Multidisciplinary Smart Grid Research and the Design of Users

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Abstract— **Working in a multidisciplinary smart grid research as social scientists, we show how engineering and economic models design and restrict users to a limited set of features. This poor design puts *a* priori limits to possible uses. In contrast, we argue that users can be "designed" as interested in and open to devices that concern them.**

Index Terms— **smart grid, users, codesign.**

I. Smart Grids and multidisciplinarity

As part of the target 20-20-20 set by the European Union, the Walloon Region in Belgium has decided to fund the FLEXIPAC project to evaluate the potential of flexibility in storing electricity through the use of heat pumps and well-insulated buildings. In this project, which spans over 2013-14, we work as anthropologists and designers, along with partners who are engineers and economists. In order to collect consumption data, smart meters have been installed in 70 households and 15 small enterprises. In this position paper, we wish to draw some interdisciplinary lessons from our participation in this research.

Although residential consumers are often considered as important actors, or co-managers of the grid, they are one of the main unknowns of smart grid development [1]. Consumers are supposed to become more "active", but that can mean different things: searching for good prices and "churning"; switching off appliances when the grid is congested or, conversely, switching on when it is windy or sunny; producing renewable energy. Today, smart grid instruments are mainly based on information, prices and technology. Aspects of environment, participation and community are hardly explored in smart grid projects. As Yolande Strengers shows, smart things are developed with the figure of "resource man", who is the fully aware and competent resource manager of the home [2].

The deployment of smart grids requires the involvement of a diversity of actors. It brings together separate social worlds, which have different goals and confer various properties and interests to beings [3]. Each profession focuses on different issues, brings specific beings to existence and construct its own reality. As social scientists we are sometimes at odd with our research partners who are grounded in different epistemic interests. We represent the part of the project that mixes anthropology, design and sociology. In order to grasp the economists' and engineers' interventions, we draw on different traditions in sociology and anthropology (sociology of usage, practice theory and STS) that enables us to analyse how users negotiate with daily life objects. In the following parts, we quickly analyse how users, social acceptance and engagement are used in the different disciplines and how these conceptions frame possible uses.

II. Engineering: users are perturbations

For engineers, the objective of the project is to model different scenarios to evaluate the potential of flexibility, i.e. shiftable loads for different types of buildings, heat pumps and occupancy profiles. Technical models are carried out on a reference building that is used to simulate different consumption patterns in the home. This allows engineers to estimate the loss of comfort that can be caused by different flexibility scenarios. They include the cost of electricity in their model.

Engineers use also emulators to simulate the energy demand of the heat pump and the boiler. In the engineer's model, the house is divided into different heated zones possibly differentiated with occupied (21°C) or not occupied (16°C). But other heat contributions and electrical demands have also to be quantified. For engineers, the user is a random variable which makes their models fluctuating. The user is thus reduced to a set of parameters that emulate his actions on the inner climate of the house: humidity, temperature and CO_2 emissions. Occupants are mentioned as "metabolic heat" or "internal gains".

For the engineer, the social acceptance question arises when an innovation is on the market threshold: "now that I have worked hard, how could the new device be adopted by users?" The acceptance of a flexibility device is thus reduced to the study of physical constraints of the heat pump, the heating system and the electricity grid, and to identify the extent to which users could comply with these constraints.

III. ECONOMICS: USERS SHOULD BE RATIONAL

In our project, economists (and electricity suppliers) seek to determine the potential and the cost of flexibility for heat pump systems. They seek to identify electricity pricing to encourage consumers to shift their heat pump loads to time where energy is cheaper. The study focuses on the development of a cost model that would minimize the "societal costs" (i.e. the cost for the provision of energy for consumers), would comply with the technical requirements and would propose a more transparent tariff, splitting the benefits of flexibility between the different actors. As an electricity supplier told in a meeting: "We need to force consumers to consume at certain moments". The profiles of electricity prices, as determined by the supplier, are intended to encourage consumers to shift loads required by heat pumps at cheaper hours, which is considered as a decisive argument. Real time (or dynamic) pricing is the ultimate objective of electricity retailers, so that they can pass market risks to their customers.

Economists require that what is valued is monetised. Values like comfort and environment have to be translated into Euros. For instance, a subjective price is given to thermal discomfort by the consumer. The economist requires also that users make rational choice and respond immediately to signals. It is at this price that behaviours can be mathematised. It goes without saying that in this model non-economic interests are not represented.

The economic criterion of social acceptance is that services must be competitive. Market is the place where potential users can just say whether they agree or not with the product in buying it or not. This shows that the economists' conception of innovation supposes that the relative absence of user acceptance during the early stage is a necessary condition for the development of innovation. When users are asked to become active, this poses however some difficulties. In this case, the product cannot be something that can be used or discarded, for it aims explicitly at transforming practices.

IV. SOCIAL SCIENCE: DIVERSITY OF PRACTICES

Social scientists are better prepared than the economist or the engineer to accept that users are not so willing to adopt new technologies that would change their daily lives. We have conducted 29 interviews and 3 focus groups with participants in using different concepts drawn on practice theory and STS, and established what we call the ecology of our investigation: building, heat pump, photovoltaic panels (if relevant), controlled mechanical ventilation, electricity consumption and appliances, meter, interface, electricity grid and… inhabitants. Ecology means here that we are interested in the links between these entities and how these links are enacted when practices are performed [3].

We have focussed our observations on what people do (and not on what they are supposed to do). We have translated the objective of the project into the following research questions: how do householders create their comfort? How do they use and control their heating system? How do respondents manage their energy consumption? Are they willing to delegate the management of their devices to external operators? We have adopted a provisional definition of flexibility: curtailing or shifting one's consumption for the benefit of a upper level (i.e. that makes sense and value to an aggregate level). The upper level can be the electrical grid, the provider, the environment, etc.

In collecting data through interviews and observations, the social scientist is faced with a diversity of uses and users, and is required to summarise this information and translate it in a useful language for the project partners. Segmentation, respondent profiles and personas are ways of communicating the social scientist's fieldwork diversity to research partners. The analysis of our data yields to four types of profiles: the economist, the ecologist, the technician and the balanced. These profiles differ in their commitment to their environmental practices and the intensity of their logic of economic calculation. When we presented our segmentation, the first reactions of the partners were to focus on the "economist" profile in order to understand what is his flexibility potential. The idea that users might be engaged in the grid management for other reasons than economical ones leave economists and engineers quite baffled.

V. DESIGN: PRACTICES AND ENGAGEMENT

Top down innovation is facing a lot of resistance to change. Numerous usage studies demonstrate the difficulty for engineers to convince the user to follow the "right gesture", "original script" or "procedure" of using a device [5]. The task is further complicated because 1) there is not a standard user but a diversity of individuals; there is not a right gesture, but a singular appropriation. 2) The device comes in the domestic sphere and its management becomes co-negotiated between household members.

The social practice scientist is relatively well prepared to deal with the issue of engagement since it concerns the reconfiguration of the relationships between humans and objects [6]. From this perspective, the practical everyday actions are based on the recognition of objects as political mediations (low energy lamp, thermostat, compost). The object acquires a participatory status: its role is to be a mediator between the public action and the environment. Feedback or demand response devices participate fully in the idea that users are not just consumers but participate, through their appliances, to a public sphere.

The participation of heat pumps to the grid balancing is part of this new type of engagement or material participation. Users are somehow asked to pass from a representative democracy (in which they choose an electricity supplier) to a direct democracy (in which they act in concert with the grid, i.e. the multitude of other users and also the sources of production). It is however not clear what today is the "material public" of the grid. It is likely that as long as the grid remains obscure in the eyes of the users, the material participation to the grid balancing will remain limited.

We are organising co-design sessions in which users participate to elaborate on the potential for flexibility and how this flexibility might design their practices. Strategies of codesign or participatory design are based on the idea that users are competent to partially transform the configurations that interest them [7].

VI. Conclusion

The current development of smart grids is chiefly done through the combination of an individualist basis (reflected in the economist's ontology) and a large technological grid (engineer's ontology). We have however observed that other developments are possible and even desirable for some parts of the population. These configurations would rest upon community levels, direct exchanges of electricity among neighbours and "ecological" interests. Flexibility at this level might be bigger because it would be based on interpersonal relationships and a higher trust among concerned actors. We are exploring these issues through collaborative sessions with users. We are nevertheless aware that this perspective goes against incumbent interests and will require a political change that takes seriously the place of nonhumans.

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