Reducing domestic energy thanks to ICT and smart technologies : key factors of social acceptance from the European project SHOWE-IT

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ABSTRACT

This paper presents some key sociological results from the European research project SHOWE-IT launched in 2011 for 4 years. This project cofounded by the European Commission in the CIP ICT PSP Program "Projects on ICT for Energy Efficiency" experiments the use of smart metering systems and energy interfaces in real-conditions, by 92 households selected in France, England and Sweden. A series of qualitative interviews made in the three countries on 40 households allowed to understand some key elements expected by tenants for future “smart” energy services. The current “information regime” in energy consumption (mainly the bills) remains too complex and fragmented for tenants, but paradoxically they have a strong knowledge on their daily habits of energy consumption, and a lot of the tenants interviewed have already adopted different kind of energy saving behaviors. This paper will detail some of these savings behaviors as well as tenants’ expectations for “User Centered” energy ICTs including simple metering display, budget service and energy management tool.

INTRODUCTION

An important step in European orientations about energy efficiency has been achieved in 2006, when the development of “smart” ICTs has benefited of strong incentives from the European Union, in a context of raising energy consumption and concerns regarding the European security of energy supply. These new technologies have been highly promoted in order to offer more consumer-oriented metering and display systems for the energy consumption of individuals. In 2008, another sector has benefited of strong interests and incentives from the UE, the building sector with the official EU reports estimating in 2008 that the building sector is responsible for 40% of the total energy consumption in Europe, and is the main contributor to carbon emissions (about 36% of total CO^2 emissions in the EU). The project SHOWE-IT started in 2011 in this specific context where since 2006 the issue of energy security has gain a very crucial consideration from EU policy makers, and where the role of both building sector, consumer’s demands and new energy ICTs devices like smart meters has been strongly highlighted in EU Communications and Directives in order to achieve energy sustainability. SHOWE-IT is a research project selected by the EC to be part of the 14 funding projects in the CIP ICT PSP Program "Projects on ICT for Energy Efficiency" from 2011 to 2014. This program of the European Commission aims to fund research projects experimenting the link between ICT and energy efficiency and especially "demonstrators" projects enabling to test technologies in real conditions.

SHOWE-IT has the particularity to be a multi-energy experiment with a complete ICT architecture that allows advanced energy metering at a household level for hot and cold water, electricity and heating consumption. The system also displays these energy data in a dedicated In-Home-Display (IHD). IHD was installed in 92 testing households living in social housings in 3 pilot sites managed by 3 different social housing organizations[1] situated in England (RBH), in France (Cité Nouvelle) and in Sweden (BoBy). Since 2010 many social housing organizations tend to develop alternative solutions, and in particular to experiment ICT systems mainly because they are cheaper and easier than refurbishment, and the potential of energy savings with ICT systems are potentially significant between 5% to 15% energy savings. In this

[1] Social housing organizations are in the SHOWE-IT project, public non-profit housing organizations with a main mission : to give access to decent and affordable housings for the citizens (social housings)

context, the main objective for the SHOWE-IT partners especially the non-for profit social housing organizations was at the origin to test in real situations the "impact" of smart meters and In-Home Energy Display on individual behaviors, and to validate the potential of energy savings estimated with these systems at the beginning of the project between 15% to 20%. The current article aims at presenting some key results about the representations and expectations of the tenants in this experiment with these new systems of metering and energy feed-back.

The spread of ICT "smart" systems to improve energy efficiency in Europe

In 2011, the rising levels of energy consumption were again highlighted and reported by the EU to pose a significant threat for the future security of energy supply. The predictions of the IEA then were that after 40 years of sharp augmentation, the energy demand would continue to increase by 45% to 50% until 2030[2], particularly among households and service activities.

The European economies are very dependent on energy supply for the historical reason that the European countries have built their growth on the development of technologies needing fossil energies, what Alain Gras called "thermo-industrial" societies. The EU has reminded in 2008 the direct link between the capacity to supply enough energy despite the increasing demand and the economic growth. The complex challenge for the EU is currently to answer to the increasing level of energy demand in the different economic sectors especially the private sector, while controlling the total amount of end-used energy in order to maintain energy security. Harold Wilhite has highlighted what he called a "*sustainable delusion*" that consists in answering to this "problem" by "confusing efficiency and reduction"[3]. The problem of "*increasing world energy consumption*" requires according to him "*heterogeneous models of action*" based first on a strong understanding of energy demands already "*encapsulated"* inside the techniques*:"the energy demand is partly embedded in the material world"*[4]. Individuals have today an important role to play in "reshaping" the energy print of techniques both by their choices of equipments and by their uses of them. Indeed, after the sixties when the number of "electro-domestic equipments" have strongly increased in the domestic space (Desjeux and al., 1996), during the last decade a new strong augmentation of electronic devices has occurred (cell phones, computers, tablets, tv, hi-fi, etc) and the domestic energy demand has continuously increased. The difficulty remains today in the way to inform and encourage individuals to operate changes in their choices and uses of equipments as well as their energy practices.

In this context, the policy makers of the EU have taken the option to encourage the development of ICT energy feed-back systems. ICTs have been directly associated with the guidelines of the Energy Efficiency Directive in 2011 with especially detailed objectives to install widely "smart" electricity meters and also advanced individual metering in water, gas and heat consumption, as well as with feed-backs to consumers. The assumption made by policy makers is that ICTs new technical solutions (i.e. smart metering and IHD energy feed-back systems) can change the individual habits of energy consumptions, and can lead to two new forms of interactions between users and energy : optimized uses or reduced uses. One of the current challenges in the actual context is to understand the acceptances and the uses in real-life conditions of these systems by the users.

The SHOWE-IT experiment : stakeholders and ICT systems

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[2] http://www.iea.org (World Energy Outlook 2008)
[3] Introduction of Harold Wilhite at the 1st International Conference "Energy and Society" – Lisbon University 2012
[4] *Ibid.*

project between 15% to 20%. The SHOWE-IT project has been launched in 2011 at the initiative of some key players in the energy transition for buildings and households : 3 non-profit public housing organizations: RBH (England), Cité Nouvelle (France) and BoBy (Sweden) and also Global Habitat (representing 7 European Public housing companies), international ICT companies such as Aqbar, Siemens, Smarvis, researchers at Ecole des Mines St Etienne, Bax and Willems, Acciona and an international energy supplier GDF Suez in collaboration with CSI, Ecole des Mines de Paris.

METHODOLOGY OF THE PROJECT

In order to reach the goal of 15% to 20% of energy savings, SHOWE-IT partners developed and installed, in 2011 and 2012, a smart ICT architecture in 92 households selected in social housings in France, England and Sweden.

The system architecture is composed of 3 different parts (each of these parts have been particularly complex and challenging to achieve) :

- 1st part : the ”smart metering system” and communicating censors to meter water and energy consumption of each household
- 2nd part : the "energy smart server" with the convergence of the metered data to a central server and the automatization of some energy options (ECA server, automatic optimization for the heating by Siemens Synco Living);
- 3nd part : the “customer interface” or so-called “In-Home Display”, a tactile tablet with new energy services installed in each household integrated in the project.

Functionalities and feed-backs in the energy display system

This system allows tenants to be informed in near-real time data about their domestic energy consumption. The metering and the display of the data is made every 180 seconds for the household consumption of heating, water and electricity. Compared to the former type of energy feed-backs received by tenants (classic bills), this system provides new quantitative data : every 180 seconds the level of consumption both in volume like kWh, liters and the equivalent in Euros and CO^2, the level for the consumption of each household (instead of collective consumption as before), and also the possibility to display the daily, weekly and monthly consumption for electricity, water and heating. The system provides also more “qualitative” data : a window shows what is the proportion of water used by equipments or uses, another window shows the temperature in each space with the heating, the temperature outside, and also tips to make energy savings.

The sociological study of ICTs’ social acceptance in the SHOWE-IT project

For Sarah Darby *“energy supply and consumption are sociotechnical in nature: technology and behaviour interact and co-evolve with each other over time”* (Darby, 2006) and the phenomenon of habits and “routines” in daily energy consumption remains complex and is the result of “aggregated factors” (Zélem, 2010). Studying both the social appropriation of a new technical system and the birth of new “routines” directly linked to this device is a very complex process that requires primarily in our view, a very rigorous and in-depth qualitative survey with users. Indeed the social appropriation of an innovative technical device relates to complex social processes including a number of elements such as the users technical culture, the social representations, the origin of the innovation, the communication and information process to the users, their former experiments of the techniques, their habits and also the “collective dynamics” (Beslay, Zélem, 2009). This is why the first two years of the SHOWE-IT project (2011 and 2012) the sociological-part of the project resulted in an in-depth qualitative

sociological investigation on 40 households selected to be part of the project in France, Sweden and England.

Our method is directly inspired by the classical comprehensive approach with the collect of actor's speech about their representations and their daily practices, and by the sociology of consumption with a strong focus made during interviews on the tenants' knowledge on their domestic life. These qualitative interviews were conducted inside the dwellings of tenants and during these interviews a second part was dedicated to interview tenants about the 1st prototype of the energy interface. One of the goals of qualitative interviews was to identify in the speech of tenants, their main expectations for both the "utility" (the contents : services, functions) and the "usability" of the interface (the support and navigation system) in order to study in a second step the map of relations existing between tenants, the 1st prototype of the ICT system and their existing "domestic energy eco-system". This collaborative design approach in the SHOWE-IT project has partly been inspired by the UCD approach (User Centered Design approach). In 2013, we have launched a second series of 42 qualitative interviews with the same type of comprehensive method but then, once the tenants had used the interface during more than a year.

RESULTS AND DISCUSSION

Information flaws and differences

In terms of energy consumption, our qualitative interviews demonstrates a strong paradox between, on one hand, the strong knowledge or what we call "self-expertise" of tenants on their domestic habits of energy consumption and, on the other hand, the current regime of information about energy distribution. The actual tools to inform tenants on their consumption are both too complex and too heterogeneous. Indeed, the energy audits and then the qualitative interviews allowed us to witness the wide diversity of energy meters, energy feed-backs and systems to pay energy bills in each country. The next part is dedicated to the description of the complex situation that the tenants experiment in the "ecosystem" of domestic energy distribution, in order to illustrate the complexity of situations observed on the experimental sites.

Metering system : the method to collect the energy index remains very heterogeneous between the different energy (electricity, heating, gas) and for water. Some index are manually recorded, in other cases, tenants have an automatic electricity index record (tenants equipped with smart meters for electricity).

Different time scales to establish the energy consumption index : also the record of energy index is not regular, it differs a lot for each tenant, between the different energy and between the system of billing.

Individual versus collective meters: some tenants have individual metering for electricity, but collective metering for water and heating with an individual billing (thanks to recalculation models by the housing companies or the supplier). And in conclusion, the bills are either based on real individual data, estimated individual data or estimated individual consumption based on real or estimated collective consumption. The information of the bills are in addition too complex and not informative enough. The units are not always easy to understand and remain difficult to relate to everyday life situations of energy consumptions, and at last the calculation models of suppliers and housing companies are very difficult to understand by tenants.

Today, the energy awareness issue is first an issue about the information given to consumers. According to most tenants, the feedbacks must include easy way to understand : the level of consumption (how the index is metered), the model for the calculation of the energy cost, and the model to calculate the individual energy costs from the collective metering.

Impact of information flaws on individuals' awareness about energy consumption

Unfortunately, neglecting the information aspect has raised misunderstandings and mistrust about energy distributors and housing companies. The information delivered to households through bills remains fragmented today and minimizes what is called the "awareness" or the "reflexivity" of individuals on their energy consumption. With the qualitative results from the SHOWE-IT project, we now share the conclusion that the phenomenon of disconnection between attitudes and behaviours and or so-called *"value-action gap"* (Verplanken and Holland, 2002) is rooted mainly for energy in the "missing link" between the energy consumption, the data displayed and the users. In a context where tenants don't receive detailed and relevant information about their energy consumption, but are encouraged to make energy savings, a worst counter-effect can be revealed : some tenants will adopt "anti-reflexive" attitude in the meaning of Aaron McCright & Riley E. Dunlap, a refusal of "reflexive action" designedly with explicit reasons. In the SHOWE-IT project the opposition of some tenants ("anti-reflexive" action) to the energy savings "principle" of this experiment is explicitly described by them as an answer to the lack of communication and information received from the meso-level actors (suppliers and housing companies mostly), and also to the lack of actions and responsibilities carried by these actors to also improve at their level the energy efficiency. The mistrust is raising in this kind of context, and tenants develop what is called classically some *"oppositional or negotiated reading"* (Hall,1973) about both the information given and the actors behind the information.

The "self-expertise" of individuals on their daily energy consumption.

Despite the heterogeneous and complex information system for energy consumption, tenants prove to have paradoxically an excellent knowledge of their domestic habits. The interviews conducted in 2011/2012 and in 2013 have confirmed that tenants can accurately describe on hourly basis their domestic practices and uses of energy each day of the week. They can detail the way they use each equipment hour after hour, the reason of these "routines", and the other users' habits in a family for example.

Our results seem to show that the week days are built on strong "routines" and what is very interesting is to compare these routines: they are more similar between generation and households of similar structure than between tenants of the same country or culture. The energy daily "routines" are mostly trans-cultural in our experiment and are characteristic of specific and shared profiles of energy consumers amongst Western modern societies (for the everyday life cycles and the regular uses of energy equipments, heating and water).

The "network representations" of tenants

An interesting result of the interviews is the way that some tenants try to diminish the lack of information between their practices and their consumption level, "symbolized" and "translated" only in index and costs in their energy bills. Some tenants "recreate" a model to understand first their energy consumption, and to create in a second time a rational link between their consumption level and their bills. Our study tends to show that the 4 following criteria are used by tenants to compare, understand and lower their uncertainty about their energy consumption : the type of housing, the type of occupancy, the type of equipment, the distribution and the billing system.

The estimations of tenants are built by putting into perspective those several elements to auto-estimate their energy consumption and more specifically the evolution in their energy consumption (and then the cost). Tenants will for example compare their actual consumption with their experience in former dwelling or house, or the experience of relatives (for example when they doubt about the potential increase of energy cost), and they will also try to compare

their consumption between equipments with different characteristics for the energy or water efficiency. What is important to keep from these results, is the fact that tenants try to find information, to “create” a rational link by themselves to explain their energy consumption and also the energy costs because the information they get in bills are mostly insufficient.

The different types of interest to make energy savings

In addition to these very specific examples, we have observed that a lot of tenants have already begun to move towards more efficient practices but not all initiated with the aim of "protecting the environment". Several key factors explain according to tenants their existing saving behaviours revealed during the qualitative interviews (saving practices adopted before the project) :

- the country's culture, the habits learned during childhood to "not waste" (especially the generation up to 50 years in each country)
- the objective to educate children and to show them "good behaviour", as it is to say saving behaviours (especially for the family with parents up to 40 years)
- to control the budget (especially for families and couples – the negotiation between tenants about energy consumption creates domestic little conflicts or discussions) and finally the protection of the environment - especially for the generation under 40 years).

Shortly, the habit of “non-wasting” has proved its importance for the generation of tenants up to 50 years, and environmental awareness has a key role to play for younger generation who are willing to pay more to choose green suppliers for electricity, as noticed in Sweden for several tenants.

The change towards energy saving practices has already begun

Some tenants have in a way “anticipated” the new energy services that are proposed to them in the SHOWE-IT project. One of the French tenants had already installed before the experiment a system of censors and meters inside his dwelling in order to check his consumption of electricity and to control it. The origin of this action is precisely the lack of information in the bills. This system called “consomètre” allows the tenant to make his own energy diagnostic / feed-back. Also some of the other tenants of the project kept an Excel file dedicated to the energy budget where they insert the billing costs in order to follow the evolution of their consumptions. Shortly, in the SHOWE-IT project we identified existing saving behaviors in what are considered the 3 main typologies of energy saving behaviors (Van Raaij and al., 1983): purchasing behaviour of energy efficient equipment, usages with daily savings and changes (in frequency, duration or intensity of use of energy or water...), and in rarest occasion are the maintenance behaviours with some tenants checking their radiators to optimize the heating system.

The expectations of tenants for new energy services are very specific

One of the main surprises of the sociological survey has been the very specific, detailed and high level of expectations of tenants for new energy services. In addition to a more easy system of feed-back (both more understandable and more informative which is the complex aspect of this issue), tenants expect key services for future energy need :

- A service to support the management of the budget devoted to energy;
- A target consumption and cost fixed in advance with warnings;

- A system to check the impact of new behaviors or equipment (tenants expect a real "intelligence" of the system with an help in planning their future consumption) and also to estimate their future energy consumption through the adoption of new practices;
- An automation systems to better manage equipments in particular heating. Automated management of heating is a real advantage according to the tenants in the SHOWE-IT project and revealed to be a key factor of sustainable use of the tablet;
- At last, tips to propose them behavioral and technical options (like equipment) in order to minimize their consumption and quantify these savings in the future.

The energy ICT system should also offer a high level of adequacy between the units presented in both the bills and the tablets, or tenants tend to have mistrust and to disinvest the tablet.

A "natural interface" for energy feed-back displays

A well as for energy services, tenants have very specific needs and expectations for the device in itself. The energy applications or interfaces must be a "simple but intelligent intuitive interface". We also tested the prototype of the energy interface about the "usability" dimension and we have established that tenants have very high expectations about new energy ICTs as they are used to high quality ICTs such as tablet and smart phones mainly developed and designed with UCD approaches (with embodiment of the so called "natural skills" of the users). Users want an access to the contents facilitated by an intuitive design and an integration of their existing habits with tactile ICTs, and the use of web navigation.

The interaction human-devices is also subtle. The location of the interface in the dwelling has been studied and we have discovered how daily habits and "mental maps" will shape the future uses of the tablet. The intrusiveness of the interface must also be questioned and designed accordingly to the tenants needs. Indeed the smart energy interface is the medium of users' reflexivity on their practices and their level of energy consumption. This perpetual link displayed between tenants, their actions, their domestic space, and their equipments might be perceived as an oppressive continuous injunction to reflexivity, to self-control and provoke at the end a rejection by the users. The interactivity of this new medium must be limited as this device become a "new actor" in the domestic space and the level in intrusiveness of this new device can strongly lower the interest of tenants (this intrusiveness lies mostly in the communicational functions such as the sound, brightness of the device as well as its location inside the dwelling).

CONCLUSION

The complex aspect of new energy ICT remains in its conceptual functioning: the energy savings are expected to be made...by the users themselves and in our case by the individuals living in social housings. The ICT system is supposed to provide information, feed-back to these users that encourage or allow them to make energy savings. The main assumption structuring the concept of energy ICT feed-backs /services /interfaces is that new forms of information about energy consumption should lead to "reflexive performances" by the users of the system, and even turning them in becoming "operators" of their domestic energy grid. The hypothesis made is that the display of new information such as near-teal time data, or the display of the equivalence in money can lead to changes in the way tenants understand their energy practices and act. Shortly, with ICT systems, the energy saving goals and the European energy efficiency objectives are partly delegated to individuals, the individual reflexive action seems to become at a micro level the way to resolve energy issues and environmental problems or "super wicked problems" (Levin and al. 2012).

In the SHOWE-IT project, we have witnessed a growing individual and collective awareness about energy demand issues and environmental impact of energy consumption, but despite a specific social context of awareness, exploiting individual "reflexivity" remains problematic. The users, the tenants, feel and understand the social pressure and the responsibility that is progressively given to them about energy efficiency but the main priority today is first to give tenants efficient tools to be really informed and to be part of the collective action of energy sustainability. The crucial point is to inform them more sufficiently about their energy consumption, the energy market, the alternative options to use energy and water, and finally to create new displays that really answer to their needs and their existing knowledge. Such systems require to be developed, an in-depth understanding of domestic practices and to take seriously into consideration the demanding method to develop socio-technical innovations in a real "user centered" approach.

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