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Transversal Actions

FINAL REPORT

"INTEGRATION OF STANDARDS, ECODESIGN AND USERS IN ENERGY-USING PRODUCTS"

«ISEU»

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Promoters

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Acronyms and abbreviations

ANEC: European Association for the Co-ordination of Consumer Representation in Standardisation
ANT: actor-network theory
BAT: best available technology
CECED: European Committee of Domestic Equipment Manufacturers
CEN: European Committee for Standardisation
CFL: Compact Fluorescent Lamp
CPU: Central Processing Unit
ECOS: European Environmental Citizens' Organisation for Standardisation
EEI: energy efficiency index
EHD: Environmental Helpdesk (of the CEN)
EuP: Energy-using Product / Energy-using Practice
GHG: greenhouse gases
ICT: Information and communication Technology
IPCC: Intergovernmental Panel on Climate Change
ISO: International Organisation for Standardisation
LCA: Life cycle analysis
LED: Light Emitting Diode
MEEuP: Methodology study for ecodesign of energy-using products
NGO: non governmental organisation
RoHS: Restriction of the use of certain Hazardous Substances in electrical and electronic equipment
SABE: Strategic Advisory Body on Environment (of the CEN)
STS: science and technology studies
TOE: tonne of oil equivalent
WEEE: waste electrical and electronic equipment

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SUMMARY

A. Context

Appliances and, more broadly, energy-using products have totally changed our lives in less than a century. However, these modern marvels convey too often an image of lightness and of lack of economic and environmental costs, as their consumption of energy (e.g. electricity, fuel coal or gas) is not directly related to practices. Public policies are increasingly encouraging the production of more efficient energy-using products. The energy efficiency of appliances is seen as a step for reducing the energy consumption of households. There are good arguments for the increase of energy efficiency of products and appliances: energy independence, energy cost and climate change. According to different models, improvements in energy efficiency since the 1970s have contributed more to our economic prosperity than traditional sources of energy supply. Energy efficiency is for this reason sometimes called "negawatt", the biggest energy source. Potential of energy efficiency improvements is still huge, but there are also doubts that it will be enough to face the major problems linked to energy consumption, as the case of appliances show.

Consumption of energy in households can be divided into the following sectors: space heating, water heating, lighting, cooking and appliances. In terms of energy consumption, space heating uses the most (53% in 2005), followed by appliances (21%) in OECD countries. But in terms of CO_2 emissions, appliances will soon catch up with residential heating. This is due to the low conversion factor from fossil energy to electricity and the steady increase of appliances in households. In OECD countries, the electricity use in appliances grew by 57% between 1990 and 2004, despite energy savings from improvements in energy efficiency. The energy share of larger appliances (refrigerators, freezers, washing machines, dishwashers and televisions) is currently about 50%. However, this share is declining as the most rapid increase in appliance energy consumption comes from increased ownership of a wide range of mostly small appliances such as computers, mobile phones, personal audio equipment and other home electronics. Standby power accounts for around 10% of residential electricity demand. In some countries, air conditioning is also a key factor. Despite the decrease of the average unit energy consumption of big appliances put on the market (apart from televisions) their total energy consumption has increased since 1990, as households possess and use more of these appliances. For televisions, energy efficiency gains have been undermined by the consumer trend towards wide screens, which use more energy. In OCDE countries, the demand for big appliances is almost saturated. However this is not the case in other countries, where increase of energy consumption for appliances and products is expected.

According to life cycle analysis, energy-using products consume much more energy when used than when manufactured — even in the case of computers, which require many resources during the production phase. It is then important that households are aware that the use of appliances is energy consuming. Most of the countries have developed energy-labelling schemes in order to educate consumers about the most efficient products. Energy labels are progressively improving the appliances market, because producers are encouraged to manufacture more efficient products. When market mechanisms are not sufficient, some countries develop mandatory performance standards, e.g. on lamps and on standby.

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".

B. Framework and objectives

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 (Jackson 2005). Studies from different disciplines (psychology, sociology, economics, …) show that increased demand for energy from households depends on a wide range of mechanisms. Expectations of comfort, cleanliness and convenience have changed radically over the past few generations (Shove 2003). Social norms have evolved quickly, leading to an increase of energy consumption. Homes, offices, domestic appliances and clothes play a crucial role in our lives, but not many of us question exactly how and why we perform so many daily rituals associated with them. There is clear evidence supporting the view that routine consumption is controlled by conceptions of normality and profoundly shaped by cultural and economic forces. Comfort is a need, but also as a social trend that can be adapted.

We are concerned with the interaction between householders and objects that are associated to direct energy consumption. Thus, the focus of our research is the use of energy-using objects within homes, and especially how are working interfaces between these objects and their users: how usages are shaped by appliances, how objects are appropriated. Our main hypothesis states that the necessary change of culture of energy could be brought by objects and, in particular, through the object/user interfaces. Objectives of the research project are of three kinds: theoretical, practical

recommendations and empowerment of the partners who are of different kinds (academic, advice agency, consumer organisation).

After having analysed the ecodesign directive implementation, we have started different experiments with households: collaborative design sessions with users, use of smart meters by households. Focus groups about the idea of energy sufficiency have been conducted.

C. Conclusion

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. 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.

The practices related to energy consumption are going to change in a direction that could be contradictory to our current standards of comfort. The mutation of the 'culture of energy' has to be accompanied in order to prevent social disruption and to limit environmental impacts. The transition towards sustainable energy culture will require understanding household practices in order to adapt them to the new context. In this perspective, efficiency and sufficiency approaches should not be seen as conflicting but as complementary. We do not know what will be transformed, or prohibited (e.g. lights). How could practices be transformed without calling to the "good will" of users (through information instruments)?

As our research has shown, the preparatory studies for implementing the 'ecodesign directive' are mainly based on technological considerations. Users are mainly addressed as rational individuals who mobilise information about energy efficiency of appliances (labels), while they are currently described as hedonistic (search for comfort). When left with these two approaches, we fall inevitably in the gap between attitudes and behaviours. Furthermore, the reduction to average usage patterns on which the EuP regulation is based does not allow for experimentations with objects. These approaches cannot take into account the creation of new relationships between an object and its user. Other ways of conceptualizing energy consumption could be brought by the objects themselves, modifying practices. An experimental approach, based on the idea that the desires of the humans are not fixed beforehand and that practices are modified by objects, would better be fitted to accompany the changes in culture of energy. This third approach would be *experimental*, i.e. allowing

redistribution within practices of the relationships between objects and users. The exploration of this experimental strategy — which already exists but is not thematized as such — is the primary recommendation we make.

D. Contribution of the project in a context of scientific support to a sustainable development policy

Consumer organisations, and NGO's in general, are a *weak actor* of the current negotiation space. Although in the perspective of sustainable development they can claim to represent broad common interests (public health, preservation of ecosystems, future generation, cultural diversity, etc.), these organisations are seldom listened when policy has to make a decision. Even when these organisations are in line with the scientists' alarm, notwithstanding the whistle-blowers, the result is a soft and lukewarm compromise, as shown by the climate change negotiations.

In the ISEU project, CRIOC-OIVO (a consumer organisation which takes part to the standardisation bodies) has gained new insights and experiences. The various formal and informal discussions that the team members have had with different stakeholders, both at the Belgian and European levels, have resonated with new decisions, as it was perceptible in the implementation of the ecodesign directive.

Contrary to what is often stated in the debates about smart meters, we have shown that electricity monitors will not help by themselves household to reduce their consumption. Therefore the implementation of 'smart meters' has to be cautiously done.

Beyond all energy efficiency policies, the partners have gained new arguments and insights about the need to adopt complementary sufficiency policies.

E. Keywords

Household energy consumption, design, energy-using products, practice theory, ecodesign directive, standards, efficiency, sufficiency, electricity monitor, learning process, appropriation, experimental strategy.

1. INTRODUCTION AND CONTEXT

Data and trends

The world economy is becoming more energy efficient, but too slowly to stabilize energy consumption (World Bank, 2008: World development indicators). The energy intensity[1] is decreasing in the EU27 countries (yearly average of 0,9 % since 1990). New members countries are doing better (yearly average of 4 % since 1996). As the energy intensity is decreasing slower than the GDP is growing, the result is an increase in the total energy consumption.

In the industrial sector, a decrease of 0,9% has been observed during the period 1993-2004, but only of 0,1% during 2000-2004. These decreases are mainly due to changes in the composition of the industrial structure. In France and Germany one third of the decrease in energy intensity can be explained by the change in the mix of production (more industries with high gross value added and low energy consumption, as pharmaceutics). There is therefore a partial externalisation of the embedded energy between developed countries (from EU15 to east European countries) and from developed to emerging economies.

In the transport sector (32% of final energy consumption in 2004 vs. 29% in 1990), consumption of energy is still increasing but the growth rate of energy consumption in the EU 15 is slowing down (this is not the case for the new members).

The services sector represents 13% of the final energy consumption and is rapidly increasing. Energy intensity of this sector has decreased only in certain countries, as in Belgium between 2000 and 2004.

The household sector represented 26% of final energy consumption in Europe in 2004: 68% of total energy is consumed for heating (72% in 1990), 14% for producing hot water, 14 % for lighting and electrical appliances (11% in 1990). Energy consumption per dwelling has been decreasing since 1990 for EU 15 but increases for Belgium (and it is higher than the average for EU 15). During the period 1990-2004, energy intensity of the household sector has decreased of 1% in the EU 15, but only 0,25% in Belgium. Figure 1 shows the Belgian household energy consumption evolution.

[1] Energy intensitty is the content in energy of the economy: it is calculated as units of energy by GDP.

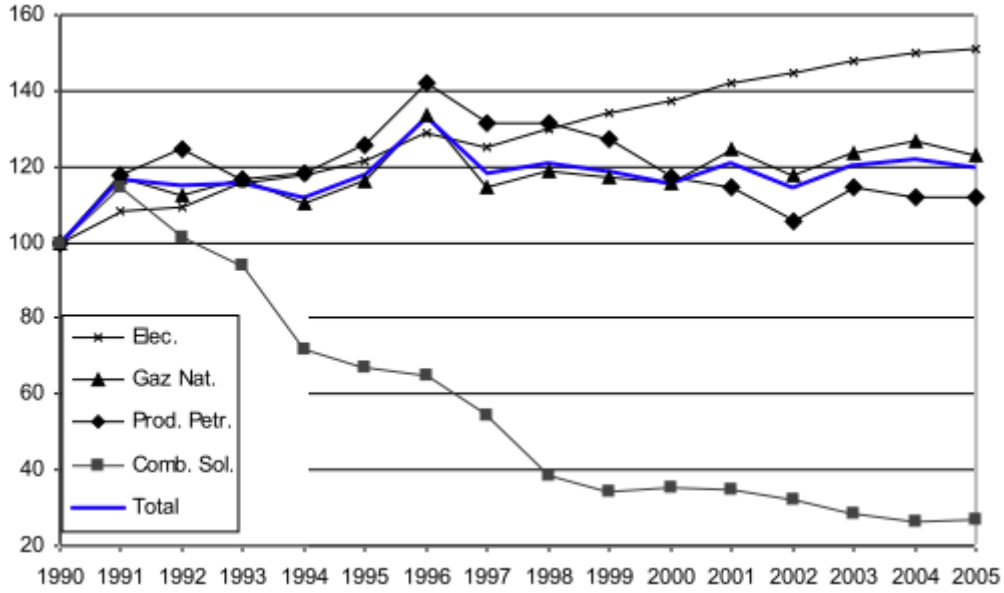

Fig 1. Evolution of the household energy consumption in Belgium, by energy carrier, between 1990 and 2005.

The reduction of energy intensity for heating is balanced by the increase in the average surface of the dwellings (+ 6 m² in the EU 15 in 2004 with respect to 1990). Belgium is the second highest EU country in terms of energy intensity calculated as energy consumption for heating by m².

Energy consumption for electric appliances and lighting varies a lot among European countries (2700 kwh/year by household) and increases constantly (1,5% yearly). The share of energy consumption of "white goods" is decreasing (45% in 2004 vs. 54% in 1990 UE 15). Lighting takes 17% of the electricity consumption, and all the other appliances represent 38%. Energy efficiency of "white goods" in the households has increased of 20% between 1990 and 2004. But energy consumption by household has only decreased of 2%. This is because of the increase of the equipment rate and more frequent uses (indirect rebound effect).

Household electricity consumption is steadily increasing in Europe (increase of 21% between 1990 and 2007 in the EU-27). This increase is explained by several trends: new appliances, households are increasingly equipped, more households. Households own more and more appliances and the share of small appliances in the total electricity consumption is now higher than 50%. As the average household size drops, the number of household rises, and the number of used appliances too.

The share of electricity in the whole household energy budget is increasing, because energy consumption for heating is either stabilising or decreasing. That means that electricity consumption is becoming a more urgent issue.

The use phase is generally the least known among the different phases (i.e. design, extraction, manufacturing, assembly, distribution, use, disposal) which are

analysed in a life cycle analysis (LCA) perspective. The production phase (e.g. from design to assembly and distribution) is now well known and databases exist allowing for a computation of production impacts on the environment. On the contrary, the assessment of the use phase is mostly done on the basis of averaged behaviours collected by different studies, not to mention the numerous "expert assumptions" for data which are still missing. The impact of real consumers behaviour is thus seldom taken into account (or roughly) in LCAs, mostly because it is not yet fully known, or at a very aggregate level which does not allow differences of use to show up. For example, the importance of the use phase is particularly obvious in the case of the management of the heating system, where the settings (or their absence) of the regulating system is one of the key factors of energy consumption in a house. Furthermore the largest impact of an EuP on the environment (through energy consumption) occurs indeed during its use phase, as one can see in the figure 2. Only in the case of computers, the energy consumption in the production phase is quite important (about 1/3 of total energy consumption over life cycle)[2].

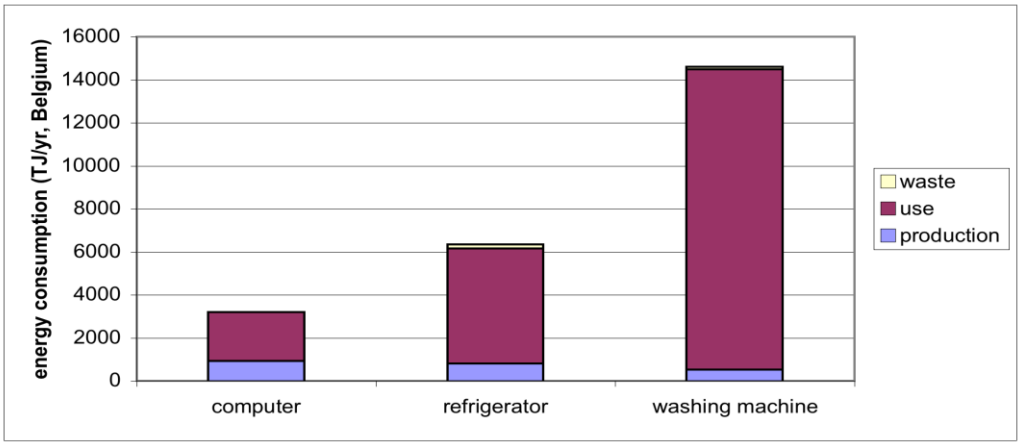

Fig.2. Energy consumption by phase for 3 EuP's.

Scientific and technological problems are also social and political

It is inescapable that sustainability issues tend towards political and philosophical questions. Sustainability concerns humans and their organisation whereas it poses more a problem than a solution. It is much easier to point to unsustainable ways of life than to indicate sustainable ones, at least if sustainable means also equitable and desirable. The problem can be posed as the following: affluent countries have to decrease their ecological footprint. That implies a reduction of the fluxes of matter, including carbon transfer from the ground to the atmosphere.

[2] It should be underlined, however, that the rising use of chips and other electronic devices in all electrical equipment increases the amount of energy required to manufacture the appliances (embodied energy).

Nowadays everybody acknowledges the necessity to reduce energy consumption, for various reasons. Global climate change is at the forefront of preoccupations now, but oil depletion and energy independence are also important issues when arguing for energy consumption reduction. IPCC (2007) and the European Commission (COM 2007) suggest that GHG should be reduced by 60 to 85% by 2050 in Europe[3]. This target will probably not be reached only by improving energy efficiency and by increasing the share of renewable energy sources. Of course these are essential means, but the question of sufficiency, that is the question about what we really need and where to stop our energy requirements, should also be dealt with (Darby 2007). A very typical example is the case of electronic and electrical equipment for households: in a few decades, we have gone from (almost) nothing to central heating, wifi computers, digital TVs and soon all sort of smart appliances which promise to optimise their functioning in the household but which will inevitably consume energy.

A quick analysis of current policy tools mobilised to tackle this issue shows that most of them are based on energy efficiency improvements. Possible consumption policy tools are however much larger as the following categories show (Zaccaï & Bruyer 2006): direct regulatory (e.g. prohibitions, product standards, admission procedures, recycling quota), economic (taxes, incentives, grants), information (labelling, compulsory or not, LCA, feedback), consumer policy (awareness campaigns, education), voluntary (branch agreement, standards), R&D (technological innovation), planning (infrastructures). Household energy consumption cannot however only be reduced by improving energy efficiency. A change in consumption patterns has been often pointed out but insufficiently exposed.

Appliances and, more broadly, energy-using devices convey too often an image of lightness and of lack of economic and environmental costs, as their consumption of energy (electricity) is not directly related to practices. The public policies are calling more and more to the production of more efficient energy-using products, as they are called. The energy efficiency of appliances is seen as the first lift to be used for reducing the energy consumption of households. This stance is also firmly adopted by companies.

As the electricity consumption of households[4] is steadily increasing, the European Commission has decided to tackle this problem, already 15 years ago by energy labelling, and more decisively by issuing a directive on ecodesign of energy-using products in 2005. The analysis of the implementation of this directive is a unique opportunity to understand how appliances are conceived, for this is the moment when a

[3] Recent IPPC documents are still more pessimistic calling for a much greater effort in reducing emissions.

[4] It should be stressed nevertheless that electricity consumption is not the predominant part of households energy budget.

new kind of requirement (i.e. taking into account of environmental impacts) has to be integrated into these appliances, obliging to reconsider them from a new perspective.

We are interested in the "culture of energy"[5], for it allows us to emphasise different points. Of course, the "culture of energy" cannot be separated from other social phenomena, but this term turns the attention to the fact that any society is organised with some expenditure of energy. We see how much this energy consumption shapes our know-how, our social relationships, our desires (Nye, 1998).

The "culture of energy" is going to change. In the current culture, energy is abundant, cheap and invisible ("high energy" culture). In the upcoming culture, energy will be fragile (i.e. intermittent sources, blackouts, etc.), complicated (e.g. by the multiplication of sources and providers), more linked to environmental awareness and more expensive. In the current culture of energy, users are defined as passive and ignorant from the point of view of energy consumption. Discourses about rational use of energy appears then as 'teachers' in face of illiterate pupils. Yet how could people become active? What would be a good practical lesson? Furthermore, we have observed in focus groups that some people are willing to know more about their instant energy consumption, and even to be "educated" by appliances. Could users be really educated by the appliances? User's guides are generally poorly written. In most cases, they are not read by users who would prefer a direct confrontation with the equipment.

The mutation of energy culture has to be accompanied in order to prevent social disruption and to limit environmental impacts. The transition towards a sustainable energy culture will require helping households to adapt to the new context. In this perspective, efficiency and sufficiency approaches should not be seen as conflicting but as complementary. The problem of rebound effects which result from an increase in efficiency can be compensated only by sufficiency strategies (e.g. increasing the price of electricity, or giving absolute figures to standards).

As we do not want to rely solely on a hypothetical technological revolution — that could provide us with cheap and renewable energy — we make the assumption that energy consumption has to be drastically lowered. This research belongs to the "Science for Sustainable Development" programme[6], and "sustainable development" means here that we have the obligation to create ways combining properly efficiency and sufficiency principles. Besides, our sciences are certainly something that has to be developed as well!

[5] Mogens Rüdiger has organised a very interesting conference on the "culture of energy" in February 2006. See Rüdiger (2008).

[6] Belgian Science Policy has funded sustainable development research programmes for almost fifteen years.

The "culture of energy" can also be an analyser of household energy consumption. This way of considering the culture of energy has several dimensions that all have to be taken together: energy-literacy, attitudes (towards the energy consumption), behaviours, equipment. A set of indicators can be developed for each dimension. It is however harder to develop reliable and complete indicators for the material dimension: quantity and quality of possessed equipment (including boilers and all the electrical appliances), the kind and amount of used energy, the envelope, the type and the characteristics of the building. People have generally more difficulties to give this information. It is then no surprise that this dimension of "material culture" is rather unexplored.

Efficient is not sufficient[7]

Energy efficiency has not reduced the global energy consumption of appliances, but has merely slowed it down. Some technologies (e.g. washing machines and dishwashers) seem to have reached their energy efficiency limit. Unless there are technological breakthroughs, energy consumption of appliances will not decrease significantly. Furthermore, different effects and associated consumption should also be considered.

Economic theory suggests four mechanisms that may act by reducing the total energy savings (Greening et al. 2000; Sorrell and Dimitropoulos, 2008). Improved energy efficiency for energy services will reduce the actual price of this service and therefore lead to increased consumption of this service (direct rebound effect). This will tend to offset the reduction of energy consumption by improving efficiency.

While the direct rebound effect for appliances seem to be small, indirect rebound effects are important. The actual reduction of the price of energy service could lead to changes in demand for other goods, services and factors of production which also require energy for their disposal (indirect rebound effects). For example, the cost savings obtained from a central heating system more efficient can be devoted to holiday overseas. While researchers have reported households keeping their old fridge when buying a new one or putting efficient lamps in places previously not lit, this effect seems to represent less than 10% of the energy gained through the increase of efficiency. However the indirect rebound effect is high: the saved energy through improvement of energy efficiency is offset by the increase of the equipment rate and more frequent use. Besides, associated energy consumption of appliances can be considerable, as is the case with computers (energy consumption of internet servers), with washing machines

[7] *Is efficient sufficient?* is the title of a report (Calwell 2010) presented and discussed at a ECEEE meeting in Brussels on the 17th of May 2010.

(the detergent can take up to the half of the total energy of a wash cycle) or with printers (paper).

The third mechanism operates mainly through price adjustments in the markets in terms of supply and energy. A fall in the real price of energy services could reduce the prices of both final and intermediate goods throughout the economy, leading to a series of quantitative adjustments and pricing, promoting the development of growth general economic and energy-sectors in particular (the rebound effect to the overall economic scale).

Transformational effects are a fourth kind of rebound effect. Energy efficiency is brought through new technologies. These changes in technology operate also at the level of consumer's preferences and transform them. Social institutions are also changed: technology trajectories are path-dependent.

Energy efficiency improvements are thus necessary but are not enough, if energy consumption has to be reduced. Efficiency is defined as the rate between output and input or between benefits and costs. Energy efficiency is using less energy to provide the same level of service. This equation is therefore very helpful in comparing devices that provide the *same* service. It is however much more difficult to compare when the service changes. This is the case when technology takes over an old practice - washing machine vs. hand washing, or computer vs. typewriter – to save time: the new appliance provides new services that have to be taken into account. The notion of service itself depends on the description: if the service is entertainment, high or low energy intensity devices can provide it. Energy efficiency is supposed to be purely technological and discards any 'behavioural interference'. An improvement in efficiency corresponds to a reduction in the amount of energy consumed for a given result without changing human behaviour. By contrast, when there is reduction of energy consumption by changing human behaviour, we are talking about conservation. Energy conservation is broader than energy efficiency in that it encompasses energy efficiency and using less energy to achieve a given energy service, for example through behavioural change.

Energy efficiency focuses on the equipment, and leads to policies dealing with the acquisition of new appliances. But these measures will increase their benefits during a whole cycle of stock replacement, which will take between 10 to 20 years for big appliances. And during this time the demand for more consuming products will grow, illustrated by the increase of wide screens and the ever-growing capacity of computers. From the point of view of green consumption, it should be considered whether or not limits should be set on the growing demand for energy. Many want stronger energy policies and programs, in order to implement the necessary mix of market- and regulatory-based instruments, including stringent norms and standards (Calwell 2010). Appealing to the global warming threat and the energy security concerns, policy makers

have been asked to consider devoting more attention to influencing lifestyles and behaviours, and now to transform practices (Wilhite 2000).

An emerging social norm

Expectations of comfort, cleanliness, convenience and communication have changed radically over the past few generations (Shove 2003,Røpke 2009). Social norms have evolved quickly, leading to an increase of energy consumption. Homes, offices, domestic appliances and clothes play a crucial role in our lives, but not many of us question exactly how and why we perform so many daily rituals associated with them. There is clear evidence supporting the view that routine consumption is controlled by conceptions of normality and profoundly shaped by cultural and economic forces. Comfort is a need, but also as a social trend that can be adapted. When considering finite energy resources, the case of appliances show the need to make efficiency and sufficiency strategies complementary. Sufficiency is not abstinence or lack of the necessities. As efficiency, it is the intelligent use of limited resources.

Rationalities of energy consumption are diverse and distributed through household activities, but these rationalities held by householders are seldom studied. On another hand, the analysis of energy-using products often neglect the use phase and makes computation from a collection of heterogeneous data. If EuPs[8] are black boxes for users, users practices are black boxes for manufacturers. These practices are to be understood not only in relation to the appliances, but also in relation to the functions that these appliances fulfil, if one wants to grasp users' roles.

Energy saving is an emerging social norm as it can be seen from different surveys but also from resistances to the new imperative (Brugidou & Moine 2010). Social norms are particularly visible when they provide the possibility of stigmatisation or even conflict. Consumers are invited to reduce their energy consumption, to be efficient, to invest properly, to change their behaviours. The new standard enables them to compare their own behaviours with others' ones. On another hand we observe (e.g. in focus groups) multiple resistances to the emerging norm: people do not want to be culpable, they argue that it is not only a question of individual will and that they have many good reasons to "consume energy".

How is emerging the new social norm of sufficiency? What does this norm mean from a materiality point of view? Comfort is certainly linked to materiality. Routines and habits are difficult to change. They however change every time a new object is

[8] EuP is an "official" term for designating Energy-using Product. We are not only interested in the production, however, but also in the consumption, the user's side. Energy-using Practices (with plural) is sometimes more appropriated to the object of inquiry. We therefore use EuP in this double sense, depending on the context

introduced. What are the dynamics of change and appropriation for the different objects?

Practice theory and the material turn

Although a 'material turn' has been observed in different social sciences, the realm of energy consumption studies remains generally focussed either on individual minds and action or on social structures. The materiality of energy consumption is generally analysed through figures given by engineers and economists. These numbers can represent either individuals (rational choice theory, closed systems and measured fluxes), that obey to the addition rule of arithmetic, or aggregated sums of these individuals (averages, social structures). The rational choice theory assumes that well informed individual optimise their interests, and is at the basis of mainstream economics that pervades current policies. The pitfalls of this theory are well known, and are particularly obvious where energy consumption is involved. People do not generally have a clear idea of what energy is, and are not so concerned by their bills.[9] The explanation is simple: people do not consume energy (Wilhite et al. 1996).

Although energy is consumed through material devices, people rarely see themselves as energy consumers. The different appliances, integrated in daily practices, provide useful services, and the word 'energy' comes about only with the (monthly or yearly) bill. Daily practices are routinised activities, embedded in stabilised technology and infrastructure. The action of energy consumption and its decision have been delegated mostly to objects (thermostats, programmes, and all the true marvels of electricity). Therefore it seems obvious to analyse energy consumption *also* through its materiality.

After different 'turns' (Rorty 1980), hermeneutic, linguistic, structuralist, cultural, a material turn has arisen in different disciplines: in STS or social studies of science (Collins 1974, Latour & Woolgar 1979), in ecological economics (Røpke 2001), in geography (Bakker & Bridge 2006, Braun 2008). And materiality has been essential for long in ethnography, history, archaeology, paleontology, to name a few. Scientific instruments, networks of practices, material flows, megatons and nanogrammes (Sachs 1999), electrical appliances, with all the engendered pollution, are all part of our modern culture. This culture certainly will leave long-lasting traces on the history of the planet. The sustainability issue concerns the range and intensity of the traces humanity can have on the ecosystems. Therefore the study of the "energy cultures", including the material aspects, seems a relevant goal in order to imagine new policies that would address seriously the sustainable development.

[9] This is only a generality, namely an average, since the issue of fuel poverty is not fixed and is even expected to increase (Boardman 2009).

When energy consumption is mentioned, *practice theory* is the approach that embraces most materiality. A material dimension is always included in the versions of practice theory that analyse consumption processes. Although materiality is not present in Schatzki (1996), Reckwitz (2002) and Schatzki et al. (2002) mention things, technologies, products. The interest of practice theory is not to eliminate the previous turns, but to integrate them in a common framework: meanings, language, procedures, bodies, materials, are all important features of our daily activities. A common general idea to the different mentioned approaches of the 'material turn' is the need to unpack the nature-culture divide: technology and society form a common web. Individuals in interaction are human and non-human, animate and inanimate. In concrete situations we always have to cope with human and non-human beings.

A key concept of practice theory is *heterogeneity*. Structures, situations, events, actions are all made of heterogeneous elements, irreducibly. However, these elements can coexist and even coordinate themselves to produce nice and smart actions. Shove & Pantzar (2005) have described a practice approach based on three dimensions: stuff, images and skills. If one wants to think about a practice, a routinised behaviour, we have to think to at least three elements: What are the things and infrastructure involved? What is the meaning of the performed action for the practitioner? What are the competences required? These three dimensions are a minimum. For instance, Warde (2005) distinguishes competence between understanding and rules. And Gram-Hanssen (2008) discerns five dimensions in dividing competences into practical intelligibility, practical understanding and rules. The importance of these approaches is to always bear in mind the irreducible heterogeneity of the dimensions.

Other key concepts of practice approaches are *relation* and *emergence*. Heterogeneous elements are tied in practices. A practice is a regular association of similar heterogeneous elements. The pattern of relations that constitutes a practice is made of body, meanings, procedures, things, etc. If behaviour is defined as the "observable action" (Cooremans 2009), the behaviour *emerges* from this set of relations (Shove & Walker 2007). Behaviour does not exist in the separate elements, but is the result of the linkage of these elements.

In our research we are interested in practices where household energy consumption is clearly involved. These practices are characterised by the presence in homes of an 'energy-using object', even though any household practice involves energy (bodily or embedded). In linking standards, users and ecodesign, we aim at exploring new ways of understanding and acting on the current issue of energy consumption.

Research questions and assumptions

The aim of the ISEU project has been to better understand household energy consumption in studying the relationships between users and EuPs. How far is it

possible to change behaviours through objects and design? This question is posed at both theoretical and experimental levels. We explore the hypothesis that cultural changes can (partly) be brought forth through objects.

Objectives of the research project are of three kinds: theoretical, practical recommendations and empowerment of the partners. The main objectives and expected outcomes were the following:

- to analyse the 'material culture' of energy of households, relying on qualitative methodology and micro-experiments with objects;
- to understand how much households are ready to change their energy consumption practices, and how they could be helped by new objects or interfaces;
- to contribute to the theoretical development of Science & Technology Studies (STS) in bringing elements necessary for integrating uses and users in this field;
- to evaluate the way the ecodesign directive is implemented, and what is its real ability to transform appliances;
- to analyse how users are explicitly or implicitly represented by manufacturers when they come to develop new products, by public authorities when they design energy reduction policies, and by NGOs when they speak in the name of consumers. This is achieved through interviews and the examination of diverse documents (as directives and handbooks);
- to make recommendations about the implementation of environmental standards, or to suggest new environmental standards;
- to make original propositions of user/appliance interfaces, validated through different conferences where different stakeholders will confront their points of view;
- to empower the consumers' representatives in standardisation committees;
- to experiment new ways of auditing the energy consumption of households;
- to suggest ways of communicating to householders energy consumption reduction issues;

2. A DIVERSITY OF METHODOLOGIES

We are concerned with the interaction between householders and objects that are associated to direct energy consumption. Thus, the focus of our research is the use of energy-using objects within homes, and especially how are working interfaces between these objects and their users: how uses are shaped by appliances, how objects are appropriated. Our main hypothesis states that the necessary change of culture of energy could be brought by objects and, in particular, through the object/user interfaces. The way people get in relation with energy consumption is indeed modified and induced by the appliances themselves. How could EuP interfaces enhance all the dimensions of the culture of energy? If the "culture of energy" goes through the uses and objects, could objects embody the seeds of a relation between energy and users? How are the uses embodied into objects in this regard, and what are the links with the environment?

To answer to these questions, we have gathered and analysed a wide range of data: quantitative and qualitative surveys of household energy consumption, analysis of the implementation of the ecodesign directive, interviews with different actors (designers, manufacturers, NGOs, households), analysis of consumer's magazines, attendance and participation to different 'stakeholders meetings', three focus groups, co-design sessions of new interfaces, micro-experiments with 'smart meters'.

We aim at developing a more experimental methodology, less based on (often) fictive measures, on more on what households are doing when at the same time they consume energy. The relation between households' practices, their energy consumption and climate change awareness is never clear from the point of view of practices. The issue is better termed as 'practices in transition' than 'behaviour change'. How can we make practices evolving towards thrifty and thriving life patterns?

This part presents the main results of our analysis of five case studies. We have indeed selected five product categories to make in-depth social and technical analysis: domestic lighting, the regulation of heating, personal computers, washing machines and smart meters. These objects offer indeed a large variety of household equipment rate, potential energy reduction, variables accessible to the users both at the buying act and at the use phase, possible substitution, existence of environmental standards, rationales of use and the existence of trade-off in the design and the use phase. We however explain first the original way we developed in order to maintain coherence throughout the whole project.

Original methodology for implementing the research questions

The network is compounded of three partners who have distinct profiles, objectives and methodologies:

- The CEDD (Centre for Studies on Sustainable Development) is a unit of the Free University of Brussels and carries out academic and multidisciplinary research related to environmental policies and strategies within the general frame of sustainable development. It has developed high expertise in sustainable consumption analysis. The Centre is used to work in partnerships and to coordinate research network.
- The ICEDD (Institute of Advice and Studies on Sustainable Development) is a non profit organisation providing advice, consulting services and research for public authorities and for community groups on sustainable development issues. ICEDD activities involve prospective studies where analysis of solutions towards sustainable development are studied, as well as development of monitoring and control tools (e.g. data bases, energy audits), promotion activities and expertise missions.
- The CRIOC-OIVO (Research and Information Centre for the Consumer Organizations) is a Public utility foundation, managed by consumers organizations, that realises multidisciplinary studies on consumer matters, including surveys on consumers attitudes and behaviours related notably to sustainable consumption, health, security of products and services, products prices and incomes. CRIOC participates in the standardization process at various levels.

The diversity of expertise among partners is a richness, but the heterogeneity of traditions and objectives of the partners is a challenge. Since ISEU project is the second research of this network, partners know each other very well. However, while the first project was a rather traditional survey about household energy consumption (using qualitative and quantitative methodologies), this project is far more explorative regarding the research questions and the involved methodologies.

In order to guarantee the coherence of the project and to develop a genuine teamwork, meetings of the network have been organised on a monthly basis. At these meetings the advancement of the work and the repartition of the tasks are discussed, as well as the discussion of hypotheses and of results, and the preparation of common communications and papers. The different tasks are indeed produced conjointly by the partners, and regular adjustments are needed.

But above all, we have developed an original methodology to lay out our research questions. The coordinator has presented a series of questions related to the project and has asked the partners for translating them to their own practices, i.e. for making sense of rather academic questions and transforming them into operational questions to get relevant information. There was then a collective discussion about these 'translations' that allowed to be sure that everybody has grasped and appropriated the research questions. Theoretical questions had to be reformulated as well. This work resulted in a document which was the framework for the 'EuP working documents'. The

idea of translating questions when they go from a domain of practice to another originates from the 'sociology of translation' (Callon, Law, Latour). Translation means, obviously, the displacement of an entity and its conjoint transformation. The questions are the same but renewed by the enrichment of another point of view with another language.

It is not the aim of the project to answer in detail to the numerous questions, but the grid provides a very useful common framework for the research team. We reckon that this exercise of question translation has helped us to cement the different blocks of which the network is made. The STS approach is then here made practical, allowing the work between heterogeneous partners. This methodology is fully part of the empowering aim of the three partners. We think that our strong and coherent interactions have helped us to disseminate interesting results to a wide range of different audiences.

Selection of five case studies

In order to go deeper in the study of conception and use of appliances, we have selected a limited scope of energy-using products. The fact that practices are compartmentalised (Bartiaux 2008) argues for a separate treatment of each EuP category. The result of a long selection process was the following:

- Regulation of heating
- Computers
- Washing machines
- Lighting (domestic)
- Smart meters (with interface for householders)

We have selected these EuPs before knowing which categories would be studied for the ecodesign directive. Our choice is quite fortunate because preparatory studies of these appliances are finished and measures have been taken (or will be this year), with the exception of smart meters that are not in the scope of the directive. We present here quickly how we have proceeded to select these categories. The selection results from different criteria applied on a table that exhibits different kinds of data for each category of household EuPs. Here are the different criteria we used for the selection:

- Estimated potential reduction
- Total energy consumption for Belgium
- Household equipment rate
- User-dependent variable during purchase.
- User-dependent variables in the use phase.
- Possible substitution.
- Technical and market aspects (actual trends / perspectives).

- Localisation of producers (design, producing parts, assembling).
- Different sectors (white appliances, multimedia, indoor climate).
- The question of gender should be present in at least one of the selected categories.
- Some categories should include objects with environmental standards and others without such standards.

In giving three different weights to our criteria, we have obtained the following ranked result:

- heating (global): we will focus just on one element of the heating, i.e. the regulation, which represents the interface between user and system;
- lighting;
- regulation of heating (appears because behaviour is supposed to affect it greatly);
- computers;
- air conditioning: this was rejected for there are very few households that have such an equipment in Belgium (and we are interested in the practices of people). It is also partially redundant with heating regulation (related to indoor climate);
- washing machines or dishwashers: both machines score the same and seem very similar; however the interfaces of washing machines are more complex and diverse; moreover, we have also already gathered knowledge about washing machines in a previous study. For these reasons, we have chosen washing machines.

We have stopped our selection with these four product categories, because they present a wide range of diversity and complexity of practices and interfaces. Lighting and regulation of heating imply both to consider a whole system in an ecodesign perspective: the way natural and artificial lights are arranged, the other parts of the heating system. Computers are very complicated, both technically and socially. Washing machines belong to the 'white goods' category and have very interesting gender aspects.

Besides these reasons, this selection meets the required criteria of category diversity, gender (regulation is more masculine while washing more feminine, computers also give way to different gender roles in its use and maintenance), environmental standards (lighting, computers and washing machines have environmental standards, while regulation of heating seems to lack of such standards).

We have added smart meters to the list, after several discussions, notably with the following-up committee and with the experts who have assessed an interim report of our project. We are interested in smart meters that give instantaneous feedback consumption to householders. Smart meters are developing very fast and they constitute very interesting interfaces for our project.

The framework of research questions has resulted in a table of content for organising the data and information gathered about the four EuP categories. Consequently, five "working documents" have been created. In discussing the first results, it has appeared that each appliance category has peculiar features and can be fruitfully analysed through different concepts. On the one hand, these conceptual questions have been chosen on the basis of the working documents: they provide insights about the specificity of each product category, and the relations we can observe between uses and environmental impacts. Each question translates the problem of moralising through objects (Foucault 1977, Verbeek & Slob 2006). On another hand, the working documents enable a transversal reading since they are constructed on the same table of contents.

Every selected EuP category (heating regulation, washing machines, lighting, computers, smart meters) has been analysed through the realisation of working documents that aim at answering to the initial research questions. These documents have been very useful to focus on original questions, as the (implicit or explicit) representations of users in the preparatory studies for the implementation of the ecodesign directive.

The researchers have also conducted an analysis of the presentation of washing machines and lighting in consumer's magazines.

Contacts with stakeholders through the 'ecodesign directive'

The 2005 "ecodesign directive" of the European commission aims at improving the ecodesign of energy-using products (EuP's) and at increasing their energy efficiency[10]. The analysis of the implementation of this directive is a unique opportunity to understand how appliances are conceived, for this is the moment when a new kind of requirement has to be integrated into these appliances, forcing to reconsider them from a new perspective. In our research, we have taken advantage of the negotiations between different actors (manufacturers, NGO's, European Commission, …), happening in Brussels, to analyse the controversies and the new knowledge produced about some household appliances. Our methodology is based on the sociology of translation in order to follow the transformation of requirements through texts (e.g. Latour 2005), and on the sociology of controversies to understand how the new constraints on EuP's are negotiated (Akrich 2005). We have realised interviews with stakeholders, have attended to stakeholders meetings when possible and have follow a course on "environment and standardisation" at the CEN (European Committee for Standardisation).

Whereas it has been easy to get interviews with NGO's representatives, it proved more difficult with corporation members. Contact with companies representatives and

[10] http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm

informal discussions are possible during breaks at stakeholders' forums and at other conferences, but they decline quickly an invitation when they learn that we work in 'social sciences'. They are more interested in engineer research than social one, although they acknowledge that our problem of energy consumption is also a social issue. We have observed that companies sometimes use surveys as an argument to sell their products. For instance, Yello Strom advertises its "smart meters" through "key findings from several market and customer acceptance tests". Some of the stated claims might be true. But we don't know how these statements have been established. We have insistently asked them to provide us with their methodology, but received no answer. There is no public document in which we might learn about the sample and the questions asked. The case of LCA shows the same kind of asymmetry of information: firms do their own LCA that they are not willing to share. Asymmetry of information is also present in the stakeholders' forums.

Collaborative design with users (co-design sessions)

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 powerless?

Households practices are particularly difficult to analyse. Conflict or controversies in households are not public. Ethnographic methodologies have to be developed in order to understand what is going on in these private spaces. In order to bypass this problem, François Jégou and Joëlle Liberman have organised collaborative design sessions with friendly 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 has fed the ISEU research project, in particular to stimulate qualitative discussions with larger samples of users as well as designers and producers of domestic appliance. All the process and the movies are available at: http://www.sustainable-everyday.net/iseu/.

Focus groups

The organization of focus groups allows the expression of a maximum of different representations and attitudes. Using techniques of association of ideas, spontaneous responses, projective and equipment to comment, the focus group can fully explore the perceptions of participants about the studied dynamics. The focus group allows everyone to express many ideas as possible. We have ensured that the composition of the group meets specific criteria in demographic, socio cultural age, disposable income, household composition to allow an exploration of relevant issues studied.

We also studied the emotional needs that individuals do not express randomly, but according to their personality structure, and this dimension is often crucial in consumer choices, beyond individual choices associated with different sociodemographic profiles. The discussion group also aims at measuring perceptions and expectations of consumers vis-à-vis the reputation of certain information and tools to allow the maximum expression of ideas to use later in a phase conceptualization of information campaigns or in the design of educational tools.

We held 4 focus groups of 8 persons:

- "Normal persons": selected on the basis of their relative attention towards energy consumption.

- "Motivated persons": contacted through Brussels Environment and the Eco-Consommation network. Selected people are already actively engaged in saving energy at home.

- "Low income persons": isolated people have income no more than 1000 euros per month; in couple or with children cannot have income greater than 500 euros per person per month. They have declared that they feel concerned by the environmental problems.

- "Low education persons": all participants have at most a degree in primary education or lower professional or technical degree. They have all declared that they feel concerned by the environmental problems.

Experimenting with smart meters

The introduction on the market of cheap electricity consumption displays allowed the launch of a survey on the use of these "smart" meters. In order to understand how appliances and technology could be better appropriated in the

perspective of more sustainable patterns of energy use, we organised a survey on the use of smart meters in households. For that purpose, we have developed an original protocol for the realisation of the survey of 21 households, which combines through its different steps (described thereafter) the competences of our interdisciplinary team (engineer, psycho-sociologist, economist, philosopher, designer). By installing "real time" meters in households (including low income households), we collected data on energy consumption, material culture (appliances, heating system, etc.), representations of energy, energy-using practices, and the effects induced by the introduction of the meter.

Due to technical constraints the choice was restricted among a few of the meters which are readily available on the market. These meters revealed to be not very user friendly nor technically irreproachable. In fact their precision is not always sufficient and they are often impossible to be installed. Furthermore once installed, we observed that they are not well designed as they provide only figures in kW and kWh or Euros. In order to obtain graphics and analyse the data one needs to download data and install a software which has proven not to be very user friendly. The meters have two main parts: the metering device, placed at the main incoming cable, and the display, which is mobile.

We paid attention to include very different households' profiles in our sample. As Darby (2006) and Fischer (2008) reviews show, studies on energy feedback are usually not clear about which households are recruited. As we wanted to escape from this pitfall, we have paid attention to recruit households through different channels.

We did not arrange a statistical sampling of households (due to a lack of resources), but we paid attention to have different profiles of households:

- households already involved in energy reduction (people working in a sustainable development context for example or having already participated to energy reduction campaign);

- households already aware of their electric consumptions and interested in reducing consumptions for different reasons (not only environmental ones), recruited through a electricity provider newsletter;

- low-income households, recruited through social housing associations (unfortunately only one of these households completed the different phases of the survey, due to cultural and social difficulties);

- households not at all interested in their energy consumption (these are people we selected for the survey but they would have not asked for anything controlling their energy consumption)

At the first step of the survey, an engineer, who presents himself in these terms, installs the measuring equipment, and gives a brief explanation of the monitor to the household. The user manual is left available and householders are invited to play with

the power meter display options. They are also suggested to try to reach a "consumption zero level", i.e. stopping completely to use electricity by switching off all their appliances. Households are also provided with a questionnaire on the possession and use of electrical appliances as well as on other data about the heating system and the home insulation, questionnaire that the household can fill at ease during the weeks of the measures. Households were asked to note the most important facts occurring during the period of the measures (as holidays, parties, etc.). The meter is left in the households for 2 to 4 weeks.

After this period of time, the engineer comes back and downloads the data, displays graphics, decrypts and discusses with the household on their electricity consumption.

After 3 to 6 weeks that the engineer has discussed the consumption data with the household, an in-depth interview was led by a psycho-sociologist. Based on the collected data (consumption + questionnaire on appliances), the researcher stayed around 2 hours within the household in order to discuss the way the household perceives and understands their consumption of energy, and analyse the experience with the monitor (in particular what they have learned and which practices have changed).

3. MAIN RESULTS, PRESENTED THROUGH THREE DESIGN CATEGORIES

Ecodesign, sustainable design, slow design, user-centred design, redesigning lifestyles, … The meaning of design has recently been extended to many different fields (Shove et al. 2007). The interest of the term design is to blur the distinction between structure and behaviour (Latour 2008), as held by practice theory. Mediations can be designed to be seducing, persuasive, or compelling (Verbeek 2005).

In order to present the results of our research, we have defined three different kinds of *design*: appliance design, information design, practice design. These are not mutually excluding categories. For instance practice design can include elements of interface design in order to provide adapted information to users. But these categories are helpful both to understand the evolution of the term design and to relate to different policies. Their gradation is from suggesting design to imposing design, and correspond also to the evolution of policies. We are particularly interested in the role of users and interfaces in each category.

Appliance design is the realm of engineers and of technical standards. Products are seen as embodying conflicts and trade-offs of constraints pertaining to different categories of requirements: technology, economy, ergonomics, social and cultural aspects, health and safety, ecology, ethics. The analysis of the ecodesign directive implementation has shown that the conception of appliances results from the crystallisation of a given power of balance between different interests. In this perspective the material culture of a society expresses what is thought to be important in that society. In a nutshell, our research shows that energy efficiency is emphasised whereas users are not well represented as long as appliance design is considered.

Information design is the realm of psychologists (and economists). The best example arose with the controversy around the redesigning of the energy label. But 'eco-awareness' and public campaigns aim also at 'behaviour change'. In our research we have investigated information design through 'smart meters' distributed to different types of households. These electricity monitors (as we have renamed them) give an instantaneous feedback of the total electricity consumption. They are expected to change household behaviours in associating a practice with a figure (kWh or Euros). The main result of our experiment is that this kind of device works only with householders for whom energy savings is already an installed practice. In focus groups, we have observed that people most interested in energy labels are generally already aware of the energy issue, although the labels may trigger a first interest. More broadly, we conclude that information seeking is a practice in itself and has a meaning only if related to another established practice.

Practice design is the realm of sociologists (and designers), or more precisely of experimenters and constructivists. This approach is especially relevant when new practices are demanded to users, or rather when objects and users have to be co-constructed. Computers and human-machine interactions give notable examples of practice design. Another example is the design of new interfaces aiming at changing practices. Reflections about slowing down activities, sharing resources, infrastructure change, choice editing (and other sufficiency strategies) belong also to this design category. This approach is both very promising and difficult to achieve. We have heard many designers who find that hopes placed in them are too big. Nevertheless many experiments and ideas arise now around this notion of practice design.

Hereunder we summarise the main results of our research according this design categorisation.

3.1 Appliance design

Standards and their translation into objects

A standard is a document defining best practice, established by consensus of all stakeholders (industries, governments, NGO's, consumer organisations...) and approved by a recognized body. This could concern a product, service, management scheme or test. It is intrinsically linked to the development of markets. A standard creates a space of circulation and allows competition within selected agents (those that do not acknowledge the standard are excluded from this space). As the European Commission states: "standards are unseen forces that ensure that things work properly."[11] (COM, 2004) Standards are developed on the basis of voluntary agreement between different parties, but they can turn into legal rule. The EU can refer to a standard when they have regulatory requirements, and even make it compulsory. Even when it does not acquire the force of law, a standard, once it is settled and accepted by a vast majority, becomes very difficult to overlook.

A specific group of standards are the 'harmonized' standards. The Commission issues mandates to the European standardisation bodies to create this type of standards. When a product abides the harmonized standards covering this product it also conform European law and may be sold on the European market and can be marked with the 'CE' mark. Most of today's standards from the European standardisation bodies linked with the environmental performance of a product are "harmonized" test standards. These are used in directives to assess the criteria defined by these directives. Notorious

[11] In the French version, the meaning is even stronger: "Telles des forces invisibles, les normes veillent au bon ordre des choses."

example is the European energy label, mandatory for different product groups. Another example of the involvement of test standards is the EU eco-label.

Standards have an impact on our environment. This is a direct consequence of the fact that they may define a product life cycle and therefore how it is made, used, maintained and treated at the end of its life. Furthermore standards could help to sample, test and analyse products or materials in relation to their environmental behaviour or conditions.

The European Commission realized the importance of the relation between standards and environment (COM 2004). Although environmental goals were already incorporated in the text of the "New Approach" back in 1985, the overall result was very poor. Few standards actually contain specifications aimed to reduce the impact on the environment, and if they contain such definitions it is mainly aimed at reducing health or safety risks[12] and most of the environmental related standards are harmonized test standards in order to measure performance for the energy label.

The European Committee for Standardisation (CEN) took the responsibility to promote the "greening" of norms, through two agencies: SABE and EHD. SABE is the CEN Strategic Advisory Body on Environment and acts as a platform where the sectors and stakeholders address environmental topics. The CEN Environmental Helpdesk (EHD) provides information and support to CEN Technical Committees when addressing environmental issues into European standards. Created in 1999, the EHD was supposed to be actively reviewing standards and submit proposals to the relevant technical committees (TC's). They would also support TC's when needed. In 2005 they changed their strategy due to inefficiency of the former approach. They took on another role by offering education and service to the TC's willing to "green" their standards. This approach was perceived by the social stakeholders as even less effective than the previous approach.[13] Nevertheless these two CEN agencies didn't really reach their goal. Very few standards actually incorporated environmental aspects. Some of the researchers have followed the formation of the CEN.

What is ecodesign?

Ecodesign is the integration of environmental aspects in the design or re-design of products. Ecodesign assumes that the burden of a product bears upon the environment should be considered and reduced at all stages along the product life cycle. These stages include the extraction of the raw materials, the manufacturing of the product, its marketing and distribution, the use and finally, the disposal of a product. The term 'product' includes goods as well as services. Therefore, ecodesign is based upon LCA,

[12] Mandate M/341 – Programming of standardisation work in the field of eco-design of Energy-using Products (EuP), CENELEC, July 2006

[13] Joint ANEC/ECOS position paper on CEN EHD – New strategy, 8 May 2006.

but is larger than the design of goods; it has indeed to consider links between objects and services, for instance energy providers are now required to give an energy service.

Ecodesign needs also to question the product itself, in suggesting for instance the integration of multiple function in one product (multimedia: tv + computer + dvd +…), in order to reduce different consumption (standby, raw material, space, energy, …). This holistic approach is often presented as a solution to the problem of sustainable development (Lewis & Gertsakis, 2001; Abele et al. 2004). However, a problem of theoretical approaches about ecodesign is that they understate the issue of trade-offs between different constraints. For instance, the question of price of suggested materials is rarely indicated.

The main argument in favour of the ecodesign approach is that the design phase or re-design of a product is the stage where the levers are most important to change the environmental profile of a product. As we are interested into interfaces between objects and users, we will analyse how ecodesign can, directly and indirectly, redefined uses as well as objects. We will focus notably on the implicit representations of users and on the system in which the studied function deliver its services.

Description of the Ecodesign directive

The directive 2005/32/EC "establishing a framework for the setting of ecodesign requirements for energy-using products" [14]. (which we call 'ecodesign directive') is a legal text which was proposed by DG Enterprise and Industry and DG Transport and Energy following the merger of two other draft guidelines, and was adopted by the Commission in 2005. It concerns all EuPs, such as electrical and electronic devices or heating equipment, with the notable exception of means of transport for persons or goods. The directive does not introduce directly binding requirements for specific products, but does define conditions and criteria for setting, through subsequent implementing measures, requirements regarding environmentally relevant product characteristics.[15] As we shall see, implementing measures deal mainly with energy efficiency of EuPs.

DG Environment was not involved in the redaction of the directive. Kautto (2007) argues that if DG ENV could have written the directive, it would have used the Article 175 that allows member states to issue stricter requirements for environmental reasons, while it was the Article 95 which was applied, meaning an harmonization of laws. The door was open in the directive: "Although a comprehensive approach to environmental performance is desirable, greenhouse gas mitigation through increased energy efficiency should be considered a priority environmental goal pending the

[14] http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm

[15] Like other 'new approaches' directives, the implementing measures will require legal standards that will have to be produced by legal standardisation bodies.

adoption of a working plan". The question of climate change has prevailed over other consideration, and we can think that an opportunity to develop wholly ecodesign has been missed.

The analysis of the implementation of this directive is a unique opportunity to understand how appliances are conceived, for this is the moment when a new kind of requirement has to be integrated into these appliances, forcing to reconsider them from a new perspective. In our research, we take advantage of the negotiations between different actors (industries, NGO's, European Commission, EU members)[16] to analyse the controversies and the new knowledge produced about some household appliances. We have realised interviews with stakeholders, and have attended to stakeholders meetings when possible.

The implementation process follows six steps[17]:

1) Selection and constitution of 'product categories'. This selection is made for each product category on the basis of the total consumed energy in Europe and on the purported reduction of environmental impacts. Twenty products were initially covered, including boilers, water heaters, computers, televisions, lighting, refrigerators, washing and dish machines, It is not always obvious to divide all the appliances into homogeneous categories, as provided by the example of lighting which is divided into: office, domestic, directional. A list of new product categories to be scrutinized has been added, and includes air-conditioning systems and food-preparing equipment.

2) In order to prepare the implementing measures, the Commission contracts out consultants to produce technical knowledge about each selected product category. These 'preparatory studies for ecodesign requirements of EuP' (abbreviated to 'preparatory studies'), made of hundreds of pages, are available on dedicated websites. Each preparatory study takes 18 to 24 months and involves 'stakeholder meetings' where industry, NGOs and other stakeholders may comment and bring their knowledge. These 'preparatory studies' are supposed to follow a common methodology (MEEuP), and described below. As we shall see, the preparatory studies do not always stick strictly to this methodology.

3) On the basis of the completed preparatory study the 'consultation forum' is gathered. This Forum is composed of experts, stakeholders and representative of Member States. It has to define and review the implementing measures, to monitor the efficiency of the established market surveillance mechanisms and to assess the voluntary agreements and other self-regulatory measures taken in the context of the directive. The Forum is then in charge of providing the first proposal of the implementing measures.

[16] Reintjesand & Jepsen (2008) analyse the stakeholder's participation.
[17] The process can easily be followed on: http://www.eceee.org/Eco_design/products

4) On this basis, the Commission writes a draft regulation. Like other 'new approaches' directives, the implementing measures can require standards and a mandate can thus be given to some European standardisation bodies.

5) This draft is discussed and possibly adopted by the Regulatory Committee, which is composed by one representative of each EU Member State. If the proposal is adopted by the majority of the Committee, it is sent to the European Parliament, according to the codecision process.

6) The regulation is formally adopted when it is published in the Official Journal of the European Union.

At this moment (February 2011), 11 product categories have been submitted to new regulation, including litghting and washing machines.

The ecodesign directive has to be understood as a part of a larger set of directives concerning energy-using products, mainly the Energy Labelling, WEEE and RoHS directives. WEEE and RoHS are concerned with disposal and recycling of hazardous electronic and electrical equipments, including washing machines, computers and other household goods. The ecodesign directive will thus not cover these matters, but has to take into account the existence of these two directives. The labelling directive proposes to label some appliances with energy-labels, showing the energy efficiency of the appliances. As this directive is concerned with energy efficiency, it is close to what is going in the ecodesign directive. In the most recent proposals for implementing measures, concerning the wash appliances, the ecodesign directive is considered as being a "push" of energy efficiency to the market, where the labelling directive is considered as a "pull".[18] The ecodesign directive set a minimum requirement for energy efficiency and alone that would only lead to a concentration of the number of appliances just above this minimum threshold. The labelling directive is supposed to pull the market beyond this threshold, promoting more energy efficient products. The labels have thus to be adapted in regard of the obligations of the ecodesign directive. Let's note that the ecodesign directive has been reviewed and enlarged to "energy-related products" (which includes for instance insulation products) (COM 2009).

LCA in practice: the MEEuP methodology

Each EuP category is analysed according the same "Methodology study for ecodesign of energy-using products" (MEEuP), finalised in 2005 by the consultants VHK, who have a long experience of life cycle analysis. The MEEuP study targets primarily the audience of policy makers, but also the manufacturers of concerned products, who will have to realize the final determined improvement potential. In this second target group,

[18] Document "Ecodesign for Washing machines" on http://ec.europa.eu/energy/efficiency/ecodesign/forum_en.htm

designers are considered the most crucial part of manufacturers. EuP manufacturers are thus not responsible for the environmental impacts of e.g. a steel or aluminium plant, but they are responsible for the choice between these two materials and the optimization of their use. Identifying these two target groups leads to the necessary development of easy and understandable indicators, which is required by the directive. By placing the ecodesign directive in the global framework of integrated product policy, the ecodesign directive also stresses the need to integrate ecodesign throughout the design process, not making it a separate activity, but rather a discipline to be used alongside electronics, aesthetics, materials sciences etc.

The MEEuP methodology determines the structure of each preparatory study according to 8 tasks:

1. Product definition, standards and legislation
2. Economics and market
3. Consumer analysis and local infrastructure[19].
4. Technical analysis of existing products
5. Definition of base case
6. Technical analysis and best available technology (BAT)
7. Improvement potential
8. Policy, impact and sensitivity analyses

While the methodology is based on a life-cycle approach and carries out an inventory of life cycle impacts of products, it is not strictly speaking a LCA, but shows some deviations. Indeed, a LCA would have compared the life cycle inventories of different improvement options in order to evaluate the best one. On the contrary, the MEEuP study chooses to carry out a life cycle inventory of one or more "typical", "average" products through a tool called Ecoreport, and then identifies the best improvement options of this "basecase scenario" through the use of life cycle costing. The reason for using life cycle cost stems for the ecodesign directive, in which the Annex II mentions that "concerning energy consumption in use, the level of energy efficiency or consumption will be set aiming at the life-cycle cost minimum to end-users".

Also, although all environmental impacts are calculated, the decisions are taken mainly based on energy consumption, while leaving out problems such as dangerous substances, waste production etc. There are rationales for choosing energy consumption as a main indicator during both the production and the use phases, for energy consumption is highly correlated to CO2 emissions, acidifying emissions, VOC emissions, etc., indeed most of these emissions stem from the burning of energy sources. However, energy consumption does not give a good indication of

[19] For our case studies, we have particularly scrutinized the task 3.

environmental impacts from the waste phase. Dangerous substances such as lead, cadmium, brominated flame-retardants do not require a large amount of energy for their production, due to their small weight in the product; however, they pose health and environmental problems during the use and disposal phases. Even if the EuP studies mention these problems, they are somewhat left behind the energy consumption issue.

Choosing one indicator (energy consumption) above the others, as well as life cycle cost as an additional indicator, is not compliant with the ISO rules of LCA. However, it is in line with the requirements of the ecodesign directive... One can therefore say that the MEEuP methodology, though based on life cycle approach and life cycle inventories, sets a different frame for the study of energy-using products, mainly centred on energy

The outcome of each preparatory study is a set of options which can be taken to reduce energy use of the equipment, but which gives the least life cycle cost to the consumer. The issue of "least life cycle cost" is an important one for the results of each study, however it is not always obvious how it was calculated. While the cost during the use phase is quite easy to calculate, based on the price of electricity, this is much less obvious for the product price.

Standardization and space of negotiation

The ecodesign directive is conceived under the "new approach" framework. This approach — not so new since it goes back to 1985 — has recourse to 'standard-setting' as a procedure for regulation.[20] Borraz (2007) has analysed the process of normalization at the European and French levels. On both level, normalization is presented as a case for a new kinds of regulation, and redistribution of power amongst different actors. His hypothesis is that the French process of normalization is in the hands of the industrials, whereas the European process is more a process of co-construction, where the Commission has a strong power. Standards can be considered as political instruments. They are the result of a 'balance of power'. The process that leads to their realization can be understood as an attempt to organize political decision on technical concerns in a democratic way. Standards have four major characteristics: 1) stakeholders, 2) scientific data, 3) consensus, 4) voluntary application.

1) The legitimacy of standards comes from a scientific and technical rationality, but also from a democratic rationality. Standards are technical products, but they are negotiated by various actors who are interested in the concerned objects. Since the scope of the standardisation process is no longer restricted to industrial and trade issues, but also covers environmental, consumer end health issues, several organizations arose to defend these interests. The European Union actively supports these organisations to

[20] http://www.newapproach.eu/

achieve a balance between economic, social and environmental considerations in the standard creation process. ANEC is the European consumer voice in standardisation, representing and defending consumer interests in the process of standardisation and certification, also in policy and legislation related to standardisation. ECOS is a membership organisation of NGOs active in the field of environmental protection, created to enhance the voice of environment within the European standardisation system. ANEC and ECOS are the main NGOs involved with standardisation of EuPs. At the EU level, many different people can participate to the production of standards. Formally, all interested parties have the same rights and influence, but in term of access to information, there are profound inequalities. The exchanges in the standardization process are indeed based on scientific data and expertise, and NGOs are for instance in a dependent situation.

2) The exchanges in the standardization process are based on technical and scientific data. There is a wide variation between the participant's level of expertise: large firms have the data and are interested in the process at the same time. Standards are clearly compromises based e.g. on political, economic and social criteria, but only the technical criteria are made visible. This can be a strong constraint because all other kinds of considerations must be expressed in technical terms. This is a process that is to the disadvantage of the parties who do not have sufficient mastery of the subject or enough resources to collect data. For instance, the power of NGOs is quite limited, since almost all technical data used to build and to legitimate a standard are provided by the representatives of the industry. Nevertheless, our analysis rests also on the statements issued by NGOs, for their critiques can reveal important controversies and therefore the constitution of objects in becoming.

3) Consensus is at the core of the standardization process. It is often defined negatively: it is not a majority vote, nor unanimity. It is more the absence of strong opposition. If one party is opposed strongly to a proposal, it cannot become a standard. This requirement can make the process very long. ANEC and ECOS complain regularly that the European standardisation is too unbalanced, with the industry having too much influence on the standardisation process. ANEC representatives feel sometimes ignored and protest that one of their studies was completely disregarded. Therefore NGOs criticise that consensus rule is not respected, and that the public interest is not taken into account in the standardisation process.

4) The standards are often presented as voluntary. It is sometimes true, sometimes not. The EU can refer to a standard when they have regulatory requirements, and even make it compulsory. The standards can acquire the force of a law, even at the international level. A problem raised by NGOs is the market surveillance. Since it is up to the manufacturer to declare conformity, there is no independent control of the standardised products that enter the European market. The majority of standardised

products only carry a "presumption of conformity" (exhibited in the CE tag). It is therefore up to the individual member states to check if the products on their market are indeed in line with the declarations. In reality the budget for such kind of surveillance is very low or almost nonexistent. Only a handful of member states conduct tests on a regular basis and even less share their results with other member states. And even if compliance problems are found there won't be any enforcing actions. The industry's representatives generally agree with ANEC that more market surveillance should be enhanced.

The normal course of action for a European directive that is conceived under the "new approach" framework is supposed to be the following: the Commission fixes requirements, and the standardisation process is called to produce a standard that correspond to the requirements. This process is supposed to let the pressure from industrials out of the process of formulating a requirement. We have however observed a lot of room for maneuver at all stages. What Borraz (2007) describes is a regulation where the political goes first and the technical is second: a standard is only an answer to a requirement decided by the European Commission. In Borraz's scheme, the Commission should independently decide of requirements, that the standardization process should settle a technical way of doing things in an acceptable way. In the Ecodesign directive the technical expertise is already subject to pressure from the industry, the producers, as they are participation in the process of negotiating the requirements themselves. We have observed that this simple framework of the New Approach directives was not sufficient to understand what happens. Nowhere in this process we observed a clear and complete separation between the political setting of requirements and the technical work of experts. And when the standard process has not even started, we can notice a lot of negotiation already.

The negotiations about the implementing measures cannot be done without a very technical discussion, which requires the industry to be directly involved. It is a kind of standardization, but still there is no need for consensus. The subcontracted experts negotiate the constraints and limits proposed by the directive. These experts have generally good connexions with the industry, and that is necessary to get relevant data (e.g. LCA). They give information on what can and cannot be done at a technical level. It happens that the Commission asks them what is possible today, at a decent cost, and without risking any possibility of the objects. For instance, the negotiation can be about what is an environmental damage in regard of the objects, or about the way to measure the impacts of the objects. The experts are supposed to come to results that they must propose, discuss and confront to the interested parties. But they are not supposed to try to come to a consensus with the industry. Of course they should have many reasons to comply with the industry demand. The industry that gives the figures to them, it is a work of DG enterprise, and the pressures from the industry would be terrible if the

Commission came up with measures that would be too difficult, expensive (or whatever) to implement. In these discussions, NGOs have often difficulties to be heard. Therefore, we can speak here of negotiation but not of consensus.

Representation of users in the ecodesign preparatory studies

Representation of users can be understood in two senses, both having an eventual impact on the construction of the appliances: mental representation of users that different actors can have (e.g. designers); or political representation through organisations. In the former section we have analysed the political representation of consumers. We turn now to the textual representation of the users in the preparatory studies of four product categories: washing machines, computers, lighting and boilers.

As already mentioned, the preparatory studies have a common structure and all of them gather information about users' behaviour in task 3: "consumer behaviour and local infrastructure". The common methodology for all the preparatory studies has been established by the consultant VHK in 2005 and suggests to collect the following data about uses: real load efficiency (vs. nominal), temperature/timer settings, dosage of auxiliary inputs during use, economical product life (in practice), end-of-life actual behaviour (present fractions to recycling, re-use, disposal, etc.), best Practice in sustainable product use. As we shall see, many of these topics are missing in the preparatory studies. We present hereunder the results of our analysis of these preparatory studies for the four selected cases: domestic lighting, heating (regulation), washing machines, computers. We leave the case of smart meters for the category "information design".

Domestic Lighting: CFL's as trade-off between efficiency, environment and quality

Electrical domestic lighting has been intrinsically linked to power network, right from the beginning. Electrical networks have actually been developed first to lighten city streets, and then to illuminate private houses (before world war I). It is only in the thirties that domestic appliances (such as the electrical iron, the radio or the fridge) have been introduced, notably to make electricity networks more profitable (Nye 1998). This strong link between light and electricity in the framework of modernity could explain different preferences between countries. For instance, it has been shown that what is considered in Europe as a good, warm and beautiful light, is very different from Japan or the United States of America (Wilhite & al. 1996). In Europe, a beautiful and warm light is associated to incandescent lighting that are used to create a warm atmosphere. Fluorescent lighting is considered to be cold and producing ugly light. In Japan, it is the opposite: fluorescent lighting is the beautiful light, used to create a pleasurable

ambiance. This difference can be understood first by the technology itself: lights and electrification have been introduced at different moments in Europe and Japan. European households installed what was available at the time of electrification: incandescent lights. In Japan, it was fluorescent lighting, less energy consuming (Bertoldi & Atanasiou, 2006). However it is difficult to distinguish between an "inherent" preference for a kind of lighting and a preference that would be linked to the introduction of a technology at a given time. That shows as well how the appropriation of a technology stabilises and can shape a culture of energy.

Through the ecodesign directive, the European Commission has decided to ban progressively the most inefficient lamps, including incandescent ones. In such a way, EU belongs to the general trend towards banning incandescent bulbs for energy saving reason. Three years ago, Brazil and Venezuela started to phase theirs out, and other countries, including Australia, Switzerland, Canada and the US, have followed suit. It is then probably be the first time that a marketed product is banned for environmental reason while requiring changes in the users' behaviours. A famous previous prohibition for protecting the environment is the removal of CFC. However their substitution with HFC has not entailed a change in users' practices, contrarily to what is required by the incandescent bulbs ban, as we shall see.

The main interest of domestic lighting resides in the different controversies triggered by the compulsory replacement of inefficient lamps by CFL's (Compact Fluorescent Lamp or 'energy saving lamp'). The first controversy is about aesthetics: the affection of people for their old luminaires, and the beauty of light itself. For old luminaires, the preparatory study is clear: users should get rid of them.[21] "Some luminaires do not accept an energy efficient retrofit lamp due to the available space and/or socked types. (…). In most cases a luminaire replacement should be recommended. Users of those luminaires should be informed in cases when replacement lamps will become obsolete in order to allow them to store sufficient replacements lamp in the cupboard. This cannot involve any problem because the cupboard store life time of these lamps is not limited." (Lot 19: Domestic Ligthing, Task 3, p. 23). ANEC has pleaded for a slow phasing out of lights that have no equivalent with a A or B energy class (e.g. some kinds of halogen), hoping that technology will save old luminaires.

Aesthetic debates concern also the beauty of light. As a previous study (Wallenborn et al. 2006) or internet forums show, many customers are still reluctant to buy CFL's, not only for their higher prices but also for their supposed lower quality of light (especially at the start up). The preparatory study addresses this question in

[21] The preparatory study has been coordinated by the VITO and is available on request at: http://www.eup4light.net/. LED's are treated in another study about 'directionl lighting'.

ascertaining the "lack of skilled and informed users". The quality of CFL's light has been greatly improved these last years. Bigger variety and more aesthetical care is also a recent trend of CFL market. These affirmations are probably true, but they do not seem to be based on studies. If users have not perceived the recent changed, it is because they lack information about what constitutes the quality of light, states the preparatory study. "Users should be clearly informed about correct lamp selection parameters (start up time, light colour, light distribution, light output, dimming method, life time, temperature sensitivity, ...). It is also recommended that users are informed about the proper energy efficient retrofit solution in case certain products become obsolete." There is however a quick reference to the fact that the quality of lighting is culturally deemed (Wilhite et al., 1996; Bertoldi & Atanasiou, 2006). Southern Europeans tend to prefer colder (bluer) light and Northern tend to prefer warmer (redder) light.

The second controversy is about 'quicksilvering' our practices. CFL's contain indeed mercury, and must therefore be carefully discarded. This content in mercury is regarded as acceptable when compared to the reduction of mercury emission in coal power plants that the use of CFL's entails. Indeed the decrease of mercury emissions resulting from energy savings (calculated for Europe) outweighs the need for mercury in the lamps. But this implies that consumers have to contract new behaviours: CFL's must not be thrown away in the waste bin as classic bulbs. This change in "end of life behaviour related to consumers" is not guaranteed. On one side, consumers have been described as reluctant (this is the reason for implementing the prohibition), another side they are supposed to be willing (they will recycle their lamps). The perception of the lamps will also have to change: they are potentially dangerous (contain toxic gases), and therefore must be recycled. Alongside NGO's state that information and awareness raising campaigns are necessary since citizens are not enough aware that these lamps should be collected separately. They seem however quite alone in demanding to reduce as low as possible the content in mercury in the CFL's.

The third controversy has a lesser extension. Some people claim that CFL's are emitting electromagnetic waves (due to the integrated ballast) and that they should not be used as bedside light for instance. The preparatory study has just a sentence on that subject: "electromagnetic fields are also causing concern to some stakeholders". ECOS has a solution to this problem and "suggests that the few people suffering from specific light sensitivity causing them harm with all possible alternatives to incandescence could get appropriate lamps in pharmacies through medical attestation."

Heating control: delegation of decision to objects

The history of domestic heating shows how deeply the way we heat our houses has been transformed since the appearance of central heating. From stoves that have to be filled regularly by hands to electronic control, the delegation of action to machines

has dramatically increased, while energy became invisible. The advent of central heating has enabled a major step forward in the safety housing and the health of their occupants. It also instituted an ideal of automation and uniformity. Compared to the fireplace or the stove, central heating ensures even temperature throughout the house and does not require daily maintenance.

In terms of consumption, programmable thermostat introduces an automatic modulation of heating during periods of absence and night. Thermostatic valves can adjust the temperature of each room more often manually. But there is still much to save in a fine regulation of temperature both in space and in time. Unless an extremely diligent family where each member is vigilant, the home is often still warmed when we are not there, so extending more or less consciously the standard of a uniform temperature.

VHK consultants have been commissioned for realising both the common methodology (Methodology Study on Eco-design of Energy-using Products) and the preparatory study about boilers. While in the common methodology study the consultants were setting specific requirements for acquiring data on uses (e.g. temperature setting, timer), this kind of data is almost completely absent in the preparatory study. As a general remark, users are hardly present in all the "ecoboiler report".

The consultants explain this absence of users analysis by the lack of data. Yet, they could have more documented the real indoor temperature setting in the different part of Europe. There is for instance a comprehensive discussion to have about the supposed increase of temperature settings, and from where come these data (Shipworth 2008). Shipworth studied the supposed increase of the average room temperature in the UK for the last 20 years. She concludes that the rise of energy use in UK heating is not due to a rise of the average temperature, but to the increasing number of central heaters. The central heaters are more efficient but more rooms are heated, resulting in an increase of energy consumption. The source of data for the supposed increased of temperature was scrutinized and Shipworth concludes that it is an artefact of the change of calculation methodology between 1984 and 2007. In the preparatory study, the most explicit description of temperature setting refers to a calculation based on a "average heat load": "An indoor temperature of 18°C is taken as an average, typically based on a living room of 20-21°C, kitchen 18-20°C, bedrooms 16°C and bathroom 24°C." Some additional remarks tend to prove that the consultants are not very confident in their sparse data.

Our analysis of the whole preparatory study shows however another explanation. Heating homes requires a whole system, and the consultants take a lot of time to describe all the technical parts of this system. The interface system/user is hardly analysed. Considered as a material agency, a heating system is the composition of the

following elements that should be considered of equal importance: boiler, circulator, emitting devices, control, indoor climate, humans, differentiated rooms, home envelope, and the relationships between these elements. In the preparatory study, the user is seen through parameters that she can more or less control. But "installers play an overriding role as the average consumers do not judge themselves expert enough to go against such an advice." (Eco-design Boilers, Task 3, p.1).

Actions like the energy supply, ignition and temperature setting have been delegated to the heating system. Therefore, the heating system is not in the hands of their users. Users have little grip on the whole system; everything is made so that users do not have to "bother" about it. The culture of energy — defined here as the knowledge and practice required making the heating system functioning — is now in the hand of professionals and imbedded in the technological black boxes. The best a user can do is to get a programmable control device (thermostat with one week timer). It is however not clear how should this thermostat be programmed. In task 1, the preparatory study critiques the setback during the night and part of the day. "From mainly anecdotal evidence it is known that it is not wise from the energy point of view to lower the set-temperature too much and it is known that there are smart and less-smart boiler control strategies to deal with this. But there is no test method to evaluate this." (task 1, p. 10) This is indeed a highly controversial statement…

The preparatory study reveals a general trend of delegating more and more the decision of heating to the system and to 'smart electronics'. To increase energy efficiency of the system, refined controls are placed at different points of the system. All the important decisions are made before the installation, and the running of the system is delegated to electronics. Therefore users can spare cognitive resources and spend their time to what they like. Increasing technology implies also more flexibility in the arrangement of the system and multiplies the number of possible systems. We have not seen however in the report questions about the control households would like to have on their own comfort. No question neither on the capability to deal with complex interfaces of thermostats, whereas one knows that programmable thermostats are often badly managed. The technological trend goes towards rendering energy always more invisible. When we recall that heating correspond approximately to 75% of household energy consumption, other strategies should be explored. Users could be empowered to monitor their energy consumption if it would be more visible or if the automaticity of the demand would be reduced. They could have more freedom of choice about the running of the heating system, while being more materially attached to it. What about the shaping of new habits: should they be regularly challenged, in order to recall the stakes of heating through fossil fuels? But is this permanent negotiation possible with objects and indoor climate and people?

Since for the user the complexity of the system is reduced to the complexity of the regulation, the interesting issue is about this complexity and the delegation of actions through this interface. Questions about the system disposition and its aim (indoor climate) could be however addressed through the regulation. The central question is how the act of decision to change indoor climate is distributed between objects and humans. How much has to be delegated to the machine? What is the information to be given to humans or to the heating system?

There are two different strategies to meet this issue. The first one is to deepen the technological delegation as brought forth through the EuP preparatory study. The second strategy is to ask more from the users by acting regularly upon their system in order to maintain a desired indoor climate. The question of sufficiency is suggested through devices that render energy consumption visible or in reducing the automaticity of the demand. In this strategy, users are asked to monitor their energy consumption. They have more freedom of choice about the running of the heating system, but are more materially attached to it. What about the shaping of new habits: should they be regularly challenged, in order to recall the stakes of heating through fossil fuels? But is this permanent negotiation possible with objects and indoor climate and people?

There are tensions between these two strategies. To what extent are they complementary or contradictory? They address the question of freedom in very different ways, and both have their rebound effects. The two strategies are not systematically contradictory. For instance, external probe or return water temperature control can be applied in each case. Both strategies do not seem to be gender neutral either. Technology seems rather the domain of the man, while the sufficiency strategy could entail a “thermostat war” between the partners in a household.

Washing machines: standardization of appliances, diversification of practices

The use of washing machines is determined by different elements that are interconnected: use of electricity and water, use of detergent, the kind of textile and its dirtiness, the load and the used programme. It is for instance possible to reduce water temperature in using a larger amount of detergent and consequently in rinsing more. The quantity of detergent to be used is never clear and their production has a significant part of total energy consumption. These elements, already complex enough, come to mix into practices in which each housekeeper interprets the social norms of hygiene and cleanliness.

Uses and practices of washing machines are well documented in comparison to the other EuPs and we know that behaviours with washing machines are diverse. The preparatory study concerning washing machines (realised by the ecowet consortium:

ecowet.org) has been led by ISIS (Istituto di Studi per l'Integrazione dei Systemi). The task 3 describes uses and washing practices based on a survey realized especially for this study and of figures extracted from various other sources. The survey has been made online, and counts 2500 people, distributed amongst 10 countries (250 per country). The households participating to the survey were selected to be representative under conditions of gender, age and household size. It is a part of a larger study on freezers, washing machines, dishwashers and refrigerator. The sample had to be composed of 100% of respondents having a washing machine and a refrigerator, not less of 70% possessing a freezer and not less than 50% having a dishwasher.

There could be some bias in this sample. First, it is an online survey, and not everyone can answer an online survey because a computer and an internet connection is needed, which could lead to a higher representation of more educated people. It is also important to note that some of the answers to the survey pose some problems to the 'ecowet consortium', but others do not. For example, the majority of the respondents declare that they use their washing machines at the full-load capacity, which is doubted by the consultants. On the opposite, the majority of the respondents declare that they use most of the time the "eco" program, which is not doubted by the consultants, but could be an answer induced by the "politically correct" behaviour related to this question.

The preparatory study aims at giving a fixed version of the behaviour of the users in regard with washing machines. It does not intend to give an historical overview of the use of washing machines, of the definition of cleanliness (Shove 2003) or give an explanation of the number of times users clean their clothes (number of times a week per person in the household). The behaviour of users is considered as the key to energy savings and the most important variable is the possibility to change temperature. It is not clear however to which actor is directed the objective of behavioural changes: users (change of practice) or machines (change of programmes). It is indeed obvious that uses are scripted by appliances (and social norms). A true ecodesign perspective could have thus suggested new ways of interacting with the products. But there is also no attempt to explain the observed behaviour (answer to the "why" people behave as such), while that has been done in other preparatory studies (cf. computers).

Because a machine offers a possible program to use, like a short-time program, then the choice is left to the user, making the user responsible for the possible savings. But the question could be asked differently, deciding to fix a certain characteristic of a machine so that the choices of the users would be limited to the more energy-efficient ones. But that goes against the scope of the directive that cannot reduce the functionality of an appliance. The behaviour of the users is considered to be given, stable, and not transformed and produced by the design of the appliances. The fact that washing machines are part of a system of codes or social norms and other appliances are not

addressed either. The preparatory study focuses only on the description of the washing machines as they are now, by themselves, and how they are used on average.

Washing machines labels are defined through three standardized performance parameters: energy consumption, cleaning and spinning. Best performances are labelled as AAA. Technology seems to have reached an optimum. The measurements of these parameters have been made up to now for a standard cycle: 60°C cotton at full load. This standard is however far from reality, as the preparatory study has shown.

The principal result of this study is the idea of a "real-life behaviour" of the households. This is compared to the standards used to calculate the energy efficiency of the washing cycles. Nowadays, the energy efficiency of washing machines is measured under standard conditions described in EN 60456: 2005 Clothes washing machines for household use - methods for measuring the performance (IEC60456: 2003 modified). This standard is also the basis for the European energy labelling system. This standard is criticised by the consultants of the preparatory study for not representing the real-life behaviour of the households. The way to measure energy efficiency is considered as a major issue, as it would contribute to change the design of the washing machines and allow the consumers to know what machines would be efficient under the "real" conditions.

The final conclusions about the survey and the users behaviour are:

- 4,9 washing cycles are done per week per household (1,7 per person per week)
- Wash programme at 40° is the most used (37%) followed by the 60° programme (23%)
- Average washing temperature is 45,8°
- Cotton and mixed are the most used programmes
- The energy saving programme/button is the most frequently used option
- Average spin speed used is 914 rpm
- Most consumers use the full loading capacity but it is agreed that this does not mean that the rated capacity is really used (or can be achieved)
- Delay start options used only in 8% of cycles
- In 50% of the cases at the end of the cycle the washing machine may stay in this mode for an average of 3 hours.

Of these, it is concluded that "the individual consumer behaviour has a major influence on the amount of energy and water used in the specific household". "Consumer training and education" should therefore be ensured and worked on.

Compared to standards, the announced load is generally bigger than maximal real load. The survey realised for the Preparatory Studies for Eco-design Requirements of washing machines shows that the average consumption of a washing cycle is 35% less than the same machine measured according to the European standard. It appears also

that consumers load their machines at 68% of the rated capacity, and use lower temperature (46°C). The result is a 5% reduced consumption of electricity compared to the standard average machine.

It is interesting to note that the labelling scheme and standards have transformed the appliances available on the market in a direction opposed to practices' evolution. AAA requirements are for instance met more easily by bigger machines, which sales are increasing. On the other hand, people load only partially their washing machines. This problem is now tackled directly by some machines: a load detection system compensates for the under-loading by modifying the washing programme parameters. Yet machines seem to react differently for the same under-loading: these behaviours have not been standardised. The amount of detergent cannot be controlled by the machine due to the diversity of detergent on the market. Consequently the optimization of rinsing is difficult. Furthermore, to get an A-label for water use, the rinse function has been reduced, impacting negatively on the quality of washing. The discrepancy between the current standard and the average practice is explained by the evolution of the practices. The evolution is linked to the increased use of more delicate and synthetic textiles, and to the development of low-temperature detergents.

Following the discussion around the ecodesign directive, a new regulation entered into fore the 1st December 2010. The standards on which the measure tests are based have been modified, for they have a strong influence on the market. Standard tests were based only a 60°c full load program and measures the total energy consumption divided by the weight of the full load. So bigger machines were advantaged compared to small ones. The energy efficiency of the washing machines must now be measured with a mix of 40°c and 60°c programs, and with a mix of full and partial load. The new performance standard proposed in the implementing measure is the result of a compromise between a proposition of CECED (European Committee of Domestic Equipment Manufacturers) and contestations from ECOS and ANEC. It is supposed to be closer to the real behaviour of users and the real trends of the market. But it requires to measure three different washing cycles, where only one was needed. It could then worsen the issue of market surveillance.

To avoid the fact that bigger machines would still be more efficient that smaller ones on a basis of 1kg of clothes, the machines are compared with a standard machine of the same rated capacity. This avoid the advantage given to bigger machines. Let's notice that a cold wash (20°C) should be available on all machines from December 2011.

There is another debate about the labelling scheme. EN standards for energy labelling tolerate a 15% uncertainty in the verification of the rated value for the energy consumption. This tolerance margin has been reduced to 10%. It seems however that measurement on different machines of the same model does not vary more than a few

percent and that some producers take advantage of the big uncertainty given by the standard to attribute labels to their machines detrimental to consumers (e.g. putting A label instead of B).

Personal computers: is another appropriation possible?

Computers nowadays do not display their energy consumption. It is indeed very difficult to know what a computer consumes. The market trend is to offer more and more powerful computers. But this trend is not only led by the hardware part of computers; softwares play a role certainly as much important as they require more and more CPU speed. It is not possible, from an ecodesign point of view, to dissociate hardware and software when it comes to market trends. But dissociating software and hardware when it comes to energy consumption is not easier. It seems that the different uses of a given computer have different energy requirements too. But it is not clear to what extent the user's behaviour really changes the consumption on a given running computer and what are the possible margins. Consumers are captive of their computer, and the buying choice is a main factor influencing the overall consumption. Giving information about electricity use of computers is thus useless in regard of practices, except for the energy saving features.

The associated consumption of computers is also important. Embedded energy of consumables and the energy used by the servers of data are unknown to the majority of computer's users. The different components of computers all have their associated consumption.

There is a paradox here, as the computers are very good example of interface between humans and machines and are designed to be appropriated by users, but in regard of the question of energy consumption, nothing is done. Historically, the figure of the user changed dramatically from a highly specialized person with the knowledge of programming to the "lay men" with no knowledge of computers, and a target for marketing purposes.

In this context there are two different strategies that concern the appropriation. The first one is to improve computers so that they automatically adapt to the need in power from the users.

The second strategy is to give the power to the user to use only what he needs at a given time. This could be done when using a given computer, but also at the time of buying a computer. When using a computer, could it possible to manually add components only when needed, or to switch them on/off. It could also be possible to implement better management of the energy consumption of computers by the user.

At the time of buying an appliance, different configurations could be sold, with different versions of OS. That would of course require the help of the programmers together with the computer's manufacturers. Configurations could be adapted to the

uses. Today computers are sold in regard of their lifetime before becoming "obsolete" which means that they will not be able to run the highly energy-demanding programs that will be available in a number of years. Changing the way we think about energy could be implemented by enhancing the lifetime of computers by focusing on function and liberties given to the users. That could help to reduce this increasing source of waste. That would also help to make embedded energy more present.

It is therefore important to study the appropriation of computers through the linkage between hardware and software. How could this configuration be transformed to meet different needs? What is the extension of hardware to be considered?

The preparatory study on computers has been realised by IVF Industrial Research and Development Corporation. It is very clear about the lack of knowledge about user's behaviour on which it is based. The introductory lines state that user's behaviour is not much known, despite the fact that some studies are available.

The usage pattern of a computer means in the study the average time a computer spends in different modes (active/idle, sleep and off). What the computers are used for during this time is regarded as a non-question, even if it can actually influence the consumption of the appliance. Playing videogames requires the use of a graphic accelerator and demands more energy than writing a text. Using internet also has an associated consumption as it requires the use of servers and data exchange. Consumables can also be considered as energy-consuming, at least for their embedded energy.

The average use of computers is considered by the consultants as representing no one's use (which is the opposite of the washing machine preparatory study). Nobody could actually use a computer as such. Because of that the usage patterns are divided in two categories: home use and office use, which would be closer to real life uses.

Office use is considered to be: turning on the computer when arriving to work, leaving it on when leaving, which will make it go into sleep mode after some time. The computer is supposed to be turned off only during weekends and holydays. This corresponds roughly to a repartition of 1/3 of the time for on, sleep and off modes. Home computers are "on" for 1/6th of the time, and in "soft off" mode the rest of the time.

The representation of users seems to be difficult for the consultants. They seem to try to find reasons for the uses, but cannot find the source of the behaviour of users outside the evolution of computers themselves. They have a problem because they cannot separate hardware, software and behaviour. As they cannot propose legislation on the use and on the functions that a computer can offer, they are left with nearly nothing to say on the importance of the use of the computers. People use computers more and more, for reasons that they give some "explanation" for, but thus they can only ask for more energy efficient computers that would consume less energy.

IVF consultants have a very great difficulty to define a usage pattern, as the uses are evolving with the new possibilities offered. The definition of a computer as a machine is clearly not enough, because its use makes it change more and more. From a basic calculating machine, computers have turned into advanced image processors, sound, video, multimedia players, but also connected machines, receiving information from internet on a constant basis, used a communication device to stay connected with people permanently. The functions they propose determine the behaviour of the users, and that is what the consultants try to explain when they give "explanations" of the usage patterns. What they have found in the studies about consumers use is always referred and explained as the results from new technologies, not as changes that could be identified as "social". And computers are not used for a single purpose, they are still machines that can do many things altogether, and that is the main reason why their use is increasing. The consultants are very aware of the fact that the uses change very quickly, rendering very obsolete the studies on uses very rapidly. But still, what they apply is a very average usage pattern for the two different uses they identify (home and office). They of course call for more studies on the matter, as every other study that "lacks the data".

The consultants are very aware that some technical features of the computers will clearly influence user's behaviour, and are trying to isolate them. For example, if the computer takes a long time to reboot, it will be turned off less often, or if the wake up from hibernation is unstable, the hibernation feature is likely to be turned off. So the machines and the systems are here considered as having a direct influence on the behaviour. The main factors influencing the decision of the users are: the time it needs to start, the price and, of course, the lack of information of the users about the fact that a computer uses a lot of energy in a idle mode. But the consultants do not go as far as to say that the users would use their computers less if they knew that it consumes a lot of energy. They do not take that side of things, not going into "display" solutions used to raise the awareness of consumers. They seem to take into account the factors influencing the behaviour of consumers only under a question of price, easiness and speed, so implicitly defining users's behaviours as hedonistic. In other parts of the text however, the consultants insists on the fact that the behaviour of the users is a rational one because users are reaching their goals. Rational and sustainable are not linked in the sense that rational does not mean sustainable. But they insist for the fact that if sustainability is to be reached, it should be enforced by the machine itself, and not by improving the rationality or the awareness of the consumers. Computers should do the job by themselves.

In conclusion, what is interesting with computers is that their evolution, their power to change the practices, the way they change our everyday life insists to be taken

into account. With computers, it is very difficult to say that more information on the energy consumption would be strong enough to go against the computer revolution.

The propositions for the implementing measure in the task 8 aim mainly at setting energy efficiency requirements, but it is considered as problematic to set maximum energy consumption because of the future evolution of the market. As the market is changing so quickly it is difficult to set an energy consumption scale for the computers. There is a strong attempt to create a scale for other products, but with computers there is no global scale and possibility to calculate energy consumption "per unit". What a computer does is not possible to fix on a scale. There is a problem of the different components of a computer that cannot be neglected to reduce its consumption of the central core or the CPU of the computers.

Discussion about standards is going on. It has been proposed to impose the energy star standard, taking advantage then of a pre-existing agreed measure. But at this point, different manufacturers do not want to make compulsory what was just voluntary.

Lessons from the case studies: the diversity of practices should be acknowledged

The following table summarises the sketches for the four studied EuPs and shows the diversity of each case. Each case is analysed through a central conceptual question. The most important moment for the user is indicated from the viewpoint of energy consumption: the acquisition or the use. The computer requires a continuous interaction (when we use it) and thus a longer learning process. Lighting and heating pertain to the realm of basic wellbeing. They appear to be an essential part of the development of humanity. Washing machines have been however instrumental for liberating women of a time-consuming task. Computers are only at the beginning of new developments between humans. Some appliances are gendered, and we know by our previous study that around the half of households are in conflict about temperature setting. The question of standards is differently treated: the problem of lighting resides in its perceived quality, even though energy labels are inciting people to buy CFL's; norms of comfort and temperatures have not ceased to increase; the interaction between hardware and software urge users to upgrade their material; while there are big cultural differences of washing practices, machines are standardised for average behaviours. The current dynamics of innovation in the product categories are also very different. The part of consumption for the whole Belgian household energy budget is also given. A quite obvious, and nevertheless striking, conclusion of the analysis of the representations of users in the preparatory studies of the ecodesign directive is the big diversity of EuPs and of their practices. Each studied product category reveals a singular technological dynamics and a different figure of users. In the case of washing machines, the

observation of a divergence between real uses and standards has led to the proposition of new standards more in phase with current practices. To enforce the ban of incandescent bulbs, users are described both as reluctant (justifying therefore the prohibition of "bad products") and potentially aware of the need of recycling the CFL's. Computers are evolving very fast, and so are their related practices; this questions the possibility to reach an agreement about a lasting energy standard for computers. In the case of heating, users are poorly considered to the extent that the control of the system is delegated to electronic devices. We have to remind here that users do not consider the different EuP's to belong to the same category. What brings EuP's together is their energy consumption, but what users perceive is different services provided by different appliances. EuP is a policy product category, and it is not even always obvious to make homogeneous sub-categories, as in the case of computers.

	Lighting	**Heating regulation**	**Computer**	**Washing machine**
Conceptual question	Trade-offs	Delegation of decision	Scripting and appropriation	Standardisation and practices
Buy/use	Buy	Use	Buy	Use
Action	Discrete	Discrete	Continuous	Discrete
Function	Ambiance; basic need	Ambiance; basic need	Transforming interactions	Liberating women
Gender	Man & woman	Conflicts	Man	Woman
Standards & norms	Energy label; quality	Social norms	Constant upgrading	Cultural differences
Current trends	Innovative	Central heating	Increasing CPU power	Optimisation (breakthrough?)
% energy household Consumption	± 14% of electricity	70% of total energy	± 2% of electricity	± 12% of electricity

Poor representation of users

In the directive, the figure of the user is present, but in a relatively diffuse way. The emphasis is put on ecodesign, for "it is estimated that over 80% of all product-related environmental impacts are determined during the design phase of a product" (DG TrEn), even though it is the use phase that has the most of impacts. Consumers are defined quite passive when using their appliances. But they are more considered at the

buying step: the directive endows them of the capacity to choose if well informed. User's behaviour is not questioned in the directive, even implicitly.

That is also reflected in the preparatory studies where consumers are reduced to "average use pattern". The user is generally regarded as non-modifiable: he is attributed immutable behaviour, impossible to change: watching television 4 hours a day and leave on standby 20 hours remaining, cooking x hours per week, washing clothes y times a year, etc. MEEuP prevents to envisage that behaviours can be modified by appliances. The diversity of profiles and practices are neither take into account, nor their evolution during the life. Average behaviour neglects also interesting phenomena as complex interferences resulting from the use of the same appliance by different persons of a household.

The analysis of preparatory studies shows also that there is no clear model for the distribution of responsibility between user and appliance for explaining behaviours. In the case of washing machines users are supposed to be free to choose the programmes, while in the case of heating a smart thermostat should ideally do the job. It is not clear if this hesitation between user and appliance depends on the consultants or on the studied appliance. We can however suspect that the way the responsibility is distributed in the preparatory studies will have an impact on the redefinition of the appliances.

The preparatory studies have a common structure and all of them gather information about users' behaviour in task 3: "consumer behaviour and local infrastructure". The common methodology for all the preparatory studies has been established by the consultant VHK in 2005 and suggests to collect the following data about uses: real load efficiency (vs. nominal), temperature/timer settings, dosage of auxiliary inputs during use, economical product life (in practice), end-of-life actual behaviour (present fractions to recycling, re-use, disposal, etc.), best practice in sustainable product use. However, many of these topics are missing in the preparatory studies. At this stage we can only hypothesise the reason of this absence of data.

Preparatory studies are huge amounts of work: thousand of pages, full of data and technological details. Unfortunately, they lack data and details about practices. 'Data do not exist' seems to be the accepted answer. We have nevertheless seen that the data used to build the representations of the users behaviour depend on the study. Besides the few references about statements on users practices, preparatory studies do not consider the huge amount of published papers on domestic energy behaviours (cf. for instance the journal Energy Policy). In the selected case studies, original data were produced only for the washing machines. The fact that uses and practices of washing machines are well documented in comparison to the other EuPs could be explained by a gender-focused analysis. Indeed, at first view, heating regulation and computers (and even lighting) are considered as objects manipulated and controlled by men. They are made by men for men, and we can hypothesise that the representation of their uses are

taken for granted. By contrast, laundry is still mainly the realm of women: this old women's practice has been delegated to machines, but they generally keep control on the clothes washing (Kaufman 1998). Designers and producers have therefore to make surveys to answer to the non-obvious question of how these machines are used. Whatever is the reality of this assumption, the collection of data has led the stakeholders forum to reconsider test standards.

As the washing machine case study shows, it could also be asked if the standardisation of the practices is actually a relevant way to represent the user's behaviour. The practices vary according to countries, but within countries and even within households. The diversity of practices could lead to different regulation and different way to design the machines. We can notice that interfaces of washing machines are among the most varied for big white products. It seems however that people use only a few programmes. But this issue is not addressed either in the preparatory study. There could be a clear proposition to set the "eco" program as the default setting on the various washing machines, but this option is not selected.

Engineering practices through efficiency strategies

For the purpose of calculating, the preparatory studies rely sometimes on "average usage patterns" — which can be far away from real practices. If we want to measure the gap between assumed average patterns and actual practices, we have first to hypothesise a priori the diversity of practices. If one wants to observe different practices, we have to postulate their existence. If not, one cannot see them. The diversity of practices can then be reduced to average patterns, bringing in mind that this reduction is often a convenient convention. In the case of washing machines, lighting and heating, usages definitions are embodied in standards. The definition of an efficient washing machine through test standard is also a definition of what is considered as "real practices", as the controversy between the CECED and ANEC shows. The quality of lighting is also defined through different standards (colour rending index, start up time, …) that do not fit always with the perception of users. Heating standards are deeply rooted in comfort norms that are not discussed, though we know that heating practices are very diverse (Wallenborn & al. 2006). In the case of the computers, uses are so diverse that it is impossible to establish a standard beyond a fragile convention.

In search for seizing the diversity of practices, we are not promoting more research in "sociology of practices", even though it could be of interest of course. But we would like to stress the need to ask important questions, even when engineers, economists or policymakers cannot answer them directly. The quality of public debate depends indeed on the collective ability to leave open and alive questions that have interest for the 'final users'. Preparatory studies are made by engineers and are technology oriented. This comes notably from the way the ecodesign directive has been

conceived: improvements are examined at the level of a product category, and relationships between objects or with users are considered as marginal. It has obviously an influence on the way the stakeholders meetings are shaped: this negotiation space is mainly technologically centred. ANEC and ECOS are evolving in this space, and their relative convergence comes from the fact that they endorse the Sustainable Consumption and Production Plans. As the methodology report (VHK 2005) states: "Consumer behaviour can — in part — be influenced by product design but overall it is a very relevant input for the assessment of the environmental impact and the Life Cycle Costs of a product. One aim is to identify barriers and restrictions to possible eco-design measures, due to social, cultural or infra-structural factors." The users' practices are here described as social, cultural and infrastructural factors that impede the full development of eco-friendly technological goods. As a consequence, the main advice concerning users is to better inform consumers, namely buyers. Practices are then not considered as an appropriation of appliances (Akrich 1995; Pantzar 1997) and an opportunity to change the culture of energy (Jelsma 1999; Wallenborn 2008).

In conclusion, the aim of energy efficiency is clearly dominating the policy agenda, since even with its different inconvenient, CFL's are being promoted as energy savers. The analysis of behaviours is reduced to the question of energy consumption, though there is very few analysis of associated consumption, as the servers for internet use, or other consumables. For instance, the embedded energy in detergent can take as much as 50% of the energy used in a washing cycle. Rebound effect is hardly indicated in the preparatory studies. This is due to the insistence on efficiency, even though strategies of sufficiency could be taken as complementary (Darby 2007). To prevent rebound effect, apart from increasing prices, interrogating needs and practices is an interesting starting point.

3.2 Information design

The final version of this report will include two small section on 1) the controversy around the energy labels and 2) the evolution of the energy issue as presented in consumer's magazines through washing machines and lighting. These are not included here by lack of place.

Smart meters

Real-time displays of electricity consumption (simply referred to as "smart meters" or electricity monitors) are now marketed towards households. These monitors show either the global electricity consumption of a household or the individual consumption of an appliance. They are announced as helping to "reduce electricity bills

and live in a greener house". Yet that remains a point of disputation for some articles claim otherwise (Marvin et al. 1999, The Climate Group 2008, Martiskeinen and Ellis 2011). The smart meter is not a stabilised technological object, as it is yet a topic of controversy. There are at least two ways at looking at the object "smart meter". First, it is seen as a part of the envisioned smart grids. Second, it is conceived as an instantaneous feedback device providing useful information to the consumers. Let's notice that these two perspectives don't exclude each other.

In the first case, smart meters are electricity meters with advanced functions: they can detail the consumption more precisely than a conventional meter and can communicate via some network with the energy provider or the grid manager. Saving energy is then delegated to the energy provider who is able to establish variable tariffs, and it is even enabled to switch off and on some equipments (washing machines, dryer, fridges) to 'shave' peak demand in electricity. The idea of variable tariffs, namely electricity cost that could vary according to the time of delivery, requires well-educated consumers, who would be able to follow the electricity cost variation and change their behaviours accordingly.

In the second case, the 'smart meter' is an electricity consumption real-time display that is supposed to help users to monitor electric appliances consumption and identify the most electricity expensive uses. These monitors are of two types. Simple counters to plug into the socket of an appliance to measure its electricity consumption and meters connected to the main incoming power of a house/flat to measure its total electricity consumption. These devices are more and more common and they are made available to the large public in shops or through Internet. They are announced as tools for reducing energy bills and promoting greener behaviour. The argument goes as follows: by providing real-time and more detailed information about energy practices, the monitors should help in motivating consumers to reduce demand as they see how much energy they are using – and money they are spending on energy. The energy infrastructure has been built to made energy consumption invisible. Previous actions made by the human body are increasingly delegated to machines. The idea of a meter is to add a device to the infrastructure that could make electricity use visible. The argument is supported by studies on consumption feedback that show that providing real-time feedback regarding electricity consumption can result in energy savings depending on a number of feedback characteristics, typically between 5 and 15% (Darby 2006, Fischer 2008). However, as we shall see, the issue of how households are recruited for the experiments and the question of what they learn is hardly addressed. Furthermore the overall experimental conditions are diverse and not always mentioned (duration of the experiment, design of the feedback, help and advice from the researchers, price of the monitor).

The main objective of the experiment was to understand what electricity consumers can learn when they use an electricity monitor, how they react to the introduction of a new appliance which is supposed to change their behaviours.

The ability to provide electricity feedback is the main rationale behind the drive for smart meters. They are expected to lead to electricity savings, because they allow consumers to monitor their energy use in real time rather than looking at their electricity bill months later (Abrahamse et al. 2005, Jensen 2008, Lockton 2008). Besides companies and the State, households declare their interest for these devices. For instance, we have observed in focus groups and in a quantitative survey that, when asked, people are rather interested in getting adapted information about their energy consumption (Wallenborn et al. 2006). In our survey of 2005, we observed that 69% of Belgian people state that they would pay attention to energy consumption if their appliances displayed this consumption. So, at first view, the different actors are interested in energy monitors. However the results of our study, and those of Hargreaves et al. (2010) — published when our experiment ended — show that energy monitor could be a false good idea. In order to understand this, we need to introduce the theoretical framework which has informed our study.

Theoretical perspectives on real-time monitor

Studies about the 'domestication' of objects emphasise the role of users in the appropriation, and underline the fact that it is often a very active process (Akrich 1995; Pantzar 1997, Aune 2007). Technologies are not just adopted and accepted, they are actively integrated in households' dynamics. This is mostly visible with new technologies, that modify a practice, and not just replace an older appliance for the same use. For example, the introduction of computers and the changes it makes in a household is certainly visible when the computer is new, or when a major revolution came, like the introduction of internet. Just replacing a computer by another one is not likely to change the practice, except if the old one is used by the children for new purposes. In these cases, computers may change the way people interact, associate with other people, inform themselves, buy things, and so on. The laundry routine and the introduction of washing machine is described by Kaufmann (1998) as modifying or being part of the negotiations taking part in a couple.

The "appropriation" concept is used to describe how users integrate the objects in their own lives, households or network. Users integrate objects into an existing set of other objects, skills and meanings. That suggests that humans are affected by the objects they integrate in daily lives. The appropriation process is a matter of reciprocity: humans influence objects, and objects influence humans. An object can change the time schedule of the family, it can change the way users interact, it can modify their symbolic network. The introduction of new technologies may change the "clocking" of

households, the rhythms and routines of households that fit in a more public organisation of time (Shove 2003). Hygiene and wealth are also organized internally, with objects, but in regard also of what is considered as being socially accepted (which is also mediated by objects). So objects play a role at both personal and societal level. There are different steps in the life of a product on a market. It can go from a very specialized niche of users to a mass-market. It can turn from a toy to an indispensible tool (cell phones, televisions). It can go the other way around, from a useful tool used for professional purpose to a widely used tool used for an entertaining one (for example phones) (Pantzar 1997). The pathway is not given and depends on the objects. When an object becomes "normal" its acquisition does not require anymore a justification.

As marketed electricity monitors are various, with different characteristics, and a price amounting to hundreds of Euros, we are still confronted to a market niche. And protocols of smart metering experiments can be very different: immediate or delayed feedback, with variations in the kind of received information, the kind of inspected appliance and the length of the experiment. The interaction between smart metering and other forms of information is at this stage rather unclear. Some studies conclude that information alone is enough for a behavioural change, some others conclude that information does not add to the economies made with smart meters. Two important effects are put forward: the drawback effect and the Hawthorne effect. The drawback effect is defined as "the phenomenon in which newness of a change causes people to react, but then that reaction diminishes as the newness wears off" (Wilhite & Ling 1995). The Hawthorne effect is the fact that people react differently when they know they are watched. Those two effects can interact with each other. Nevertheless, academic studies give an idea of the maximum of reduction that could be reached. Most of the literature concludes that it is possible to reduce the energy consumption, but the numbers and figures vary greatly (Darby 2006).

In all these studies, it is however never clear how participants have been recruited. These studies are usually done with highly motivated people, who tend to be better educated than average and to have higher income (Abrahamse et al. 2005). Liikkanen (2009) has developed interesting ideas about how to design a smart monitor, but his experiments were done with "extreme users", namely people willing to loan an electricity meter and ready to learn from it. That is typical of the results we have about the use of electricity monitor. In order to get round this problem, we have contacted households with various degrees of interests in energy (including low income), and developed an original protocol to grasp what household learn with an electricity monitor, as we have described at the "methodologies" section.

Findings of the social experiment

In order to try to synthesize the huge amount of collected data, we have compared the consumption of each household to the average consumption of a RUE (rational use of energy) household. According to this comparison households are grouped on as in figure 3: consuming more than the average (yellow), normal consumer (red), RUE (light blue), "super" RUE (blue). We observe that "super RUE households" are over-represented in our sample: we will see that this is related to a pre-existing interest in the monitor.

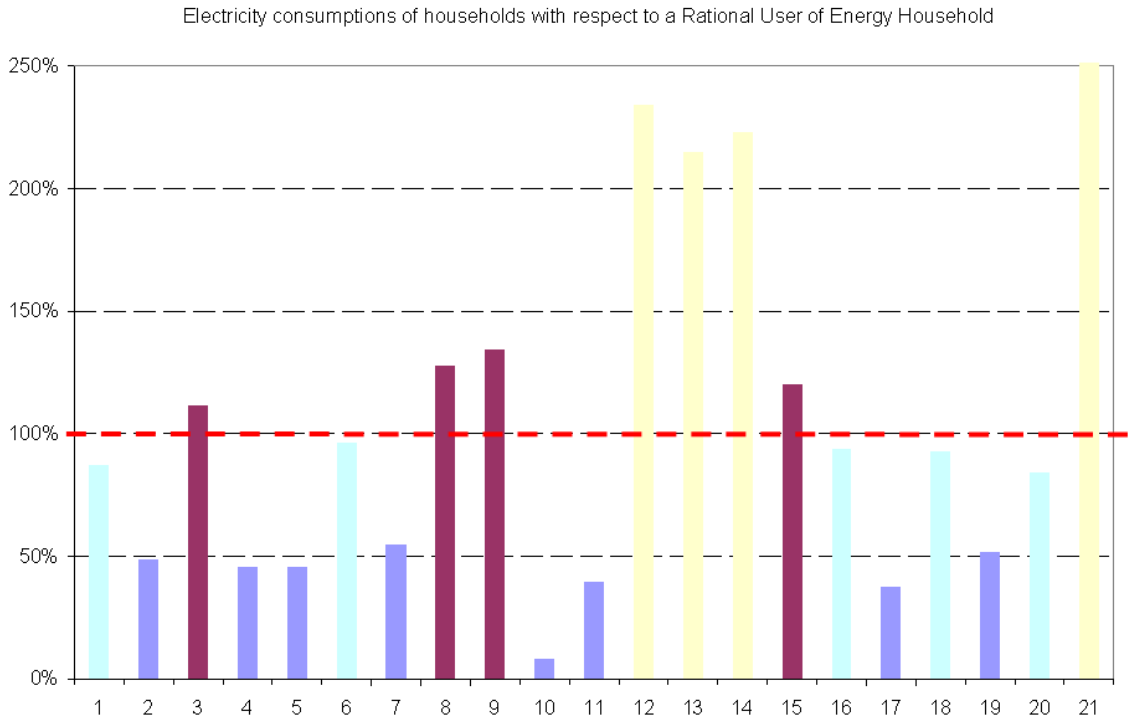

Figure 3: Consumption of the surveyed households with respect to a RUE household.

Through the presented protocol, we have gathered a huge amount of data on the material culture of 21 households. Table 1 summarises the main results of the survey. We organise them according the following dimensions:

- Perception change. This dimension points to the fact that the perception of electricity consumption has been changed or not after the introduction of the meter.
- Behaviour change. On the basis of the in-depth interview, we establish whether some behaviours have changed after the introduction of the electricity meter.
- Self-declared thriftiness. Does members of the household consider themselves to be thrifty?
- Observed wasteful behaviours. This dimension indicates that households declare to have wasteful behaviours related to energy consumptions (through in-depth interviews).

- RUE comparison. This dimension indicates the level of energy consumption, according to a standard RUE (rational use of energy) household: HIGH, NORMAL, RUE, super RUE (cf. figure 1).
- Energy interest. Through the recruitment channel, we can label households in the the following categories: involved (the household has already taken part to other energy experiments), interested (it has been recruited through mails), not interested (it has been recruited through individual contacts), low income (it has been contacted through social services which manage social housing).

Table 1: summary of the main results

	Perception change	Behaviour change	Self-declared thrifty	Observed wasteful behaviours	RUE comparison	Energy interest
1	YES	YES	YES	NO	RUE	Interested
2	YES	YES	YES	NO	Super RUE	Not interested
3	YES	NO	+/-	YES	NORMAL	Interested
4	NO	NO	YES	NO	Super RUE	Involved
5	YES	NO	YES	+/-	Super RUE	Involved
6	YES	NO	+/-	YES	URE	Interested
7	YES	YES	YES	NO	Super RUE	Involved
8	YES	NO	YES	YES	NORMAL	Not interested
9	YES	NO	+/-	NO	NORMAL	Not interested
10	YES	NO	YES	NO	Super RUE	Involved
11	NO	NO	+/-	YES	Super RUE	Interested
12	YES	NO	+/-	+/-	HIGH	Interested
13	NO	NO	+/-	+/-	HIGH	Interested
14	YES	NO	NO	YES	HIGH	Not interested
15	YES	NO	+/-	YES	NORMAL	Interested
16	NO	NO	NO	YES	RUE	Low income
17	YES	YES	+/-	NO	Super RUE	Involved
18	YES	NO	YES	NO	RUE	Involved

19	YES	YES	YES	NO	Super RUE	Interested
20	YES	NO	YES	NO	URE	Involved
21	NO	NO	YES	YES	HIGH	Not interested

Before discussing the results presented in the table, and interpreted through the interviews, we should recall that this methodology is qualitative, and that no quantitative conclusion can be drawn from it. For instance, a side effect of our interdisciplinary protocol is the manifest discrepancies between the statements made by households in written questionnaire administrated by the engineer and the observations made by the psycho-sociologist. For instance, some households wrote that they hardly do any 90°C washing cycles, while in reality it is a current practice. This gap between declarations and practices is well known, but indicates how much quantitative surveys on household consumption should be treated with caution. In the rest of this section we present the main results and point to several striking correlations.

First of all, while perception of electricity has changed in most of the cases, behaviour change has not followed. Many users have learned through the electricity monitors that heating (water, rooms, oven) consumes much electricity. In some cases, it has been possible to track down "bizarre" nightly consumptions, that resulted from water heaters without clock regulation.

After the utilisation of the monitor, five households state that they have changed (or they are going to change) their behaviour towards the use of electric appliances during the survey, at least for one or more of the appliances they found out to be energy intensive. These households are all households which do not show any sign of wasteful behaviour during the interview conducted at the end of the survey, and are RUE or even super RUE.

Among the 8 households showing wasteful behaviour for one or more of the appliances from their interviews, no one expressed the intention of changes in behaviour, even if 6 of them said to be attentive to energy saving. Among these 8 households, 5 acknowledge their consumption patterns and are aware of being above or in the consumption average. Nevertheless they do not want to change their behaviours causing these consumption patterns. The other 3 households did not acknowledge their consumption patterns and the most energy intensive uses.

It is interesting to note the reasons provided by the 5 households who do not want to change their behaviours even if they recognize their relatively high consumptions with the monitor. The change in the behaviour could cause a conflict within the household as some wasteful behaviours are associated to the good perception of a role in the household (washing clothes at 90°C is associated to a 'caring mother').

When a potential conflict can arise between a couple in areas such as the temperature set for the washing machine or for heating, even when one partner has obvious technical skills, this partner prefers to remain silent in order not to create a conflict. Each member of such a couple has its own field of activity that consumes energy and other members cannot interfere with it.

Another, paradoxical, reason that prevents 'behaviour change', is the self-esteem of the user about technical skills. The user of one of the appliances has, or thinks to have, the technical knowledge enabling him to justify his choices and consumption patterns. In other cases, the (over)consumption of energy in a particular practice is associated with activities or services that provide "pleasure". In such circumstances, the consumer may not consider reducing these consumptions because he prefers to offset them with savings in other areas. These people will eventually be more tempted to buy more efficient appliances than changing behaviour.

Among households who do not want to change their behaviour, 3 reported not having acknowledged any trouble in their mode of consumption from the monitor experience review. We can explain that because either they do not have the skills to understand recommendations, or they said they did not discover anything they already knew, or while seeing their consumption patterns and the peaks in consumption, they consider that their consumption is normal.

The five households who declare to be ready to change their behaviours after the survey are motivated by a specific perception of the environment: they value ecology in a philosophical or political sense, more than for economic reason. These households who can appropriate the meter are in fact already well informed towards energy consumption.

Overall we found that current electricity displays are not well designed, for example they provide only figures in kWh or Euros. Graphic representations are more useful for households to track down unsuspected consumption, but are not easily understood without the explanation of an expert. We have also noticed counter-productive effects when users realise that some appliances consume little: they hence conclude they can use the device more. Because absolute consumption is often meaningless for households, they require comparisons in order to know whether they are on the right track.

Finally, we have observed a loose link between the number of appliances possessed by a household and its global electricity consumption. This relation is stronger in the case of lamps: high energy households have a larger number of lamps than the average. Beyond the issue of behaviour and use, this indicates the importance of material aspects in energy consumption. The relation between the number of possessed appliances and a motivation to conserve energy has also been observed in the focus groups.

Conclusion: will electricity monitors help households to conserve energy?

Cost of the energy monitors that would be imposed on household has begun to fuel debates in France and in Belgium. At the moment, most of the experiments are made with free or cost-reduced monitors (and so we did). It is therefore not clear to know what price could be paid by households for an unclear service. The privacy of the data is also a hot topic. It is therefore crucial to understand better what could be the positive role played by the introduction of these new devices.

Most of the results of this study are in line with Hargreaves et al. (2010)[22]. For instance, men are generally more interested in the device than women. All households declare to have learned something (hidden consumption) but some of them also state that it has not going to change their behaviour. The introduction of an energy monitor can trigger conflicts within households, and the display can be discarded to pacify relationships. We have also noted that people have difficulty to interpret figures in kWh, and that the conversion in Euros does not look impressive (household can only save a few Euros by year for a given behaviour change). There are indeed many debates about the kind of display that would be useful for households (Pierce et al. 2010), about which data to exhibit and how to present them. The place in the household of the display is also an issue: should it be fixed in the living room or should it be mobile?

When monitors are not integrated to pre-existing practices, the meter is readily absorbed in the daily background as any other new appliance. The presentation of the real time electricity consumption is not handy, and the sudden peaks are not easy to interpret. Notwithstanding reservation about the design of the meter (not easy to be installed and to be read, need literate users), we think that such a meter, to be efficient, should be integrated into an existing appliance to get a chance to be used. The data provided by the meter could be carried to the user through Internet or through the mobile phones, for instance, so that this information would arise in pre-existing practices. Furthermore, for some kind of household, a follow-up of the consumption should be organised. We therefore suggest that users should be implicated in the design process, and that this design should allow some room for different kinds of users.

Our results are not statistically significant, but they give a good indication on 1) which households are today ready to use an electricity monitor, 2) how to improve the monitor and what surrounds it. We have observed that the monitor can change electricity perception, but that only households already interested or involved in energy savings are willing to use and learn with the monitor. We conclude that monitor can be integrated in existing practices but they do not trigger by themselves new practices. In

[22] The discrepancies with this study could be explained by a different recruitment scheme. Their sample is described as 'early adopters'.

other words, information works only with households already informed or willing to understand the provided information. This observation was already made in focus groups where we noticed that people who don't feel enough informed about an issue are also the ones not searching for information, whereas people actively looking for the information that interests them find not difficult to get it. Searching for information is therefore wholly part of a given practice, for it is related to meaningful activities performed by households. How information is integrated in practices remains however an open question.

Could electricity monitor diffusion be seen as the diffusion of other technological innovations (e.g. PC, mobile phones)? As the service provided by the device is quite peculiar (electricity consumption and nothing else), the question is how to interest people to the issue of energy. Internet has been generalised because it has offered more and more services and entertainment. By contrast, energy monitor however concerns only one (important) aspect. It adds to existing appliances. A probable future of these monitors is to be integrated in existing devices, as PC or mobile phones. In conclusion, we believe that if we want to empower electricity users, we have to invent other ways of making energy precious than making it visible through a small monitor, even though such a device can help well educated people to develop awareness about their electricity uses. These ideas have been validated during a meeting we organised with designers and academics.

3.3 Practice design

Co-design sessions as experimental situations

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. Besides the necessary energy efficiency improvements, the question of sufficiency is never asked. Whilst 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'.

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 in 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. Brohman et al. 2010). 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? 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 reasonable way? This section summarises the results of the co-design sessions organised by François Jégou (SDS, Strategic design and sustainable development research agency) and Joëlle Liberman (Egérie Research) in the ISEU framework. The aim of their research was to

imagine new devices co-elaborated with users in order to reduce their energy consumption. The main objective of co-elaborated scenarios is to explore the possibilities to induce behaviour more in line with sustainable use of energy by changing the design of household appliances in general and the five selected categories of appliances in particular.

Subtractive principle and lighting environment

CFL's have been observed to lead to rebound effects: letting the hall lamp on all night long, putting new lights in removed areas,... 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, and requires often to go from one switch to another. It also implies additional cognitive load for the user because he or she has to identify which lamp has to be switched off before switching on another lamp, and to select which switch to be operated. For these reasons, we have explored a 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.

1. Moving the energy between the luminaries. The basic design principle of a switch should be the substitution and not the addition. 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. 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. The subtractive principle can be applied automatically and the reset can be a presence detector or rather a detector of absence. 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 gradually switched off.

3. Lighting of the space. The lights are more or less equipped to mark the occupied area. As designers say, light *modulates* space. Lighting materialises the planned activities. In particular, in living rooms, central lights are less used to the benefit

of a range of ambient lighting. 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.

Semi-manual interface principle and thermal regulation

The principle of semi-manual interface develops systems that operate autonomously, controlled by programming, aimed at achieving heating savings in some rooms. It enables the user to easily change intuitively the programme in order to provide additional temperature occasionally in time and space. It should reduce user cognitive overload in the fine thermal regulation, for instance in following movements of people in the home while facilitating users with manual regulation.

1. Modulating the automatic thermostat. Thermostats and indoor thermometers are generally discrete objects, small, applied to a wall so that the information they make available requires that the user is interested and close to it. The ambient temperature in particular is much less present than the clock in the domestic space. We have seen that the design of heating regulation ranges from the ideal of fully automatic to the delegation to the user through the fine modulation for each room. The models of the most sophisticated thermostats combine daily and weekly programs requiring the householders to clarify their regular practices; besides they are often complex and have unlovable interface. In contrast, the fine control of each room involves good will from users who should intervene manually on each radiator valve whenever they leave a room or change the programming of the thermostat.

The application of the semi-manual thermostats presupposes to get the object in the daily life of the user, giving it a status closer to that of a remote control found on the table that moves on and with which we interact more easily. The remote thermostat allows first to define a programming of the temperature in each room independently: children go to bed early and the night temperature begins when they are in their bedrooms, parents are rarely in their bedroom so that the absence temperature is maintained until late evening.

Beyond this basic programming, the thermostat works like a very simple remote control: the user can choose between a lower temperature of sufficient when performing activities and a more comfortable temperature when staying still. The user can demand a higher temperature, that will remain switched on during an hour and is automatically switched off. If the householders go to the living room, the thermostat is moved and brought with them. The mobile thermostat is responsible to set back the low temperature comfort when householders have left a room. In addition, the thermostat

displays the temperature in a clearly visible and allows to visualise the activity of the boiler burners: it makes heating 'visible' as a fireplace that can be easily revived.

2. Compensating time temperature. The same semi-manual principle assumes that one can occasionally increase locally the temperature. While a low default temperature can be given in different rooms (as bedrooms), it is sometimes required to heat it for a short moment (e.g. to get dressed). A radiant booster then works like a pool shower: pressing the switch provides 30 seconds instant heat and is then switched off. Being regularly forced to turn on avoids excesses. The same concept applies when coming in a room with low temperature for removing the cold feeling, letting the time to heat up. If a radiant booster is inherently wasteful in energy, its use remains very limited in space and time and it helps the user to get used to a lower atmosphere temperature the rest of the time.

Resetting default principle and clothing care

The principle of default redefinition is to design systems that provide basic performance, both efficient and sufficient, while occasionally allowing a more expensive mode. This principle should allow to prompt low energy-intensive washing processes and to push evolution of users habits.

The laundry is a highly diversified practice, and complicated by advertising strategies dramatizing dirt linen and contamination risks, triggering a sense of guilt and the need for hygiene, and exacerbating the mysteries of the alchemy of laundry. This situation is worsened by the fact that laundry does not incite to experimentation: the risk of spoiling clothes, for instance in mixing improperly some textiles or colours is far too important to allow housekeepers to experiment. Therefore users adopt the behaviour of low risk. They repeat what has been working and avoid situations that have caused problems in the past. They are confident in the merits of their way of doing, so without having any way to test other ways of doing.

1. Slow washing. The supply of washing machines on the market offers a multitude of programs and settings that extends from accelerated washing cycle to soft treatment for delicate textiles. Washing considered as 'normal' is more or less the average of these possibilities. The principle of redefining the default washing machine involves a reinterpretation of how to wash clothes with a machine and hence the meaning of programs.

The laundry is the result of a combination of 4 factors: the agitation of the machine, detergent, water temperature and cycle time. While the progress in a society of consumption has always been to ensure a rapid and efficient cycle, the environmental concerns lead conversely to consider a very long cycle requiring for the same wash a small agitation, less detergent and water at room temperature. This method of washing is already available almost on all washing machines on the market, under the form of

programmes for gently washing delicate fabrics. It is very possible without major structural adjustments of the machine to offer a basic programme that would limit the consumption of energy in extending the wash time for 6-8 hours. If this solution seems completely the opposite of market trends, it does not imply a significant change in the practices of households who already launch a machine in the morning to retrieve clothes the evening, or conversely launching at night for the next morning. The machine can still do the same job in less than an hour but with a considerably higher amount of energy. The machine default would be set to this slow washing, leaving the choice to the user to accelerate it and consuming more.

2. Programmable washing machine. Competition between manufacturers of machines and abuse of marketing differentiation between the models led to sophisticated washing machine interfaces, making it difficult to control the basic washing and a plethora of programmes with only a few used really. The redefinition of a default on the other hand could offer an simplification of the interface that would suggest only one mode of light washing optimized to suit the widest range of textiles, a short cycle of low temperature economic and ecological. This basic programme would be offered by the manufacturer as the optimum way to balance cleanliness, low consumption and ease of use. The machine is ready for use without the need for special settings as is the case for a camera that makes a default photo, an oven or a mobile phone. If desired, and after a first test, the user can modify this basic programme of the washing machine as she or he likes: speeding up or slowing down, raising or lowering the temperature, adjusting the spin and rinse. Satisfied, he can save his own programme as a radio station is saved on an car radio. The machine suggest thus to the user to explore anew her or his own washing habits from a basic configuration.

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 thermal regulation systems are often non-adapted. When users are given the possibility to imagine other ways of interacting with their heating system, following a sufficiency principle, they reveal that our houses have embodied standard thermostat systems that do not fit desirable practices anymore.

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 the research team 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 domestic practices, to take a distance from them and enable the families to re-invent progressively their daily ways of living.

Our ethnographic design 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 thermal regulation systems are often unadapted. When users are given the possibility to imagine other ways of interacting with their heating system, following a sufficiency principle, they reveal that our houses have embodied standard thermostat 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 interviews 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 optimisation. 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 interesting as the result. We think that transition towards a sustainable society will require much more transitory experimental situations.

Finally from the point of view of design principles pursued to create and develop the artefacts constituting our daily environment, the results of the study points to a considerable evolution. Mainstream design taught in most of the design schools and books insists on easy use of objects. Following the precepts of ergonomics, objects have to be designed as functional as possible, requiring less effort and investment from users. The notion of 'design for all' extends usability to ensure accessibility and easy use for all the population including small, weak, old, people and those physically and/or mentally disabled. This basic principle to ensure a maximum of functionality for all is so important and necessary that it is hardly questioned. Progresses towards accessibility of use have been one of the main challenges along the history of design (and still is for many products as thermostats for instance) but this trend should not be considered as univocal. Lessons learned during this study has shown that sustainability concerns

challenges aspects of over-functionality of our daily environment: thermal comfort in modern housing for instance is so easy to obtain that it looses its value and disappears in everyday life. Thermal comfort turns to be a negative quality, a quality that is only perceived when it is lacking (Carmagnola, 1991).

On the opposite, the principle of design exemplified in the two propositions presented above, advocates for a *sensible ergonomics*, an accessibility to thermal comfort that is sufficiently good for obvious reasons but not too good to induce inconsiderable consumption from the users. In other words, the functionality is not a maximum to be reached but should be the result of the very process of equipment design. The level of accessibility should be carefully thought and defined in close collaboration with users so that it is just at the edge between discomfort and overconsumption. And we have to bear in mind that this edge moves accordingly time, space and households.

Consequently, the results of our research questions the simple tension usually discussed between efficiency and sufficiency. The design brief is not to *get the same with less* as stated by the hypothesis we start with but a creative process to imagine *something else* that represents an equally enjoyable (or even more enjoyable) alternative which happens to impact less on the environment.

4. CONCLUSIONS AND RECOMMENDATIONS

While we know we have to transit quite fast towards a low carbon society, the active role of users and their interaction with their appliances are generally envisaged only through attitude and behaviour change. The problem is that the environment does not appear in households' daily practices: households do not consume energy, they use different objects that provides services. Therefore, rather than starting from attitudes, we think it is essential to start from what people are doing, from their everyday practices (Røpke 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. Moreover consumption and schedule organisation are increasingly individualised, relying on the multiplication of personal appliances. These elements of the current 'culture of energy' help to explain that efficiency gains borne by new appliances are more than absorbed by the proliferation of new energy-related practices. The transition towards a new culture, or a so-called socio-technical regime, requires to change the energy conception: the users need to be conscious that energy is precious, and are able to transform their practices accordingly.

The practices related to energy consumption have always changed. But they are going to change in a direction that could be contradictory to our current standards of comfort. The mutation of the 'culture of energy' has to be accompanied in order to prevent social disruption and to limit environmental impacts. The transition towards sustainable energy culture will require understanding household practices in order to adapt them to the new context. In this perspective, efficiency and sufficiency approaches should not be seen as conflicting but as complementary. We do not know what will be transformed, or prohibited (e.g. lights). How could practices be transformed without calling to the "good will" of users (through information instruments)? Users are mainly addressed as rational individuals who mobilise information about energy efficiency of appliances (labels), while they are currently described as hedonistic (search for comfort). When left with these two approaches, we fall inevitably in the gap between attitudes and behaviours. Furthermore, the reduction to average usage patterns on which the EuP regulation is based does not allow for experimentations with objects. These approaches cannot take into account the creation of new relationships between an object and its user. Other ways of conceptualizing energy consumption could be brought by the objects themselves, modifying practices. An experimental approach, based on the idea that the desires of the humans are not fixed beforehand and that practices are modified by objects, would better be fitted to accompany the changes in culture of energy. This third approach would be *experimental*, i.e. allowing redistribution within practices of the relationships between objects and users. The exploration of this experimental

strategy — which already exists but is not thematized as such — is the primary recommendation we make.

Technology has driven life pattern transformation for many decades, and has made energy consumption soaring. In order to meet international agreement on energy, we will need other technologies. It is probably not only a question of having less technological objects and of developing renewables, but also of changing the collective appropriation of technology. Most of the time, technology happens on the market without any collective deliberation about the purpose and functioning. The decision to develop appliances and to put them on the market pertains mainly to private companies. The ecodesign directive process promised to change this fact, but it eventually proved that NGOs have not enough access to data and resources to make their arguments heard. The representatives of the environment and of the consumers are too weak to make energy consumption an issue when negotiating appliances.

The problem of energy consumption by households is today mainly addressed through the improving of energy efficiency. This has been shown in the analysis of the ecodesign directive implementation, but could also be seen through other EU and national policies. This directive originally aimed at dealing with the different environmental problems posed by energy-using products. Energy efficiency concerns a functional unit, not the whole appliance (TV screen, volume of a fridge), or a standardised cycle (washing machine). Eventually, the main criteria for improving the performance of an EuP is to reduce the life cycle cost of an average base case. Our critique of this approach is twofold: technological objects are not isolated; users and practices cannot be correctly approached by 'average' representations. Our main conclusion is thus that there is a perversion of initial valuable policy aims when the only considered means are the energy efficiency and technological standardisation. In this perspective, the question of rebound effect is not efficiently tackled.

While the ecodesign directive focuses on 'product categories', the possibilities developed with users show that the analysis of the *system* is determinant. Brezet (1997) defines four types of innovation: product redesign; product innovation; function innovation leading to a change in the way the functions of a product are fulfilled (e.g., product-to-service switch); system innovation in which technological, institutional and social changes are combined. EuPs are obviously in relation with users, but they are also always part of a system. That means that objects have associated consumption that should also be considered: servers for computers, detergent for washing machines, etc. For instance, the embedded energy in detergent can take as much as 50% of the energy used in a washing cycle. And this share will increase if low temperature programmes are more used.

The ecodesign directive is mainly concern with product redesign, while co-design invites to see the product in its system and leads to product innovation. This is

not obviously enough, for we will certainly require system innovation. Nevertheless, the focus on household leads inevitably to a range of possibilities limited to products inside homes. To cope with a systemic approach, installation standards should be considered. End of life is not examined either. Why not to implement lifespan standards for technologies that cannot be improved, in order to counteract programmed obsolescence of EuPs?

Our case studies show that there is a huge diversity of practices and possible strategies: each EuP has its own characteristics, and own ecodesign requirements. It entails that standards are often far from real situations. The diversity of users is generally not taken into account: the variability in the objects is not in congruence with the variability of uses. The different exhibited examples show that when one considers energy efficiency without uses and users, one can be led towards solutions that are not optimum for saving energy. The attention given to technology solutions without integrating the diversity of uses, namely in forgetting the users, is probably not well adapted to the challenge of reducing energy consumption. It has also great implications for communicating with users, e.g. for policy campaigns. For the case of lighting, it will be very interesting to follow the implementation of the incandescent bulbs ban. How will users adapt or resist to the change? The case is peculiar since it requires not only a change of behaviour (as for instance in the compulsory use of security belt), but also an adaptation of objects (e.g. luminaires).

Preparatory studies are huge amounts of work: thousand of pages, full of data and technological details. Unfortunately, they lack data and details about practices. 'Data do not exist' seems to be the accepted answer. We have nevertheless seen that the data used to build the representations of the users behaviour depend on the study. Besides the few references about statements on users practices, preparatory studies do not consider the huge amount of published papers on domestic energy behaviours (cf. for instance the journal Energy Policy). In the selected case studies, original data were produced only for the washing machines.

The analysis of the preparatory studies shows also that there is no clear model for the distribution of responsibility between user and appliance for explaining behaviours. In the case of washing machines users are supposed to be free to choose the programmes, while in the case of heating a smart thermostat should ideally do the job. It is not clear if this hesitation between user and appliance depends on the consultants or on the studied appliance. We can however suspect that the way the responsibility is distributed in the preparatory studies will have an impact on the redefinition of the appliances.

The delegation of decision to technical objects implies that default settings are scripted into appliances. Default settings are however hardly analysed. Yet an eco-programme could be set by default in different machines (e.g. washing). More generally

energy networks are built to add easily new activities and appliances. The general default settings of energy networks are conceived in such a manner it is easier to consume more than to save. In this perspective, designers can help to rethink systematically all the default settings which are most of time inconspicuous.

In search for seizing the diversity of practices, we are not promoting more research in "sociology of practices", even though it could be of interest of course. But we would like to stress the need to ask important questions, even when engineers, economists or policymakers cannot answer them directly. The quality of public debate depends indeed on the collective ability to leave open and alive questions that have interest for the 'final users'. Preparatory studies are made by engineers and are technology oriented. This comes notably from the way the ecodesign directive has been conceived: improvements are examined at the level of a product category, and relationships between objects or with users are considered as marginal. It has obviously an influence on the way the stakeholders meetings are shaped: this negotiation space is mainly technologically centred. ANEC and ECOS are evolving in this space, and their relative convergence comes from the fact that they endorse the Sustainable Consumption and Production Plans.

The political representation of consumers' organisation in European standardisation processes is a rather recent evolution, and deserves a closer analysis. How far are the representative consumers organisations ready to put forward sufficiency criteria? The current support for reducing absolute energy consumption seem limited, though a new culture of energy should bring us towards that aim. Efficiency and sufficiency are often opposed. We are generally summoned to pick one side: either you are favourable to technological progress, or you want to reduce the grips of technology on your daily life (for environmental or other reasons). We think that this opposition is misleading and that we need both energy efficiency and energy sufficiency. Sufficiency can mean different things: using less each appliance, buying less different appliances. We can observe a multiplication of small appliances on the market and in households: some of these appliances are not submitted to any standard. We believe there is a need for launching a societal debate about sufficiency. Sufficiency will not be achieved only through voluntary measures. Sufficiency is not abstinence or privation. It is intelligence use of limited resources (Princen 2005). It should not be a "sad passion" but a joy, an increase of our power of acting, as Spinoza could say. Sufficiency could be smart, if it includes objects and technology. Voluntary simplicity or transition movements are not clear about the place to give to technology. We think it is important and interesting to carry on investigating how objects can help us to feel sufficient and, conversely, how the limited energy resources can act as a trigger of innovations, which would necessarily mix objects and users.

5. POLICY SUPPORT

The different partners of the ISEU project take part in different committees or advice councils, and write regularly reports to the public authorities. The discussions during our meetings, and the writing of working papers, have had echoes in these activities. We were then able to bring ideas as the compartmentalisation of practices, the problem of users representation, the importance of user/appliance interface, the issue of efficiency/sufficiency, in the following activities where decision makers were involved. Without being exhaustive, members of the team have participated to the following relevant committees and meetings:

- Meetings of the Federal Public Service Environment (SPF – Environnement) to prepare the « Consultative forum » of the EuP directive implementation.
- Federal Council for Sustainable Development (and one intervention at the Annual Conference of the European Environment and Sustainable Development Advisory Councils)
- Participation in the Public consultation on the European Charter on the Rights of Energy Consumers for DG Energy and Transport; on the European Charter on Fuel Poverty.
- Intervention before Ministers about energy consumption (and social justice).
- Participation in the jury to select ICT products for the elderly "Digi-awards about user-friendly ICT use", King Baudouin Foundation .
- Participation in a Interreg project called Abilitic, about prospectives in the domestic heating sector and attended the discussion group on the future demands of the consumers in the domestic energy field.
- Writing of a Memorandum of the consumers' organizations for the Belgian public authorities.
- Participation in the Belgian public consultations on the environment and sustainable development:
- Since 2008 CRIOC is an active member of the workgroup ICT within ANEC. Since 2006 CRIOC is an active member of the ANEC workgroups environment, and since 2002 of the workgroup Domestic Appliances and Child Safety and the general Assembly.
- Since 2008 CRIOC is an active member of the EuP project team. The role of this team is to contribute with technical expertise to the identification of consumer relevant aspects and consumer requirements in the EuP process and to prepare consumer positions on eco-design. Results of the ISEU project will be utilised within this team if applicable.

- CRIOC is a member of the board of directors of the NBN, the Belgian standardisation body.
- CRIOC is a member of the Hoge Raad van Normalisatie/Haut conseil de Normalisation. This council gives advice to the ministry of economy about possible improvements and shortcomings of the standardisation activities in Belgium.
- Realization of a "Procedure d'avis energetique et certification de performance des batiments" for the Walloon Region.

It is never easy to gauge the influence of a scientific research on policy. However, we have been struck that some of our critiques of the implementation of the ecodesign directive have been corrected while we were discussing with some stakeholders.

ULB organises soon with the King Baudouin Foundation a meeting about "climate change mitigation policies and social justice". The issue of smart meters will be raised.

Main recommendations:

Energy policies should not focus only on improving efficiency but have also to adopt sufficiency strategies (cf. conclusions), notably in multiplying micro-experiments that engage users.

Contrary to what is often stated in the debates about smart meters, we have shown that electricity monitors will not help by themselves household to reduce their consumption. Therefore the implementation of 'smart meters' has to be cautiously done.

6. DISSEMINATION AND VALORISATION

The research network have organised two conference:

- 27/04/2010, Brussels. A "non conference" about *Designing Household Energy Practices* have gathered 25 designers and academics from all Europe (despite the activity of the Eyjafjallajokull volcano). A special format has allowed the researchers from different disciplines to have fruitful exchanges.

- 02/12/2012, Brussels. The conference (in Dutch and French with simultaneous translation) was about: "Reducing electricity consumption in the residential sector. The role of auditors as ambassadors of a new culture of energy." The conference first aimed at raising awareness of electricity consumption (besides heating) to energy auditors and a larger audience.

A last conference will be organised in Brussels on the 9th of April 2011, during the European Union Sustainable Energy Week (EUSEW), about: "Energy efficiency is not sufficient. What are possible sufficiency strategies?". A policymaker will conclude the conference.

Members of the team have given numerous talks about energy consumption, users and design at international and national conferences, crossing joyfully the disciplinary boundaries. The 17 counted international conferences comprises: ECEEE, (Social) studies of science and technology, Design, in Europe but also in Asia and in the USA. More than 50 conferences have been given in Belgium around the themes of energy consumption and sustainability, before very different publics (policymakers, architects, local associations, energy auditors, etc.).

CRIOC-OIVO has used several media to spread the messages resulting from the ISEU research: TV, websites, press releases, etc.

As ICEDD teaches energy auditors, this 'captive' public has been assaulted with sufficiency ideas.

During the 4-years project ULB has built an important academic international network around household energy consumption:

- Working parties in Lancaster (around Elizabeth Shove)
- Participation to the launching of the PIERI (Paris7 Interdisciplinary Energy Research Institute)
- ANT-E (Actor Network Theory & Energy), organised by Thomas Berker (Trondheim, Norway)
- Frequent contacts with the GRETS (sociologists of EDF)

ULB and ICEDD (with the Antwerp University) are currently funded by the Belgian Science Policy to lead a study about "Household Energy Consumption and

Rebound Effect". ULB has a research contract with Electrabel (main Belgian electricity provider) in order to help its consumers to reduce their consumption. ULB has projects with François Jégou and a SME around objects of domestic energy, that could be funded by the Walloon Region.

7. PUBLICATIONS

Peer review

Wallenborn G., Prignot N., Thollier K., Rousseau C., Van Cutsem A. (2007), « Energy-using products as embodying heterogeneous requirements », *WIT Transactions on Ecology and the Environment*, Vol 105, C.A Brebbia & V. Popov (eds.), WIT Press, 2007.

Wallenborn G. (2007), "How to attribute power to consumers? When epistemology and politics converge", in *Sustainable Consumption, Ecology and Fair Trade*, E. Zaccaï (ed.) London, Routledge, pp. 57-69.

Wallenborn G., Dozzi J. & Lennert M. « Inégalités écologiques : une analyse spatiale des impacts générés et impacts subis par les ménages belges », *Espace Populations Sociétés* 2008-1, pp.127-143.

Prignot N. & Wallenborn G. (2009), « Standardisation of practices and representations of users in the ecodesign Directive », Proceedings of the ECEEE Conference, 1-6 juin 2009, La Colle-sur-Loup, France.

Wallenborn, G. (2010), "Lighting" in *Green Consumerism. An A-to-Z Guide*, Juliana Mansvelt(ed.), Sage Publication.

Wallenborn, G. (2010), "Energy efficiency of products and appliances", in *Green Consumerism. An A-to-Z Guide*, Juliana Mansvelt(ed.), Sage Publication.

Wallenborn G., Orsini M. & Vanhaverbeke J. (2011), "Household appropriation of electricity monitors", Journal of Consumer Studies, Special Issue on "Household Technology and Sustainability".

F. Klopfert & G. Wallenborn, "Les 'compteurs intelligents' sont-ils conçus pour économiser l'énergie ?", Terminal 106 (To be published in 2011).

Others

Wallenborn G. (2006), « De l'environnement au social : jalons pour une culture de l'énergie », *Etopia* 2.

Wallenborn G. & Dozzi J. (2007), « Du point de vue environnemental, ne vaut-il pas mieux être pauvre et mal informé que riche et conscientisé ? », in *Environnement et inégalités sociales*, P. Cornut, T. Bauler and E. Zaccaï (eds.), Editions de l'Université de Bruxelles.

Wallenborn G. (2007), « What does 'energy efficiency' means for the households ? », in *Energy Efficiency – Key Pillar for a Competitive, Secure and Sustainable Europe*, C. Hey (ed.), Background Material for the EEAC Statement and Annual Conference 2007, Evora.

Wallenborn G. (2007), « Quelles politiques énergétiques pour affronter les inégalités en Belgique ? » Politique 53 (février 2007)

Rousseau C., Writing of the leading article in Symbioses, educational magazine, dedicated to global warming and education (september 2008)

Orsini M. & Wallenborn G. (2008), « Thermophiles and thermophobes : what are the household practices of energy consumption »Hans Schnitzer, Sergio Ulgiati, 6th Biennal International Workshop Advances in Energy Studies, Towards a holistic approach based on science and humanity, Proceedings, Graz University of Technology, Graz, pp. 160-168.

Wallenborn G. (2008), « The new culture of energy : how to empower energy users ? », *The Culture of Energy*, M. Rüdiger (ed.), Cambridge Scholars Publishing, pp. 236-253.

Prignot N. & Wallenborn G. (2008), « Designing Uses of Energy-Using Products Through Participatory Scenarios », Sustainable Innovation 08. Future Products, Technologies and Industries, 13th International Conference, 27th - 28th October 2008, Malmö University, Sweden.

Wallenborn G. (2009), « Penser la consommation pour elle-même. Quelle ontologie pour analyser la consommation ? Exemple de la consommation domestique d'énergie. », in *Consommer autrement: La réforme écologique des modes de vie*, Michelle Dobré & Salvador Juan (eds.), L'Harmattan, pp. 29-38.

Marcelle H. & G. Wallenborn, « Crise écologique et sociale », La Libre Belgique mai 2009.

G. Wallenborn (2009), "Inégalités écologiques et justice sociale", Texte de l'intervention au Forum des Associations, Lille, novembre 2009

Jégou F., Liberman J. & Wallenborn G. (2009), « Collaborative design sessions of objects proposing energy-saving practices », First European conference on energy efficiency and behaviour, Maastricht, 18-20 October 2009.

Wallenborn G. (2010), Integrating Standards, Ecodesign and Users. The ISEU Project, *We can change the weather,* VUB Press, Brussels.

REFERENCES

Abele, E., Anderl, R., Birkhofer, H. (eds.) (2004), *Environmentally-Friendly Product Development. Methods and Tools*, London, Springer.

Abrahamse, W., Steg, L., Vlek, C., Rothengatter, T. (2005) A review of intervention studies aimed at household energy conservation *Journal of Environmental Psychology* **25**, 273–291.

Akrich M. (1995), "User Representations: Practices, Methods and Sociology", in Rip A., Misa Tj., Schot J. (ed.), *Managing Technology in Society. The Approach of Constructive Technology Assessment*, London, Pinter, pp. 167-184.

Aune, M. (2007), "Energy comes home", *Energy Policy* 35, pp. 5457–5465

Bakker K. & Bridge G. (2006), "Material worlds? Resource geographies and the 'matter of nature'", Progress in Human Geography 30, pp. 5–27.

Bartiaux F. (2008), "Does environmental information overcome practice compartmentalisation and change consumers' behaviours?", *Journal of Cleaner Production* 16, pp. 1170-1180.

Bertoldi P. and Atanasiou B. (2006), "Residential Lighting Consumption and Saving Potential in the Enlarged EU", in Bertoldi P. (edt.) *Proceedings of the 4th International Conference on Energy Efficiency in Domestic Appliances and Lighting* (EEDAL06), 2007, London.

Borraz, O. (2007), "Governing Standards: The Rise of Standardization Processes in France and in the EU", *Governance: An International Journal of Policy, Administration, and Institutions* 20, pp. 57–84.

Braun, B. (2008), "Environmental issues: inventive life", Progress in Human Geography 32(5), pp. 667–679.

Brohmann B., Heinzle S., Rennings K., Sleich J., Wüstenhagen R., 2010, "What's driving sustainable energy consumption? A survey of the empirical literature", Centre for European Economic Research, Discussion Paper No. 09-013.

Brugidou, M. & Moine M. (2010), "Normes émergentes et stigmatisation", JADT 2010 : 10es Journées internationales d'Analyse statistique des Données Textuelles.

Calwell C., 2010, *Is efficient sufficient? The case for shifting our emphasis in energy specifications to progressive efficiency and sufficiency*. Report prepared for the European Council for an Energy Efficient Economy (eceee).

Carmagnola, F. (1991). Luoghi della qulità, Estetica e tecnologia postindustriale. Domus Academy Edizione, Milan, Italy.

Collins, H. M. (1974), "The TEA set: tacit knowledge and scientific networks", *Science studies* 4 (1974), 165-86.

COM (2007), "European Strategic Energy Technology Plan' (SET-Plan)", Communication from the Commission to the Council, the European Parliament, the European economic and social Committee and the Committee of the regions.

COM (2004), Integration of Environmental Aspects into European Standardisation, Communication From The Commission To The Council, The European Parliament And The European Economic And Social Committee.

Cooremans, C. (2009), "The role of formal capital budgeting analysis in corporate investment decision- making: a literature review », ECEEE 2009 Summer Study.

Dahan, A., S. Aykut, C. Buffet et A. Viard-Crétat, (2010), Les leçons politiques de Copenhague. Faut-il repenser le régime climatique ?, *Koyré Climate Series*, no 2, 45 p.

Darby, S. (2006), "The effectiveness of feedback on energy consumption. A review for defra of the literature on metering, billing and direct displays", Defra.

Darby, S. (2007), "Enough is as good as a feast – sufficiency as policy", ECEEE 2007 Summer Study.

Debaise, D., (2004), "Qu'est-ce qu'une pensée relationnelle ?", *Multitudes* no 18, pp. 15-23.

Directive 2005/32/EC of The European Parliament and of The Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products.

Fischer C. (2008) Feedback on household electricity consumption: a tool for saving energy?, *Energy Efficiency* **1**, 79–104.

Foucault, M. (1977), *Discipline and Punish: The Birth of the Prison*, New York, Vintage.

Gram-Hanssen, K. (2008), "Heat comfort and practice theory. Understanding everyday routines of energy consumption", Proceedings of the SCORE Conference, Brussels, March 2008, pp. 53-72.

Greening, L.A., Greene, D.L., Difiglio, C, (2000). "Energy efficiency and consumption -the rebound effect: A survey", *Energy Policy*, 28, pp. 389-401.

Hargreaves, T., Nye M. & Burgess J. (2010), Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors, Energy Policy 38, 6111–6119.

IPCC, 2007, Fourth Assessment Report (AR4): http://www.ipcc.ch/

Jackson, T. (2005), *Motivating Sustainable Consumption. A review of evidence on consumer behaviour and behavioural change*, A report to the Sustainable Development Research Network: http://www.comminit.com/en/node/219688

Jelsma, J. (1999), "Philosophy meets design, or how the masses are missed (and revealed again) in environmental policy and ecodesign", In: *Consumption, Everyday Life and Sustainability*, reader for ESF Summer School 1999, Lancaster university, Lancaster, Center for Science Studies, Lancaster University.

Jelsma, J. (2003), "Innovating for sustainability: Involving users, politics and technology", *Innovation* 16, pp. 103-116.

Jensen J. O. (2008) Measuring consumption in households: Interpretations and strategies, *Ecological Economics* **68**, 353–361.

Kaufmann, J.-C. (1998), *Dirty linen : couples and their laundry*, London, Middlesex University Press.

Kautto, P. (2007), "Industry–Government Interaction in the Preparation of a New Directive: Nokia, Industry Associations and EuP", *European Environment* 17, pp. 79–91.

F. Klopfert & G. Wallenborn, "Les 'compteurs intelligents' sont-ils conçus pour économiser l'énergie ?", Terminal 106 (To be published in 2011).

Latour B. (2008), "A Cautious Prometheus? A Few Steps Toward a Philosophy of Design (with Special Attention to Peter Sloterdijk)", Keynote lecture for the *Networks of Design** meeting of the Design History Society Falmouth, Cornwall, 3rd September 2008.

Latour B. & Woolgar S. (1979), *Laboratory Life: The Social Construction of Scientific Facts*, Beverly Hills, Sage Publications.

Lewis, H. & Gertsakis, J. (eds.) (2001), *Design + Environment*, Greenleaf Publishing Limited, Sheffield UK.

Liikkanen L. (2009) Extreme-user approach and the design of energy feedback systems. In *Proc. of EEDAL 2009* - 5th International Conference on Energy Efficiency in Domestic Appliances and Lighting.

Lockton D., Harrisona D. & Stantona N. (2008), Making the user more efficient: Design for sustainable behaviour, *International Journal of Sustainable Engineering* **1**, 3-8.

Manzini, E. (2009). New design knowledge. Design Studies 30, 4-12.

Martiskainen, M. & Ellis, J. (2011), The role of information and communication technologies (ICTs) in household energy consumption - prospects for the UK, *Energy Efficiency* (to be published).

Marvin S., Chappells H. & Guy S. (1999), Pathways of smart metering development: shaping environmental innovation, Computers, *Environment and Urban Systems* **23**,109-126.

Nye, D. E. (1998), *Consuming Power: A Social History of American Energies*, Cambridge, Mass., MIT Press.

Pantzar, M., (1997), "Domestication of Everyday Life Technology: Dynamic Views on the Social Histories of Artifacts". *Design Issues* 13, pp. 52-65.

Reckwitz, A. (2002), "Towards a Theory of Social Practices: A Development in Culturalist Theorizing," *European Journal of Social Theory* 5, pp. 243–63.

Ropke, I. (2001), "New technology in everyday life - social processes and environmental impact", *Ecological Economics* 38, pp. 403-422.

Røpke, Inge (2009), "Theories of practice – New inspiration for ecological economic studies on consumption." *Ecological Economics* 68:2490-2497.

Rorty R. (1980), *Philosophy and the Mirror of Nature*, Basil Blacwell, Oxford.

Rüdiger, M. (ed.) (2008), *The Culture of Energy*, Cambridge Scholars Publishing.

Sachs, W. (1999). Turning vision into reality: Rethinking how sustainable business must operate in thefuture. Brussels: Workshop of the Federal Council for sustainable development, 9/29/1999.

Schatzki, T. (1996), So*cial Practices: A Wittgensteinian Approach to Human Activity and the Social*, Cambridge, Cambridge University Press.

Schatzki, Theodore R., Karin Knorr Cetina and Eike von Savigny (eds) (2001), *The Practice Turn in Contemporary Theory*. London & New York: Routledge.

Shipworth, M. (2008), "Central Heating : an Energy Efficient Technology Scripting Energy Inefficient Behaviour?", *4S-EASST join conference 2008*, Acting with Science, Technology and Medicine, Rotterdam, the Netherlands, August 20-23.

Shove, E. (2003), *Comfort, cleanliness and convenience: the social organization of normality*, Oxford, Berg.

Shove, E. & Walker G. (2007), Governing innovations in systems of practice: sustainability, transitions and everyday life, Paper prepared for Workshop on 'Politics and Governance in Sustainable Socio- technical Transitions' 19-21st September 2007, Berlin.

Shove, E. and Pantzar, M. (2005), "Producers and Practices: Understanding the invention and reinvention of Nordic Walking", *Journal of Consumer Culture* 5, pp. 43-64.

Shove, E., Watson M., Hand M. & Ingram J. (2007), *The Design of Everyday Life*, Oxford, Berg.

Sorrell, S. & Dimitropoulos, J. (2008), "The rebound effect: Microeconomic definitions, limitations and extensions", *Ecological Economics* 65, pp. 636-649.

The Climate Group (2008), SMART 2020 : Enabling the low carbon economy in the information age, Report on behalf ot he Global eSustainability Initiative, Creative Commons.

Thevenot, L. (1994), « Le régime de familiarité. Des choses en personne », *Genèses*, 17, 72-101.

Verbeek, P-P. (2005). *What Things Do – Philosophical Reflections on Technology, Agency, and Design*. Penn State.

Verbeek, P.-P. & Slob, A., eds., (2006), *User Behavior and Technology Development*, Dordrecht, Springer.

Wallenborn, G. (2008), "The new culture of energy : how to empower energy users ?", in *The Culture of Energy*, M. Rüdiger (ed.), Cambridge Scholars Publishing, pp. 236-253.

Wallenborn, G., Rousseau C. and Thollier K. (2006), *Specifying household profiles for more efficient energy demand-side management*, Final Report CP50, Belgian Science Policy (French report, English summary).

Wallenborn G., Prignot N., Thollier K., Rousseau C., Van Cutsem A. (2007), « Energy-using products as embodying heterogeneous requirements », *WIT Transactions on Ecology and the Environment*, Vol 105, C.A Brebbia & V. Popov (eds.), WIT Press, 2007.

Prignot N. & Wallenborn G. (2009), « Standardisation of practices and representations of users in the ecodesign Directive », Proceedings of the ECEEE Conference, 1-6 juin 2009, La Colle-sur-Loup, France.

Wallenborn G., Orsini M. & Vanhaverbeke J. (2011), "Household appropriation of electricity monitors", Journal of Consumer Studies, Special Issue on "Household Technology and Sustainability".

Warde, A. (2005), "Consumption and theories of practice", *Journal of Consumer Culture* 5, pp. 131-51.

Weedman, J. (2005). Designers, Clients, And Knowledge Production. D-Lib Magazine 11 (7/8). www.dlib.org/dlib/july05/khoo/10_weedman.pdf

Wilhite, H. & Ling R. (1995) Measured energy savings from a more informative energy bill, *Energy and buildings* **22**, 145-155.

Wilhite, H., Nagakami, H., Masuda, T., Yamaga, Y., Haneda, H., (1996), "A cross-cultural analysis of household energy use behaviour in Japan and Norway", *Energy Policy* 24, pp. 795–803.

Wilhite, H., Shove, E., Lutzenhiser, L. and Kempton, W. (2000). Twenty Years of Energy Demand Management: We Know More About Individual Behaviour But How Much Do We Really Know About Demand. ACEEE 2000 Summer Study on Energy Efficiency in Buildings.

Zaccaï E. & Bruyer V. (2006), "Environmental product policies and consumers: challenges and misunderstandings" in M. Pallemaerts (ed.), *The EU Internal Market and the WTO Multilateral Trading System: Constraints and opportunities for national environmental product regulation*, VUB University Press, Brussels, pp 21-43.