Energy Use in Existing Dwellings: An Ethnographic Study of Energy Use Patterns in The Domestic Sector in Ireland

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Abstract
Energy efficiency research in dwellings has traditionally focused on technical matters, implying increased fabric insulation standards and using energy efficient appliances reduces energy consumption. However this research has been shown to have limitations in the form of the impact of policy and new technologies. As a result there is now widespread recognition of the importance for researchers to engage a broader approach of non-technical research of energy use such as occupant behavior. Monitoring of energy use down to a single appliance is now possible and relatively inexpensive. This paper presents the results of an ethnographic study, supported by monitoring, of energy use patterns for six dwellings with a diverse occupant demographic in Ireland. The study supported by monitoring found that occupant sex, age and behavior predominantly affected energy use followed by the presence of technology rather than the building fabric itself. Energy use in older technically less efficient dwellings with older occupants was found to be substantially less than that of the younger occupants in supposed more energy efficient houses. When given feedback, occupants were dispassionate when presented information in terms of energy units (kWh) but absorbed information straightforwardly once the same information was expressed in monetary terms. From the research it is clear that technology and modern living has had a transformational effect on the way we use energy which pose many problems for the future. Ethnographical research is a long established discipline in the field of social science but its importance is just burgeoning in relation to understand energy use patterns in buildings. Thus, in addition to the results the paper presents the lessons learned during the process and proposes a framework for future ethnographical research of energy use in dwellings.

Keywords - behaviour; energy consumption; ethnography; feedback

1. Introduction

Energy efficiency research in dwellings has traditionally focused on technical matters, overlooking the effect of human social behavior in energy use analysis [1]. This has led to policy makers being under informed about

the key drivers of energy use in the residential sector. To bridge this gap a new non-technical research approach is required to ensure policy has a robust foundation. The Dwelling Energy Assessment Procedure (DEAP) is the National Methodology for calculating domestic energy consumption in Ireland. The procedure fulfills the requirements of the Energy Performance of Building Directive [2] and follows the standard methodology IS EN 13790 [3]. The methodology calculates the energy efficiency characteristics based primarily on construction characteristics of the dwelling, and merely assumes standard consumption behavior of the building dwellers [4]. Occupant behavior varies significantly between individuals [5], which may result in large variations in the energy consumption of similar buildings. Therefore, promoting and achieving 'energy-conscious' behavior amongst end users is a logical means to of reducing overall energy consumption. The measures by which people will change their attitudes to energy use is little understood and approaches that have been implemented to date have had limited success. To successfully effect change, energy use behavior must first be understood. This paper provides a critical review of ethnography as a technique assessing residential sector energy consumption.

2. Ethnography

Ethnography may be described a most basic a form of social research, having a long history, it also bears a close resemblance to the routine ways in which people make sense of the world in everyday life [6]. This methodology is one of the few methods which, has the ability to provide depth of insight and context into the behavioral choices of residential consumers [7]. It involves a particular set of methods that involve the person carrying out the research to participate, overtly or covertly, in people's daily lives for an extended period of time [8]. This is done by watching what is happening listening to what is said, asking questions, collecting relevant data to fulfill the focus of the research. Therefore, ethnography is a process in which the researcher participates. Ethnography has been described as a type of research that requires the researcher to share in the living of the groups which are being observed [9]. This requires large portions of time being spent observing occupant behavior in the field in order to verify and measure impacts based on lifestyle [10]. In 1985, a study [11] recognized the need for an ethnographical approach to study energy consumption. Since then only a small number of studies have emerged in this area. During the 1990's, interest grew in studying energy consumption relative to everyday experience. In recent years, the value of ethnography has been recognized, particularly within consumption studies [12].

One of the largest ethnographic research studies in the energy industry, conducting 136 two-hour in-home visits throughout the state of California to understand how households make day-to-day decisions on their energy use [7]. This study examined the process of how residents make their daily

practices meaningful through their attitudes and beliefs. The study found that householders perceived that lighting efficiency was the best way to save energy 'exceeding other measures in excess of 100%' and that 'households cannot readily determine what contributes the most to their energy use'. This demonstrates a lack of understanding by dwelling occupants about energy intensive appliances in the home and the need for research to understand human behavior patterns in order to effect change.

3. Occupant Feedback

Giving people feedback about their energy use is one way to start visualizing that usage which may also have the potential to change behavior [13]. The theory behind feedback is that once people receive information about their energy behavior, they are likely to form attitudes on those behaviors and act accordingly. Studies examining the influence of direct feedback of energy consumption [14, 15, 16] found that more likely to undertake energy efficiency measures when energy use and savings are visible, when provided goals and motives (evaluation of outcomes) and that consumers who actively use an in home display (IHD) can reduce their consumption of electricity by an average of 7%. The studies concluded that there are also benefits when information is personalized and presented in an explicit way.

4. Research Strategy

Following an initial pilot study it was determined that observation alone did not allow for the quantification of the effect of energy use behavior. To support the observations, energy monitoring and assessment of energy bills was carried out. Table 1 outlines the framework developed and used for the study. Dwelling selection was based on occupant demography and selected from 4 broad categories, as shown in Table 2:

- Young people with children;
- Young people with no children;
- Elderly people with children;
- Elderly people without children.

Dwelling characteristics, outlined in Table 2, were recorded for quantitative energy analysis and comparison based on size, primary and secondary heating systems. All houses were detached. Study period in each home was from 08:00 to 22:00. Observation and monitoring concentrated on three areas: space heating, electricity, water; an approach similar to the quantitative research undertaken [8]. Following the observation period a questionnaire was completed by the occupant. These questionnaires related to the dwelling characteristics, demography, and typical weekly appliance usage and fuel consumption.

Table 1. Framework for analysis of domestic energy use behavior

Energy	Electricity	Water	Heating
Stage 1 Initial Fieldwork	Ethnographic study carried out over 14 hour period Questionnaire	Ethnographic study carried out over 14 hour period Questionnaire	Ethnographic study carried out over 14 hour period Questionnaire
Stage 2 Subsequent Fieldwork	Electricity bills for a 12 month period assessed Wireless electricity monitor installed for a 7 day period Questionnaire	There is no water metering at present in Ireland Questionnaire	Oil and solid fuel bills for previous 12 month period assessed Questionnaire
Stage 3 Compilation of Data	Yearly, Weekly & Daily total. Occupant usage of lighting. Occupant usage of appliances, e.g. cooker, microwave, shower.		Yearly, Weekly & Daily total. Occupant appliance usage; primary and secondary heating
Stage 4 Analysis of Data	Rationale behind lighting and appliance usage Patterns identified Analysis presented	Rationale behind water usage Rationale behind appliance usage Patterns identified Analysis presented	Rationale behind primary heating usage Rationale behind secondary heating usage Patterns identified Analysis presented
Stage 5	Feedback & Questionnaire	Feedback & Questionnaire	Feedback & Questionnaire
Stage 6 Analysis	Secondary Analysis & Conclusions	Secondary Analysis & Conclusions	Secondary Analysis & Conclusions

Table 2. Dwelling demography and physical characteristics

Dwelling	A	B	C	D	E	F
Number of Occupants	4	5	3	3	2	2
Occupants age (years)	40, 39, 7, 5	38, 40, 7, 5, 1	76 ,68 ,31	62 ,59 ,25	83 ,74	33 ,33
Area of dwelling(m^2)	204	208	180	154	145	303
Dwelling age (years)	8	8	40	300 (renovated)	250	3
Primary heating system	Oil Central Heating	Oil Central Heating	Oil Central Heating	Oil Central Heating	Open fire	Heat pump
Secondary heating system	Open fire	Open fire & stove	Open fire & stove	Open fire	Electric storage heaters	Open fire

Subsequently, electricity consumption was recorded over the period of a week with the aid of OWL electricity monitors. An example of household energy consumption logging on one day of the ethnographical study is presented for household A in Fig. 1. The data as presented is a coalition of the ethnographical observations study and the readings from the electricity monitor. The graphical format demonstrates the majority of appliance usage by occurs in the morning, mid-morning and early evening and as expected the kitchen has the most appliance usage. Also the female member of the household used most energy. This procedure was replicated for each of the other households and included water and heating usage. Energy usage was extrapolated using the reflective questionnaires and the combination of collated data.

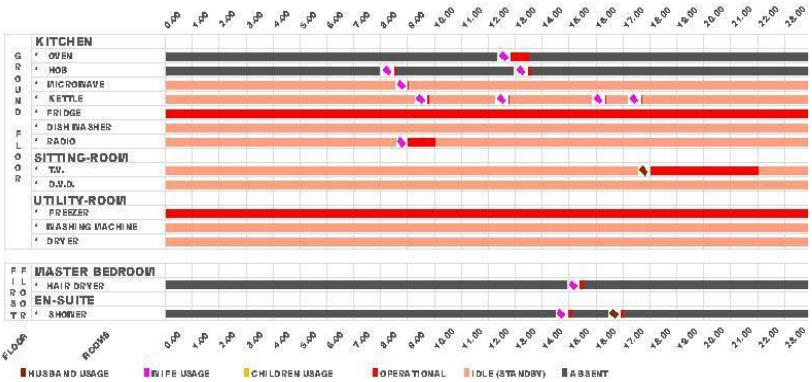

Fig. 1 Dwelling A: Occupant appliance usage for 24 hour period (January 2012)

5. Observation and Monitoring Results

Although only a small number of households were used in the study a wide variety of behaviors were observed and energy use levels monitored. When daily consumption was examined using results from the OWL monitor it was clear that all dwellings displayed peaks and troughs of electricity consumption at similar times during the day. Greatest consumption was generally in the morning when occupants arose and meal preparation times, midday and early evening. Dwellings where occupancy rate are higher i.e. more time spent in the house, exhibit more daytime activity midweek than others. Family size directly influences consumption, as does the age and sex of occupants. Examples include:

- Households A and B with young children use the television for longer periods of time. They leave the hall light on overnight as security for younger children;

- Households A, B and F, (younger generation) use room lamps rather than the main light fitting in households which are generally consist a number of halogen bulbs;
- Shower usage increases dramatically in houses with younger occupants. Younger people shower on average 6 times per week, whereas, the older generating bath far less often. Females spend longer in the shower than men;
- Kettle usage is typically highest in dwellings with older occupants;
- A strong correlation exists between the level of solid fuel consumption and the age profile of the occupants – the older the occupants, the higher the quantity of solid fuel consumed. These dwellings were of poor thermal insulation standard and had inefficient heating systems. However, in general there is less electrical powered technology in the dwellings of the older occupants. Consequently, though the building fabric and previsedenergy efficiency were poor, these households used less energy overall. Older householders tend to turn on outdoor security lighting in the evenings, until late at night.

The initial questionnaire revealed the main motivational factors that occupants felt were responsible for consumption included the following:

- Thermal Comfort related to time spent in dwelling, a factor highlighted by previous research [17, 18];
- Ambiance and security (lamps in room and outdoor lighting left on);
- Habit, routine and lifestyle;
- Lack of Information about energy intensive appliances and real cost of space heating.

This suggests that even if a dwellings fabric was upgraded overall energy use would not be substantially altered.

6. Behaviour Change

The second questionnaire ascertained that when occupants were made aware of their habits through feedback, some change was prompted. Occupants in all dwellings felt more energy conscious having participated in the research and noticed behavioral differences regarding energy consumption. Some behavioral changes include:

- Dishwasher filled to capacity, rather than turning on at the same time each day;

- Baby monitor turned on only when child is in a separate room whereas before the monitor was left on even if the child was in the same room;
- All occupants were more conscious of leaving lights on in unoccupied rooms and understood the benefits of energy saying light bulbs. Wasteful use of lighting avoided. Example dwelling C, used the bedroom light and bedside lamp at the one time, now use of one or the other;
- Computer/laptop put on standby when leaving the room rather than to leaving them on. In general items that were traditionally left on standby overnight were now completely turned off;
- Full flush option for toilet only used when needed. If two people using the toilet consecutively, the toilet is flushed once.

The following reasons were given for changes in behavior:

- As a result of daily consumption habits being underlined, occupant attention was drawn to areas of waste and over usage;
- Once the occupant understood the energy intensive appliances there was an incentive to save money on electricity bills;
- Standby electricity consumption is relatively invisible and occupants were not aware that standby items consumed so much.

When occupants were given feedback about their energy usage in terms of kilowatt-hours (kWh) they expressed that they did not have 'a feel' for the magnitude of this energy unit. As a result they could not grasp the real effect of changing behavior and lost interest. When presented the same information in terms of actual monetary cost the occupant could understand the real consequence of their energy use behavior. Typically this stemmed from householders viewing the bottom line cost on their bills rather that the energy use itself.

7. Lessons Learned

When initially developing the research methodology, ethnography was proposed as the sole assessment tool. Following a pilot study it was found that just like energy monitoring alone ethnography does not provide the whole picture of energy usage. Observation needs be combined with monitoring to allow for assessment of the consequence of the energy use behavior. Where possible wireless monitors should be used to reduce installation time and aesthetic impact on the building.

Domestic water metering does not currently exist in Ireland. This limited the ability to accurately assess water usage.

The research set out to covertly observe and record detailed energy use patterns without influencing behavior. Though ethnographical techniques are relatively simple in principle, carrying out this methodology in a domestic setting is not straight forward. Unlike a commercial or community environment where an observer can integrate into a large population across a large area, in a domestic setting the observer may be the only other person in the building. Therefore, it is virtually impossible for the occupant's behavior be uninfluenced. This was particularly the case as one of the occupants left a room and left the lights on so the observer could complete their notes. In several circumstances the observer was offered a cup of tea and food. It may not be possible to totally negate the presence of an observer but if the study is carried out over an extended time period, example up to a year, the occupant will tend to become less aware.

It is important when giving feedback that the information is presented using generic and non-technical terms when possible. There is a propensity amongst professionals who understand energy to assume that everyone understands the term. This was shown in each of the households not to be the case.

It is imperative that ethical protocols are developed and implemented. Occupants must be made explicitly aware of what is involved and consent to the observation of personal behavior, including bathroom use. Treat the person being observed with respect. Keep in mind that it is a privilege and responsibility to observe another person's experience.

8. Proposed Framework for Future Research

To improve the validity for any future research a number of amendments to the framework used in the initial study are proposed:

- Demography: Extend demography to include social and private households of all sizes, ages and income with a greater geographical spread.
- Monitoring: To assess the effect of energy use on the building environment monitoring should be extended beyond heating, electricity and water to include temperature, humidity, carbon dioxide (CO_2) and lighting levels. Monitoring should be undertaken for a period of 12 months to account for seasonal variations and for a further 12 months post any feedback to assess initial influence and any drift with time.
- Ethnographical observations: Undertake observational study over a 24 hour period for a long as possible; minimum once per month for 24 months.

- Interview: Ensure that an in-depth interview does not turn into an interrogation. From the interview carry out a reflective analysis and develop a feedback questionnaire.
- Feedback: Furnish occupant with data and advice about energy savings obtained from the yearlong study; repeat the study for another 12 month period to establish if there is any change in behaviors or patterns.

A portion of the year two analysis should assess any drift in energy use behavior back to pre-feedback habits.

9. Conclusion

Ethnographic research provides a unique insight into the everyday lives of individual households that quantitative monitoring alone cannot. Monitoring to a single appliance is easily achieved and is relatively inexpensive but cannot define the purpose of the appliance usage and if it is being used in a wasteful manner. Ethnographic research fills in these blanks, identifying human behavior patterns from which strategies to make users more energy-conscious can be developed.

Overall older occupants in poorly insulated dwellings use less energy than younger occupants in modern well insulated dwellings with modern heating systems. Not only are older people by nature more frugal but in general they possess less technology associated with modern living. As building fabric design becomes more efficient there is a proportional increase in energy demand from technology. The reflective questionnaire revealed that there is not always a necessity for energy use but that the occupant may be doing so for emotional reasons. This proportional increase in technological energy use and emotional comfort will cause increasing problems in the future whereby the current trend of providing extra insulation will not have any net benefit.

When given feedback a change in behavior was reported, however, the long term influence of this feedback needs to be explored as there is evidence that there is a fatigue effect, whereby, people lose interest or forget the motive for change in behavior. When interacting with householders, providing feedback and advice, is imperative that energy professionals communicate in a manner that general public can comprehend. Researchers must look beyond traditional disciplines associated with the energy sector for guidance.

Social scientists regularly utilize observation techniques as a means of determining behavior, however, this long establish discipline has yet to establish a firm footing as a means of establishing energy use patterns in buildings. From the research it is clear that energy use in dwellings is a complex interaction between the buildings fabric and occupant behavior and

further research is required to understand behavior before effective behavior change strategies can be developed and implemented.

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