

IDENTIFICATION OF EVERYDAY FOOD-RELATED BEHAVIOUR PATTERNS WITH HIGH POTENTIAL FOR DIRECT AND INDDIRECT ENERGY SAVINGS: KTH LIVE-IN-LAB EXPLORATIVE CASE STUDY

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1. Introduction

Nowadays, electricity consumption associated with food-related everyday behaviors is significantly increasing due to the situation of covid-19, which continuously forces people to cook mostly at home. If the estimate of energy usage associated with cooking was previously determined by 2-7% of the total electricity consumption from the household's total energy demand, then today this figure has grown up to 15-20%. This means that we need to find more energy-efficient ways for everyday residential cooking.

It is clear, that different customer segments have different food-related behavior patterns. For our research, we have chosen the category of young single living students. Moreover, each of the students will represent one of the four personas profiles. The experimental study was designed to examine in detail the behaviors of four students at a living laboratory (KTH Live-in-Lab) over a month to identify specific patterns of food-related behaviour with the low, medium, and high level of energy usage. The behavioral insights were recorded through the collection of large amounts of data from home appliances, everyday surveys, receipts from the grocery store, wearable devices, home IoT sensors. Despite the small study group, we tried to focus specifically on identifying behavioural patterns that are associated with individual choices of a

particular persona profile and its impact on energy consumption. Such patterns can be identified and tracked at the individual level, and only then proceed to a larger-scale experiment. Another reason in favor of a small group is the need to collect a very large amount of data and rather active involvement of each individual from the study group for in-depth interviews, everyday surveys, feedback sessions, etc., which is easier to control within a smaller group where the research can be done with appropriate quality.

During the pre-test experimental part, when we tried to investigate How the participants prepare food in as much detail as possible, it immediately became clear that it was also necessary to observe What the participants were preparing. If the data on How food is prepared gave us an objective understanding of the direct energy consumption of activity, then the data on What they eat allowed us to make a primary classification of indirect energy consumption

This experiment made it possible to identify not only behaviour patterns with high energy usage, but also analyze which strategy for behavioural change fits a particular persona. In other words, we have developed personalized strategies for behavioural changes.

2. Background, History, Review-of Literature, or Methodology

The United Nations Intergovernmental Panel on Climate Change (IPCC) makes it clear that climate change is due to human activities and it recognizes buildings as a distinct sector among the seven analyzed in its 2007 Fourth Assessment Report [1,2]. Though technological advances and strict regulations are important ways for promoting energy conservation and improving energy efficiency [3], it has been more and more recognized that behavioral factors are of great significance in achieving energy conservation [4-7]. Also, the main objective of many energy and environmental policies is to achieve households' energy conservation by changing their energy use behavior [8]. It has been suggested that behavioral changes can be just as effective as technological changes [9].

Historically, energy-saving programs and policies have relied largely on technological or economic interventions. By combining technological interventions with behaviorally informed design principles, the motivation to a pro-environmental behavior can be increased on the one hand and reduce CO₂ emission produced by buildings on the other hand [9,10].

One of the everyday activities, which electricity consumption is mostly growing for the last years and have the biggest dependency on tenant behaviour is cooking. Food is the single strongest lever to optimize human health and environmental sustainability on Earth [11]. The food sector is responsible for a substantial share of the greenhouse gas emissions affecting climate change [12] and people are starting to realize the importance of their own everyday habits in relation to climate change [13]. As for individuals there are several ways to minimize the personal carbon footprint, where one approach is changing the eating habits, e.g. what kind of food to consume, how to cook it, and where the food has been imported from. The scientific literature focusing on cooking energy efficiency is mainly about the efficiency of the cooking appliances and

few studies focus on the influence of cooking behaviors. Furthermore, a study focused on the user's influence on electric consumption of cooking [14] states that up to 25% of the electricity use can be reduced by changing specific habits.

The methodology in this study was based on four stages:

Stage 1: Personal profiles design (personas)

During this initial stage, we organized a process of analysis of several personal profiles of KTH Live-in-Lab students and identified four types of personas for a more angular experiment, detailed study of food-related behaviour data for a representative of each persona.

Stage 2: Data collection process

During this stage, we have organized a data collection process according to the ethical approval and GDPR. The main focus was to identify electricity usage patterns in food-related everyday behaviors for direct energy calculation and analysis of additional data about the ingredients/products for indirect energy evaluation (transportation index, packaging index, processing index). The additional objective on this stage was to identify data-related issues and obstacles through making a data quality journal.

Stage 3: Strategies for potential energy savings

All data from the second stage became a foundation for creating strategies for potential energy savings. At this stage, we had mostly analytical process, during which we tried to build different behavioral models and scenarios for each individual.

Stage 4: Feedback sessions and process evaluation

At the end of the experiment, we have organized a series of individual feedback sessions as well as a bigger group survey with several representatives of each persona type.

The residential food system analyzed in this project includes different aspects; the physical infrastructure (kitchen), end-user activities (grocery shopping, cooking, recycling), resource flows (food, water, energy, waste) and the end-users emotions (personal feelings, perceived influence on decision making, health). Therefore, the residential food system is divided into the following four subsystems. System 1 (S1) is the system that represents the individual itself, which in this case is the single-tenant being the student. The single-tenant will interact with system 2 (S2), being the kitchen. What enters the kitchen comes from the grocery stores, being system three (S3). The grocery store inflow is mainly coming from suppliers and distribution centers, which will be defined as "The world" - system four (S4). S4 also consists of trends affecting decisions made by the individual. In terms of project delimitations, the project will mainly focus on S1 and S2, while S3 and S4 will be regarded as in- and outflows.

3. Results and Findings

This explorative case study enabled to develop several strategies for direct and indirect energy saving in food-related everyday behavior with realistic data availability. The process of data collection was rather well accepted by the participants and showed that there is a potential to use such a methodology to build a self-monitoring tool or to conduct further scientific research on the consumer food system. Each of the strategies was discussed both with the experiment participants themselves and with a larger group. The resulting strategies should be tested with a larger group of participants in the future, but already today they can be recommended for use and testing in other buildings with a similar type of tenants, as well as be used in digital services aiming to reduce the electricity usage of the food-related everyday activities. The next step would be to simplify data collection and analysis to scale up this process of evaluation.

The main structure of indicators and dataset can be used for a variety of applications with some adaptations to different purposes. Knowledge of food habits gathered through that process could also be valuable to public authorities to adapt the food environment at the city level, or to architects designing apartments and kitchens. One could also think of a system showing to the consumer a reduced number of indexes at every food shopping and even creating personal accounts to see the evolution of one's consumption. Yet, to reach more effectiveness, sustainability assessment could be mixed with other actions targeting other drivers of the food system all along the supply chain because they influence consumer's behaviors.

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