New needs for better understanding of household’s energy consumption – behaviour, lifestyle or practices?

Kirsten Gram-Hanssen*

Danish Building Research Institute, Aalborg University, A.C Meyers Vænge 15, København SV 2450, Denmark

It is well known that occupants strongly influence the final energy consumption of buildings, however, for several reasons more detailed knowledge is needed. These reasons include being able to model energy consumption, being able to adapt energy-efficient technologies and buildings to user practices and being able to persuade consumers to lower their consumption. This paper presents different methodological approaches to study households’ energy consumption including (1) register and survey methods with statistical analysis of large databases, (2) heat-consumption studies with surveys, qualitative interviews and indoor measurements and (3) detailed end-use metering of electricity consumption combined with surveys and qualitative interviews. The notions of either behaviour or lifestyle are often used when discussing variations in energy consumption. In this article, it will be argued that neither of these approaches is the most useful when analysing households’ energy consumption, as much of consumption relates to unconscious habits and technological structures which are not very well understood in behavioural or lifestyle approaches. Practice theory will be introduced as an approach that better includes both unconscious habits and technological structures and this will be discussed against the three methodological approaches and the different reasons to call for deeper insight into households’ energy consumption.

Keywords: households; energy consumption; practice theory; end-use metering; lifestyle; behaviour

Introduction

Energy consumption in buildings accounts for 40% of the end-use of energy in the EU, and reductions in this consumption are a key to achieving the substantial reductions in CO₂ emissions that are part of the EU-2020 target. Low-energy buildings, passive houses and zero-emission renovation are all important measures in reaching this goal. There is, however, substantial evidence from demonstration projects and research documenting that it is not enough to focus only on efficient building technologies. To unfold and supplement the technical potential of these efficient buildings, the users and their everyday habits have to be taken into account as well.

Focus on variations in household’s energy consumption can be on either variation between different types of households or on discrepancies between expected and real consumption. When it comes to variation between households, it is generally accepted and well documented that occupants substantially influence the energy consumption for space heating and that in identical buildings energy consumption may vary by several 100%, depending on the inhabitants

*Corresponding author. Email: kgh@sbi.aau.dk

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How to interpret and understand the reasons behind these variations between types of households is less well understood, however, and to some extent contested. When it comes to discrepancies between expected and real consumption, it is also well documented that new efficient buildings, or energy-renovated buildings, often do not meet the expected low levels of energy consumption when measured during real-life use (Larsen & Brunsgaard, 2010). There might be several reasons for this discrepancy, including the rebound effect and the more recently defined pre-bound effect. The rebound effect within energy-efficient building technologies has been known and described for decades, focusing on how the full potential of the expected savings is often not achieved when new energy-efficient technologies are introduced. Instead the expected savings are devoted to higher comfort. When people know they have efficient buildings and technologies, they tend to care less about saving. On the basis of different types of studies, it is suggested that on average 20% of the expected energy savings are not achieved (Gram-Hansen, Christensen, & Petersen, 2012; Sorrel, Dimitropoulos, & Sommerville, 2009). Recently, researchers have used German data to introduce a pre-bound effect, indicating that the measured energy consumption for existing buildings is on average 30% lower than the calculated theoretical consumption, and furthermore there is a tendency that the higher the calculated energy consumption, the bigger the discrepancy between calculated and measured consumption (Sunikka-Blank & Galvin, 2012). It is thus concluded that “the Germane databases suggest that, in general, the worse a home is, thermally, the more economically the occupants tend to behave with respect to their space heating” (Sunikka-Blank & Galvin, 2012, p. 270). The rebound and the pre-bound effect thus together indicate that the way people operate their homes; their everyday habits of adjusting their indoor climate, as well as their norms of comfort vary with the energy efficiency of the building in which they live.

One thing is acknowledging the importance of how inhabitants influence the energy consumption; another thing is how to utilise this knowledge. There are at least three different types of applications, or three different ways of introducing more knowledge about users into the aim of reducing buildings’ energy consumption. First is the wish to make better models of energy consumption. Energy models include a variety of models used for different purposes, including modelling on a macro-scale (Swan & Ugursal, 2009), which might be used for national energy planning, and on a micro-scale, the modelling of energy consumption in relation to buildings (Brohus, Heiselberg, Simonsen, & Sørensen, 2009, 2010; Mihalakakou, Santamouris, & Tsangrassoulis, 2002). Second is a wish to develop efficient building technologies that better meet the needs of users and support the users in more energy-efficient practices. As energy modelling of buildings is a strong tool in developing more energy-efficient building technologies, these two purposes are related to each other. The third purpose is to gain more knowledge about what householders do and why they do as they do in their everyday life, and thus possibly be able to turn these practices in a more energy-reducing direction. Better feedback to the users is part of this; however, it is important to recognise that better and more feedback to households does not necessarily imply substantially lower energy consumption (Darby, 2010).

When it comes to the first purpose of making better models, what is needed are various sorts of energy data at household level combined with data on the households, their practices and the buildings and their surroundings. When it comes to the second purpose of developing technologies that better suit the users, the same type of data might be relevant but supplemented by dialogue between users and designers on technology requirements. When it comes to the third purpose of better understanding households’ practices in order to be able to point at means of turning them in a more sustainable direction, again detailed data on what practices are behind energy consumption are needed, but in this case these data also need to be interpreted theoretically in order to understand the dynamics of changing them.
There are thus good reasons to dig deeper into all sorts of detailed data on households’ energy consumption. This article will present different types of data approaches; each with their strength and weakness, including register data, survey data, qualitative data and detailed metering. In different combinations these data can give insight into the inhabitants, their practices, their technologies and buildings, and their energy consumption. The data presented here is from Denmark and obtained over the last 12 years, and they will to some extent be compared with similar data from other countries. Before going deeper into these studies, however, there will be an introduction to different theoretical approaches of understanding the dynamics of households’ everyday life practices.

Theoretical approaches to households’ energy-consuming practices

From technological approaches of understanding users, the notions of behaviour and lifestyle are often used synonymously and without further consideration. From a social-science perspective, however, there are considerable differences between the two concepts, and more recently many scholars studying energy consumption from a social-science perspective have started to use a practice theoretical approach as an alternative. The following will first give introductions to the concepts of behaviour and of lifestyle and the ways these understandings can and have been used to analyse energy consumption. Moreover, the limitations of these approaches will be discussed. Following this, practice theory will be presented, as it has been developed among researchers studying energy consumption.

Behavioural approaches

In the behavioural approach, focus is on the individual and on the relation between attitudes, norms, intentions and behaviour, as it is assumed that individuals behave consistently. The most influential approach is the theory of reasoned action by Ajzen & Fishbein (1980). In their work, people’s intentions are a product of their attitudes and norms, and the researchers propose that it is likely that people actually behave as they intend to do. This approach, or variations of it, has been used in many types of consumer studies and also within energy-consumption studies (Abrahamse, Steg, Vlek, & Rothengatter, 2007; Brandon & Lewis, 1999; Wagner, 1997). A good example of this approach within energy-consumption studies is a project which looks at the effect of feedback information on 120 households (Brandon & Lewis, 1999). This study reports on a project where different types of information were used to give household feedback on their energy consumption, and to measure the effect. The theoretical understanding behind the project was that households’ energy consumption is a product of (1) Income constraints, (2) Socio-demographics, (3) Behavioural and structural potential for change, (4) Environmental attitudes and (5) Feedback. Results showed that income and socio-demography can explain some of the historical consumption (energy consumption level before project start), whereas environmental attitudes and feedback could explain some of the changes in consumption during the project. This study thus suggests that in the understanding of the level of normal consumption, sociological parameters may be more influential than attitudes, whereas the understanding of changes may rely more on the behavioural and psychological approaches.

Lifestyle approaches

When it comes to the understanding of how socio-economics relates to consumption, the sociological approaches of lifestyle may be relevant. The most renowned sociologist who worked on lifestyle is Bourdieu, who in his famous book “Distinction” showed how consumer taste in
everything from food, music and leisure time to housing consumption can be understood as structured by both economic and cultural capital (Bourdieu, 1984). He also introduced the notion of Habitus, which deals with how, unconsciously during their upbringing, people take in the cultural structures of their social surroundings and learn how to behave and what to like and dislike. Taste and the way people behave are different in e.g. a working-class family and a middle-class academic family, not only because of different economic constraints, but also because of different cultures, and according to Bourdieu these differences are also part of how we all show to our self and to others what social group we belong to and what groups we distinguish our self from. Using this approach to lifestyle in the study of energy consumption was especially discussed in the late 1990s (Jensen, 2001; Gundelach & Kuhn, 2000). Late-modern sociologists such as Beck (1992) and Giddens (1990) proposed a lifestyle concept that was less focused on social classes and more focused on how individuals stage themselves and show identity to others through their consumption. This approach was also used in understanding energy and other environmental aspects of housing consumption (Spaargaren & Van Vliet, 2000).

**Practice theoretical approaches**

However, it was also problematised to what extent the lifestyle approach, with its strong focus on showing identity through consumption, is actually valuable for studying mundane consumption such as energy consumption (Gronow & Warde, 2001). Rather, it was argued that the routinised and technologically structured parts of consumer practices had to be more in focus to understand households’ energy consumption (Shove, 2003). It is this line of thinking that has now led to the establishment of a practice theoretical framework for understanding energy consumption in everyday life (Gram-Hanssen, 2010a, 2010b, 2011; Hargreaves, 2011; Røpke, 2009; Røpke, Christensen, & Jensen, 2010; Shove & Walker, 2010; Strengers, 2010). In this practice theoretical approach, focus is on the collective structures of practices and on what guides the practices people perform in their everyday lives. Energy consumption is not a practice in itself, but all the different things that people do at home which consume energy, such as cooking or washing, are practices and these are guided by different elements. Although it is the individuals who wash clothes in their homes, this practice must be understood as part of a collective structure in which some common rules are followed for what clothes washing actually involves. There is no complete agreement among those working with this practice theoretical approach on the naming of the elements, but I will introduce the approach as described and used in (Gram-Hanssen, 2010a, 2010b, 2011). Here, there are four elements holding practices together; embodied habits, institutionalised knowledge, engagements and technologies. Embodied habits are important for the routinised practices in everyday life which consume energy. Often people perform these practices unconsciously, as it would be unbearable to consciously think about all the small things that we do every morning for example, such as waking up, turning the light on, taking a shower, putting the coffee on, etc. Conscious decisions might influence practices as well. This might follow influence from information campaigns on healthy foods or on energy-saving campaigns; however it is important to understand that there is no simple causal correlation between knowledge and practices. Engagement is an element implying that the practices mean something to the people who perform them. There is a goal or a reason guiding the practice. From an energy-conservation perspective, one of the problems is that this goal is about the reason to perform the practice and thus mostly not about energy. When you are cooking, the goal is to serve a dinner and not to save energy. Finally, technology is also seen as an important element in holding practice together, especially when it comes to energy-consuming practices. It is obvious that technologies such as freezers and electric cookers influence the way that people make food compared to previous times where these were not common. When understanding energy-consuming practices, it is thus
relevant to include all these four elements at the same time and to understand that practices are not just something individuals decide based on their norms and attitudes.

Discussion of approaches
To summarise these three different theoretical approaches, the behavioural approach has a psychological focus on individuals and sees their behaviours as guided by intentions which follow from norms and values. In contrast to this, the lifestyle and practice theoretical approaches are sociological theories which to a larger extent include the collective aspect of consumer practices. The lifestyle approach focuses on the visible consumption which can be used to show social status and distinction, whereas the practice of a theoretical approach to a larger extent includes the routinised and the technologically structured consumption. In the following paragraph, three different empirical approaches to studying households’ energy consumption will be introduced, and following this the discussion paragraph will return to arguing advantages and relevance of the above three theoretical understandings of households’ energy consumption.

Methods and approaches when studying households’ energy consumption
The methodology of this article is to present and discuss three different Danish studies that have been undertaken over the last 10 years to show the strengths and weaknesses of different types of data related to the different purposes discussed in the introduction of this article. First is a study of large databases, including both electricity and heat consumption in households. Following this is a study with detailed methods of studying heat consumption and finally there is a study with detailed methods of studying electricity consumption.

Large databases
As an example of a large database, I will first present a register database in which energy consumption as delivered to the household is combined with data on the inhabitants in each household and with building information. This database is possible to compose because of extensive registration of both buildings and persons in Denmark, combined with legislation allowing researchers under certain security restrictions to combine these sets of data. Information on inhabitants includes age, gender, income, assets, education, marital status, children and nationality. Information on buildings includes building year, type, size, ownership and installations. Energy in this database includes electricity and district heating as delivered to the address in year 2000. All households are based in the city of Aarhus, the second largest city in Denmark, and it is called the Aarhus database. OLS (ordinary least squares) regression analysis for different building types was made with SPSS (statistical package for social sciences) to determine what variables correlate with the amount of consumed electricity and district heating, respectively. This study, or parts of it, is further described in Gram-Hanssen, Kofod, and Nærvig Petersen (2004) and Petersen and Gram-Hanssen (2005).

The following will show results of the regression analysis based on this Aarhus database, and focus will be on consumption of district heating in detached houses and on electricity in apartments.

Table 1 shows regression analysis of 22,400 detached houses, where all available variables in the data set have been analysed for correlation with the amount of district heating consumed. The order of the variable is determined by the individual explanatory power of the variable after accounting for the influence of the house size. The size of the house has been included as a variable, rather than analysing heat consumption per square metre. The reason for this is that, as described in the introduction, research shows how heating habits may vary with the type of
house that people are living in, including its size. Thus, it is relevant to assume that it is easier to keep a lower temperature in part of a larger house compared to doing the same in a smaller house. Still the analysis shows that size of the house is the main variable for the amount of heating consumed, followed by the construction year. These two variables together can explain 39% of the variation within energy consumption for space and water heating. What is interesting is that when looking for an explanation for most of the variation, which thus relates to the habits of using heat, it is apparent that the available variables can only add an extra 4–5% of explanation of the variation. Most of the variation thus must be explained by habits which do not relate to standard socio-economic background variables of the population.

Table 2 shows regression analysis of 40,000 apartments, where all available variables in the data set have been analysed for correlation to the amount of electricity consumed. All apartments

<table>
<thead>
<tr>
<th>Background variable</th>
<th>Cumulative explanatory power</th>
<th>Explanatory power, after accounting for building size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of the house (m²)</td>
<td>28.3</td>
<td>( \text{Change in } R^2 % ) 10.5</td>
</tr>
<tr>
<td>Construction year (pre-1920 and 10-year intervals)</td>
<td>38.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Inhabitant age and aged squared</td>
<td>39.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Number of toilets in the house</td>
<td>40.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Inhabitant education (skilled, shorter and longer)</td>
<td>40.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Per 100,000 DKK in gross income</td>
<td>42.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Ownership</td>
<td>43.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Number of inhabitants</td>
<td>43.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Nationality</td>
<td>43.3</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Table 2. Background variables explanation of electricity consumption in apartments, only significant variables included (\( n = 40,000 \)).
are heated by district heating, thus electricity is only used for appliances and lighting. The order of
the variable is determined by the individual explanatory power of the variable after accounting for
the influence of persons in the household (the right column). For electricity consumption, the
main explanation is the number of people living in the household. The size of the apartment
also has some explanatory power, and the income of the household has a little influence as
well. The majority of the available variables, though significant, only contribute with little expla-
natory power. Two-thirds of the variation in electricity consumption among households in apart-
ments cannot be explained by standard socio-economic background variables of the occupants.

Studies of large databases from other national contexts are most often based on survey data
combined with energy data from utilities, as due to regulations the possibility of working on reg-
ister-based data only seems to be possible in Denmark. A Dutch study documents that building
characteristics determine 42% of the variation for heating consumption (space and water), and
the data also confirm that the household characteristics can only explain very little. The data
set builds on survey data combined with energy consumption from utilities and building infor-
mation from energy inspections. These data are thus not solely register based as in the Aarhus
database, but the number of households (3000) in the sample is large enough to compare with
register-based data. In the Dutch study app. 4% of the remaining variation in heat consumption
can be explained by socio-economic data (Santin & Itard, 2009; Santin et al., 2009). A study
based on US data concluded in line with this that besides weather characteristics, building charac-
teristics are the main determinant of energy for space heating and cooling purposes, followed by
behavioural aspects, though in this study the researchers also include the relation between occup-
ant characteristics (like age and income) and building characteristics (like size and type of dwell-
ing), making the indirect effect of the occupants much more important (Steemars & Yun, 2009).
Studies of the Aarhus database similarly confirm that different types of people live in different
types of neighbourhoods (Gram-Hanssen & Bech-Danielsen, 2004).

There are thus huge variations in heat and electricity consumption among households, which
relate to the everyday habits of the families. It is, however, apparent that these variations cannot be
properly understood unless we get more insight into what practices the families actually perform
in their everyday lives related to energy consumption. It has to be recognised that similarities in
energy consumption might relate to very different types of habits. High heat consumption might
thus relate to high hot water consumption, to extensive ventilation or to high indoor temperatures.
High electricity consumption might similarly relate to very different practices such as extensive
washing practices or extensive computer activities. For these reasons studies which include more
detailed measurements of either heat-consuming practices or electricity-consuming practices are
relevant and these will be further described in the following.

Heat consumption: measurements combined with survey and qualitative interviews
The second Danish study that presented here is a study of 1000 terraced houses studied by a mix
of methods, including the use of a survey (response rate 50%) combined with electricity and dis-
trict heating as delivered to the addresses, technical measurements and qualitative interviews. The
terraced houses include six different types of buildings and within each type the individual apart-
ments are identical. The six types of buildings include both owner-occupied and rented social-
housing apartments; all situated in Albertslund, a suburb of Copenhagen. Based on survey and
energy-consumption data, 32 households in two different building types were selected for tech-
nical inspection and measurements of temperature and air exchange. Also based on survey and
energy-consumption data, 10 households were selected (from the 32 being measured) for detailed
qualitative interviewing. This study, or parts of it, is further described in Gram-Hanssen (2003,
The method of qualitative interviewing is well described in the literature (Coffey & Atkinson, 1996; Kvale, 1996). In this study, qualitative interviews were carried out using open-ended question guides where interviewer and interviewee had a structured conversation during 1–2 h at the home of the interviewee. The aim of the question guide is to make the interviewee talk in his/her own words about their everyday life routines, ideas and values. Interviews were recorded and afterwards transcribed and analysed; both to reveal what was actually said, but also to analyse “between the lines” — what interviewee hesitated to talk about or what they were very eager to talk about. This combination of quantitative survey and qualitative interviews is quite usual in social-science research. In some social-science studies qualitative interviews are made first to get insight into what questions to pose in the survey. In other studies, it is the opposite and the survey is done first and then used to select informants to further develop issues from the survey. The latter was the case in this project. In this project, data were also combined with technical measurements of room temperature and humidity in both the living room and bedroom (by data loggers) and with air-exchange measurements based on passive tracer gas in selected households (Bergsøe, 1992). In general, it is not common in social sciences to combine qualitative interviews with this type of technical measurement, as most topics studied in social sciences are not measurable with metres. Within energy consumption studies, however, it is possible and most often preferable that the social-science approaches are also combined with actual measurements. From a methodological point of view, this involves some challenges, as we then have qualitative subjective input from the interview and quantitative objective input from the measurements dealing with the same issues. The purpose of doing this should not (primarily) be to validate what the interviewee said e.g. about their indoor temperature. The interesting part should rather be to understand how the objective measurements relate to the subjective understanding from the residents of their perceived indoor temperature, humidity or air exchange, and how measurements relate to residents’ expressions of their indoor-climate practices. The following will present some insights from the analysis on heat consumption based on this mix of methods.

In some of the families, where we have both interviews and measurements, there is correspondence between the measurements and what people say they do, and in these cases it might also be possible to read the related effect on the annual energy consumption for heating. An example of this was a family who were very conscious about how they ventilated and heated their home, and at the same time very conscious about not using more energy than necessary while still keeping a rather high temperature in the living room when they were at home. This family was one of the families with the lowest level of energy consumption for heating and it might be interpreted that they were technically knowledgeable and interested so their practices were somehow optimised according to their goal and they were obviously proud of their technical knowledge and practice. This tight relation between intentions and practices is rare however. Another example from the interviews was a family who thought that they had low temperatures, and especially said that they liked to sleep with low temperature. Furthermore, the family was to some extent environmentally concerned; however our measurements showed not that low temperatures and their annual energy consumption were among the highest in their neighbourhood. Rather than using the measurements to find incorrectness in the expressions from the inhabitants, this discrepancy is analysed as an example of how this family’s routine of opening windows and doors and regulating radiators followed other logics than what could be assumed from their intentions. The reasons behind their practices should rather be understood as them bringing in habits from previous dwellings and other areas of their everyday life, and that their practices were primarily directed by other meanings than energy savings; meanings such as “not liking closed doors” and “enjoying lots of fresh air”. These cases are further described in Gram-Hanssen (2010a).

In this study, unfortunately we did not have possibilities to distinguish between energy used for hot water and energy used for space heating. When relating between qualitative expressions
from occupants on their indoor practices, or their showering practices, of course it is highly relevant to be able to relate to energy consumption for each of these practices rather than relating to combined heat consumption.

**Electricity consumption: end-use metering in combination with other methods**

The third Danish study to be presented here deals with electricity used for appliances and lighting. This study was part of the EU EURECO project with end-use metering of electricity in four European countries: Denmark, Italy, Portugal and Greece (Sidler, Lebot, & Pagliano, 2002). The EURECO project included end-use recording in 100 Danish households, all situated in the fourth largest city in Denmark, Odense, for one month in 1999 or 2000. The recording was performed with a discrete metre plugged in series with each appliance, and data were automatically transmitted every 10 min. Furthermore, a specially developed lamp-metre kept track of lighting use every 10 min. A questionnaire survey was later also carried out among these households (with 71 responding households) on their everyday practices and attitudes, and on the basis of these replies 10 households were selected for qualitative interviewing in a similar way as described in the study above. Selection criteria for interviewed households were high versus low electricity consumption and interest in saving versus not interest in saving. This study, or parts of it, is further described in Gram-Hanssen (2005) and Gram-Hanssen et al. (2004).

This type of detailed end-use metering provides insight into the huge variation in households’ end-use electricity consumption. In Figure 1, the maximum, the minimum and the average yearly electricity consumption for different end-uses in the 100 measured households are shown. For example in one household they only used 50 kWh for washing, whereas in others they used 750 kWh, in one household they used 0 kWh for standby and in another household standby was measured to be 1300 kWh per year. The biggest variations were for “Rest, including cooking” which is not surprising as besides from cooking, this was also the residual, meaning a gather-all category for what was not measured by the rest. When interpreting these variations in each end-use, the study included both data from the survey and from qualitative interviews. First, the analysis including survey data will be reported.

![Figure 1](image_url)
Figure 2. Distribution of electricity end-use depending on the number of persons in the household. For 1-person households the figure is based on 8 households with an average of 1604 kWh/year, for 3+person households the figure is based on 58 households with an average of 4340 kWh/year. Figure based on (Kofod, 2005).

Figure 2 shows how the average distribution on end-use in electricity differs with size of households. Here, it is seen that there is a clear tendency that people living alone use a larger share of their total electricity on cold appliances (freezers and refrigerators), whereas the opposite is the case for wet/dry appliances (washing machines, tumble dryers and dishwashers). An interpretation is that cold appliances are a basic load in a home and independent of the number of persons in the household, and thus in larger households, with larger total electricity consumption, this becomes a smaller proportionate share. On the other hand, washing machines, tumble dryers and dishwashers are more likely to be found in bigger households and they are more likely to be used more often if more people live in the household. Number of persons in the household thus not only influences the total amount of electricity consumed but also influences the distribution of electricity by end-use.

Table 3 shows the percentage distribution by end-uses related to the age of the oldest person in the household (taken as an indicator of the whole family’s place in the lifecycle). The total consumption depends on the family’s stage in the lifecycle, with the most electricity consumed between 30 and 50 years of age. The actual amount of kilowatt-hours (not shown, can be calculated from the figures in Table 3) used by refrigerators and freezers does not depend on inhabitant age. Dishwashing and washing/drying make up a smaller percentage of the total electricity use among older people compared with younger people, whereas older people use a larger share of their electricity on lighting compared with younger people. Older people use as much electricity for computers, television/radio as younger people, but it seems that older people are more likely to turn off the standby consumption. Similar analyses can be made using income and other socio-economic variables.

These analyses are only indicative of the relationships between background variable and electricity end-uses, as the number of households in the survey is too small for proper statistical analysis. However, the analyses might help explain why background variables such as age and income only explain very little of the total household electricity consumption shown in the Aarhus database analysis. People do not consume electricity; they do different things and have certain appliances, which consume electricity. Analysis of larger end-use data samples might, therefore, reveal stronger relations between socio-economic background variables and end-use consumption than between socio-economic background variables and total electricity consumption.

Table 4 shows end-use consumption related to the interest in saving energy. It is seen that electricity for cold appliances seems independent of interest in saving energy, and also electricity for TV/radio and computer are quite independent of the interest in energy savings. Lighting and
### Table 3. Distribution in percentage of end-use of electricity in detached houses in relation to age.

<table>
<thead>
<tr>
<th>Oldest person’s age (Years)</th>
<th>Average electricity use (kWh)</th>
<th>Number of households</th>
<th>Refrigerator/freezer (%)</th>
<th>Dishwasher (%)</th>
<th>Washer/dryer (%)</th>
<th>TV/radio (%)</th>
<th>Computers etc. (%)</th>
<th>Lighting (%)</th>
<th>Standby (%)</th>
<th>Other (inc. cooking) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–29</td>
<td>2950</td>
<td>2</td>
<td>29</td>
<td>0</td>
<td>18</td>
<td>11</td>
<td>2</td>
<td>10</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>30–39</td>
<td>4154</td>
<td>17</td>
<td>19</td>
<td>7</td>
<td>14</td>
<td>5</td>
<td>3</td>
<td>12</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>40–49</td>
<td>4070</td>
<td>25</td>
<td>22</td>
<td>4</td>
<td>12</td>
<td>6</td>
<td>4</td>
<td>13</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td>50–59</td>
<td>3911</td>
<td>17</td>
<td>28</td>
<td>3</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>13</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td>60–69</td>
<td>3063</td>
<td>5</td>
<td>38</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>14</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>70–79</td>
<td>3018</td>
<td>5</td>
<td>30</td>
<td>2</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>15</td>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>

Source: Odense data, n = 71.

### Table 4. Distribution of actual end-use of electricity in detached houses, in relation to the household’s own view of their carefulness in saving energy.

<table>
<thead>
<tr>
<th>Careful about saving energy</th>
<th>Average electricity use (kWh)</th>
<th>Number of households</th>
<th>Refrigerator/freezer (kWh)</th>
<th>Dishwasher (kWh)</th>
<th>Washer/dryer (kWh)</th>
<th>TV/radio (kWh)</th>
<th>Computers etc. (kWh)</th>
<th>Lighting (kWh)</th>
<th>Standby (kWh)</th>
<th>Other (inc. cooking) (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, very</td>
<td>3515</td>
<td>28</td>
<td>870</td>
<td>181</td>
<td>391</td>
<td>193</td>
<td>113</td>
<td>433</td>
<td>354</td>
<td>980</td>
</tr>
<tr>
<td>Yes, some</td>
<td>3802</td>
<td>31</td>
<td>848</td>
<td>140</td>
<td>432</td>
<td>219</td>
<td>169</td>
<td>480</td>
<td>390</td>
<td>1126</td>
</tr>
<tr>
<td>Normally not</td>
<td>4906</td>
<td>12</td>
<td>892</td>
<td>264</td>
<td>739</td>
<td>259</td>
<td>144</td>
<td>796</td>
<td>559</td>
<td>1256</td>
</tr>
</tbody>
</table>

Source: Odense data, n = 71.
washing/drying are the end-uses that show most dependency on the attitude to energy saving, however, compared with the variation in these end-uses in Figure 1, it is apparent that factors other than interest in saving energy influence as well.

From the qualitative interviews, we get more insight into the different everyday practices of the families which can help explain these variations in end-uses. Behind the big variations in cold appliances are variations in what (type and amount of) appliances people have and how they use them depending on different food practices. An old couple explained how they use the freezer for fruit and vegetables which they grow themselves, as well as for purchases of special offers, whereas a family with young teenagers mostly use it for fast food which the children can make themselves in the afternoon. A middle-aged couple explained how they just got rid of their big chest freezer as they now prefer to eat fresh meat and vegetables rather than frozen. They elaborated that before it was “in” in their circle to buy meat in large quantities directly from farmers and then freeze it, but this is not the case anymore. Apparently these different food practices can influence household electricity consumption, but they have no relation to interest in energy savings.

For washing practices there are also huge variations in how many loads the families say that they wash a week, varying from 1 to 18 loads a week. This relates to similarly huge variations in how often and why people put clothes out for washing. In some families all clothes and towels are washed after each use, most often out of convenience more than from a hygienic perspective: It is easier to wash than to keep track of who used what towel, or how often these trousers have been worn. Other families might have other practices but these practices are rarely linked to concerns for energy consumption. The qualitative interviews thus give some explanation on why environmental attitudes or interest in energy savings often has little influence on the energy consumption in the household.

Discussing methodological and theoretical approaches

*Discussing the proposed theories in light of the methodological approaches*

In the theoretical introduction, it was shown how the behavioural approaches assume that people act as they intend to do and that their intentions are a product of their attitudes and norms. In the detailed studies of heat consumption in Albertslund and of electricity end-use in Odense, it is apparent, however, that people’s intentions when they consume energy have very little to do with the amount of energy consumed. If people have intentions guiding what they do, then these intentions are related to the practices that they perform, whether this is the practice of keeping a nice indoor climate, food practices, washing practices or other energy-consuming practices. As described in the practice theoretical approach, one of the things that guides practices are meanings or engagements. These might be understood as a more collective kind of intention. Where the behavioural approach focuses on what the individual chooses to do based on their intentions, then the practice theoretical approach focuses on how the individual is a carrier of a practice e.g. the washing practice, which is a collectively developed entity that can be performed with smaller or bigger variations by its practitioners. The most important difference between the behavioural and the practice theoretical approach is thus the question of how individualised and how conscious people’s actions should be understood, where the practice theory will emphasise the collective structures and the unconscious habits. Furthermore, the advantage of the practice theoretical approach is that it also includes technological structures as well as different types of institutionalised or otherwise shared knowledge as part of what constitutes practices.

From the database analysis, it was seen that socio-economic background variables had quite a limited explanation power when it comes to understanding variations in heat or electricity
consumption. The more detailed studies on end-uses and practices behind the total energy consumption, however, indicate that some of these end-uses might be structured more in relation to socio-economic background variables than to the total energy consumption. This is not surprising, as people do not consume energy as such; rather they perform different kinds of practices and these practices, in different ways, entail energy consumption. There is, thus, some evidence that parts of households’ energy consumption are to some extent structured by where people are in their lifecycles or what their economic possibilities are. This is based on empirical evidence, however, which is not related specifically to any of the theoretical approaches presented here, but it is evidence which must be taken into consideration, irrespective of the theoretical interpretation used.

When it comes to the lifestyle approach, the theory section describes how this relates to different social groups or individuals showing status and identity to each other, and it describes how this approach is most useful when analysing conspicuous consumption, whereas energy consumption is a highly invisible consumption. There may, however, still be some reasons to include the lifestyle approaches when understanding the patterns behind energy consumption. As some of the studies which rely on large databases with socio-economics, building information and energy consumption show, the type of people living in a specific type of building is not random, and therefore socio-economics do have an indirect link to energy consumption. Old, large detached houses often consume more energy for heating than small, new semi-detached houses, and using lifestyle analysis on what type of people are living where, can reveal that there are huge differences, not only related to economic capital, but also to the culture among the different types of people living in different types of neighbourhoods (Gram-Hanssen & Bech-Danielsen, 2004). The lifestyle approach can explain how both cultural and economic capital are decisive for housing patterns and consumption, and it might, therefore, also be relevant indirectly to explain differences in energy consumption related to housing type and size.

**Discussing methodological approaches in relation to different purposes**

In the introduction, three different purposes for getting more insight into households’ energy consumption were presented, including better modelling at the macro- and micro-level, constructing low-energy buildings that better support sustainable occupant practices and finally assisting households in lowering their energy consumption, including giving feedback on their energy consumption. In the previous paragraph, different approaches were presented as to how to study households’ energy consumption. In the following, I will discuss the advantages of each approach in relation to these three purposes.

The first approach involves analysing total energy consumption at household level with background information on occupants and buildings. The advantage of this approach is the sample size and the fact that there is no dropout from unwillingness to participate. When it comes to modelling, especially on a macro-level, these types of data are relevant as they provide aggregate information with high accuracy. When it comes to micro-modelling, and the purpose of making buildings that better suit the users’ practices, these types of data are often too aggregated. At the least, the data need to distinguish between heat consumption for space and for hot water. Finally, when it comes to understanding households’ consumption and giving feedback to consumers, research shows that efficient communication to the end-user on their own consumption needs to include more information than just the total consumption of heat or electricity (Fischer, 2008).

The second and third approach includes more detailed measurement which can be related to specific practices of either heat consumption or electricity used for appliances and lighting. These measurements are furthermore combined with quantitative and qualitative data to help explain the
background for the consumption. The advantage of these data is the level of detail and specifically that they are split up into what types of practices energy is actually used for. This is important for micro-modelling of occupants in buildings and thus also for developing buildings that are better adapted to occupants. Detailed heat consumption data analysis is particularly interesting here, although electricity consumption from appliances and lighting is also relevant, as in new low-energy housing this is thought to contribute to a good deal of the heating of the buildings, and might also contribute to overheating of the buildings in summer time. When it comes to understanding households’ energy consumption in order to help them save energy, including giving feedback on their consumption, then both detailed heat and electricity consumption which is split up by end-uses related to the practices people perform in their everyday lives is most relevant. However, this information is not enough. Insight into how to communicate with households on these issues is also very important, as the way the feedback is communicated might be as relevant as the information itself.

Conclusion

It has generally been well documented that householders influence the energy consumption, however, as this special issue also illustrates, there is an emerging interest in even better describing and understanding this. The purpose of this article has been twofold; on the one hand to qualify the theoretical interpretation of households’ consumption pattern and on the other hand to introduce and discuss different types of empirical methods to study households’ energy-consuming practices. When it comes to theoretical understanding of households, technologically oriented approaches often use the words behaviour and lifestyle synonymously to indicate that the inhabitants influence the final residential energy consumption. In this article, these concepts and their background have been introduced and discussed and it has been argued that practice theory as recently developed within sociological energy studies might be a more relevant approach.

In the last three decades, quite a lot of research has been done on the influence on energy consumption from users of buildings and technologies. However, the renewed interest in this type of research demands even more detailed knowledge than seen previously. Detailed empirical data can be expensive to obtain, especially if they also have to be linked to end-use metering and technical measurements in large numbers of households. When these types of surveys and measurement campaigns are undertaken, it is, therefore, very important that they build on a solid foundation, including a reflected theoretical understanding of what structures households’ practices.

This article argues that practice theory is the best way to conceptualise energy-consuming practices in everyday life. For designing empirical studies this implies that one first has to define what practices are behind the energy consumption. For each of the practices, the four elements which hold practices together then have to be studied, together with the detailed energy measurement related to this practice. These four elements are (1) the technologies, including the size, amount and efficiency of them as well as related infrastructures, (2) the knowledge people have of these technologies and their use, including what rules they have been taught to follow by different types of intermediaries such as caretakers, energy advisors, craftsmen or sales persons, (3) the routines and habits which are an unconscious part of all everyday practices and which can date back to childhood or to other part of everyday life and (4) engagements which are the different reasons why people perform these practices and which often do not relate to energy, environment or economy. This means that when designing questionnaires or interview guides for qualitative interviews, as well as when doing analysis, these four elements should be kept in mind.
When looking at the three different types of methodological approach, there are different implications of this. For the large databases, data related to engagement, routines or knowledge are not available, so it is primarily the technology element which can be studied. The recommendation would thus be to make sure that a statistically significant share of the households live in new low-energy buildings in order to be able to detect whether these buildings (that is technologies) follow the same patterns as other buildings after all socio-economic variations have been taken into account. All possibilities of including time-based energy-consumption data are also relevant, as these might distinguish between different types of practices “hidden” in the total energy consumption. Likewise, whenever possible, data where hot water and heat consumption for space can be separated from each other are preferable, as these relate to very different practices. This type of study, using large databases on energy consumption combined with household and building characteristics, can be useful, especially when dealing with different types of modelling of energy consumption. It is recommended that this type of study be done in countries such as Denmark, where it is possible to combine data from different official register databases. For other purposes, however, this type of information has to be supplemented by more detailed metering and measurements, as well as more qualitative data, which are divided between the different energy-consuming practices performed by households.

When it comes to the more detailed studies of end-use metering of heat consumption, again the most important aspect is to be able to distinguish between energy used for space heating and for hot water, as this relates to very different practices. Here, it should also be mentioned that studies of end-use data on hot water are very scarce, but relevant as this consumption will make up a growing proportion of the total heat consumption in households, when building-related consumption is reduced by the introduction of low-energy buildings. When it comes to detailed studies of indoor climate, the most interesting aspect is probably to find new ways to compare and combine qualitative interviews with measured data and with survey or register data. Survey and qualitative interviews should be designed to reveal information about knowledge, routines and engagements related directly to the practice that is being studied. When it comes to the aim of making detailed modelling of buildings to be used when designing new low-energy buildings, this type of study is probably the most suitable.

Similarly, for electricity end-use studies, survey and qualitative interviews should be designed to reveal information about knowledge, routines, engagements as well as the technologies related directly to each of the practices studied. This can be quite extensive, as electricity is used in relation to many different practices, guided by different elements. Furthermore, there is still a lack of studies which are statistically significant and can tell what socio-economic variables explain what end-use practices. In these cases, it is important to be aware that there might be very fast changes in the direction of growing consumption because of the end-use consumption of information and communication technologies. This type of study, together with detailed heat consumption studies, is the most relevant type of study when the aim is to get more knowledge about how to persuade or assist householders in substantially reducing their energy consumption e.g. through feedback on their individual energy-consuming practices.

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