Jégou F., Liberman J. and Wallenborn G.,
"Collaborative design sessions of objects
proposing energy-saving practices"
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Abstract:

How to design products that may influence users towards new and more sustainable behaviours? Beyond the eco-efficiency of domestic equipments, is it possible to think them so that they suggest to their users they should be used in a thirfty way? Design generally pushes consumption and tends to be part of the problem: how to use the same design skills to make enable households behave in a more responsible way? How could new interfaces empower user rather than making them importent?

This paper focuses on the ISEU ("Integration of Standardisation, Ecodesign and Users in energy using products") research project funded by the Belgian Science Policy and particularly on a 6 months co-design session with users, conducted

by Strategic Design Scenarios and Égérie Research, Belgium; The purpose of this session was to collaborate with families and to associate them to participative design sessions to define together with design teams, innovative design strategies and related sets of domestic appliances likely to induce energy-responsible behaviours of households. The development of the paper focuses on two main aspects of the research project: a first part presents the collaborative work with the users, the tools and interactions used to ensure their involvement in the design process. A second part describes the results obtained at a methodological level proposing four design guidelines to favour energy-responsible behaviours and at a practical level to describe eight new concepts of products in the sectors of lighting, heating regulation, clothing care and energy smart meters.

Designing practices

In the search for more sustainable consumption patterns, "behaviour change" has become a motto. A usual way to deal with this aim is the idea to change first attitudes of consumers, so that a behaviour change will follow. There is however more and more research showing that practices are not changing so easily, especially when consumption is inconspicuous as it is the case of household energy consumption (Shove 2003, Jackson 2005). From the point of view of design much of the political agenda is on ecodesign. According to the directive 2005/32/EC "establishing a framework for the setting of ecodesign requirements for energy-using products" (EuP), ecodesign means: the integration of environmental aspects into product design with the aim of improving the environmental performance of the EuP throughout its whole life cycle".

As our research has shown, the preparatory studies for implementing the 'ecodesign directive' are mainly based on technological considerations; uses and users are hardly considered (Wallenborn & al. 2009).] Besides the necessary energy efficiency improvements, the question of sufficiency is never asked. Though efficiency and sufficiency are generally considered as opposite concepts and strategies, we think we have to make them complementary. Indeed we ought to combine acceptable additional efforts for the users (sufficiency) with improved usage process (efficiency) and explore how to 'do nearly the same with less'.
While we know we have to transit quite fast towards a post-carbon society, the active role of users and their interaction with their appliances are hardly envisaged. The problem is that the environment does not appear in households' daily practices: households do not
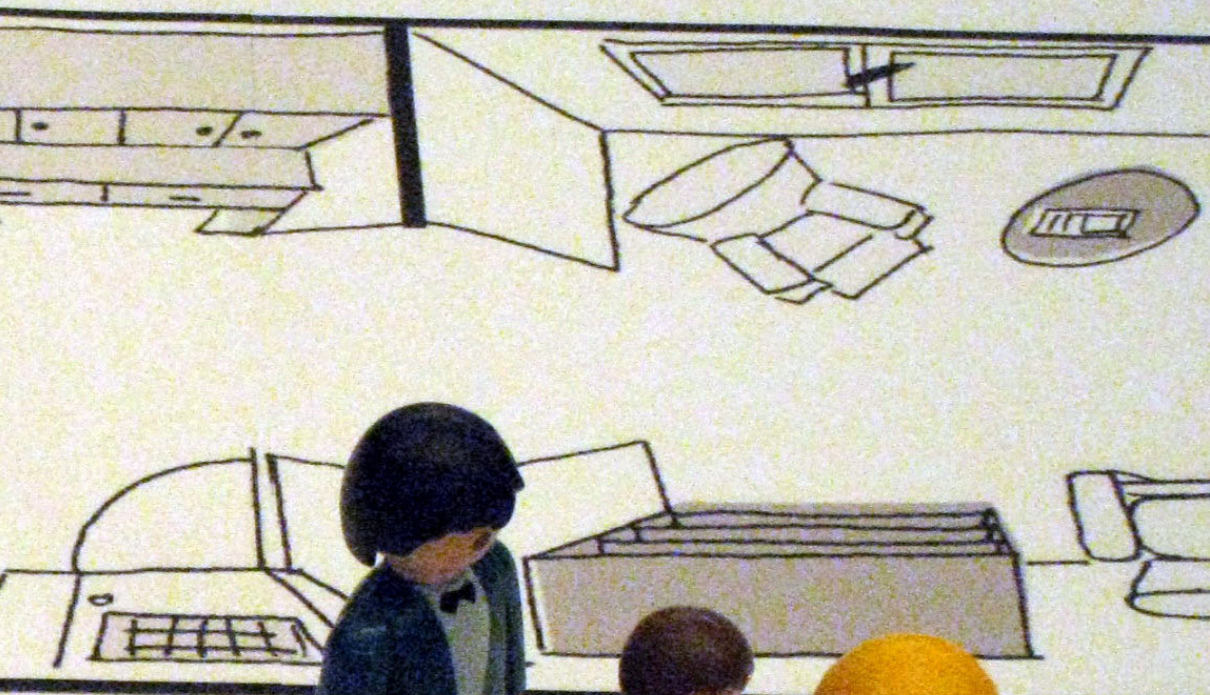
consume energy, they use different objects that give them services. Therefore, rather than starting from attitudes, we think it is essential to start from what people are doing, from their everyday practices (Ropke 2009). In their daily life, households are engaged in practices (cooking, washing, working, entertaining, etc.) that are meaningful to them. Energy consumption is only one aspect of these practices, and it usually comes unnoticed.

Manzini (2009) pleads for a design that would overcome the pitfalls of eco-efficiency and those of the individual choice as a sustainable solution. But how could design start from households' practices? How to design products that may influence users towards new and more sustainable practices? Beyond the eco-efficiency of domestic equipments, is it possible to think them so that they suggest to their users they should be used in a thrifty way? Design generally pushes consumption and tends to be part of the problem: how to use the same design skills to enable households to shift their practices more in line with a sufficiency principle? How could new interfaces empower user rather than making them impotent?

There is an abundant literature about objects, their use, user-centred and participatory design, and the links that can be made with Science & Technology Studies (Weedman 2005, Shove & al. 2007). The notion of script exemplifies well the kind of thought this literature. When objects are designed, they are infused with the description of the user's behaviour. But more than that, the objects are designed for allowing certain behaviour and counter others. Jelsma (2003) defines scripts as "the structural features of artefacts encouraging certain user actions while counteracting others". Scripts have a prescriptive force that steers users in a certain direction. The symmetrical concept, from the point of view of appropriation by users is the affordance. In these narratives objects and users are actively interacting. We have however to acknowledge that the way users and objects are considered are usually far away from this active power.
There are currently two dominant ways of considering users, as hedonistic or as rational. The hedonistic point of view describes how households are currently consuming their energy, as is revealed in

different studies (e.g. Shove 2003). In these situations, consumers are mainly moved by their research of pleasure and comfort. Energy-using products are seen as devices providing enjoyable services: in their daily practices, households do not realise they are consuming energy. Household's capacities of action are not intrinsically limited, but they are always inclined towards easiness. From the rational approach point of view, the individuals are considered as rational actors that act on the basis of a valuation of their actions. In this perspective, the role of policy is to organize the conditions for this rationality to be effective. Policies must make available the right information, at the right moment. It must standardize and encourage customers to choose correctly the products. This point of view is mainly present when speaking about the moment of buying an appliance. Rationality means here that users calculate and optimise their use of resources.

If we remain hesitating between both hedonistic and rational approaches, we are stuck in the famous 'attitude-behaviour gap'. We propose therefore a third approach that is found in the literature on design or learning, for instance (Pantzar 1997, Darby 2005). We call this approach experimental or relational. The sufficiency can only be addressed in this approach because humans are not predetermined, they are relational, they change when they get in relation with objects (Thevenot 1994, Debaise 2004). Humans and their desires are produced in their relationship with the objects they have. It is the situation in which people are that determines their own behaviour. The reality of this approach is a process: it emerges from action, from practices, and can be discovered only in the concrete relation with the appliances (Reckwitz 2002). According to this point of view, the cultural situation is not fixed. The desires of the consumers and what they are ready to accept can only be discovered in the meeting of new situations and objects.

What happens when households are placed in other situation than hedonistic or rational? What are they able to create as new device enhancing changes in user energy saving behaviour? This is the starting question of the present paper. We will present some results of the collaborative sessions with households, centred on 4

household appliance categories: lighting, heating regulation, washing machine, computer.

These co-design sessions with users lasted 6 months and were conducted by Strategic Design Scenarios and Égérie Research, Belgium. Families were invited to collaborate and to participate to design sessions to define together with design teams, innovative design strategies and related sets of domestic appliances likely to induce energy-saving practices. The first part of the paper presents the collaborative work with the users, the tools and interactions used to ensure their involvement in the design process. The second part describes the results obtained at a methodological level proposing four design guidelines to engender energy-saving practices. This paper focuses on the process brought by the co-design of new lighting systems. By contrast, these experimental situations show how much our current lightings are rigid.

Be this paper enlightening!

Cet immeuble qu'ils construisent en face, ça nous coupe un peu la lumière et il y a pas mal de nuisance. Les trottoirs sont enfoncés par les camions et ils se garent n'importe comment.

Ma maison

J'aime lorsque je suis dans ma cour, je suis isolée des autres voisins.

Marie-France D a 56 ans, elle est veuve et vit avec son 2e fils de 21 ans.
Elle vit dans une maison avec un jardin.
Jusqu'ici elle ne faisait pas spécialement attention à ses dépenses énergétiques.

La cuisine est au centre de la maison, je l'aurais mis à l'ombre avec une grande pièce ouverte.

Les grands placards du hall d'entrée font tout le mur de droite en entrant. Cela permet de cacher le désordre !!!

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vue quartier :
clos fermé = sécurité pour les enfants, moins de bruit, calme et agréable.

jardin et terrasse arrière : manque les séparation = pas très intime !!!
Je n'aime pas : ils n ont pas encore mis les séparations des terrasses et les passants marche sur nos terrasses au lieu de sur le trottoir !!!

Barbara D vit avec son fils de 5 ans et son chien.
Elle habite un petit appartement de deux pièces en rez-de-chaussée.
Elle est contente que la rue soit en cul-de-sac, car son fils peut jouer avec les autres enfants sans risque.
Elle essaye de faire des économies d'énergie pour faire des économies d'argent principalement.

la cuisine américaine ouverte sur le séjour, c'est très agréable quand on reçoit des amis.

salle de bain : super

A côté de notre jardin, un gros débarras, où les jeunes jettent leur déchets.

J'adore les terrasses et ce côté de jardin qui a le plus de soleil.

La boîte haute tension que je n'aime pas.

Carina M vit avec son mari et leurs 2 enfants (2 ans et 5 mois).
Elle habite dans une maison neuve achetée il y a peu.
Sa famille essaye de réduire la facture énergétique.

Notre belle cuisine ouverte

Je trouve la salle de bain un peu petite car j'aurai aimé avoir une douche en plus.

Les photos ont été prises avec un appareil photo digital sony et les défauts diminués avec le logiciel picasa. Photos envoyées par internet via connexion adsl.

Ce qui me déplait : chambres donnent sur rue et passage fréquent des trams.

Ce qui me plaît : vue sur le kauwberg, verdure calme, salon plein sud.

Nuria vit avec son compagnon et deux enfants (Ruben, 12 ans et Léna, 2 ans). Ils sont une famille mosaïque.
Ils habitent un grand appartement, dans un quartier résidentiel très calme.
Ils n'ont qu'une seule source d'énergie : l'électricité, ce qui ne leur plaît pas.
Ils recherchent l'efficacité et l'optimisation.

Le séjour (sans salle à manger avec vue sur le kauwberg)

La salle de bain (baignoire, machine à laver, lavabo et sèchoir)
La salle de douche (plus souvent utilisée)

La cuisine (équipée avec balcon de dégagement)

Nuria est contente d'être proche de la forêt, d'avoir un grand living et d'être près des transports en commun. Mais elle déplore le bruit des trams et l'humidité de l'immeuble.

Ce qui nous plaît :
1/ agréable terrasse en plein sud ouest à l'abri des vents.
2/ la véranda

Ce qui nous déplait :
1/L'absence de garage
2/ La N4 itinéraire de délestage de l'autoroute E411

Olivier M vit avec sa femme et leurs 2 enfants (11 et 13 ans).
Ils vivent dans une maison avec un grand jardin mais malheureusement pas de garage.
Ils réfléchissent au moyen de faire les meilleures économies et viennent d'installer un chauffeau solaire.

Une petite cuisine récemment réaménagée

Un salon agréable et frais en été, avec un feu ouvert pour l'hiver

Une petite salle de bain à rénover

1   Collaborative design with users

The co-design sessions with users has been developed during 6 months in four phases starting with online discussion with 16 families, discussing their energy consumption patterns, exchanging pictures of their living contexts and progressively building trust for the second phase of self-investigation training and ethnographic observations at their homes. The third phase has invited the families to work together with design teams at Strategic Design Scenarios offices and to co-design new product concepts. Finally the fourth phase consists in delivering to the families, mock-ups of the products they co-designed, makes them familiarise with these new equipments in their homes, and asks them to describe why they think these new appliances are likely to improve their energy-consumption practices in front of a video camera. The short video clips of users presenting their involvement in a design process, the results they obtained and the behaviours changes they expect will feed the following of the ISEU research project, in particular to stimulate qualitative discussions with larger samples of users as well as designers and producers of domestic appliance.

1.1 Casting online

"First, let's start with knowing each other better!"; "Could you introduce your family? You and the children..."; "What is your professional activity?"; "What about your house?"; "I can't imagine where you live... Could you send us some pictures? "How do you feel in your neighbourhood? What is the atmosphere?"; etc.
The collaboration starts with an exchange of mails with the different families involved. The initial recruitment focussed on 16 middle class households different in size, incomes, age, type of housing and family status. But the discriminant criteria of selection were their motivation to reduce their household impact on the environment, their concerns for sustainable issues and above all their willingness to take part and play with all family members together in a series of exchanges, dialogues, meeting on the theme: "We will control our energy consumption".

◀ Sample of exchanged mails with the recruited families during the casting process.

This last criterion is fundamental for the success of this type of participative design. Compared to proper qualitative/quantitative investigation, the representativeness of the sample is much less important that the openness of people to collaborate both in giving access to their contexts of life and in exploring their current life patterns. The scope of the process is not to test the potentials of any market proposal but to generate new ideas that could change ways of using energy. Whereas classical marketing approach is completely oriented towards identification of existing trends in order to conform to them, the goal is here different, quasi-opposite, searching ways to escape trends, exploring behaviours in depth and activating different human inclinations than the ones leading to today's overconsumption. It is a real 'casting' process similar to selection processes of actors. The role of the film is only different: we have actively searched for users who exhibit specific characteristics like curiosity, flexibility, positivity, instead of inertia, conservatism and egocentrism.

The conversation by mail was carried on during 4 weeks bringing progressively the families to talk about the 4 categories of products selected by the ISEU project: "How are you organised in your family with the laundry?"; "How frequently do you adjust the heating regulation? Who is in charge of setting the temperature?"; "What is going well with the use of the computer at home? What's less easy?"; "Could you tell me an anecdote about the use of the lighting system in your family?"; etc.

This technique has been inspired by the analysis of trust building process in peer-to-peer relationships on Internet. For instance, how people living 6000 km from each other and who never met before manage to become progressively confident enough to exchange their respective houses during summer holidays? They get in contact through a website, exchange their email addresses, began to talk about where they live, what their houses look like, how many bedrooms are available for the kids and if they would agree to feed the cat... Progressively they discuss a wide range of subjects, disclose more personal and intimate elements as long as they fell more confident in the relationship and after 15 to 20 exchanges they feel

safe (or sometimes not) to leave the key of what is probably their most valuable property to strangers that have become friends.

In the ISEU project, the process was similar but shorter and after 6 rounds of mails exchanges, 8 households out of the 16 initially involved in the first phase were short-listed according to the above criteria and invited to take part in the second phase.

1.2 Visiting 'friendly users'

The purpose of this approach is to involve users in ideas generation process to stimulate and 'debug' designers creative thinking. The previous phase aimed at selecting 'friendly users' which value is less in their testing capabilities and market representativeness than in their willingness to design a supportive environment toward new and more sustainable way of living (Snyder 2003; Jégou 2009). Reciprocal to the concept of 'user friendly' where physical environments and objects are designed to facilitate users tasks in everyday life, the idea of 'friendly users' focuses on people who are encouraging the emergence of new projects, trying to bring constructive critics, to suggest improvements and to overcome imperfections of early prototypes.

In the second phase, families are proposed to host the project team at their home around a cup of tea or a glass of wine. Here again the protocol is inspired from real life typical socialisation situation such as between neighbours inviting each other for a drink and generally a short tour of their house.

The aim of this informal visit is to better understand the specificities of the different contexts of life and their potential interaction with energy consumption related practices. As any ethnographic-like approach, the purpose of sharing some moments of family life is to check differences between what they declare and what they effectively do, to link their judgements to the context in which they live and to better understand their aspiration from their current situation.
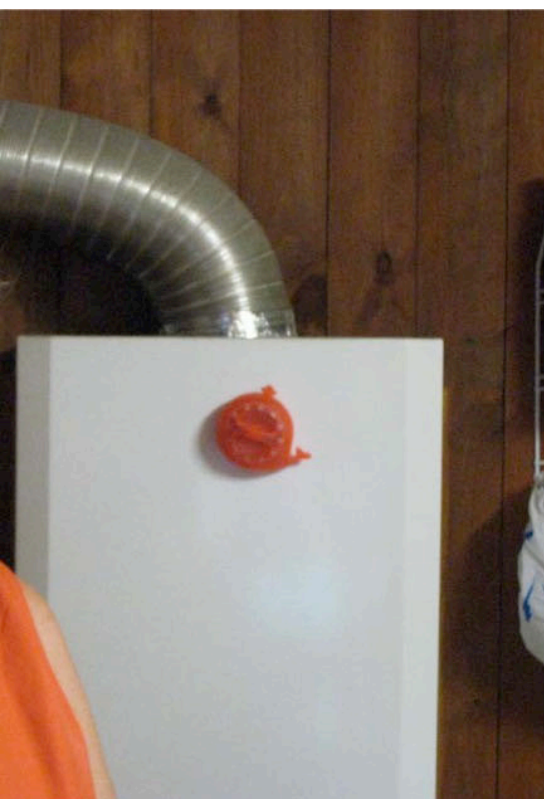
Marie-France D. advocates for programmable thermal regulation but she proves to be incapable (as many other users) to explain how her quite complex device was working. Olivier M. stigmatises his wife for her excessive use of additional heater in the bathroom but it appears that himself plays computer games late at night and leaves an electrical blanket on to get his bed warm when he finally decides to go to sleep...

Beyond the confrontation between perceptions and reality, immersions in households' life, even for short periods, allow empathy with the users (Evans, Burns and Barrett, 2002). In a project-oriented process, the experience of real bits-of-life is often a rich stimulation.

Most of the visited households have a main central light in each room. In living rooms they tend to be never switched on and more disseminated ambient lights are preferred. Therefore they tend to become 'off-lights' perceived mainly for the design of lighting and its decoration effect in the room. In the kitchen and in bedrooms central lights are also inconvenient because they project shadows on the peripheral working surfaces and in cupboards and wardrobes. But by default, they correspond to the main switch at the entrance door and users switch them on when they enter the room and add a second specific light for the task they have to perform...

Finally, immersion and empathy with users in their living situations, allow partly to make irrelevant the non-representativeness of the sample of users involved. Chatting in the garden with the dog playing around, passing from the laundry waiting in the basement to the computer in the attic, visiting the bedrooms following the kids, etc. give access to a quick and global comprehension of the users. It allows to guess more accurately where are the effective motivations and contradictions of each individual and finally to differentiate singularities from the general in the observations.

◄ Joëlle H. is highly respectful of the environment but very chilly. She has therefore developed a wide range of tricks for her and her 2 daughters in negotiating with this contradiction: the family computer is installed in the attic where there is no heating so that the connection time is 'automatically' regulated; a kitchen timer is installed in the shower to remind that 10 minutes is enough...

Pour éteindre les lumières
inutiles...

Ex.

...j'ai installé un interrupteur général:
je peux éteindre tous les éclairages de
la maison d'un coup et je ne rallume
que ceux dont j'ai besoin...

B

Pour ne pas chauffer
n'y a personne...

Ex.

...chez nous chacun à un petit
thermostat personnel dans la p
on chauffe que là où les gens se
trouvent...

Joëlle H. declares to be a 'waste buster' but she reveal to be excessively chilly. This particular contradiction forced her to be inventive in finding a series of tricks (e.g. silk underwear and flannel bed linen in the winter, reading in bed rather than in the sofa…) to save energy while keeping an acceptable comfort. Joëlle is very interesting as she encapsulates an extreme version of the contradiction between sustainability and individual comfort.

1.3   Discussing proposition cards…

Beyond empathic immersions in families' contexts of life, those visits intended also to discuss some hypothesis of alternative design for energy using domestic appliances. A series of 4 to 8 breakthrough alternatives in terms of users practice changes were proposed to the families for the 4 categories of products focused by the ISEU research:
• In order to reduce the time period when the lights are on…
…the lighting in each room is based on double switch: it switches on and off automatically when I am quickly passing by and I manually force it to stay on when I decide to remain in the room;

• In order to limit the total amount of lights which are on…
…I have a system that limit lighting to 20 Watts for economic bulbs per person. We can't go beyond this limit and if we want to switch on one more light, we need to switch off another one first.

• For an environment that favour lighting…
…for a more efficient lighting, I paint the walls and ceiling in bright colours, I put mirrors and light curtains, I choose simple lighting providing direct light and easy to clean.

• In order to reduce the temperature without feeling cold when I don't move…
…in the living room, we keep the temperature somewhat lower and we have a warming sofa that balances locally the temperature when we feel chilly in front of the TV.

◀ Example of proposition cards and users discussing their opportunity and conditions of implementation at their homes.

The ideas introduced may not be innovative as such: some were very banal propositions but they all potentially may represent important shifts in the current behaviours of the users.

The propositions were presented through a set of cards that systematically:

- intends to save energy;
- shows a domestic situation implementing the proposition;
- describes the proposition as if it was a quote from a user.

This presentation was designed in line with the previous phase of discussions by mail. Actually it intends to look like an excerpt of one of these mails: informal speech from conversation between neighbours; a functional picture showing what it is about... The pitch is peer-to-peer advising. The purpose is to confront the hosting family with statements of other people who organise their domestic environment in different ways. These statements are, on the one hand, realist since some people are living like that and, on the other hand, are engaging for nobody criticises my current way of doing but I am just showed that doing in another way is also possible and enjoyable.

The very form of cards allows the users to manipulate literally the different propositions: they keep close the one they like and remove the other; they group what they assess as complementary or of the same nature and they progressively organise a hand of cards they feel more comfortable with or interested in.

1.4   Playing design games

The third phase of the participative design with the families consists in proposing them to take part to some of the design projects they contribute to trigger in the previous phases. The proposed context is completely different: families were no more in their domestic environment. Two families were invited for an evening in a design consultancy in Strategic Design Scenarios offices. Learning from the previous steps is shared with them and 2 design exercises are proposed lasting about one hour each.

The discussions around the proposition cards focusing lighting raised a series of design demands as for instance:

- Economic light bulbs seem to be widely accepted. They are now more accessible and the quality of the light they provide has been improved. But their systematic diffusion is limited because their shapes are incompatible with many lightings design;

- Main switches on the wall near entrance doors are mainly commanding the central main light of the room which is less and less used compared to disseminated lights creating an ambiance or functional spot lights dedicated to specific activities and areas. The consequence is a complicated sequence of use where users enters the room, switch on the main central light to reach the specific light they want to use and go back to switch off the main light they don't need anymore (when they make the effort to do it)...

More fundamentally than these technical questions, the management of the lighting system appears to be quite primitive and a rational use of the lights requires a permanent attention from the part of the users. In other words, users are not very much supported to reduce their consumption of energy for lighting. Where in other sectors cameras and computers sets alone in stand-by or goes off when they are not used, lighting in corridors and public toilets are equipped with presence sensors, hotels rooms offers a general switch at the entrance door connected with the keys in order to ensure an easy and complete switching off when going out etc, it seems that most of the domestic lightings did not evolve a lot from the time the electricity was introduced in the homes. Lighting as products varies in thousands of sophisticated designs but lighting as systems in the home is still more or less based on entrance switch commanding a central light hanging in the middle of the ceiling and a series of plugged stand alone lighting with their single switch. More precisely, lights are designed as single objects and as a decorative system for the home. Nearly no reflection is spent to make it an efficient system supporting rational use of energy within the household. The different waves of domotic did not brought any convincing applications in this field because they were driven
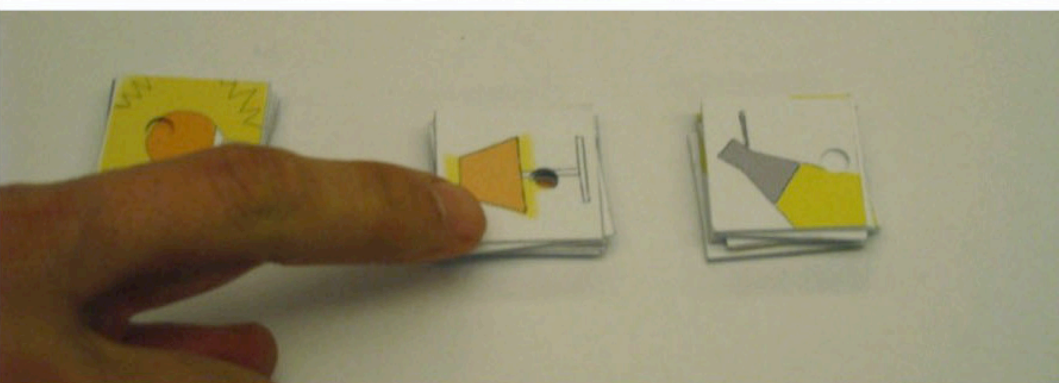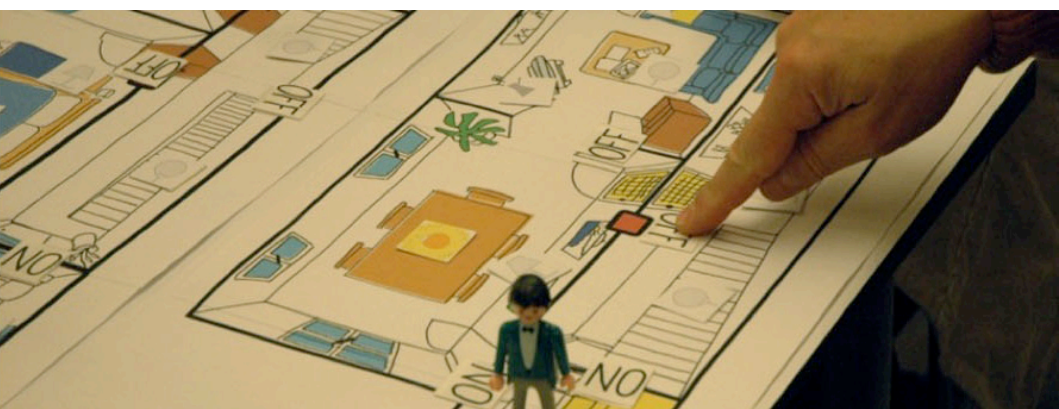
essentially by technology push and did not took really users concerns into consideration. Parents are still running after their kids to teach them to switch off the lights and reduction of energy waste is based on the compliance of all the family.

For the lighting topic, the design exercises were then focussed on the exploration of the lighting system starting from the user point of view. We will go ahead presenting 2 examples in that direction.

The first design exercise is a type of exploration: the aim is to investigate a domestic function with new eyes and trying as much as possible to get rid of the current

A single house is proposed to the 2 participating families in the form of a top view of the 3 floors. The family living there is represented by 4 figurines in scale (a mother, a father and 2 kids) and furniture is already in the space but not the lights. Small cards with drawing of ambient lights, spotlights and main lights are proposed. The 2 families discuss where to put them. The purpose of this starting phase is both to familiarize with the space and place the 2 families in a posture of negotiation: they are aiming at designing new products for a market and not for their respective use only. The interaction forces them to compromise, to forget what is too specific in the attitudes or expectations and focus possible agreements. A clock is set to the hour when the family gets up and task is to 'live' one full day switching on and off the lights when necessary. For that 'magic switches' are provided: they allow to control any lights from anywhere and the scope of the game is to reduce the number of lights used and the duration for which they are left on all day long. The protagonists are free from locations, connections and setting of the switches. They just focus on tracking useless lights and using their magical switch to invent fluid ways to do it. A zenithal camera records their movements and decisions as well as the content of their exchanges and argumentation.

The second example of design exercise is a kind of performance: it starts from a given strategy engaging in new energy-saving practices, and the aim is to explore both its efficiency and its attractiveness for the users.

◀ 'exploration' type design exercise aiming at investigating atypical sequences of use in the interactions between switch and lights.
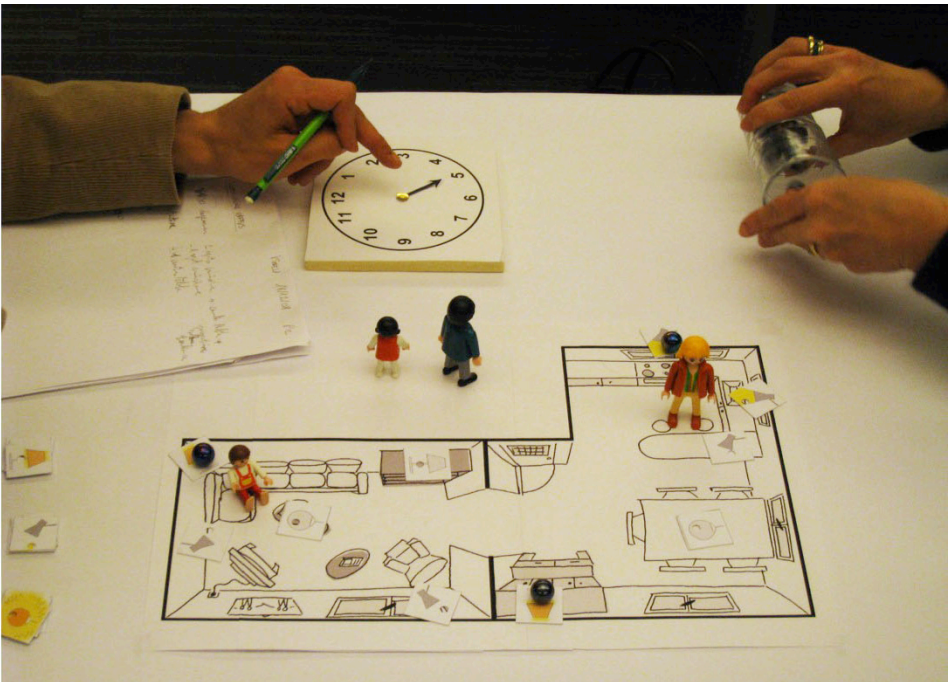
The promising concept was to question the basic setting of relationship between switches and lights: one switch command one light or sometimes more lights but there is no relationship between the different lights. Technically electric circuits are organised in 'parallel' or in 'series' but not in 'networks'. One lamp does not influence another: 2 lights can be perfectly left on one close to the other while only one is useful. A user can switch on a light in more rooms whereas s/he can be only in one at a time... To tease this situation, we imagine another principle: a switch could be a device to pass the energy from one light to another. The 2 participating families were provided with a top view of a large living room and the same setting starting phase of the previous exercise: a family in figurines and a series of cards with different types of lighting to install. They receive also a glass with small balls representing quantities of energy: to switch on a light, they just need to put a ball on it. To switch another light (if they move in the space along the day) they had 2 possibilities: either they add one more energy ball or they just move one from one light to another. The setting of the interaction shows explicitly the quantity of energy they use at the same time and passing the energy from one lamp to another is easier than picking another energy ball at the bottom of the glass. The final purpose of this somewhat strange setting was to observe the potentials and barriers of switches that facilitate the passage of energy within a network of lights all along daily living activities.

The results of both exercises are real design activities, not in the sense of shaping the external form factors of a product but of tracking emergence of new scenarios of interaction between users and products. They go much beyond classical testing of products on the one hand but on the other hand, users are not designing products alone: it is more a matter of collaboration between professional of innovation (the design team) and professional of usage (the families), both keeping their particular interests and bringing their respective skills to the definition of new propositions.

◀ 'Performance' type design exercise aiming at 'stretching' potentially promising strategies in rational use of energy over daily living activities.

2 Translating sufficiency into design guidelines to engender new practices

For each of the 4 categories of domestic appliances focused by the ISEU project an original interpretation of the current situation emerged from the early investigations with the families, showing why according to them the current appliances proposed on the market were not facilitating energy-saving practices or, worst, were favouring energy overconsumption. For each category of equipment, a new design attitude has been identified between the users and the design teams that brought, on the one hand, to a series of emblematic concepts of new products and, on the other hand, to four design guidelines to favour energy-saving behaviours with a general value going beyond the product category they emerged from. For each product category, the sufficiency principle has been translated into more concrete principles.

- **"Subtractive principle and lighting environment"** allows imagination of new light switches and light distribution in the living environment to minimise the number of lights on;

- **"Semi-manual interface principle and thermal regulation"** reduces user cognitive overload in the fine thermal regulation following movements of people in the home while facilitating users manual regulation;

- **"Resetting default principle and clothing care"** allows to prompt low energy-intensive washing processes and to push evolution of users habits;

- **"Eco-conscious artefacts and smart energy meters"** facilitates interaction of users with energy metering enabling them to streamline household practices.

We will develop here more in depth the first principle and the resulting products going ahead with the case on lighting. Compact fluorescent lamps have been observed to lead to rebound effects: letting the hall lamp on all night long, putting new lights in

removed areas, ... (Verbeek & Slob 2006). Furthermore, the home lighting system (lights, switches,...) promotes the ever-increasing use of lamps. It is easier to light a new lamp after each move, a new activity in the housing, than to replace it with another. Adding one more light requires one action while substitution implies two actions (switching off and switching on), and requires often going from one switch to another. It also implies additional cognitive load for the user because s/he has to identify which lamp has to be switched off before switching on another lamp. It requires to select which of a multiple switch on the wall should be operated in order to avoid switching all at ones and arriving at the end of each evening with all lights on in particular in living rooms and shard spaces.

For these reasons, we have explored what we called the 'subtractive principle': systems should be designed that encourage or maintain energy consumption at its lowest level, that facilitate the reset lighting, that substitute a light source for another, and encourage the symbolic lighting of spaces.

2.1   Moving the energy between the lights.

The basic design principle of a switch should be the substitution and not the addition: if I switch on a light then probably I should switch off another one to ensure energy saving; if I am here I am not elsewhere; if I switch on the central main light of the room then leaving ambient lights on has no sense anymore; if I light on the working place in the kitchen then I don't need the living room spot light for reading...

A switch must be designed and configured to suggest turning off a lamp at the same time to turn on another. The idea is to 'move' literally the energy of a bright point to another and keeping a minimum of luminaries lit despite the evolution of the household activities. The switch is dedicated to a sub-group of luminaries identified as being rarely used together. It works primarily as a 'toggle' between two or more lamps, allowing also the simultaneous switching on but above all promoting the subtractive principle.
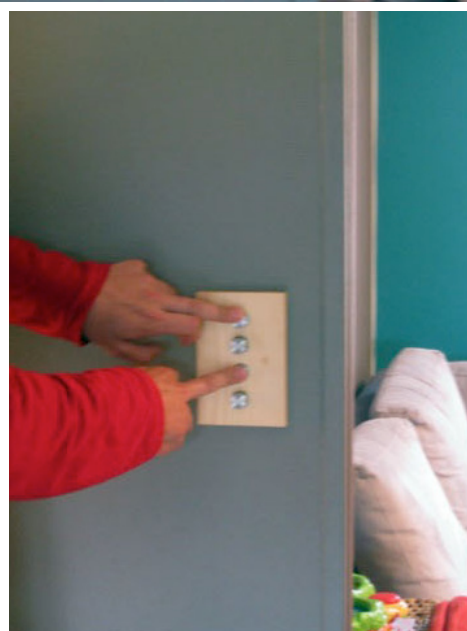
2.2   Resetting the lights.

Another approach to the management of the too easy addition of lighting is to switch to 'reset': a switch for the whole home or for each floor of a household would switch off all lights at once. This system is often present at the entrance of the hotel rooms. However, this switch should not be allowed to switch on everything that was off: it must function as 'reset' for each lamp, as if they had been switched off individually. Coming back home or changing from floor, the user is in the position of switching on only what so he think useful reducing then the overall consumption.
The subtractive principle can also be applied automatically and the reset can be triggered by a presence detector or rather by a 'detector of absence': it is not in fact switching on the lights that requires support. Except when carrying bulky things, the gesture of switching on the light when entering a room has become an integrated habits for the user (and it is often more reliable and precise than any movement detectors). But turning off lights in rooms where there has been nobody for a few minutes could save energy. Thus we can consider that, in the transition or working zones, lights would be switched off (gradually to avoid surprising users with sudden darkness) and 'subtract' as much as possible useless lamps.

2.3   Flagging the space with lights...

To 'be' in room in the evening, in the living room or between the kitchen and the dining room implies that the light is on. More precisely, 'lighting' a large space as a living room has a symbolic meaning of occupying the space even if one stays at only one place at the time. Lighting materialises the planned activities: I prepare the breakfast in the morning and I switch on the light in the dining room even if I don't need it because I am still working in the kitchen for 10 minutes. Preparing the breakfast means preparing

◀ MOVING THE ENERGY BETWEEN THE LIGHTS_ Stéphane J. is presenting the mural multiple switch that works with 'radio' buttons: pushing one on release the other off. When Stéphane switch on the living room, the light in the corridor switch off automatically. If he really wants to keep both on, he needs to push on both buttons at the same time. This slightly counter ergonomic setting makes it easier to substitute rather than to add a light inducing more energy saving when lighting the house.
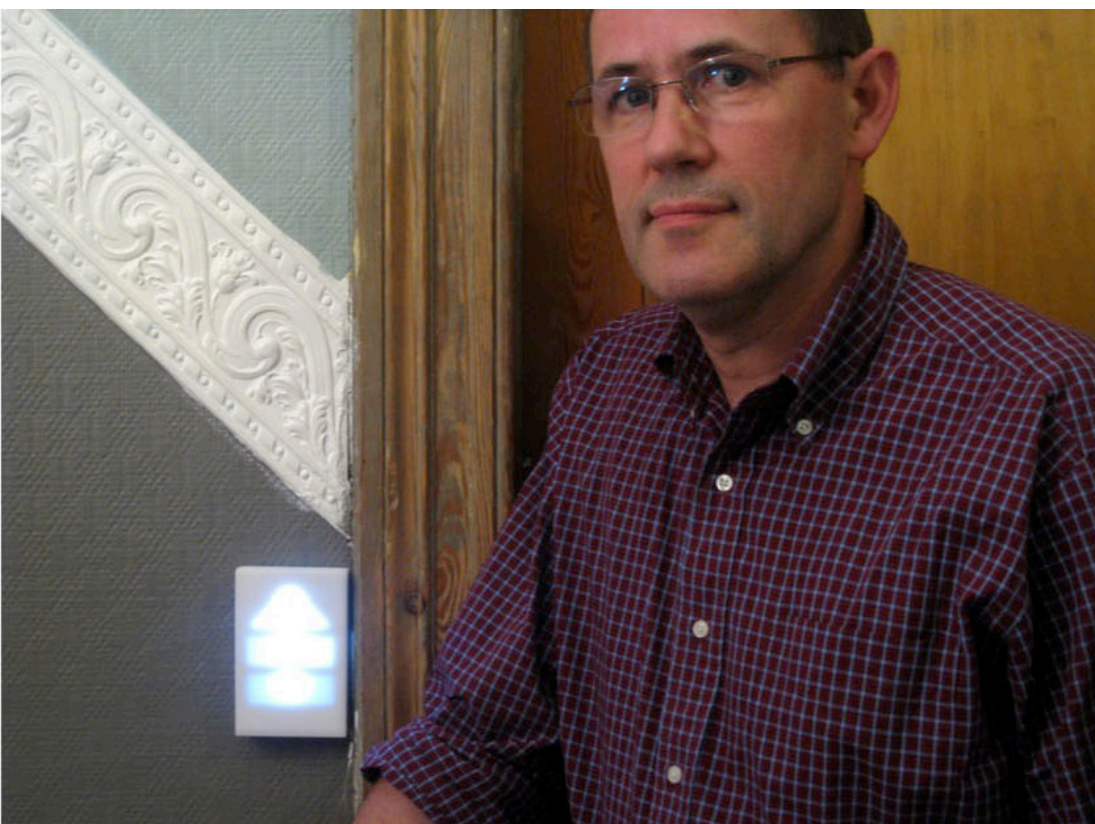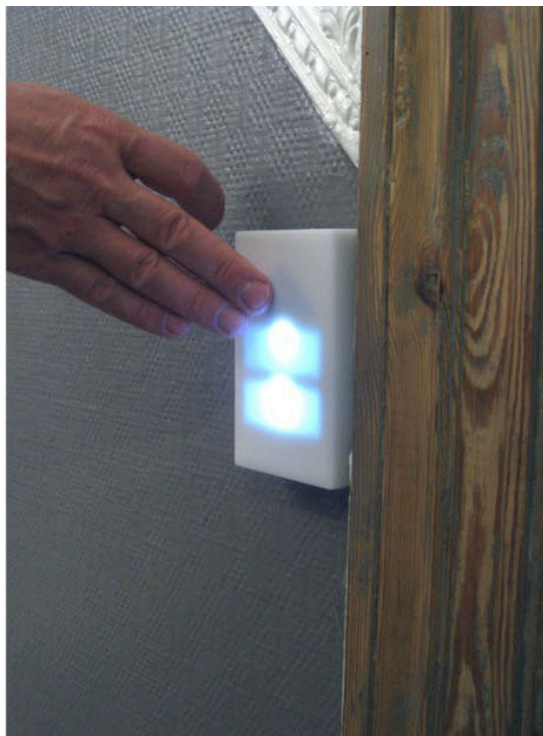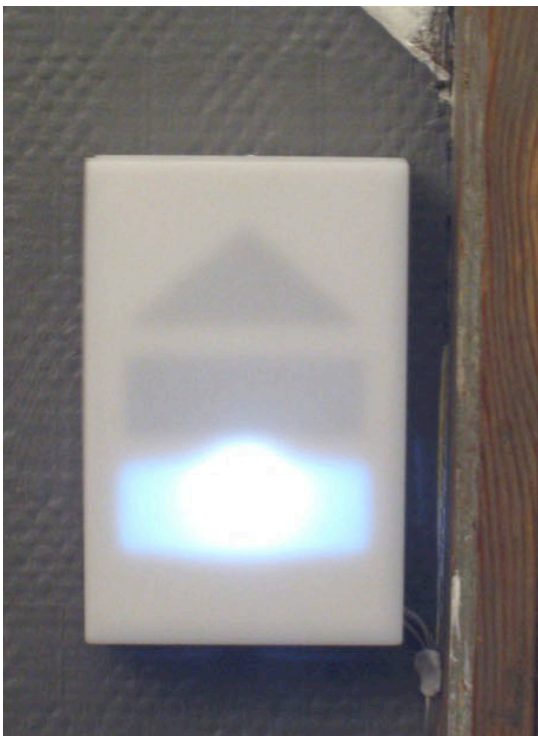
a friendly and welcoming space for the family as much as toasting the bread. In contrast, leaving a space in the dark means that it is not occupied: switching off the kitchen signifies that the meal is over, it is not time anymore for eating and the family leave the living room for different activities.

The lights are then more or less equipped to mark the occupied area. In particular, in large living spaces with often open and communicating rooms, more and different lights are used. A mix of spotlights and ambient lights allow to 'flag' the space or as decorators would say, light modulates space. This practice is often expensive even when lighting points are equipped with energy saving light bulbs. The subtractive principle implies to design 'diffuse lighting' consisting of several bright spots of very low intensity but distributed to mark the space: a picture of this concept could be found today in the use of candles, which illuminate little but marks the occupancy of a space.

◀ RESETTING THE LIGHTS_Olivier M. installs the general switch he contributes to design between the stairs and the living room. The switch indicates when lights are on at each of the 3 floors of his house. When he goes out or when the family comes down for the dinner, its very easy even for the less compliant people to switch off. The switch is a switch-off only device: it resets all lights and eventual other devices to off and it's up to the user to decide light by light which one they want to switch on again.

3. Conclusion: users as experimenters

The conclusions of the specific co-design sessions within the ISEU research project gave rise to 2 levels of benefits:
- the user-centred approach starting from household activities generated very interesting results without any technological improvement of the eco-efficiency of the domestic appliances: only resetting usage patterns by a redesign of existing components 'from the shelf' shows promising propositions in streamlining energy consumption practices of households;
- the very process of the co-design sessions, the progressive training of the families, their involvement in the design of their own future environment brought us to consider all the interaction process and the material developed to be used during the sessions between users and designers as a sort of training toolkit to question people domestic practices, to take a distance from them and enable the families to re-invent progressively their daily ways of living.
Beyond concrete propositions for new energy-saving practices, our research has also shown interesting lessons we can learn from the interaction with households.
Our ethnographic approach has revealed that households are much more creative in the way they save energy than the usual representations conveyed by the "rational use of energy" flyers for instance. All the process, particularly the collaborative sessions, shows how much our current lighting systems are often unadapted. When users are given the possibility to imagine other ways of lighting, with a sufficiency principle, they reveal that our houses have embodied standard lighting systems that do not fit desirable practices anymore.
To observe the willingness of families to play and imagine new devices, we had however to move away from the idea of ready-made products. After the first interview it appeared indeed that the propositions presented as products or services led respondents to a hedonistic situation, like "Would I buy or not?" rather than a change of attitude motivated by a desire to save energy such as: "Is this a good research direction that I can apply?". If there is a reason functioning in this approach, it is not the one of the

rational individual seeking to maximize its welfare within a given budget. The co-design sessions showed that participating families are much more in a playful and explorative situation than a pure economic calculation. Families who were ready to play the game, reveal the current system's constraints when asked to turn to energy-saving practices. Experimental situations are transitory, they always end up in final results, in "products". But the process itself is as well interesting as the result. We think that transition towards a sustainable society will require much more transitory experimental situations.

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