# eSAX - An Automation Experience Questionnaire Framework for Energy Systems

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## ABSTRACT

Automated systems are becoming increasingly prominent in various domains and application areas in our everyday life (e.g., transportation, healthcare, home energy management) and can provide an important contribution to making our world more sustainable. In the context of smart homes, such systems have the promising potential of combining a long-term energy usage reduction in daily life with a considerate approach to user comfort. To increase the success probability of such automated systems it is important to sufficiently ensure user acceptance and satisfaction. To do so, it is crucial to consider users' attitudes, concerns, and expectations already during the design process. In this paper, we present the energy system automation experience questionnaire framework eSAX which can support researchers and designers in designing automated energy systems that meet users' needs and expectation, mitigate their concerns, and are trusted.

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## CCS CONCEPTS
• **Human-centered computing→HCI design and evaluation methods.**

## KEYWORDS
Automation; User Experience; Home Energy Management System; Questionnaire

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## INTRODUCTION
Making our world more sustainable is of great importance. Automation can make a valuable contribution to this endeavor by optimizing energy usage and increasing the comfort level of more sustainable behavioral choices. Over the last years, significant efforts have been put into the development of new approaches to support users in understanding, monitoring and controlling their energy usage (e.g. [9, 10, 12–14]), but the establishment of durable behavioral changes remains a challenge. The employment of automated systems carries a particular promise in this context since smart home energy management systems enable the automation of appropriate changes in the energy usage of a household without noticeably compromising end user comfort. This is achieved by providing users with effective tools to control their energy usage, an informed choice in how to employ these tools, and the automated carrying out of choices which removes the need to do so actively and repeatedly. Examples of how this can be achieved are automated minor adjustments to the heating and cooling system settings at peak times, automated shifting of energy intensive processes such as the charging of an electric car in response to green energy availability in the grid, or the sustainability-oriented use of energy storage and energy-generation capabilities in prosumer households [8].
However, the success of new technology always depends on user acceptance and trust becomes a special acceptance component in the context of automation technology [5]. Automated systems are faced with the particular challenge of balancing automation and user control in a way that maintains the feeling of being in control while significantly reducing the necessity of any conscious input from the user. This can, in example, be achieved by making automatic processes running in the background visible and by providing possibilities to interrupt the system manually. Therefore, it is of great importance to the successful implementation of automated systems to understand human-automation interaction (cf. [4]), the concerns that arise with regards to automated systems, and the role of trust towards such systems.
In this paper we present the eSAX *e*nergy *s*ystem *a*utomation e*x*perience questionnaire framework which is composed of 4 different modules: *General Attitude*, *Expectations, Experience*, and *Trust*.

The modules consist of existing questionnaires, one of which was slightly adapted to fit the context, a new scale gauging expectations towards automated energy management systems, and a number of open questions. They aim at gaining a better understanding of users' general attitudes, specific expectations and concerns, trust towards the system, and how users experienced the actual use of an automated energy system. The modules can be used independently, combined freely, or applied as full framework. The findings from the application of this questionnaire framework promise interesting insights with the potential to guide system design in order to further acceptance.

## RELATED WORK

Research in human-automation interaction aiming at gaining a better understanding of users' interactions with automation systems (cf. [4]) has been conducted in many different domains and application areas (e.g. [1, 11, 15]). Over the last years a number of automation experience questionnaires has been developed, addressing aspects such as general attitudes towards automated systems, the role of expectations, and existing concerns (e.g. [1, 6, 11]). These questionnaires look at different domains and application areas, i.e. healthcare, transportation, banking, or household appliances. In the context of smart homes, Brush et al. [2] conducted a qualitative study on long-term use of home automation to investigate why participants use automation. The focus of their interviews was on participants' experiences with home automation technology including what led them to install it, favorite and least favorite aspects, use by guests, how often the system was modified, and whether remote access was enabled.
Several works have been published that attempt to understand the relationship between trust and the use of automated systems. In example, Jian et al. [5] developed a scale to capture general feelings of trust towards automated systems, Gold et al. [3] conducted a driving simulator experiment to investigate how the actual experience of automation effects attitude towards and trust in automation and Körber et al. [7] investigated how trust levels towards an automated system are affected by trust-related content in previously provided information about the system. Despite the multitude of work published with regards to automation experience there is, to the best of our knowledge, no comprehensive framework available that allows an in-depth investigation of user attitudes, trust in, and experience of automated energy management systems.

## AUTOMATION EXPERIENCE QUESTIONNAIRE FRAMEWORK

We developed the eSAX framework with the goal of providing a tool to investigate the relationship between user concerns, trust, attitudes, expectations towards, and experiences with automated energy management systems. The framework consists of 4 modules: *General Attitude*, *Expectations, Experience,* and *Trust*. Each of these modules includes a set of questions and allows researchers and designers the flexibility to compose a questionnaire tailored to their needs. Depending on the chosen modules, the framework can be used for general attitude capture, for guidance during early stages of the development process of a system, or to evaluate the experience with a high fidelity prototype or an implemented and running automated system.

*Module A - General Attitude.* The goal of this module is to identify general attitudes towards automation. Its components can be used to gain an impression of overall attitudes and to take note of existing attitude differences with regards to automation application area (e.g. healthcare, banking, transport). This module is composed of the Automation-Induced Complacency Potential Questionnaire and Automation Attitudes Questionnaire (taken from [1, 6, 11]).
*Module B - Expectations.* This module aims to understand user expectations towards automated energy management systems. It includes a newly developed 10-item questionnaire to capture preferences and expectations towards automated energy management systems via a 5-point Likert scale (ranging from 1 =strongly disagree to 5 = strongly agree). Item examples are "I am willing to accept energy-related setting changes, as long as my comfort is sustained." or "A fully automated energy system would make my life easier.".
*Module C – Experience.* This module is currently comprised of a list of open questions that address actual personal experiences with an automated energy management system such as "Which expectations did you have towards the automated energy system?" or "Which features of the automated energy system do you rate as most negative and why?". Module C is considered as under construction and will be developed further.
*Module D - Trust.* This module captures to what extend an automated energy system is perceived to be trustworthy. For this purpose, a questionnaire measuring users' trust in automated systems developed by Jian et al. [5] was adapted to fit the context of automated energy management systems. The module further includes a set of open questions to collect more detailed information about users' trust-related expectations towards automated energy systems (e.g., "Do you believe the automated energy system will provide correct information? Please explain you answer.").

## NEXT STEPS

Our next step will be to test the automation experience questionnaire framework by using it to evaluate an automated energy management system at a project demonstration site. The system we will investigate has a central focus on balancing automation and user control and it is of special interest to us if this is achieved successfully. Next to measuring perceived system usability and usefulness we will therefore use the presented framework to look at how users feel about the automation aspect in terms of existing attitudes, expectations, trust, and how the system automation was experienced.
Based on our findings we will review the eSAX framework carefully to identify what works well and how we can improve weaker aspects and will make appropriate adjustments. A further goal is to extend the framework step by step to eventually incorporate a range of different use cases from other application areas (e.g. automated public transport ticketing systems or shopping carts).

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