



Original research article

# Scripting, control, and privacy in domestic smart grid technologies: Insights from a Danish pilot study

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## ABSTRACT

Smart grid research in Denmark has increasingly turned its focus on aggregator trading flexibility achieved by remotely controlling appliances, studying the technologies involved rather than the control. This paper investigates how different types of control were envisioned and designed for a two-year smart grid trial in Denmark with 20 private households. Using the notion of script, processes of in- and de-scripture were used to gain insights into perceived and enacted control. Based on empirical data from 26 interviews and three workshops, we show how the in-scripture process of control can be characterized as dynamic and includes negotiations between the residents and those responsible for the project. Second, we show how users de-script control, and third, we outline the project owners' reaction to the user's de-scripture of control.

The design of the remote control appears to have promoted a preference for 'passive consumers' within a smart grid. This design prompts questions about how the users in smart grid development are envisioned and configured using different ideas about control. With current development and the need for additional energy reductions, consumers who invest in photovoltaic solar cells and electric vehicles lose interest in delivering their energy to the system level.

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## 1. Introduction and background

Throughout the world, electricity systems may undergo significant changes in the near future. In most countries, the reason for these changes is closely linked to environmental aspects: to increase the amount of renewable energy sources in the energy system and the energy efficiency [1] to reduce global warming. As the renewable energy sources with the largest potential fluctuate, structural changes within the electricity system are needed. One method for implementing this change is the implementation of smart grids, which are intelligent electricity systems with a two-way flow of digital communication between a supplier and a consumer [2]. In the Netherlands, Norway and Switzerland, smart grids have been tested in households to gain a more controlled use of electricity [3,4]. Similar to other European countries, Denmark has developed an ambitious plan for substituting a large part of the technology in the energy system, which has led to large investments in smart grid research. The Danish vision of smart grids is

linked to a new aggregator role that will remotely control specific technologies within households [5]. Smart grids will cause changes on many levels of an electricity system according to experts in the field; however, the new energy system will depend on a consumer role that significantly differs from the current consumer role [6,7]. Danish stakeholders in the energy field seem to envision (and prefer) consumers as passive participants in the energy transition, where technologies and price incentives are considered to initiate an appropriate and required system-wide behaviour [8]. Other countries may have encouraged or planned a more active participation than the Danish smart grid strategy [9] seems to entail because smart grids need consumers as partners to consume energy when an abundance exists, as highlighted by Lunde et al. [7]. If the smart grid vision is to be realized, consumers need to act according to the system's needs and take on a different and more active role in relation to the system [7]. Other scholars connect the new role of consumers with flexible demand; thus, consumers shall become flexible by investing in 'flexible loads,' such as electric vehicles (EVs) and heat pumps (HPs). This flexibility connected with new monitoring and control tools will ensure the stability of the grid [10].

Balta-Ozkan et al. [11] identify two conflicting visions for consumers in smart grids. Either the main change that occurs is purely

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technological, with passive energy consumers, or the consumers take an active role in the use of technology as part of the solution by actively engaging with the processes of energy provision and consumption. Goulden et al. [12] argue that the second vision (of energy citizens) may ensure a more effective smart grid, in which intelligence is utilized from both devices and users.

This new situation, with either passive or active consumers, entails new control situations in relation to the consumer, the aggregator and the technologies, as people's homes are changed by physical installations and interference with their everyday consumption. 'Control', however, is a complex notion. Smart grid research that refers to control seems to focus on the technologies facilitating control and how to use control for promoting either passive or active consumers rather than studying control itself. It is the aim of this paper to study control from the perspective of the smart grid designer and the resident. Still, 'control', 'control issues' and 'control situations' related to smart grids and households have different meanings: they may relate to the automation of consumption, such as when consumers are in control of the settings of their own new devices or relate to aggregators or specific parts of the system that enable a new remote control of electrical devices. Thus, households become arenas where new situations of control materialize [13], and the purpose of our study is to collect abundant data from studying issues of control at home.

We use the term 'issues of control' and the term 'control situations' interchangeably and refer to situations where the participants in Insero Live Lab or the project owners exercise control over their technologies and/or consumption. The term 'control elements' refers to the physical parts of the perceived or exercised form of control. It can, for instance, consist of technologies or software codes. Furthermore, a distinction is made between the physical control of the technology, the ability to manage the settings (control, for instance, by monitoring devices), and the *sense of control*. According to Langer [14], people may have an illusion of control and believe that they have more control over the end results when they are actively involved in the process. *Feeling in control* may provide people with a sense of empowerment via the use of a technology that enables active involvement; likewise, people may feel a lack of control and a sense of being disempowered when they are not able to administer technology as intended. In our empirical analysis, we identify and discuss if/when people feel in control, situations in which they would have preferred to be (or not be) in control, and why they experience these feelings.

Despite the fact that smart grids offer an entirely new situation of control to households, few studies have focused on issues of control over and within a household (exceptions exist, e.g., [6,15,16]).<sup>1</sup> This lack of research interest is a surprise because issues of control exist in all smart grid trials and affect all parties that install smart grid technologies. Although contextual characteristics usually hinder cross-country comparisons, issues related to control may be comparable and have a broader applicability: what people want to control at home and the extent of this control or their wish to be controlled may be less structurally defined and more personal, which generates generalizable ideas to consider when designing a smart grid trial or strategy. To provide an in-depth perspective on control issues, we investigated a smart grid trial with 20 Danish households that were equipped with smart grid technologies whose monitoring was performed by the company in charge of the installation (Insero) and the participating households. The remote control was conducted by Insero.

<sup>1</sup> However, none addresses an intervention that involves a combination of photovoltaic solar cells (PVs), electric vehicles (EVs), heat pumps (HPs), and remote control, including a high degree of complexity, as investigated in this research project.

## 2. Research question

This study contributes rich empirical research on how control is adapted in households that are equipped with a large assortment of smart grid technologies. Because research on smart grid households and issues of control is scarce, this contribution is not only relevant for research in this field; through our human-centred, ethnographic research methodology and our use of the concept of script, this paper also represents what Sovacool [17]<sup>2</sup> suggests is needed for further progress in energy research: putting humans before technology.

From December 2013 until May 2015, we investigated how issues of control were being scripted [18] into the trial by the responsible project and the trial initiator (the company Insero) and how the technologies and control elements were de-scripted by the households that participated in the trial.

Both in-scripting and de-scripting may provide a more general understanding of what is at stake when smart grids are introduced into private homes. Thus, the purpose of our study was to investigate how the new situation of control and the new technologies influenced people's control over their own homes.

We consider the empirical data to be a case study that may produce new social, cultural, philosophical or technical insights by examining how control is planned into smart grid experimental projects by project designers, how smart grid technology affects human life and how people attempt (or do not attempt) to take control of the technology. In this trial, we investigated how smart grid technology that was installed in people's homes affected the residents. A major element of the trial involved control in the form of 'technological control' related to the integrated part of the technology but also the idea of 'being controlled'. Few studies have addressed the meaning of 'control' for people living with it and the implications of being controlled in smart grid experimental projects, which can be seen as studying people who enact and live out 'the vision of the smart grid' [15]. We present empirical data on how control was embedded in the technology, practised, perceived and employed by the residents. Before presenting the analysis, which substantially evolves around the control issues that relate to the smart grid technology, the concepts employed in the analysis are discussed. The following section briefly describes the applied data material and methods in this study, followed by a description of the concept of script [18] and control, to highlight the essential characteristics of the concepts and situate 'control' in the context of private homes. By explaining the significance of the home to people, the importance of control by the residents is illustrated.

## 3. Data material and methods

A smart grid trial named 'Insero Live Lab' is the source of this research, and the participants involved include the technical contributors, viz., the producers and suppliers of the smart grid technology elements, such as HPs, EV, sun wells, sensors, PVs, smart metres and the eButler monitoring system; public participants who reside in the region, including the community of Hedensted (Hedensted Kommune), VIA University College and the Green Tech Centre; 20 private families and homes in the Stenderup community, which constituted the research site and test zone (Insero Live Lab); the Insero group, which is responsible for the development of software for the remote control and aggregator (Insero Software), investigating energy business solutions for the HPs (Insero Energy),

<sup>2</sup> Compared with authors in this field, our backgrounds seem unusual: We are women; one of us has a background in Design Engineering & Innovation, and one of us is an experienced anthropologist.

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