and income. For instance, younger generations have grown up with ICT and thus find it easier to apply the technologies, and educated people often become familiar with ICT through their work. To obtain a broad picture, we chose informants from 20 to 70 years of age, men and women with different educational backgrounds, different family situations, and from different areas of the country.

All informants were recruited with the help of the authors' personal networks; friends, colleagues and other personal contacts were asked to suggest persons from their own personal networks who used ICT in connection with many daily activities but were not really computer experts. On the basis of these suggestions, the informants who appeared to have a diverse use of ICT were contacted. After a first round of in-depth interviews with seven informants, we carried out short telephone interviews with 18 more people, in order to select informants who could elucidate additional use patterns in a second round of interviews. The telephone interviews usually took about 15 min; the prospective informants were asked if they used the computer and Internet in connection with personal communication, entertainment, shopping, personal hobbies or to upload information to the Internet (e.g. video recordings or family pictures). Seven informants with ICT use that had not been covered during the first round of interviews were selected for the second round of in-depth interviews.

In-depth interviews lasting about 2 h were carried out with 14 main informants in their homes; in three cases, these informants' partners took part in the interviews as well. In total, 17 persons were interviewed face to face. Before the in-depth interviews, informants were instructed to fill in two forms. One form covered all the ICT equipment in the household (40 types of equipment

were mentioned, and informants stated how many they had of each type); the other covered use of the computer and Internet in relation to a list of 48 activities that were organized in the following groups: communication, entertainment, information, purchase and sale, work at home, education, hobbies and volunteer work, administration and finances, domestic work and management of the dwelling, and finally health. Informants ticked off which applications they used each week, monthly, or less often. These forms served as the basis for the semi-structured interviews (Kvale, 1996) covering the families' everyday lives, the activities involving ICTs and changes in these activities over time, as well as the changes in equipment and Internet and television connections over time. If the informants did not bring up energy concerns themselves, the interviews concluded with direct questions regarding energy.

The following analysis is based on condensation of the transcribed interviews into summaries that organize the informants' descriptions of their use of ICT according to the groups of activities listed above.

Use of ICT in Danish households

Two general observations can be made on the basis of our interviews. First, ICTs have become integrated in a wide range of the informants' everyday practices. Although ICTs, such as the computer and the mobile telephone, were introduced for carrying out a limited number of practices – like playing games, word-processing, communication – they are no longer seen as dedicated to specific activities. Rather, they have become part of almost any practice. This indicates that the interpretive flexibility of these 'new' ICTs is much wider than the flexibility of the 'old' ICTs, since the latter tended to be integrated into practices defined by the technology itself: phoning, listening to the radio, or watching television. In contrast, the home computer and the Internet constitute a general infrastructure that can be integrated into a wide variety of practices.

Second, the integration of new ICTs in everyday practices is in many cases accompanied by diversification of these practices. This diversification is particularly pronounced in connection with the informants' daily communication with relatives and friends, but examples were also found in relation to other practices, e.g. watching television on an ordinary television set and on the Internet (reported in Jensen et al., 2009). Previous consumption studies have identified similar processes of continued diversification in other fields of consumption and describe this as an important driver behind consumption growth in general (Pantzar, 1992; Røpke, 2001).

A more detailed presentation of these observations starts below with the practices related to "staying in touch" with friends and relatives, which serves as a good example of the diversification that accompanies the integration of ICTs. Then, we turn to the integration of ICTs in relation to other domains of everyday life, where their use might seem less obvious: do-it-yourself; sports and recreational activities; and volunteer work. These examples are illustrative of the diffusion of ICT across many practices.

"Stay in touch"

In this paper, practices related to "staying in touch" comprise communication between relatives and friends who do not meet on a regular daily basis, and where the aim of the communication is to exchange news about their lives and activities. This category excludes communication related to the daily practical and symbolic reproduction of the relations between close relatives, i.e. between partners or between parents and children. The practices related to "staying in touch" are important for reproducing meaningful relations between friends and relatives. All informants have experience with these practices, and several identified these practices as a cluster of activities that can be understood as an entity.

Before the so-called digital revolution in personal communication, practices of "staying in touch", in addition to physical presence, involved mediated communication in the form of telephone calls and sometimes letters. Today, these forms of mediated interaction have been supplemented – and to some degree replaced – by a wide range of other media and Internet services such as mobile telephone calls and short text messages (SMS), email, instant messaging, weblogs, IP-telephony and social networking websites like Facebook. The informants employ a great variety of combinations of new devices and services to "stay in touch"; some informants primarily use email and mobile telephones, while others combine several Internet services. The informants ascribe different meanings to the media; for instance, some informants associate MSN Messenger with threats like virus, spyware or the risk of child abuse (two of the informants have forbidden their children to use Messenger), while others enthusiastically embrace it as an "interesting and quick" way of communicating with friends and relatives. In spite of these differences, the interviews show that most people have integrated a number of the new ICTs into the practices related to "staying in touch".

In the following presentation, we focus primarily on one informant, Grethe, who – compared with the other informants – uses a large number of Internet services in her daily communication with friends and relatives. Since examples similar to Grethe's different uses of the Internet can be found in the other interviews, her account is illustrative of the diversity of the use of ICTs in the practice of staying in touch with others. Grethe is 51 years old, trained as a librarian, and she works with development of services and organization at the local library. She takes great interest in new ICT and has a playful attitude towards trying out new media and services. Together with her husband Rasmus, who is a mason, she lives in a detached house in a provincial town. Grethe and Rasmus both have children from previous marriages: Grethe has two adult sons (21 and 30 years old), while Rasmus has two children (13 and 15 years) who live with their mother and visit Grethe and Rasmus often.

Like most of the other informants, Grethe sends and receives several personal *emails* to/from relatives and friends on a daily basis. She often uses email to make appointments or to obtain news about the others' personal lives. Grethe explains that emailing represents an easy way to "stay in contact" in a busy everyday life.

> Grethe: 'How is it going with one thing and another?' you know….If you are busy and don't have much time to see each other, then it's nice to just send a mail like that (…). Make dates and just keep in touch regularly.

Grethe also often communicates with friends and relatives through *instant messaging*, particularly Google Talk and the chat feature on Facebook. When she is working at her computer – and logged on to her Google and/or Facebook account – her contacts can see that she is online, and they often write short greetings to her. Grethe explains that most of it is "just chit-chat": "Hi, when shall we meet again?" or "what are you doing?" Sometimes, she logs out or changes her status to offline, because the messages interrupt her work. Some other informants also use instant messaging on a regular basis. Esben, a 51-year-old electrician and service manager, finds it easy and cheap to use Messenger to communicate with his nephew in Australia. The nephew

sometimes sends pictures via Messenger, which Esben prints out and gives to his mother, his nephew's grandmother.

Grethe has a profile on *Facebook*, which she originally created because she was interested in visiting her niece's Facebook profile. Later, she became "friends" with her own sons, and then with some of their friends and so on. Grethe and her "friends" write short greetings to each other, and she describes Facebook as a "paradise for teenagers" and as "pure amusement". Facebook was still quite new at the time we conducted the interviews, and therefore only a few other informants used Facebook. One of these is the 35-year-old female university student, Gry, who has 120 "friends" on Facebook. Although many of her "friends" are connected with her work as a volunteer in a political party, Gry also meets several personal friends and acquaintances on Facebook. Some of the acquaintances are old friends, e.g. from high school, who have found her profile on Facebook and invited her to be their "friend". Gry thinks that Facebook has made it possible for her to stay in contact with more acquaintances, some of whom are "people I wouldn't have been in contact with otherwise…". Gry likes to visit her friends' profiles as she is curious to know how they are doing. Interestingly, most of the informants experienced with Facebook feel some ambivalence in relation to it; they find the universe of Facebook fascinating and captivating, but at the same time – and for the very same reason – they are afraid of spending too much time on Facebook. Gry even describes herself as "addicted" to Facebook:

> Gry: You always have to just check your Facebook, even though it's ridiculous. Nothing new has happened (…), but I just have to check anyway and click into my friends – see what they have joined… I really think you have to make some rules for yourself, because you can use an awful lot of time on nothing.

Grethe frequently takes digital photographs when she and Rasmus are together with friends and relatives (e.g. at dinner parties). Afterwards, she edits the pictures in Google's image editing programme Picasa, uploads them to a folder on Picasa's *web album*, and then by email invites those who attended to visit the folder and download the pictures. Grethe also uses Picasa's web album to stay in contact with former neighbours who moved to Singapore some time ago. She uploads and shares photographs with them from social gatherings with their neighbours so that they can follow life on their street. Similarly, the former neighbours upload pictures from their own life in Singapore and share them with Grethe and Rasmus.

Rasmus' children write about their personal life on their own *weblogs*, and if Rasmus or Grethe have not heard from them for some time, Grethe sometimes visits their blogs to see "what they are busy with at the moment". She also occasionally leaves a greeting in the form of a comment. Grethe explains that the weblog is a way of "keeping in contact" with them, when they are too busy to stay in touch with their father and her.

The empirical material includes other examples of how the integration of new ICTs results in a diversification of the practices related to "staying in touch" with friends and relatives. For instance, several informants use *IP-telephony* (Voice over IP, VoIP) on a regular basis. One example is 28-year-old Benny, who makes audio-visual calls to his parents via Skype; it "gives a really nice feeling that one can see each other", he explains. Another example is Steen, a 49-year-old truck driver, who frequently plays the *multiplayer online role-playing game,* World of Warcraft, with his 26-year-old son. Their characters "meet" and "fight together" in World of Warcraft, and while they are playing, they use Skype to talk together about shared game experiences as well as personal matters that have nothing to do with the game.

Some general observations can be made about "staying in touch" and the use of ICT: first of all, our interviews reflect the diversification enabled by the multiplicity of possibilities for mediated interaction with friends and relatives that has emerged on the Internet. Some of these possibilities resemble previous forms of communication (e.g. Skype as an inexpensive alternative to landline telephony), while in other cases the link to previous modes of communication is less obvious (e.g. video-telephony, instant messaging, multiplayer online role-playing games, weblogs and sharing digital photographs on the Internet). Our interviews also support results from other studies on mediated communication which indicate that, along with the integration of new ICTs, the practice of "staying in touch" with others may be in the process of transformation towards a continuous flow of frequently recurring interactions. Each interaction often lasts a short time and in many cases is asynchronous. This mode of mediated interaction is similar to what Licoppe (2004) denotes as "connected presence", and Christensen (2009) refers to in his analysis of the daily mediated communication between family members (both studies focus on mobile telephone usage).

Another important observation is that the diversification is closely related to an increase in both the number of devices people employ in their communication with others, and the length of time these devices are in use or turned on. Thus, several of the informants explained that they often had their home computers turned on and online during most of the afternoon, as they experienced it as inconvenient to turn the computer on and off each time they wanted to check their mail, visit Facebook, see who was online on instant messaging services and the like. However, this use pattern, which is characterized by frequent use of the computer and the Internet during afternoons and weekends, is not only a result of the diversification and increased use of ICT for mediated communication; it is also a result of the integration of ICT in almost every kind of everyday practice. This pervasiveness of ICT is in focus in the following sections, which discuss the use of ICT in relation to do-it-yourself, recreational activities and unpaid work.

Do-it-yourself

Several informants had experiences with do-it-yourself (DIY) in relation to renovating and refurbishing their homes, and all of them used ICTs. Lise is employed in the IT department of an insurance company and lives in an old farmhouse together with her husband. At the time of the interview, Lise and her husband were busy with a larger DIY project; they were renovating their home, the main building and two wings of the old farm. To prepare the rebuilding of the main house, Lise used the programme Microsoft Visio to visualize both the front and the layout of the house. Although the programme is designed to visualize projects, systems and processes through the use of flowcharts, Lise found that it served her purpose well. The drawings were very useful as input for decision-making and for discussions with others. A similar example is John, a 37-year-old project manager. He lives together with his wife and two children in a detached house in the countryside, where the family is in the middle of a thorough indoor renovation of their main house. John has used Second Life to visualize their new home and illustrate how it will look inside and out when the renovation is finished. Compared to traditional programmes used for visualization, John especially likes the possibility in Second Life to move the avatar around in the virtual version of their future home; it gives the feeling of actually being there:

> John: You can really get a feeling of what kind of a house you're actually making. (…). You can find a lot of programmes for

doing this, but you can't feel as if you can go inside. … (…) But here I could actually say to my friends [with an avatar in Second Life], "Just come by our place so you can (…) walk around our [new] house. This is how it looks."

John also experiments with creating a connection between the 'virtual house' in Second Life and the actual electrical system in his home, so that it is possible to control the switches in the house directly from Second Life and for instance turn lights off or on from his workplace.

Lise also finds net shopping very useful in connection with the rebuilding project. They succeeded in finding old roofing tiles that match the ones they already had, for example. Other informants describe similar examples. Tyge, a 43-year-old IT employee, has bought many products and materials, such as plumbing articles, via net shopping, which he finds convenient; the products are delivered directly to his home address, and he can shop from home at any time. Some of the informants document the different steps in the rebuilding process by taking digital photographs, which they use both for their memories and to show friends and others interested in rebuilding projects.

Sports and recreational activities

Several informants are active in sports. Lise rides her own horse every day. The horse is presently stabled at a neighbouring farm while Lise and her husband renovate their stable. When it is finished, Lise intends to hold two horses. She will install a web camera in the stable and access the recordings through a website, both from work and home. She also considers monitoring the fold in the daytime, so she can keep an eye on the horses while she is at work:

Lise: So I can see how the horses are doing and 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 early.

Esben, who is 51 and a member of a rifle club, gives another example of web-based monitoring. He has a safe where he stores the club's weapons at home, and for security reasons, he has installed a web camera. If anything moves in the room where the safe is, a picture message is sent to his mobile.

Lise teaches riding twice a week, and she wanted to video-record her trainees to use as a learning tool. For this purpose, she plans to replace her old video camera with a new digital camera that records directly onto a DVD. She also wants to record her husband running; and he could record her riding. The informants (or their partners) who like to run all have running computers that measure the length and gradients of the route and monitor the speed and pulse of the runner. Esben and his wife also use a running computer for their long walking tours, and he uploads the results to the computer on their return. Another informant uses an internet-based route map on which it is possible to draw his route and measure its length.

ICT is also used for recording in connection with other kinds of recreational activities Benny, who works with music history research in his professional life, also composes and sings in a choir in his leisure time. He is a member of a small association of composers, which has its own concert choir specializing in new compositions inspired by Renaissance vocal music. Benny sometimes records the choir's concerts on a mini-disc and later edits the results on the computer, removing the applause. He can then burn the sound file onto a CD so he can discuss the composition with the other composers. Brian, a 70-year-old retired businessman who was involved in amateur theatre for many years, no longer acts; but he follows the local theatre and has video-recorded their performance of a well-known musical. He made four recordings of the whole musical and used them to edit one high-quality version, which was then put on DVD. About 100 copies were sold.

A popular pastime among the informants is singing in a choir. 53-year-old librarian, Merete, and her husband Michael, participate in a beginners' choir that has a Facebook group where the music is available so the members can practise at home. The Facebook group is also used to try to attract more men to the choir by 'advertising' about all the nice female members as well as for social communication between the members. Merete also uses YouTube to search for songs they plan to sing and hear how they sound in the original versions. She uses the Internet in relation to other pastimes, such as her line dance class. When she cannot figure out the steps, she finds videos that teach the dances on YouTube.

Another informant, Helle (the partner of Steen, the truck driver), became an amateur genealogist when her cousin made a website where family members could upload texts, photographs and films about their ancestors and develop a genealogical tree. One way Helle finds information for the website is by searching online databases, which is now easier since church registers have been scanned and made available on the Internet.

Volunteer work in associations or political parties

Several informants are involved in volunteer work as coaches or active members of associations. Benny is on the committee of the small association of composers, the members of which use a website to exchange information and coordinate activities. The website includes both a weblog and "internal pages", which are only for members. The committee members also often use Skype's chat feature to communicate about practical details (e.g. to arrange time and place for meetings), and they have held a few meetings over Skype, supported by web cameras. Tyge, who runs and plays badminton at the local athletic association, is involved in coach meetings and takes part in the association's committee. Much communication related to committee work is carried out by email, and he receives mails almost daily with questions from association members. Tyge also uses the local municipality website to search for information about how to apply for funds for sports activities. Similarly, one of the other informants, a female karate coach who trains a children's team, communicates with their parents by email. She also contributes news and information about the team to the club's website and finds inspiration for her work as a coach on the websites of other karate clubs.

ICT is also used to establish and maintain broader networks related to volunteer work with contacts and persons with similar interests. Thus, Benny has a profile on both MySpace and Facebook, where he primarily introduces visitors to his interests in singing and composing. He mainly uses Facebook to receive news about coming events by reading the messages posted on the Walls of his friends' Facebook profiles. Benny explains that some fellow members of the association are much better than he at utilizing these kinds of contacts to develop collaboration with people in other countries. An example of this involves an English writer, who originally contacted Benny and the other members via MySpace:

Benny: (…) an English writer, who I had contact with, but the others [members of the association] have a lot of contact with him (…). And it has developed into concrete cooperation – he is a writer and writes lyrics to our music (…) and that has meant a lot. I met him several times. When the others invited him to Copenhagen, I went along. And I think that is just great.

The female university student, Gry, also uses Facebook as a way of gathering news and information in relation to her involvement in voluntary political work; she finds Facebook useful for organizing campaigns and meetings. Gry has many political contacts, and Facebook's list of "friends" helps manage all her contacts.

Dynamics and barriers

The interview material can supply many more pages of examples of the integration of ICTs in various practices, from political grassroots activities and travel experiences to parents' communication with teachers at their children's schools. The examples illustrate that all kinds of public institutions, organizations, associations and interest groups have embraced the Internet, and that our informants actively support this by using the facilities, sometimes very creatively. That political encouragement exists for developing information society is apparent, for instance, in the digitalization of archives and the communication systems used in schools. Many activities also involve the use of commercial products in addition to the computer, such as web cameras and running computers, commercial services such as Facebook and Picasa, and commercial software such as image-editing programmes. Since business firms search for business opportunities to implement the widespread diffusion of computers and the Internet, practitioners are offered a proliferation of supportive tools that interact with and become integrated in their practices. Business innovation often involves a search for products or services where designers try to script specific uses, and this of course also applies to much specific ICT equipment and software. However, the interpretive flexibility of the computer, the Internet and – although to a lesser extent – the many related products and services is great and offers a large potential for user creativity. Some of Lise's ideas mentioned above are illustrative; as she says: "I use my PC for everything I can possibly think of using it for".

The integration of ICTs does not always proceed as smoothly as the examples above may indicate. On the contrary, nearly all informants mention problems, for instance with compatibility. At the time of the interviews, the diffusion of Windows Vista created many problems and frustrations. For instance, Merete and Michael have Vista on their new laptop, but Merete's new MP3-player and the editing programme for Michael's digital camera do not work with Vista, and they cannot find a Vista-compatible driver for their scanner; in the short term, they solve their problems by using their old computer. There are also many other problems. Helle and Steen experienced problems with the installation of Skype and with setting up the virus programme so that it did not prevent them from playing advanced games. Some of our informants regard it as a hobby in itself to help others with their ICT problems. Esben helps a large group of relatives and friends, without compensation except for an odd bottle of wine. His interest in computers goes back to Commodore 64, and he enjoys repairing them, cleansing them of viruses, and trying out new equipment, programmes and Internet services. One person Esben helps is his 82-year-old father-in-law, who can communicate his problems to Esben over Messenger. If it is a bit complicated, Esben can take control of the old man's computer on the Internet by using a freeware crossover programme.

To sum up, the combination of commercial innovation, public encouragement and user creativity adds up to widespread changes in many everyday practices, and sometimes even encourages people to engage in practices that did not interest them previously (cf. Helle's interest in genealogy). We turn now to the energy implications of these changes in practice.

Implications for energy consumption

As already mentioned, the use of ICT is reflected in the increasing share of household electricity consumption. In this section, we concentrate on exemplifying the links between the observed practices and the related electricity consumption, rather than providing a detailed overview of the variety of links between ICT use in households and energy use. For such an overview of direct, indirect and derived energy impacts, we refer to Røpke et al. (2008) and Willum (2008).

In the first place, increased electricity consumption results from the increasing number of computers. When people integrate computers and the Internet into all sorts of activities, they increasingly want to have access to their own personal computer instead of sharing one with others. For heavy users, like most of our informants, this has already been standard for years, and many have more than one computer per person. Several reasons are mentioned for having more than one computer: For instance, some informants keep their old computers with previous versions of operating systems in order to be able to use software that is not compatible with newer operating systems such as Microsoft Vista (cf. the example with Merete and Michael); and some informants have two or more computers dedicated to different practices. People increasingly combine several ICTs in their performance of single practices; and/or they perform two or more practices simultaneously with each practice depending, for instance, on different Internet services. One example is Steen, who finds it convenient to have two computers running at the same time while he plays World of Warcraft; one for World of Warcraft and Skype, and one for browsing the Internet for additional information.

The pervasive integration of especially the computer and the Internet across everyday practices also makes it impractical to turn off the computer(s). While at home, many informants leave their computer turned on (sometimes in standby mode) and return to it several times during an ordinary evening or weekend. Most of these informants consider this a question of convenience.

In addition to computers, many other related devices use electricity. Specialized equipment is available for many practices, such as the webcams, headsets, external hard disks and digital cameras used by our informants. Some equipment is not very energy-consuming while other devices contribute more to the electric bill: such as plasma screens, projectors, and game computers, as well as equipment that must be on at all times, such as home servers, IP telephone connections, surveillance cameras, and set-top boxes that are continually updated. The process of diversification adds to the growing variety of ICT equipment, since specialized devices can be more attractive than multi-purpose equipment due to their improved performance (e.g. a digital camera usually produces better pictures than the camera in a mobile telephone).

The pervasive integration of ICTs into everyday practices increases the importance of the availability of mobile devices. Mobility thus becomes an aspect of the diversification process of both practices and devices. One participant in our short telephone interviews, a 20-year-old technician, described how he used his mobile telephone intensively to "chat" with friends on MSN Messenger and check his email while on the move.

For each single practice into which ICT is integrated, the increase in direct and indirect energy consumption may seem negligible; however, the pervasive integration of ICT across a large number of practices involves considerable impact on total energy

use related to everyday life. ICT may also be used to reduce electricity consumption in the home, for instance by managing heating and lighting. One informant was engaged in such management, but in general the potential for using ICT for energy savings has not yet been tapped. The increasing energy consumption related to household use of ICT may also be counteracted by derived energy impacts related, for instance, to teleshopping and teleworking, but until now, studies of these impacts tend to be inconclusive (Jørgensen et al., 2006).

Policy implications

In conclusion, the third round of household electrification may be said to be proceeding at full speed and, like the previous rounds, contributing to increasing electricity consumption. There is, however, an important difference: while previous rounds were combined with active promotion of increased electricity consumption, the present round takes place in an era characterized by increased focus on climate change and a call for energy savings. Until recently, this fact has had little influence on the domestic integration of ICT, but this may be about to change.

Producers naturally focus on providing hardware and software that consumers can be expected to find tempting, and as the empirical study illustrates, users are engaged in applying the new technologies in the development and diversification of a wide range of existing practices. The rationales of ICT integration emerge from each practice, such as using ICTs to find special materials for renovating houses, attract new members to a club, improve sports performance, socialize and so on. The interpretive flexibility of the new technologies opens many possibilities, and amidst all this engagement, the implications for energy consumption tend to disappear from sight or end up at the bottom of the priority list. This low priority also relates to the complexities involved in the acquisition of ICT equipment and software, which requires users to familiarize themselves with new technical terms.

Public regulation has begun to intervene in market processes with campaigns to increase consumer awareness of standby consumption, by implementing standards that remove the worst products from the market, and by labelling products to encourage consumers to buy the most energy-effective brands (Jensen et al., 2009; IEA, 2009; OECD, 2009b). But regulation is lagging behind – the process takes time, the number of devices is huge, and the technological development so fast that it is difficult to keep up. Obviously, it is important to speed up the process to put more effective public regulation in place, as recommended by IEA (2009).

Since the basic functions of data processing can be used for monitoring, managing and manipulating all kinds of equipment, ICT also holds promise of saving household energy consumption. The first steps have been taken with sensors to regulate lighting, and many other ideas are in the pipeline. During recent years, increased attention has been focused on the possibilities of reducing domestic energy consumption through the use of 'smart metering' to provide feedback to households about their energy use. Studies indicate that the most promising feedback systems provide households with frequent information on a disaggregated level (i.e. appliance-specific breakdown) and in an accessible and appealing way by the use of computerized and interactive tools (Darby, 2006; Fischer, 2008).

The most important perspective relates perhaps to the integration of wind energy and other sustainable energy sources into energy systems. This calls for smart metering to encourage consumers to use energy when the sustainable sources are available, and to store energy for later use (e.g. in batteries for electric cars). Actually, such trends may add to residential electricity consumption while saving fossil energy in a macro perspective. If the potentials of ICT for saving energy are to be realized, public intervention will be needed, since the necessary preventive incentive in the form of continuously high energy prices has not emerged automatically, in spite of the approach of peak oil – a situation where petroleum extraction cannot be increased any more (Campbell and Laherrere, 1998).

Previous rounds of electrification have co-evolved with broad social transformations. Such products as the vacuum cleaner and the refrigerator were first integrated into existing cleaning and cooking practices, and then gradually became part of profound changes in everyday life. There is no doubt that the computer, Internet and other ICTs will gradually become part of radical socio-technical transformations, although the direction of these changes is not yet clear. From an energy perspective, it is important to emphasize that the direction may be influenced by a wide range of policies – extending beyond narrow energy policies. For instance, ICT may be used for working at home and saving energy for transport – unless, encouraged by tax exemptions for work-related transport, people are motivated to move further away from their workplaces and travel further the few days they do go to work (Jørgensen et al., 2006).

At present, the potential of ICT for saving energy is often emphasized, both by ICT communities (e.g. at OECD conferences on Green ICT) and by green organizations (see WWF publications: Buttazoni, 2008; Pamlin and Pahlman, 2008). The risk exists that this promotion will end as a pious hope and function as a Trojan horse for infusing more ICT into everyday life. Like Hilty (2008), we wish to emphasize that realizing the potential for energy savings will not come about by itself. In addition to policies focusing on improvement of ICT equipment's energy efficiency, there is a strong need to develop policies that can curb rebound effects, encourage all actors to focus on applying ICT in ways that save energy, and influence the direction of the emerging socio-technical transformations. It is beyond the scope of this paper to develop a political programme to encourage realization of the positive potential of ICT and to curb the negative impacts, but some elements may be suggested: ensure a drastic rise in the price of energy and maintain a high price over time, combined with economic compensation to the poor, nationally and globally; remove "perverse" subsidies for transport; subsidize development of renewable energy technologies and investment in the transition of energy systems towards better integration of these technologies; and increase consumer awareness of the impacts related to the number of devices as well as the importance of energy efficiency. Hopefully, further work in this field will open for the development of much more elaborate programmes.

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