A time-geographical mixed-methods approach: studying the complexities of energy and water use in households

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The objective of this study is to describe and assess a methodology based on a time geographical approach for studying energy and water use in households. Energy and water resources are often used in routinized activities, and in activities considered as private, normal and ordinary, which makes them difficult to explore in research. In this article, we give an account of a mixed-methods approach using time diaries, metering data, interviews and simple observations, and analyse and discuss its methodological and empirical implications from two Swedish case studies. We conclude that the suggested combination of methods, despite some complications, provides a comprehensive account of household energy and water use to which various theoretical perspectives could apply. Energy and water using activities are defined in terms of time, place, quantity, material and social context, and are related to user perspectives on resource use and usage data. Such knowledge provides important input for information campaigns, technological retrofitting and other systemic changes in striving towards sustainability.

Keywords: time geography, methodology, water, energy, households, everyday life

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Introduction

A key to sustainable development is to reduce the use of natural resources (UN 2015). Households could contribute by using more environmentally friendly products, using fewer resources and being more efficient. Seemingly mundane and simple activities such as washing, cleaning, airing and cooking are critical simply because they are repeatedly done by many people. Are there any ways such activities can be done differently and less often, and be less resource intensive? To approach this issue, we must study individuals' activities in households and their rationale. In this article, we suggest a comprehensive methodological approach; a combination of time diaries, metering data, interviews and simple observations, to unveil and recognize household resource use in its material and socio-cultural context, and thereby enable an understanding of everyday practices and their significance in terms of resource usage. Mixed-methods approaches have the potential to disclose different perspectives and provide a deeper examination of the issue in focus (Valentine 2001). The

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complexity will become visible and thereby subject to analysis (Widerberg 2002). Also, with the use of multiple methods the weaknesses of a single method can be counterbalanced (e.g. Rose 1993; McLafferty 1995; Moss 1995).

The methodological combination described and assessed in this article is theoretically based on time geography. Time geography has been found to be a suitable approach to cover the seemingly insignificant and taken for granted, yet vital, aspects of everyday life (Ellegård 1999). Time-geography focuses on the individual's possibilities to execute activities in relation to the site-specific material and social situation at hand – *the action space*. Everyday life is defined by all individual activities, but when studying it, a certain aspect or activity is usually in focus. The time-geographical analysis stresses the importance of acknowledging the continuous interaction between all individual activities and the entire activity context, irrespective of which everyday life aspect interests us in research. During the course of a day, activities with different goals and meanings succeed and also inflect each other, since they take place in a time-space constrained environment (see Pink *et al.* 2015a).

A time-geographical approach has been used in a range of research studies on individual activities related to, for instance, energy use (e.g. Ellegård & Palm 2011; Hellgren 2015; Isaksson & Ellegård 2015), water use (Krantz 2005), working life (Ellegård *et al.* 1994; Trygg 2014; Trygg & Hermelin 2017), rehabilitation (Andersson 2009; Åström 2009; Orban *et al.* 2012; Bendixen & Ellegård 2014; Örmon *et al.* 2015), mobility (Schwanen & Kwan 2008; Vilhelmson & Thulin 2008; Chen *et al.* 2011) and gender differences (Kwan 1999, 2000; Schwanen *et al.* 2008; Scholten *et al.* 2012). Commonly, studies inspired by the time-geographical approach use the time-diary method to collect empirical material. The method is based on a time-geographical perspective on the constitution of everyday life, and enables an individual's routines, rhythms and activity patterns to be captured. The time-diary method also forms the basis for the mixed-methods approach presented here. A time diary should not be mistaken for a respondent diary, a written biography (systematically) describing a period of an individual's life (Clifford *et al.* 2016). Nor should the present time-diary method be confused with the many national time-use studies conducted for statistical purposes, with pre-established activity categories, 'main' activities and time intervals. These studies do not consider the contextual relationship between activities and the social and physical time-space orders, known as the action space. For an extended review of such time-use studies, see Hellgren (2015). The time-diary method proposed here is more open-ended, which increases the likelihood that minor and uncontemplated activities such as routines will also be noted (Ellegård & Nordell 1997).

There are several studies on household energy use using time-diary data in isolation (Widén & Wäckelgård 2010; Aerts *et al.* 2014; Hellgren 2015), aggregating and modelling behaviour aspects of energy use. In studies with qualitative ambitions, time diaries and interviews are used in combination (e.g. Ellegård & Palm 2011), sometimes also adding metering data (Krantz 2005; Karlsson & Widén 2008). Metering data is also used as a single empirical material when modelling household energy use (Hjerpe 2005; Widén *et al.* 2009; Rohdin *et al.* 2012). The founder of time-geography, Torsten Hägerstrand, warned against the use of aggregated and out-of-context approaches when studying human practices: "one risks becoming lost in a description of how aggregate behaviour develops as a sum total of actual individual behaviour, without arriving at essential clues toward an understanding of how the system works as a whole" (Hägerstrand 1970, 11). Hence, in the following we put forward a mixed-methods approach that provides broad and detailed empirical material on the contextual premises of individual and household water and energy use, allowing for various kinds of qualitative analyses and theoretical applications.

Everyday-life studies in homes – theoretical framework

When studying everyday life aspects, the focus is on individual activities and how these constitute meaningful parts in an individual's life. Time-geography appears to advocate an individualistic perspective on activities, but in a household where several individuals live and interact, each of the different individuals' activities must be studied in combination.

A household is often seen as one unit, forgetting that it is a social entity commonly including several individuals (Isaksson & Ellegård 2015). The social relations within a household matter for how the

home time-space is arranged. A household is both a social entity and a physical entity. Therefore, when studying everyday life features in households, it is important to study both the physical context in relation to individual activities and the social interaction, displaying for instance gender roles, division of household work, household negotiations and norms of conduct. Everyday life is a totality from the household members' perspective and hence must be treated as such when being researched (Ellegård & Palm 2011).

A simple definition of a household is one or more individuals living in the same dwelling. The household social context entails members being involved in common tasks together, but with a dependency on each other for the execution of individual plans and projects. Water and energy are resources used for the fulfilment of different household undertakings and are often allocated by negotiations. Evidently, individuals in households also use resources in other places, but with the household as the category, the focus is on the resource use taking place within the home. In connection with home as 'place', Massey (2005) suggests that it is a collection of stories, articulations and processes – a spatio-temporal event. In Buttimer's (1976, 277) terminology, it is the "lifeworld": "the culturally defined spatiotemporal setting or horizon of everyday life", whereas sense of lifeworld is everyday experiences consisting of routinely accepted patterns of behaviour and interaction. To the spatio-temporal event of a home, Pink *et al.* (2015b) add practices, discourses, materiality and energies. Lifeworld should be seen as an experienced world where time and space limit the experience. To be able to study and recognise the lifeworld, routinized behaviour should be at the centre of attention (Buttimer 1976).

Tuan (1975) describes the home as the centre of meaning and the pivot of daily routines, constructed of experiences. The home is the place of constant return: "we go to all kinds of places but return to home" (*ibid.*, 155). Specific parts of the home might be private to the individual (e.g. the bedroom, the rocking chair). When such places change, the focus, physical world and meaning for the individuals living there will change at the same time (Tuan 1975).

Hence, to understand how to approach the household use of energy and water, it is important to understand the complicated interaction between individual everyday life activities, socio-cultural norms, social negotiations, gender roles, economic constraints, technological systems and buildings, etc. Commonly, research aiming to investigate and understand the household use of energy and water resources relies on few data collecting methods and often presents aggregated, estimated, modelled or simulated individual behaviour (Widén *et al.* 2009; Willis *et al.* 2011; Hellgren 2015). Even though no modelled or simulated person exists, such studies are useful in the sense that they provide information on possible 'critical' activities or attitudes in relation to for instance the use of energy and water, and what time of day usage can be expected to peak. However, they are less concerned with questions such as why resources are used at all, how everyday routines and activities relate to actual usage, or if, how and why routine change transpires. These qualitative aspects of everyday life are important to cover, since they may reveal the not so obvious reasons behind the use of water and energy resources, and may suggest other methods to make resource use more efficient.

Time-geography emphasizes the importance of materiality and space for human activities, but also recognizes the social and cultural dynamics behind physical arrangements. The socio-cultural norms are powerful when it comes to defining individual needs and wants. It is the social aspects, for example our ideas of a good life, norms, regulations and values, and the negotiations taking place around them, that affect which activities are prioritized and how time-space is arranged to enable their execution (Hägerstrand 1985, 323-324).

The use of water and energy are often related to our understanding of what it means to be 'clean', what is 'convenient' and how to achieve 'comfort' (Shove 2003). Hence, water and energy use is not an activity in itself but is integrated into numerous everyday activities of different characters. Therefore, it is not possible to study energy or water use as such to answer questions about how resource use generates, develops and changes, but it is necessary to include the entire household activity pattern. Some activities using water and energy are done frequently in a repetitive and often unreflecting manner – the *routines* (e.g. Ellegård 2001; Latham 2003). Thanks to taps, sockets, power buttons and electrical switches, resource use takes place effortlessly and in an uncontemplated manner. The routinized use of water and energy resources is further reinforced by their provision

through large technical systems, the operations of which are not transparent to the user (Krantz 2012). In addition, water and energy use sometimes relates to private activities. Hence, the elusive character of water and energy using activities makes the study of them challenging and requires certain approaches and methods.

There are different ways to generate empirical material for understanding everyday life. Interviews, questionnaires, observations and focus groups can all provide insightful material. However, unawareness of one's own routines and disclosed technical systems are conditions that challenge the use of such methods in isolation. Only by raising individual awareness of one's own routines can they be fruitfully discussed in a research interview.

A mixed-methods approach – study design

In the following, we propose combining time diaries, interviews, metering data and simple observations to get a more comprehensive understanding of household use of water and energy. The potential of the mixed-methods approach is illustrated by two Swedish case studies. The methodological approach is constructed from theory and empirical experience, and is thought to work as a researcher's guide for similar studies. The study design should be regarded as a rough description of applicable elements in the research process, which may have to be adapted to the specific research objective and other case-specific circumstances.

The study design is divided into seven steps (Fig.1). The researcher's individual path (a time-geographical concept illustrating the movements of a physical object or human in time-space) can be followed throughout the research process.

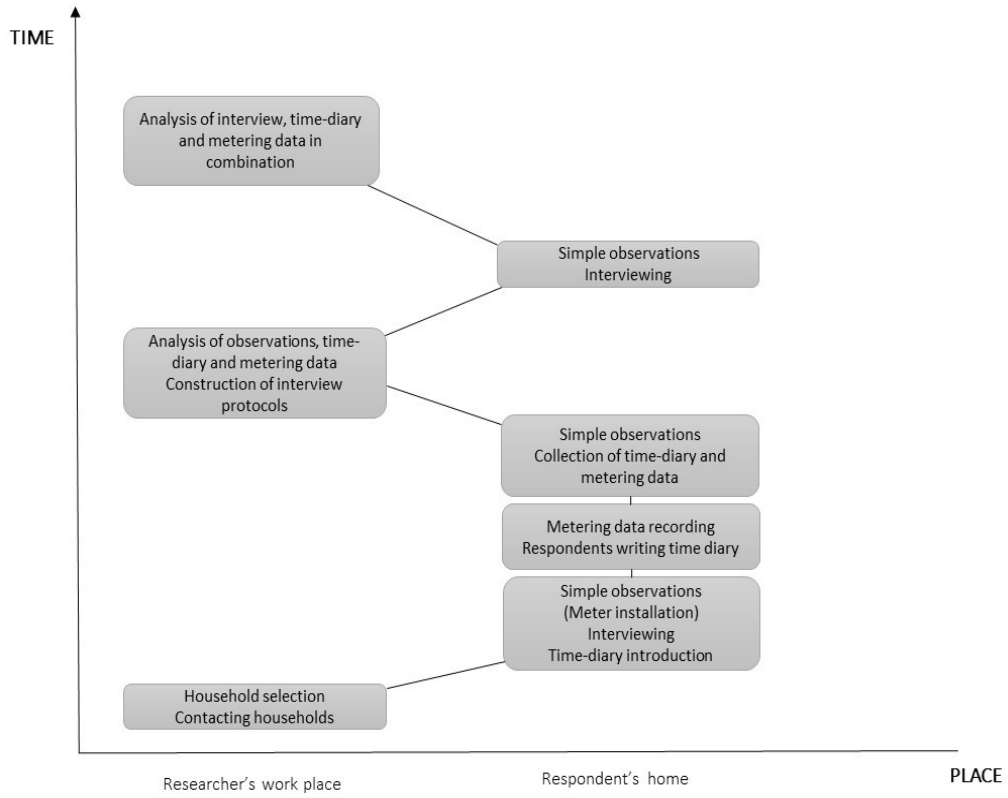

Fig. 1. Study design.

Step 1: (Fig. 1): Households are selected according to the study focus and research questions. The households are approached by an invitation letter and/or a phone call.

Step 2: Studies of household activities are ideally made where they take place – in the home of the respondent. During the first encounter, the researcher introduces the time diary to the study participants and explains how to journalize it. The researcher can take the opportunity to conduct an open interview and simple observations to cover contextual aspects (social as well as physical). It is important that study participants are informed about the study focus and central activities to record in the time diary. A time diary is often activity-driven (Ellegård 2001), which means that the activity itself is the starting point. One activity ends when a new activity starts. A basic time diary layout and authentic examples of information content are illustrated in Table 1.

Table 1. Time diary layout and example of content.

Day: _____

Time	Activity	Place	With whom	Electrical appliances	Comments
00.00	*Sleeping*	*bedroom*			
02.20	*Toilet*	*bathroom*		*torch, lamp, toilet*	*Feeling cold and tired*
02.25	*Sleeping*	*bedroom*			
05.15	*Toilet*	*bathroom*		*torch, lamp, toilet*	
07.05	*Wake up, help with compression stocking*	*bedroom*	*employee*		
07.15	*Toilet, taking medicines*	*bathroom*		*toilet*	
07:30	*Rest*	*bedroom*			*Feeling tired*
08.15	*Preparing breakfast*	*kitchen*		*micro*	
08.30	*Breakfast*	*kitchen*			
09.00	*Washing face and hands. Toothbrush.*	*bathroom*		*electric toothbrush*	
09.15	*Getting dressed*	*bedroom*			*Cold*
09.30	*Making the bed*	*bedroom*			*Cold*
09.45	*Newspaper*	*kitchen*			*Cold*
10.20	*Telephone*	*kitchen*		*mobile phone*	*Get contact with health care.*
10.30	*Newspaper*	*kitchen*			*Cold*
11.00	*TV*	*living room*		*TV*	*Cold*

Activities and information related to each activity are recorded horizontally from left to right, starting with the time of day *when* the activity begins, continuing with *what* the activity is, *where* it is carried out and *with whom*. Depending on the study focus, it is possible to add columns detailing the activity, for example use of electrical appliances or water usage. A comments column is also usually added, enabling respondents to clarify things or add information.

The traditional time diary is in paper format, but digital applications and online methods have been developed recently, where study participants can register activities on their mobile phone or tablet and share these electronically (Vrotsou *et al.* 2014). Metering equipment must be in place or be installed. To enable correlation with the time diary, metering data needs to be of high resolution and be defined at least by the hour.

Simple observations can contribute valuable information aiding the analysis of time diaries, metering data and interviews. Observations can be done in a structured way, by asking the study participant for a tour of the house or apartment, or in a more disclosed manner (as mentioned above). The private nature of some activities, such as those taking place in the bathroom, and the time aspect limit the possibility to observe actual routines. Thus, the observations are rather about studying participants' use of their home, the physical arrangements and available apparatus and tools. Simple observations could also be used to perceive the natural environment and climatic conditions and how they relate to household activities.

Step 3: Study participants record their activities in an individual time diary. Ideally, the time diary covers one week to capture the weekly activity rhythms, but shorter time intervals can also be chosen. Metering data is registered simultaneously.

Step 4: Metering data and time diaries are collected. If the researcher personally collects the time diary, it is possible to take the opportunity to ask about the respondent's experience of the study and time diary and add further observations. Such reconciliations may increase the researcher's understanding of the time-diary information quality. Time and distance can, however, constrain this practice. Then, the study participants are given a stamped envelope during the introduction to the time diary to send in the time diary, and questions are asked at a later stage (for example in the interview).

Step 5: Time diaries are analysed together with the metering data and simple observations. The time-diary analysis can be supported by using the software, "Vardagen" ("Everyday life") (Ellegård & Nordell 2011). Respondents' activities are encoded according to a set list of codes available in the program (e.g. paid work has the code 900, toilet visit 480) and when entered into the software it generates an individual activity path (Fig. 2).

In Figure 2, time is marked on the y-axis, and the codes for different sites are marked on the x-axis. The red line represents activities, the green line represents locations and movements, the dark blue line represents electronic devices, the light blue line represents moods and the purple line represents togetherness. Since all activities are defined in time, actual metering data on water and/or energy use can be related to each activity. A meter registers resource usage at household level, which elevates the importance of trying to cover all household members' individual activities. From the combined information in time diaries and metering data, household-specific questions can be added to a general interview protocol.

Step 6: The study participants are contacted again and asked for a follow-up interview at home. The interview, which can be individual or conducted with the household as a group, can be about clarifications on the execution of activities and routines, thoughts about one's own and others' resource use, and ideas on different options for how to act. Interviews are used to understand the time-diary recordings and to get more information regarding the purpose of the study. The interview questions should both address the research question and follow up on new things that could be vital for understanding the issue under scrutiny. Consequently, the interviews are preferably semi-structured, since the main purpose is to explore individual activities and routines, which could vary decidedly in terms of both practice and motivations between different respondents. If applicable, this is also the time to provide participating households with some results from the time-diary and metering data. More observations can be carried out.

Step 7: At this stage, all empirical material is collected and the final analysis starts.

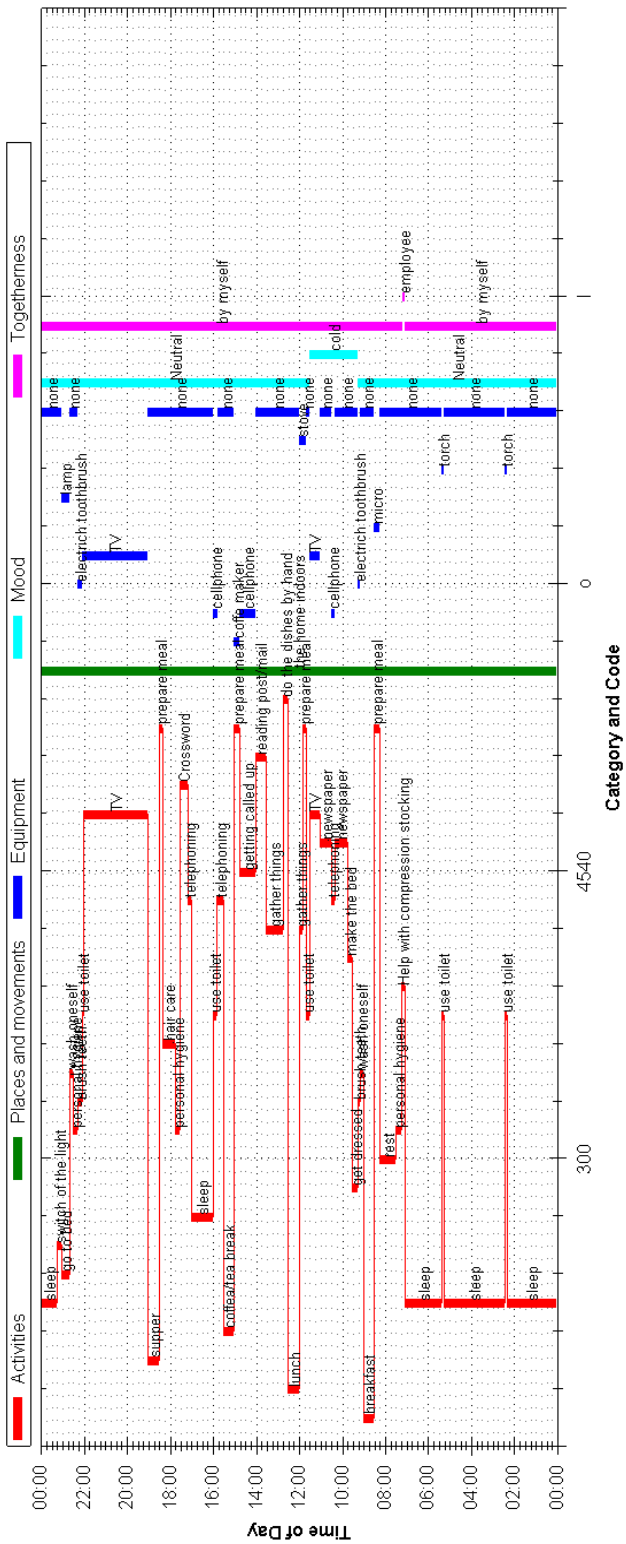

Fig. 2. Time diary – activity path.

Application of the mixed-methods approach

In the following section, examples of methodology application are provided from two actual cases. The first case concerned a building complex in need of renovation, where the study aimed to understand the reasons behind the high energy usage and to what extent it involved residents' activities. Study participants wrote a time diary for a week covering all individual activities. Metering data on temperature, carbon dioxide concentration, humidity and electricity consumption were collected for each apartment. Metering data and time diaries were followed up by interviews of approximately one to two hours, individually or in groups.

The second case aimed to study the household use of hot water before and after the implementation of individual metering and debiting (IMD) of hot water. The mixed-methods approach was used to map the original water use routines, when costs for hot water usage were collectively shared and included in the basic rent. Study participants wrote an individual "water time diary" for three consecutive days, two weekdays and one weekend day. Individual (apartment) metering data on hot water usage was obtained from the housing company with a precision of 1 litre registered at hourly intervals. All study participants were interviewed individually or in groups.

The combination of methods provides empirical material on the same topic but of different characters. The examples below are only meant to visualize the usefulness of merging empirical data from different methods and do not fully demonstrate all major ideas developed or the total analysis of the two cases.

Case 1

In the first case, focusing on household energy use, activities in relation to apartment ventilation emerged as

interesting. The metering data from a three-room rented apartment on the second floor showed recurrent drops in apartment temperature to under 19 °C. Usually, the indoor temperature was around 22 °C. The apartment holder, a single woman aged 58, noted "airing" in the time-diary activity column at corresponding times, but the rationale behind this activity was unclear. During the follow-up interview, taking place in the woman's apartment, she explained (our translation from Swedish): "I air my sheets every morning. At the same time I let the cats out on the balcony [...] I want to let some fresh air into the apartment."

She continued explaining that the balcony door was usually wide open for about 20 minutes once every morning and once every evening. She also let the cats out on the balcony several times for shorter periods during the day, resulting in a generally low apartment temperature. The metering data and the time diaries were from November 11–24, a period where the average daily temperature in this part of Sweden is 3 °C. When asked about her apartment ventilation, she was unaware of its existence. Researchers pointed it out to her (connected to the kitchen fan), and at the same time they noted (simple observation) that she had turned it off. When asked about it, she responded that she found the sound to be too loud. Apart from the balcony door, she also opened the windows every morning, many of which stayed open all day during all seasons. She said that this routine was due to waking up in the morning and sensing no air in the apartment, which gave her headaches.

Another ventilation example came from a retired couple aged 65 living in a three-room rented apartment on the third floor. The metering data and the time diaries were from January 27 to February 1. The metering data showed that the carbon dioxide concentration was high, and that the temperature peaked at 25 °C (from 22–23 °C) at specific times. The time diary revealed that the temperature peaks primarily occurred when the respondents used the kitchen. During the simple observations, it was noted that the kitchen fan, ventilating the whole apartment, was turned off. In the interview, the male explained (our translation from Swedish): "I think it is too cold in the apartment so I turn off the kitchen fan." He explained that he had cut his electricity costs by half by this measure. The ventilation (the kitchen fan) is operated by electricity. Even though he wanted his apartment to be warmer, he also wanted to lower his electricity bill.

Case 2

In the second case, focusing on household hot water use, one can conclude that bathing and showering habits have notable effects on volumes used.

A single woman aged about 70 lived on the third floor in a two-room rental flat with kitchen and a bathroom. The metering data for a winter period between mid-October and the end of January displayed irregular usage, varying between 10 and 320 litres of hot water a day, with usage peaking about two times a week. The three time-diary days displayed metering data of 12, 29 and 183 litres of hot water. During the day with the highest usage (183 litres), the time diary noted "Filling up a hot bath" and "Having a bath, shower afterwards" at the same time as the metering data showed 167 litres of hot water. Hence, bathing seemed to be a critical activity in terms of resources, which was followed up on during the interview. About her bathing and showering habits, she said (our translation from Swedish): "I have no showering habits, I never shower, only after baths... [...] It is maybe because one gets cold, one has aches, I have a little bit of eczema and so on... It is to feel good... it is cure... treatment..."

She explained her preference for bathing partly being a generational issue. In the 1960s, it was common to rent a room and one had to ask the property owner for permission to use the bath, which usually took place on Fridays. Showers were not part of daily routines, which continues to inform her habits to this day. Showers are taken out of necessity, to remove shampoo, soap and 'dirt' from the hair and body after bathing, and when visiting others. She provided a vivid example of the difference between a bath (at home) and a shower (at her daughter's) (our translation from Swedish):

> (When bathing) I have steaming hot water... almost to the point that I burn myself [...] and I fill the tub as much as I can without it spilling over [...] I am glad I can get in and out of my tub because I cannot take baths at my daughter's house – she has no handle to grab, it is so big and you have to turn like this and you feel like a walrus... I don't like these big bathtubs... at my daughter's I have to

> take showers [...] we had a discussion, my daughter and I, about hygiene... she thinks I do not shower enough and I say it is a hassle and cold and I do not want to... but it is convenient with underfloor heating and it gets dry and you stand behind those cabin doors... but no... [...] here (at home) you are alone and when you have taken a bath you can walk around naked and air-dry.

Later in the interview, she also told what bathing meant to her and how she planned to be able to continue this activity in the future (our translation from Swedish):

> I can take a bath two times a day if I feel cold or have aches or other difficulties and I can bath once a week and everything between [...] bathing is one of my favourite things in life, nestling down into a hot bath is positive [...] If you look at other apartments, you cannot live on the third floor forever if you experience difficulties with stairs with increasing age [...] I want a balcony and a bathtub. I asked the janitor if I could get a handrail over the bathtub, but it had to be approved by the area manager.

Results and discussion – evaluation of the mixed-methods approach

When placing individual activities at the centre of attention, we can discover how people experience, behave and perform at specific places. The examples from the two cases show the intimate connection between routines, resource use, technology, materiality, and personal experience of comfort, cleanliness and social relations – for example the situated experience of the home (Tuan 1975; Buttimer 1976; Massey 2005; Pink *et al.* 2015a). Activities organized and performed at home, such as airing or taking a bath, are the result of many different aspects, for example experience of the material and technological arrangements of the home (feeling cold, bad air causing headaches), economics (cost of electricity and water), health, age, social negotiations and cultural aspects (e.g. norms of cleanliness, gender roles). The mixed-methods approach can capture all these issues. Activities at home are often routinized and go unnoticed in the sense that individuals do not think of the extensive coordination of people and things involved in seemingly simple activities such as laundry and cooking, and how activities related to different aspects of everyday life succeed each other.

As the examples show, the time diary is the underlying method in our mixed-methods approach, to which information from the other methods is added. Time diaries are suitable for understanding what activities individuals engage in at different times, where and with whom, and are intimately connected to the time-geographical perspective bringing the importance of time, place, space and materiality into the analysis of individual routines. At the individual level, a rhythmic pattern may occur, visualizing for example the central role of the home, appropriate locations for specific activities and the importance of technologies and social relations for the execution of everyday activities. The time-diary method enables the researcher to 'virtually' experience how study participants lead their everyday life.

The basis for useful empirical material is accurate time diaries. Sometimes respondents do not know which everyday activities to focus on, for instance which activities use hot water or energy, which also emphasizes the importance of instructing study participants to write down all activities. However, if the study focus will entail recording many small activities (like water usage), it can be necessary to instruct study participants primarily to focus on particular activities. Otherwise, potential study participants may consider their involvement to be too demanding, jeopardizing their contribution. Nevertheless, even time diaries with less information are of importance since they can provide important information about everyday life activity patterns and be used as preparatory materials for interviewing.

In practice, the information content of time diaries varies, and women are generally more detailed. This also implies that it might be difficult to get all family members to fill in the time diary since it is time consuming and it is also difficult for children to participate. Hence, the method risks being biased towards covering more comprehensive information from single households and pensioners, compared to families with children, where only the adults participate. In a time diary, study participants can deliberately exclude activities or forget to record them. The fact that study participants can choose what to reveal is both a strength and a weakness of the method. It is a strength because respondents can maintain their personal privacy, and a weakness since it may mean important information is left

out. The latter emphasizes the need for other methods to triangulate the time-diary information, and the triangulation enhances the possibility to detect such empirical difficulties.

Since the time diary records the time when activities are carried out, it is appropriate to combine time-diary information with metering data based on volumes or quantities per unit of time. As the case examples indicate, it has been very important to discover energy and water using activities of primary importance in relation to the aim of study. The time diary can be designed to instruct study participants to provide estimates of resource use in relation to activities, for instance noting time spent in the shower or estimates of water used when washing dishes. These estimates can subsequently be contrasted with metered usage. The simple observations provide information on the physical context of activities in the home in particular, which is helpful when analysing the time diary. In the ventilation example, simple observations noting that the kitchen fan was off were crucial for interpreting the metering data and asking the respondent relevant interview questions.

Everyday life routines that are previously unfamiliar to the researcher are exposed and open to exploration. Studying the content of a person's constant flow of activities and related resource usage creates questions in relation to the overarching questions of *how* activities are carried out and *why* activities are carried out at all and in a certain manner. Hence, the fact that bathing and showering practices use large amounts of water is hardly a novel finding per se, but since the methodology also provides knowledge of the wider social and physical contexts of use, it is possible to find answers to how changes in use can come about. The time-diary information, together with metering data, provides a foundation for constructing relevant interview questions and the interviewing process. For the respondents, the time-diary writing enhances a reflective approach towards their own routines, making them possible to verbalize. Prior to partaking in the study, individuals in households might not understand the relationship between routines and water and energy usage. However, the awareness effect may also lead to routine change, which may be problematic if this is a non-intended effect. To install or read meters with the respondents' knowledge is also a bias in this sense, although it is difficult to bypass this ethical issue. This methodological implication should be treated with care.

The empirical examples show the importance of the interview method including the importance of tactile experiences, feelings and reasoning surrounding the resource using activities. The importance of home as a spatio-temporal event becomes especially evident when, as in the bathing example, activities at home are contrasted with when similar activities are performed in another spatio-temporal setting.

The empirical material provided from the mixed-methods approach is very dense; even a small selection of households would provide a great deal of information. The 'thicknesses' of the empirical material makes the methodological approach time-consuming. The methodological process involving meetings, time diary writing and interviewing means that study participants must invest significant time to be part of the research project. This might also make it more challenging to find study participants compared to only using one single method (e.g. interviews or enquiries).

The triangulation of methods increases the potential to carry out an accurate analysis of household water and energy use, since mismatches between self-reported data (interviews and/or time diaries) and metering can generally be sorted out. The study participant sometimes does not want to reveal and discuss certain routines, and then it is difficult to push the issue further. In our experience this is not a common problem, but most of the time there is a good correlation between the different empirical materials.

Conclusions

Knowledge of households' conditions of use of water and energy is important to support resource efficiency. In this article, we emphasize the importance of combining several methods to learn about households' everyday resource use. We argue that in the specific cases the energy and water using routines would not have been captured in such a comprehensive and detailed manner without the combination of methods. The time diary is a method that discovers routines in a more secure manner, and at the same time enables respondents to reflect on their own activities, thereby enhancing the interview situation. Adding metering data to the time diary, we can also show the importance of a

certain routine or activity in terms of resource usage. From this information, interviews are constructed to understand what is behind routinized activities (why they are executed in the first place and in certain ways) and how study participants reason on different courses of action. Simple observations complement the picture and provide information on the physical arrangements for resource using routines in particular, enhancing the interpretation of the other empirical material.

Use of energy and water have been in focus, but the time-diary method can also be used for other research questions, and with other combinations of methods. For example, working life studies have added time schedules, norms in the work place, measured distance to work and policy analysis to grasp the working life context (see Kwan 1999; Trygg 2014), and studies of travel patterns have combined time diaries with physical visualizations and geographical information systems (GIS) (see Kwan 2002; Lee & Kwan 2011). Also, when using survey time-diary data, the individual activities can be presented as a sequence analysis over time (longitudinal study) with tools such as VISUAL-TimePAcTS (Vrotsou *et al.* 2009).

The proposed study design is an ideal case, but as the cases show, there is a need for adjustments and variations in the details depending on for example the character of the study, the geographical distance to the case study area and available metering data. Future research could also benefit from recent technological developments, enabling recording activities, coding and analysis in digital applications. In addition, if digital time diaries could be matched with digital metering energy or water use data, this would speed up the analytical process.

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