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SCIENCE FOR A SUSTAINABLE DEVELOPMENT

Integration of Standards, Ecodesign and Users in energy-using products

"ISEU"

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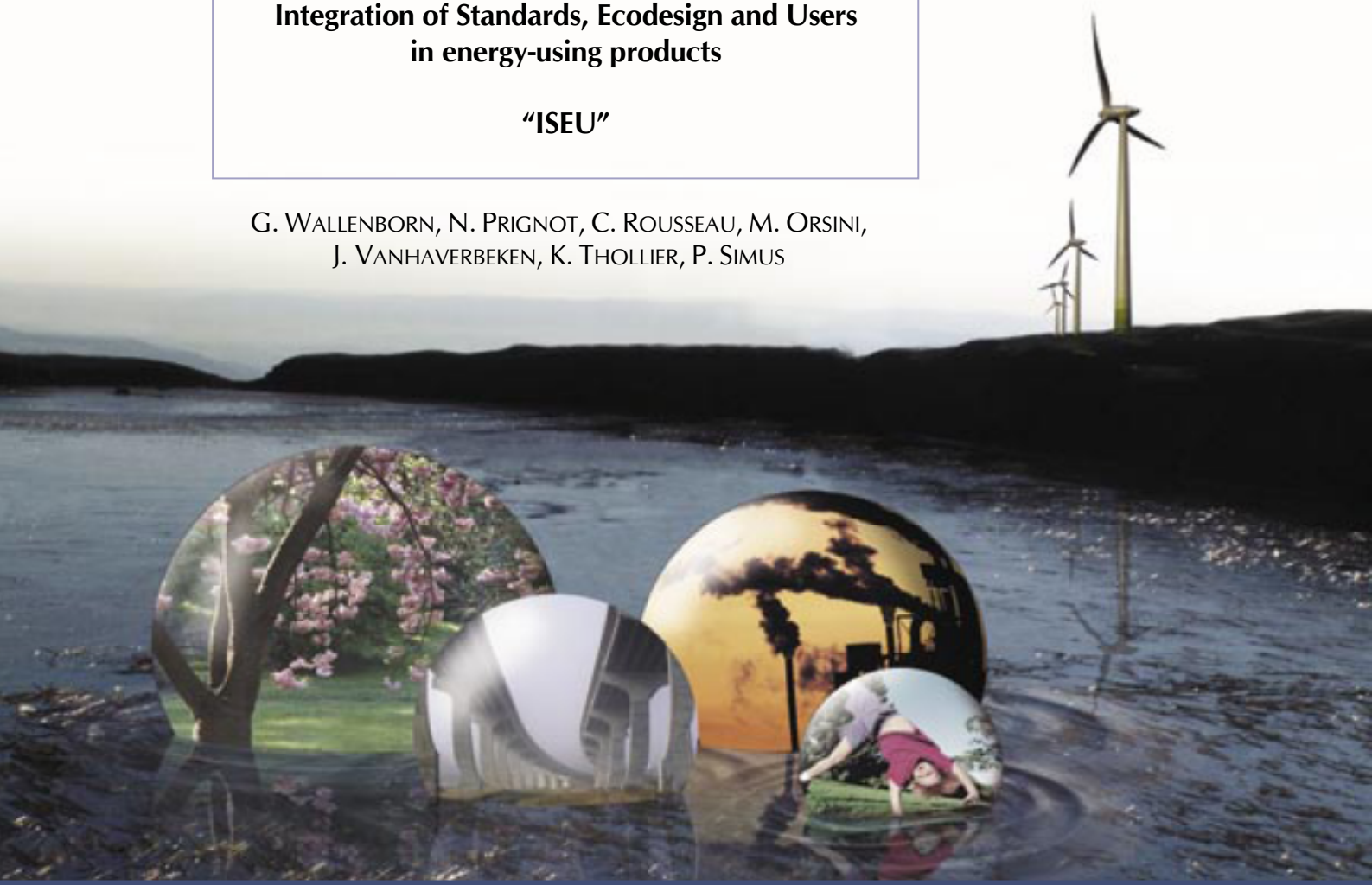

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FINAL REPORT PHASE 1

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

SD/TA/07A

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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

Structure of the report

This report presents the main results of the first phase of our research. During these two first years, through desk research, interviews with different actors, attendance and participation to different 'stakeholders' meetings' and production of ecodesign scenarios, we have begun to analyse how domestic appliances and their uses are designed together, and what is their place in the current 'culture of energy'.

In the second phase of our research (2009-2010), we will carry on the analysis of the implementation of the ecodesign directive, and will start a survey about the use of smart meters by households.

The present report is divided into six parts. The first part introduces to the general theme of our project, and exposes the objectives of our research, our main research questions, as well as an original interdisciplinary methodology that has allowed the partners, coming with heterogeneous backgrounds, to appropriate the questions. We give there the reasons of our interest in the use phase of the EuPs[1] and in the representations of the users.

The second chapter gives some theoretical resources and concepts needed to answer to our research questions. What can be understood in household energy consumption when putting objects at the centre of the stage? Since we have to follow different tracks (fabrication of the products, households' practices), we will briefly present the idea of a 'practice theory' and the actor-network theory. EuPs will be seen as incorporating cultural and political elements, with many other constraints, and this incorporation is subject to many different controversies.

The third part is on energy efficiency and sufficiency. As we have noticed that energy sufficiency and rebound effects are not always well known, we devote a small chapter to these notions, and indicate some of their implications for public policies.

The fourth chapter describes the implementation of the ecodesing directive, and makes a critical analysis of this process. In order to understand how EuPs are conceived, we are following implementation of the 'ecodesign' directive for some specific products. Through interviews and participation to 'stakeholders' forums', we are following how new energy-products for households are negotiated. The discussions about the 'implementing measures' of the ecodesign directive are an invaluable source of information.

The fifth chapter presents five case studies: domestic lighting, heating control, washing machines, personal computers, smart metering. It constitutes about the half of our report, because it is the most original part of our research. For each case study, we have established a working document organised around our research questions. To answer to these questions, we have collected data in the 'preparatory studies' of the ecodesign directive, and from other sources. We have chosen a transversal question for all cases: how the different appliances are conceived on the basis of presupposed uses and users? In order to establish contrasts with the representation of users in the preparatory studies of the ecodesign directive, we have added some results of the work realised by a subcontractant (François Jégou and Joëlle Liberman) about new devices co-elaborated with users in order to reduce their energy consumption. Each case is however analysed through specific problematics.

In order to understand the gap between explicit policy aims (based on rational agents) and the reality of practices (householders are better described as hedonistic), we have developed a theoretical framework, which adds to the two first 'ontologies' (rational and hedonistic) an experimental ontology.

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[1] 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

Acknowledgements

We are grateful to the "follow-up committee" of our research for having brought us with passionate discussions and very interesting ideas. We have met numerous individuals coming from industry, NGO and administration, that we thank warmly.

1. RESEARCH QUESTIONS AND SCOPE OF THE RESEARCH

1. The household material culture of energy

Today 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 (2007) suggest that GHG should be reduced by 60 to 85% by 2050 in Europe[2]. 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.

The electricity consumption of households[3] is steadily increasing. This is the reason why the European Commission has decided to tackle this problem, already a few years ago by energy labelling and ecolabels, and now more decisively by issuing a directive on ecodesign of energy-using products. 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 (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"[4], 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. This mutation has to be accompanied in order to prevent social disruption and to limit environmental impacts. The transition towards 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, which is only one of the possible means).

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[5], and "sustainable development" means here that we have the obligation to create ways combining properly efficiency and sufficiency principles. Besides, our science is certainly

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

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

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

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

something that has to be developed as well!
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, equipments. 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.
We have developed our interest in the "culture of energy" of households in our previous study (Wallenborn et al., 2006). This project familiarised us with the literature about perceptions, attitudes, behaviours and practices related to household energy consumption. Through a quantitative survey and qualitative methods (i.e. focus groups and individual interviews), we concluded that the "material dimension" of the culture of energy is often a stronger determinant of current consumption than knowledge, attitudes and behaviours. For instance, we have observed that energy-consuming practices are fragmented, "compartmentalised" (Bartiaux, 2008) according to the activity sector (heating, lighting, cooking, washing, …) and the equipment used in each activity. This means that the same person can be very attentive to her energy consumption with one type of appliance while not seeing or realising her consumption with another. That can be explained by different factors as the consumption dynamics, personal motivations and interactions between household members.
From the households' viewpoint, energy is distributed in a series of actions, the purpose of which is not to consume energy but to provide a set of services.[6] This set of services is disparate and as a rule is not perceived to belong to the energy category (unless people are questioned on this point). Some households have got into the habit (through education in particular) of paying attention to certain uses, but energy-consuming practices continue to come in for varying degrees of thought. Another blind spot for possible indicators is the inaccessible domestic interactions. It is not easy to describe the many interactions occurring between members of a household, and leading to energy consumption. Our segmentation has shown that practices of energy consumption are very different from one household to another, and are generally better explained by socio-demographic variables (as the social group) than attitudes. The sheer number of used electrical appliances seems to explain much of the electricity consumption.
We have then made the hypothesis that the culture of energy should be studied through the energy-consuming objects and their provided services, even though it is difficult to theoretically separate the culture of energy from the other social practices. This perspective leads to focus on the interactions between households and their energy-using products.
Policies tend to give their attention to sustainable production (of energy). When they come to consider sustainable consumption, and call upon a 'change in consumption patterns', they generally use policy instruments directed at changing attitudes. 'Socio-cultural factors' are often supposed to be more important for understanding practices. These factors are deemed to be modifiable and to offer a firm grip. However, the material dimension of the culture of energy is virtually unexplored when forging policy instruments. The adopted perspective of the study is the mutation of the culture of energy, understood particularly in its material dimension.[7]

2. Objectives of the research

The main objective of the ISEU project is to understand household energy consumption in studying the relationships between users and EuPs. How far is it possible to change behaviours

[6] Household energy consumption is rarely conspicuous (Veblen, 1899; Shove 2003), i.e. that it is not directly linked to a social status — contrarily to other modes of consumption (e.g. car or clothes).
[7] Knappett & Malafouris (2009) explores the notion of "material agency"

through objects? This question is posed at both theoretical and experimental levels. We are exploring the hypothesis that cultural changes can (partly) be brought forth through objects. We will assess at the end of the project the relevance and promises of this approach.
Objectives of the research project are of three kinds: theoretical, practical recommendations and empowerment of the partners. The main objectives and expected outcomes are the following:

- to analyse the 'material culture' of energy of households, relying on qualitative surveys and energy audits
- 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

At the end of the project, in 2010, four specific conferences will gather different public (representatives of industry, ecodesigners, public authorities, energy auditors, educators, academics) to discuss and evaluate our propositions.

3. Why focusing on the use phase?

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 extensively 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.

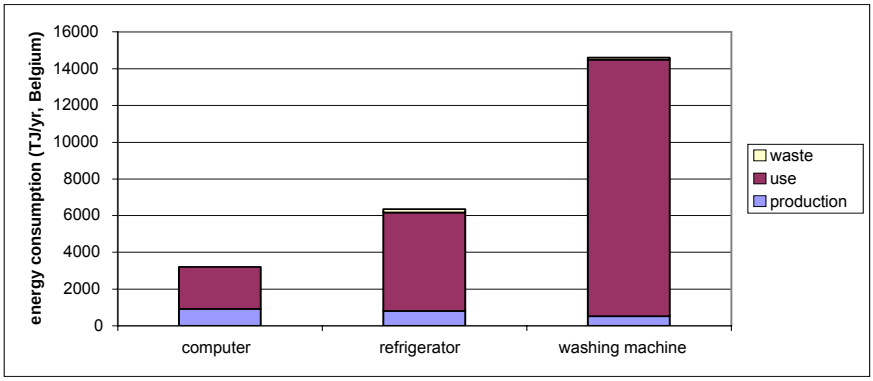

Fig.1. Energy consumption by phase for 3 EuP's.

On another hand, the largest impact of an EuP on the environment occurs indeed during its use phase, as one can see in the figure 1. 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)[8].
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.

4. 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 CRIOC (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 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 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

[8] 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).

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 will help us to disseminate interesting results to a wide range of different audiences.

2. PRACTICES AND OBJECTS

We are concerned with the interaction between householders and objects that are associated to a 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 (affordances). For this we need also to analyse two different subjects, to which different theoretical approaches have to be adapted: 1) how the energy-using objects are conceived; 2) how these objects are used. We use the 'actor-network theory' to tackle the former question, and the 'practice theory' to deal with the latter, and present briefly hereunder their interest for our research.

1. Actor-network theory

The material culture of energy is made up of a fascinating profusion of marvellous objects. EuPs provide us with a series of services, relieving painful tasks, emancipating women, creating comfortable climate, connecting us, etc. The electrification of houses and the diffusion of central heating have deeply transformed our practices and habits. Science and technology studies (STS) are very appropriate to analyse these transformations, for it tries to overcome the traditional alternative of determination (things are led either by technology or by society) (Bijker and Law 1994).

The actor-network theory (ANT: Latour 2005) is very useful to follow the construction of artefacts, and fits well with considerations on sustainable development. An object is both a construction of heterogeneous elements and part of different networks. The object is working and can be moved only because networks are carefully maintained, notably through metrology and standards. We can think of cars requiring roads and provision of fuel, or of the electrical network carefully maintained at 220V. Objects are seen as associations, nodes of networks that tie material elements with human practices, empirical and symbolic resources. An object is seen as the folding of heterogeneous times, spaces and actors (Latour, 2002). The idea that products and technologies are made of entities and relations allows to analyse their production and their working. From this point of view, technology can be seen as an analysis of human relations (Callon, 1987). ANT is sometimes called 'sociology of translation' for an actor-network is changed when it is displaced: its internal relations hold together because of relations to the context.

In the case of EuPs, this approach has several consequences. Appliances are not only a material arrangement; they are also household agencies, constructed through social and symbolic relationships. EuPs can be considered as traces of a culture of energy: each device belongs clearly to a determined epoch. Appliances are technical and social, irreducibly. Material culture of energy is therefore not only material. Analysing an appliance means to list all the relationships around them, including their associated consumptions. EuPs are at the junction of at least three different networks:

- the "production" network, from the extracting of raw materials to the disposal, through the household, including production and distribution. It is possible to see how 'environment' is translated into the appliance at each place of the network;
- the energy network, essential to the functioning of the EuP;
- the household, compound of human relationships, practical tasks, desires, values,… and gathered in a singular space.

The practices of EuPs can be analysed through the distributed action between the user and the appliance: action can be more or less delegated to the machines, for instance in scripting some practices into the objects (Latour 1993, Shove 2003). It has an important consequence for our project since it entails that behaviours are more or less shaped by appliances, and that objects are moralising devices (Foucault 1977, Verbeek & Slob 2006). Moralising means here that mores (i.e. the way people behave) are changed through objects. Technical objects can embody morality, as the beep of the safety belt when not tied up. Material agencies induce certain mores and prevent others. In our research we are interested mainly in two categories of

moralising: 1) the incorporation of standards in the processes and products; 2) the way uses are shaped by the objects. How are environment, on one hand, and users' practices, on the other hand, scripted into objects?
ANT shows its limits however when coming to users, since this approach mainly analyses the process of innovation and supply construction. How would it be possible to integrate uses and users in this picture? How far is the study of demand side relevant for this approach?

2. Practice theory

What does consume energy, the user or the object? The obvious answer is both, although involved in a practice which purpose can be a lot of different things but the explicit aim of consuming energy. Energy consumption is a very aggregated indicator that informs us little about its origin and reasons. A practice is a "routinized type of behaviour which consists of several elements, interconnected to one other: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know how, states of emotion and motivational knowledge." (Reckwitz 2002)
According to 'Practice theory'[9], agency is distributed among humans and non-humans. This theory is a reply to 'action theory' that describes action as a behaviour caused by an agent in a specific situation. According to action theory, the agent is purely human and is motivated by desires, beliefs or reason. This leads obviously to models studying mainly the relation between attitudes and behaviours. On the contrary, practice theory is more equipped to describe unconscious activities and daily routines, as well as the interaction between bodies and objects in which understandings, procedures and engagement are involved. Action is then not simply an implementation of an intention. It is constituted by the agency (a capacity to act) carried by a nexus of heterogeneous elements. The practice is achieved through the connexion of different actor-networks. That implies that the origin of agency is undetermined, distributed among different actors, human and non-human.
Practice theory allows to understand different phenomena related to household energy consumption: compartmentalisation of practices, appropriation and domestication of appliances, negotiation between members of the household, habits.
We have observed that there is no single, homogeneous electricity consumption pattern, no consistent electricity saving pattern (Wallenborn et al. 2006). The diversity of rationalities and the compartmentalised practices depend not only on the households, but also on the activity sector within a household. For a same sector and a same household, it can also vary with time. Electricity consumption can be understood only by examining it in relation to the various sectors of activity (lighting, cooking, cleaning, recreation, etc.). It is explained by the fact that people use services provided by appliances, and do not associate energy consumption. (Though some appliances, as big American fridges or plasma screens, are acquired for other satisfactions than their utility). In this sense, some uses are motivated by a diversity of reasons: for instance, lighting is used to create atmosphere, space or security feelings.
The interface between an object and a user can be described by the couple script/affordance. 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. Practices are scripted by the conception of the appliance (Akrich 1995)."Scripts are the structural features of artefacts encouraging certain user actions while counteracting others" (Jelsma 2003). Scripts have a prescriptive force that steers users in a certain direction (Shove 2003). On the other hand, appliances are also affordances[10]: the appropriation of an object by a user can never be completely closed. Users are not passive in the domestication process of EuPs (Ingram et al. 2007). While a script implies an author (engineer or designer), the notion of

[9] Practice theory has been developed by Schatzki (1996) and Reckwitz (2002), and summarised in Warde (2004).
[10] The affordance is the property of an object or system having easily discoverable action possibilities. Rather than "to provide" or "to make available", designers often use "to afford" as meaning "to suggest" or "to invite".

affordance indicates a possibility for the user (Bardini 1996).
Literature on innovations in practice demonstrates that manufacturers and producers are routinely unable to control the fate and fortune of the things they make, and that consumers, far from being external to systems of innovation, are central to them (Franke and Shah, 2003; Shove and Pantzar 2005). The introduction of a new appliance in a household change practices and sometimes relationships between persons. There is a phase of negotiation with the object, which can be prolonged between humans (cfr. thermostat). Eventually, a new habit is shaped. The process of appropriation leading to habits is crucial to understand, because it conceals key moments when it is possible to influence practices
The notion of 'appropriation' is used to describe how users integrate the objects in their own lives, households or network. Users integrate objects into an existing network of other objects, practices and meanings. Technologies can be embraced, subverted or resisted in everyday lives on a personal level, as well as societal level. Studies about appropriation emphasise the role of users in the appropriation, and underline the fact that it is often a very active process (Pantzar 1997). Technologies are not just adopted and accepted, they are actively integrated in households' dynamics. This is mostly visible with new technologies, that modify something, 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 much, 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, inform themselves, buy thing, and so on. When an appliance breaks down, all these unnoticed changes become apparent. 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.
User is actively taking part in the functioning of the system. The action is not simply an implementation of an intention, for it is constituted by an agency (capacity to act), a nexus of relations. Practices are the incorporation of the dynamics of the object, and its memorization by the body, as in the case of driving, sports, household activities. From a semiotic point of view (see Jelsma 2003), objects radiate meaning, and they move humans and drive them to action. The humans are moved, but are also active because they transform the meaning, they "read" objects and give them meaning. And this meaning is not only theoretical, it does not stand on the simple level of understanding; this meaning is also important for the uses that the users will have. The uses are co-defined by the objects and the humans. There are different modes of integration of technologies in daily lives: service oriented, technical, symbolic, etc. 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. It can change the way users interact, can modify their social identity. It changes the division of labour in households. The appropriation of an object is always a negotiation: with its technical features, and with other members of the household when it is collective. For instance, we have observed that more or less half of the households have conflicts about the setting of the indoor temperature.
Appropriation of a new technology is not only a process of domestication in households, it is also a process of historical change at the societal level. There are different steps in the life of a product on a market. It can go from a very specialised niche of users to a mass-market. It can turn from a toy to an indispensable tool (cars, televisions, home computers). 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 (cell phones). Products can undergo transformations "from "toys" to "instruments", from "luxuries" to "necessities", from "pleasure" to "comfort", or from "sensation" to "routine". These different transformations should be understood altogether as changes in networks of objects, for these transformations do not occur with one object at a time, but that the acquisition of an object often leads to the adoption of others (microwave oven, freezer and prepared meals). When an object becomes "normal" its acquisition does not require a justification anymore. Pantzar (1997) argues "that, rarely, is a new commodity a response to some basic need". These commodities replace older ones with the same purpose, or are introduced with no practical function whatsoever.

New habits are more or less quickly contracted, according to the objects. For instance, radio has spread out much faster than appliances for household tasks. In Denmark, washing machines were rather quickly adopted, while fridges were slower to integrate households in reason of the related pattern of shopping (Thorndal 2008). New technologies of information and communication are diffused faster that previous objects. It seems that the modification of household routines is linked to the change of routines outside the home, as well as the evolution of social norms and values.
In conclusion to these considerations, based on the actor-network and practice theories, we can state that energy-using products incorporate cultural and political elements. This is important to acknowledge when analysing the way EuPs are conceived and negotiated. The political dimension is visible through the balance of power between different interests that results in the definition of the EuPs. But it is also visible with the ceaseless call to solve environmental problems through energy efficiency. Furthermore it leads to methodologies that emphasise the role of controversies and constraints surrounding these objects.

3. Controversies and constraints

A methodology to analyse the composition of the EuPs as an association of heterogeneous elements is to follow controversies and debates occurring when they are in the making. This non-essentialist approach of technology allows a democratic approach, in the sense that the fate of a technology is not predetermined (Rogers, 2008). Different collective actors (companies, NGOs, administrations…) have their say on the definition of the products precisely because this definition is not established in advance. Controversies are therefore a very interesting entry for analysing the positions and arguments when new objects are under negotiation. As we shall see, controversies are not lacking about the implementing measures of the ecodesign directive.
Each energy-using object embodies a series of constraints pertaining to different categories of requirements: technology, economy, ergonomics, social and cultural aspects, health and safety, ecology, ethics… The term 'constraint' should not be considered as a limitation, but rather as what obliges to create new relations (Stengers, 1996). Constraints are mutually negotiated for eventually constituting an appliance. To be put on the market, an appliance must meet legal standards, notably safety standards. Producers have interest in marketing desirable objects, working properly for the expected use, at an attractive price but allowing to make profit. Therefore, if there were no legislation imposing lower energy consumption or requiring a lower impact on the environment, ecological standards would not be a primary issue for producers. Ecological standards add on other criteria and materialise new conflicts and necessary trade-offs. Negotiations imply that a compromise has to be reached between the different requirements, and that the result exhibits the balance of power and interests that have acted to make this result functioning. It is for this reason that an EuP embodies political and cultural values. This approach permits to analyse which constraints could be improved in a sustainable perspective. The interest of studying the implementation of the ecodesign directive resides in the fact that EuPs have to be negotiated anew by the introduction of new requirements. Controversies have effectively arisen and revealed how EuPs can be today incorporated in EU policy.[11]

[11] We have developed further our model in Wallenborn et al., 2006.

3. ENERGY EFFICIENCY AND SUFFICIENCY. HOW TO PREVENT REBOUND EFFECTS?

1. Rebound effect and households

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.
Unfortunately, efforts in the field of eco-efficiency are offset by the "rebound effect", which can go up to undo the gains in terms of reducing energy consumption and even increase consumption.

2. What is the rebound effect?

The rebound effect is the fact that improving energy efficiency does not result in the reduction of energy consumption by the amount provided by a simple technical model. 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.
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.
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.
These mechanisms explain a series of observations made in different sectors. The world economy is becoming more energy efficient, but too slowly to stabilize energy consumption (World Bank, 2008 : World development indicators). The energy intensity[12] 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 virtual 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

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

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.

3. The weight of household in the energy consumption

The household sector represents 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 2 shows the Belgian household energy consumption evolution.

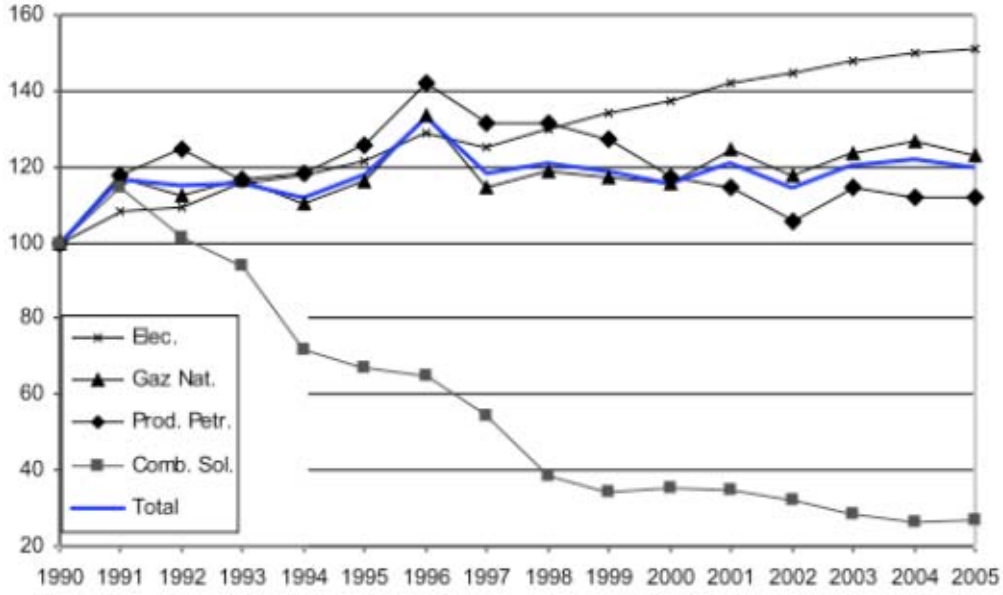

Fig 2. Evolution of the household energy consumption, by energy carrier, between 1990 and 2005 in Belgium.

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 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 others 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).

4. Implications of the rebound effect for public policies

The potential contribution of energy efficiency policies should be assessed. A recent study has modelled the system-wide effects of improving energy efficiency in Scotland (Hanley et al. 2009). They expect a large rebound effect, and link it to the income growth. As the economy grows, incomes rise, further encouraging rebound effects. In extreme cases, the consequent increase in energy demand actually exceeds the reduction in energy use due to the initial efficiency improvement. These extreme rebound effects are termed 'backfire'. The authors

conclude: "Improvements in energy efficiency generate important system-wide output and substitution effects that tend to increase energy use, and act as countervailing influences to the direct effects of being able to 'produce more with less'"(p. 705).
Although energy efficiency is commonly considered an effective way to deal with climate change and sustainability issues, the authors emphasise that the results do not suggest that energy efficiency improvements are ill-advised. Rather, the research demonstrates that policymakers need to be aware of the economic response to changes in prices and incomes as a result of improved efficiency and consider how to avoid or counteract rebound effects. For example, carefully implemented taxes on energy to offset falling prices could help avoid backfire. The classical and obvious answer to rebound effects is indeed the increasing of energy prices, proportionally to the gains in energy efficiency. Although that poses many technical and social problems, economic tools should certainly be implemented.
In our project, we want however to explore other strategies to avoid rebound effects, notably in suggesting new interfaces between users and appliances. As we are concerned with household energy-using practices, and as energy efficiency of appliances is the mainstream policy, we suggest to investigate other dimensions than technology. The impact of appliances on the environment depends largely on the context in which they are used, including user behaviour. Behaviour change is often considered as the fastest and cheapest way of reducing energy consumption. Behaviour change means doing in another way in the existing technological and legal framework. We can find many examples in booklets provided by public and private bodies. It appears however very difficult to change behaviours, for many reasons (Zaccaï, 2007). And 'behaviours' cover a wide range of practices: acquisition, use (settings), non-use, substitution, etc.
Today market is mainly supply-oriented, while demand is unarticulated. And that poses many problems for a sustainable consumption policy. The demand is either considered by companies as expressed on the market according to individual desires, or as something that should be 'managed'. "The consumer wants it" say companies, because it has been sold. The consumer is here considered as an individual (singular noun) and her or his demand cannot be expressed but with existing products, and under the great influence of dealers and advertising. For household energy consumption, the term "demand side management" implies more rationalisation of household practices, either through more efficient appliances or through behaviour change. These views on 'consumers' are obviously entrenched in a kind of reductionism that supposes that practices can be rationalised (through the market) and that they should be rationalised in some cases.
We should not expect from EuPs more than what they can offer. It is of the highest importance of looking at efficiency, but wee need also to analyse all other aspects of these appliances. It is why the ISEU project is interested both in efficiency and sufficiency approaches. It is indeed clear that improving energy efficiency will not be enough to achieve policy objectives of greenhouse gas reduction. Therefore they have to be accompanied with sufficiency strategies. Both approaches are seen as complementary, for only sufficiency approaches can counteract the rebound effect resulting from the increase of efficiency. The most obvious mean to reach sufficiency is to raise energy prices. We make however the hypothesis that material agencies can help and even empower users to reduce their total energy consumption. It is important that services provided through energy consumption will still be delivered to each category of the population.

4. IMPLEMENTATION OF THE ECODESIGN DIRECTIVE

Through the analysis of the implementation of the ecodesign directive, we take the starting point on the regulation at the European level about these objects. This is not because we think that the higher the regulation the most important it is. It is because we are able to follow the construction of this regulation, which poses many questions, and makes various actors come together at the negotiation table. The way in which EuPs for households are taken into account is very interesting as the result of negotiations. And this result will certainly lead to modification of the objects themselves, and thus to modifications of our energy consumption.
Through the process of implementation we met various actors and procedures that translate differently the objects, the environmental preoccupations and the users. These different translations make different realms of actions, different possibilities for modifying the world. We begin with a definition of ecodesign, as we shall see how this concept has been used in a particular way by the Commission. We will then describe what is the origin of the directive and how it is currently implemented.

1. 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, 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.

2. The ecodesign directive, step by step

The directive 2005/32/EC "establishing a framework for the setting of ecodesign requirements for energy-using products" [13]. (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.[14] As we shall see, implementing measures deal mainly with energy efficiency of

[13] http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm
[14] Like other 'new approaches' directives, the implementing measures will require legal standards that

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 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. Hopefully, the directive is under revision in order to integrate new product categories, and emphasis is given to different environmental aspects.
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)[15] 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[16]:

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 are currently 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 released last October, 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.
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.

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will have to be produced by legal standardisation bodies.
[15] Reintjesand & Jepsen (2008) analyse the stakeholder's participation.
[16] The process can easily be followed on: http://www.eceee.org/Eco_design/products

At this moment (March 2009), three product categories have been submitted to new regulation: standby modes, simple set-top boxes and non-directional lamps. Battery chargers have been approved by the Regulatory Committee and will be soon discussed at the European Parliament.
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".[17] 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.

3. 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, 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[18].
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

[17] Document "Ecodesign for Washing machines" on http://ec.europa.eu/energy/efficiency/ecodesign/forum_en.htm
[18] For our case studies (see chapter 5), we have particularly scrutinized the task 3.

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 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.

4. 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.[19] 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."[20] (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 example is the European energy label, mandatory for different product groups. Another example of the involvement of test standards is the EU eco-label.
Borraz (2007) has analysed the process of normalization at the European and French levels.

[19] http://www.newapproach.eu/
[20] In the French version, the meaning is even stronger: "Telles des forces invisibles, les normes veillent au bon ordre des choses."

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 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.

5. What is the functionality of an EuP?

The ecodesign directive is presented as a breakthrough in EU product policy for it introduces many innovative elements together with concrete application of the principles of the "better regulation" package. This process is very interesting indeed and will have indubitably positive effects on the household energy consumption —though it is not possible to tell to what extent. But it is mainly based on a restricted definition of energy consumption, and not really on a ecodesign approach. The reduction of ecodesign to energy consumption was questioned at length in the experts meetings, particularly by representatives of other DG and NGOs who wanted that other pollutants were not forgotten in the legislation.

The implementing measures depend on what is considered as a functionality of the appliance. That leads to rather conservative measures, to the extent that appliances and their uses are not questioned. If the size of a television screen is a functionality, it is then not possible to enforce measure that could lead to set a maximum size for television screens. At a stakeholders' meeting about televisions, there was a question about the relevance of measuring the energy consumption by screen size without limiting it. It was answered that the directive cannot legislate on a maximum size of screen, as this would mutilate an important functionality of the device: "there shall be no significant negative impact on the functionality of the product, from the perspective of the user" (article 15). Therefore, even if a television which consumes a significant amount of energy (due to a large screen) may be given a better classification than a small

television consuming less, but less efficient by cm². This issue of measuring 'functional units' is also found with, for instance, fridges and washing machines. As the case of washing machines shows (see below part 5.6), it encourages manufacturers to construct bigger appliances, for the energy efficiency by unit (kg of clothes for washing, volume for fridges) is better when the appliance is bigger. There can be no fixed limit to the consumption of an appliance, because that would endanger one of its basic functionality. In this framework, the question of sufficiency is not addressed.

In the preparatory studies, the analysis is not made about the system in which the product works (e.g. installation of lighting), and thus associated consumptions are not considered. Through the discussions around the ecodesign directive, there is no question about the appliance itself: how should or could they be changed? What are the best interfaces for which users? There is no debate about what are the appliances we need to adapt to the new culture of energy. The culture of energy is tackled with the producer bias. Ecodesign is restricted to appliances, and the whole system in which appliances are set is not considered. In this view, it would be helpful to study how standards could be applied to a system that consumes energy rather than its separate parts.

5. CASE STUDIES

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 designers and manufacturers, representation of users in consumer's magazines, etc. and have been engaged with users in participatory scenarios. We have 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.

This part presents the main results of our analysis of five case studies. We focus our analysis on the interfaces with users, but without limiting ourselves to this consideration. We begin with our theoretical approach of the question of the way users are considered in their relationship to appliances, allowing us to introduce the need of an 'experimental ontology'. In the two following sections we present the process of selection of our five case studies and the methodology used by a designer to develop propositions co-elaborated with users ('collaboratories'). We pursue in summarising the results of the five cases studies, and we show how users are represented in the EuP preparatory studies for the ecodesign directive. We end with some conclusions and recommendations.

1. Three ways of considering user-appliance relationships

Considering the mutation of the culture of energy, and assuming that it is possible to accompany households in this mutation, the question is: what are users capable of and what change of practice can they accept? To answer to the first question, that of capacity of users to deal with the energy consumption issue, it is possible to identify three types of response based on different ontologies: rational, hedonistic, experimental.[21] To describe and understand the household energy consumption, we need at least these three different ontologies. The idea behind the use of the word "ontology" is to avoid reductions: ontologies are not only representations; they allow to mix humans and objects. Behaviours and attitudes of users, appliances, rules, standards, energy networks, symbols, all are beings taken on the same plane. Any situation can be described as the superposition of these three ontologies, each ontology being more or less present. These ontologies are not absolute: they are related to our question of research: what are the current trends and possibilities towards a new culture of household energy that would be brought forth through appliances?

It could be tempting to argue that rational ontology corresponds well to current policies and fit well to the discourses of industry, for it resonates with economist's and engineer's points of

[21] This part has been developed after a suggestion made by Pierre Lannoy at our third follow-up committee. We have presented it in paper presented at the conference "Sustainable Innovation 08" (Malmö): Prignot & Wallenborn, 2008. The idea to analyse the practice through different ontologies owes much to Descola (2006). As an anthropologist, he has indeed analysed the various human practices and their 'associated entities'. An ontology is a system of distribution of attributes to this or that existing objects, plants, animals, people, minds and so on. Each ontology is a distribution of natures and cultures.

view: the implementation of the ecodesign directive would be the extension of rational ontology to objects. In the same vein, the hedonistic ontology describes well current uses of energy — as our survey has shown (Wallenborn et al. 2006), the main stated motivation to improve one's equipment is comfort. And then, experimentalist ontology would be reserved for the cases where there is a clear will and awareness of trying and appropriating an object.
It is however much more reasonable to consider that the three ontologies (and possibly others) are present in households, as their segmentation reveals. The question is thus: could the EuP (or the system) integrate a diversity of users and uses? Could it match simultaneously a rational user, a lazy or a curious? Can it accept that the user goes from an ontology to another, from a logic of use to another? Is it possible to conceive a diversified supply of appliances, corresponding to different underlying ontologies? Some objects are invented for women or for men, for children or adults, for disabled persons, etc… would it be then feasible to broaden the range of relevant ontologies? These questions will be tackled in the STS framework and through 'practice theory' (cf. chapter 2.2). This theoretical approach allows indeed to understand the process of appropriation or domestication of appliance, and fits well with an experimentalist ontology. Above all, it assumes that practices and objects are co-elaborated.

Hedonistic ontology

The hedonistic ontology describes how households are currently consuming their energy, as is revealed in different studies (e.g. Shove 2003). In this ontology, 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 or laziness. For example, in the preparatory studies of the ecodesign directive on television, consumers are supposed to watch TV for 4 hours and then leaving the television in sleep mode, and they are unable to switch the television off completely. But in the Computers preparatory studies, the users are supposed to be able to switch off all energy saving features of the computers easily, in order to not have to wait for the screen or the computer to wake up. So the capacities of the users are not limited, but they are always inclined towards doing the least possible effort.
Users are also considered as subject to social inclinations, their social image matters more to them than the idea of environmental protection. In the hedonistic ontology, households are searching for maximising their pleasure with their available resources. Marketing is for instance swift for mobilising emotions in order to occupy this ontology. The role of policy in this ontology is to produce regulation to force consumer to adopt a sustainable and sometimes undesirable behaviour, for example by banning cheap unsustainable products, energetically inefficient (e.g. incandescent lights). From the point of view of sustainable development, hedonistic behaviours are considered as irrational.

Rational ontology

The rational ontology describes well the idea behind many current policies on energy efficiency: in order to reduce energy consumption, one must encourage manufacturers to produce energy efficient appliances and inform consumers that they have an advantage to buy them, notably through the energy labelling scheme. In the preparatory studies of the ecodesign directive, users and uses are reduced to "average use pattern"; for instance, TV users are supposed to let their appliance 4 hours a day with "on mode"; users seem to be empowered only to switch off the standby mode. As we have seen, ecodesign is mainly reduced to energy efficiency in the implementing measures.
In the rational ontology, 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 ontology is mainly present when speaking about the moment of buying an appliance. Rationality means here that users calculate and optimise their use of resources. A problem of this ontology

is the rebound effect (cf. chapter 3). In this ontology, the question of sufficiency is not addressed. Another big problem of this ontology and the hedonistic one is the consideration of fixed entities; for instance, humans do not change or vary, they have fixed desires and usage patterns.

Experimental ontology

The third ontology we propose is found in the literature on design or learning, for instance, and we call it an experimental or relational ontology (Pantzar 1997, Sauer & Rüttinger 2004, Darby 2005). The sufficiency can only be addressed in this ontology 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 ontology emerges from action, from practices, and can be discovered only in the concrete relation with the appliances (Reckwitz 2002). In this ontology, 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. The socio-technical landscape is framing the cultural landscape, and their mutual interaction is what matters for the possibilities of energy reduction.
This ontology allows for diversity of uses and change. As we shall see, questions that can be asked in this ontology are not addressed in the ecodesign directive. In the experimental ontology, EuPs are considered as embodying conflicts and trade-offs of constraints pertaining to different categories of requirements (cf. 2.3). For these reasons, the experimental ontology is much more appropriate for design research. How to build in another way the relation of the energy consumers to the environment? Ecodesign could be of some help to answer to this question. But ecodesign has to be taken in its original meaning: analysing the system in which the desired function would deliver its services. Interfaces of energy-using products shall then be considered as a part of a system.
The problem for this experimental ontology lays in the difficulty to make a priori measurements. Only experimenting with the objects can confirm or infirm what the possibilities are. The way users will react is difficult to anticipate or calculate.
The three ontologies are summarised in the following table. From an analytical point of view, hedonistic ontology is concerned with humans (householders), rational ontology with energy (a typical engineer's term) and experimental ontology with consumption seen as a practice.

Name of the ontology	**Hedonist**	**Rational**	**Experimental**
Analytical framework of our research	Household	Energy	Consumption
Aim of the ontology	Comfort, convenience	Efficiency	Exploration
Representation of the users	Lazy, passive	Average pattern	Active
Perception of the EuPs	Service, black box	Must be efficient (ecolabels)	Negotiation btw ≠ constraints
Moment of household action	Using	Buying	Changing
Logic	Maximisation	Optimisation	Creation
Motivations	Pleasure, symbols	Social norms, savings	Playful, curiosity

Example of actors mobilising a discipline	Marketing & psychology (emotions)	Policy & economics (informations)	Design & sociology of practices (doing)
Role of policy	Prohibiting behaviours or objects	Developing individual's rationality	Trying/meeting new objects/practices

The culture of energy is today mainly understood in rational and hedonistic ontologies. When left with these two ontologies, 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 ontologies cannot take into account a new relationship tested between an object and its user. The introduction of a third ontology is needed to accompany the required change of culture of energy. If hedonistic ontology describes well the current uses of EuPs, while the rational ontology deals with buying EuPs, the experimental ontology is about changing of EuP. Hopefully, the three ontologies are always present to some extent. These three ontologies exist at the same time (and there might be other ontologies for our problem). These ontologies are not dialectical moments, succeeding each other, but can be superposed to describe a given situation. For each situation an ontology is however dominating the others. Today, the cultural change requires to foster the experimental ontology.

2. Collaboratories

This section summarises the methodology used by François Jégou (SDS, Strategic design and sustainable development research Agency) and Joëlle Liberman (Egérie Research) to develop collaboratories. 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. We have called these co-elaborated scenarios "collaboratories".

The idea of collaboratories belongs to the experimental ontology. It is for us very important to explore what it is possible to do with appliances in order to make an assessment of the results of the ecodesign directive. In order to follow the construction of new constraints for technology, we needed to open the range of possible ways of conceiving interfaces between users and appliances.

The change of appliance design means in particular, the modifications of all tangible and intangible elements defining the use these objects. For example, a remote commander for lighting of a room leads to interaction easier than a wall switch. A switch controlled by a detector of presence will limit the unnecessary lighting of empty rooms, but will irritate users when switching off untimely. A combination of the two systems would tend to empower the user who will choose to 'force' permanent lighting in a room where he intends to stay or choose a temporary lighting where he just pops in. The cost of cognitive choice for the user is negligible and has some educational value leading to each use to question the feasibility of restricting the lights that are likely to become unnecessary. This simple example illustrates how the design of the interface can induce different effects among users (facilitation/complication; choice/automation; accountability/disempowerment...) and eventually change their behaviour.

Involving 'friendly users'

The example developed above shows how the usual scenario arises from the nature of the devices, the psychologies of users and complex phenomena of inter-feedback between the two. To act effectively on this ground, to avoid the rebound effects and encourage virtuous circles, we advocate an approach of co-development with users. More than the analysis of expectations on the one hand and testing hypotheses other hand, the methodology described below is to create a process of co-creation in the form of several iterative loops where users are both

proposers and filters of their own assumptions, both designers and users. They are supported throughout the process by professionals who help them to progress, both in the analysis of their difficulties and in shaping their intuitions. The methodology is based on the following steps:

1. Casting and recruitment of friendly users (selection of 8 households)
2. Guided visits to users' homes
3. Co-construction of a new solution
4. Delivery and setting of solutions

At the moment of writing the report, the step 4 has not been completed yet. This step will result in video clips and power point presentations showing different scenarios of uses conceived by the households. These clips will allow the researchers to present the scenarios to different people and public.

The purposes of this approach will be analysed as an ideas-generation process involving users to stimulate and 'debug' designers creative thinking based on a 'casting' of 'friendly users' which involvement value is less in their testing potential rather than in their willingness to invent a supportive environment toward new and more sustainable way of living.

Developing design guidelines to favour energy-responsible practices.

Families were invited to focus on the five selected categories of domestic appliances. For each of them an original interpretation of the current context emerged from the early investigations with the families, showing why according to them the current appliances proposed on the market were not facilitating a rational use of energy or worst, were favouring energy overconsumption. For each category of equipment, a new design attitude has been identified between the users and the design teams that brought, on the one hand, to a series of emblematic concepts of new products and, on the other hand, to four design guidelines to favour energy-responsible behaviours with a general value going beyond the product category they emerged from.

Processes, motivations, resulting guidelines and related concept products are presented in detail in the case studies. The conclusions of the specific collaboratories sessions 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 solutions in streamlining energy consumption practices of households;
- the very process of the collaboratories sessions, the progressive training of the families, their involvement in the design of their own future environment brought us to consider all the interaction process and the material developed to be used during the sessions between users and designers as a sort of training toolkit to question people domestic practices, to abstract from them and enable the families to re-invent progressively their daily ways of living.

3. Selection of product categories

In order to go deeper in the study of conception and use of these appliances, we have selected a limited scope of energy-using products. The fact that practices are compartmentalised argues for a separate treatment of each EuP category. The result of a long selection process is 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 an 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
- 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 choose 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, e.g. 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. It appears that smart meters are developing very fast and that they constitute very interesting interfaces for our project. We will test the use of smart meters by households in the second phase of our project.

The framework of research questions (cf. chapter 1.4) 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. On another hand, the working documents enable a transversal reading since they are constructed on the same table of contents.

4. 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 in 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.

In the rational ontology, a uniformity of the "good light" will be sought, and criteria will be used to determine what is the correct light for human eyes, how light should be distributed in a room. Energy efficiency will be put forward and the rational humans are supposed to buy these lamps because they are cheaper on the long run. In the hedonistic ontology, the fact that incandescent light is better will be taken for granted, and the idea will be to rule out incandescent lights, as they are not sustainable. In an experimental ontology, the desires for lighting will be taken into account. How will the lights be understood when compact fluorescent lighting will be the only available lights? How to produce desirable fluorescent lighting, both in the technical and social senses? Other uses of lighting are taken into account, not only producing light in order to distinguish objects, but also to create warm atmospheres, to create a feeling of security, and so on. Not only the bulbs themselves are important, but the whole arrangements of lights in the houses, the whole lighting system (including natural light). How will people appropriate CFL's (compact fluorescent lamps), what does it change in their homes? These questions are never addressed by the preparatory studies. In this third ontology we can only guess what could happen. In this third ontology, the role of policy is also to allow and promote experimenting. In Belgium for example, CFL's are sometimes given freely to let people try and experience them.

The European Commission has just decided to ban progressively the most inefficient lamps, including incandescent ones.[22] 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.

Three controversies

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

[22] LEDS are only a temporary solution, due the lack of rare resources that are needed to produce them. However other options are developed and the light market is evolving very fast.

luminaires, and the beauty of light itself. For old luminaires, the preparatory study is clear: users should get rid of them.[23] "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 pleads 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 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). There is here a clear conflict between two ontologies: one describing and the other prescribing. 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."

Regarding the use of CFL's, the preparatory study has a short discussion about the harmonic interference in the low voltage network. Indeed the replacement of incandescent lights (which have no reactive power) by CFL's (which have a reactive power due to the ballast) could provoke disturbances on the network. Even if the answer is that the effect on the voltage quality would not be affected, this is a rare case where uses are considered as connected together —

[23] 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'.

facilitated by the material network of electricity.

Collaboratories: 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 all the 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.

5. 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.

Absent users

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…

Which ontological mix?

The current trend in heating systems can be explained by the implementation of a rational ontology (delegating decisions to objects) in the name of a hedonistic ontology (comfort). The preparatory study reveals indeed 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. 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, and based on a rational ontology. 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 once launched the running of the system is delegated to electronics.
The second strategy is to ask more from the users by acting regularly upon their system in order to maintain a desired indoor climate, and is more based on a experimental ontology. 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.

Collaboratories: Semi-manual interface principle and thermal regulation

The principle of semi-manual develops systems that operate autonomously, controlled by programming, aimed at achieving economy heating allowing the user to easily alter them intuitively 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 as the clock in the domestic world. The design of control systems for heating ranges from the ideal of fully automatic to the delegation to the user through the fine modulation for each piece. The models of the most sophisticated thermostats combine daily and weekly programs requiring the user to clarify its prior practice and set up a complex and often unlovable interface. In contrast, the fine control of each piece involves complacency 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 design 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 made at the outset, the thermostat works like a very simple remote control: it lets you play between a low temperature of comfort, economy, sufficient when doing activities and a comfortable temperature when standing still. The user can demand a higher temperature, that will remain switched on an hour and is automatically cut. 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 burners of the boiler: it makes heating 'visible' as a fireplace that can be easily revived.
2. Compensating time temperature. The same semi-manual principle assumes that you can occasionally increase the temperature. In the morning when I wake up, I leave my room and the night temperature can remain all day until the evening when I returned at bedtime. However, when I get dressed or I change my clothes, I like a little heat, very timely, just on me. A radiant booster 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.

6. 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 standards of hygiene and cleanliness. As we shall see, the diversity inside the hedonistic ontology prevents the rise of rational and experimental ontologies.

Diversity of practices

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.

How test standards can shape appliances

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.
The standards on which the measures are based have indeed a strong influence on the market. As the Standards nowadays use only a 60°c full load program and measures the total energy consumption divided by the weight of the full load, bigger machines are advantaged compared to small ones. It is thus proposed to modify the scale used to measure the energy efficiency, in order to avoid that bias. The energy efficiency of the washing machines should be measured with a mix of 40°c and 60°c programs, and with a mix of full and partial load. The actual version of the new performance standard proposed in the implementing measure is based on a proposition of CECED (European Committee of Domestic Equipment Manufacturers). This new standard would use different washing temperatures and different loads of the washing machines combined together. It is taken from the conclusions of the preparatory study, but has been contested by ECOS and ANEC for not being close enough to the real behaviour of users and the real trends of the market.
To avoid the fact that bigger machines would still be more efficient that smaller ones on a basis of 1kg of clothes, the machines should be compared with a standard machine of the same rated capacity. This will avoid the advantage given to bigger machines, but will not give an advantage to smaller ones either (ECOS 2008, ANEC 2008). It seems however that the Commission is not going to take this measure.
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 will be 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).
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.

Collaboratories: 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, stoking a sense of guilt to face the need for hygiene, and exacerbating the mysteries of the alchemy of laundry. The behaviours of the users appear to be even more unique, intimate and inflexible. This situation is exacerbated by the fact that laundry does not incite to experimentation: the risk of spoiling clothes, for instance in mixing improperly some textiles or certain colour 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 swear 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, in the form of programs for gentle 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 day. The machine keeps its capacity to do the same job in less than an hour but with a considerably higher 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 a sophisticated interfaces washing machines 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.

7. 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?

Computers: uses and technology evolve too fast to be measured

The preparatory study on computers is being 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 determines 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.

Collaboratories: an eco-conscious principle?

The issue of energy in the use of computers is not important to users. The device consumes relatively little in regard to the extent and perceived value of its benefits. It represents an 'intelligent' object par excellence and the user expects it manages autonomously its energy

consumption. We consider thus the computer under the particular perspective of an appliance skilled with a sophisticated control system and capable not only to optimize its own use of energy but also to manage the other appliances connected to it, which are part of the same household sub-system.
An eco-conscious principle would allow to design systems that can autonomously optimize their use of energy, initially configured on the basis of an aggregation of consumption data in the form of indicators relevant to the user and easily adjustable daily by it.
The peripheral devices of the computer are more or less dependent and controlled by it as they are integrated or connected. Printers, scanners, speakers, external hard drives have their own power supply and requires management by the user of their power and their starting to limit their energy consumption. Instead of manually operating on their respective switches, these could be controlled directly by the computer (via USB or bluetooth), that would also measure their energy consumption. The set forms thus a 'cluster' of equipment complying with the eco-conscious principle. When installing the peripheral devices, a dedicated software allows to configure their consumption profiles and the printer, for example, will only be switched on at the request of a print or for the duration of computer use. Once configured, the energy-using devices behaviours will be managed in a manner transparent to the user able to analyse the consumption of each device and if necessary, to return to the configuration settings of the profiles consumption.

8. Smart metering: what could be expected for users?

"Smart meters" here mean 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 distributor. This communication can be one-way or two-ways. A one-way communication only allows for the meter to tell the distributor how much energy is consumed over a given period of time. A two-ways communication also allows the distributors to send information, updates, prices, tips or whatever they think important, to the users. Remote switches could also help, as they could start appliances when the price is below a certain amount, or during a certain period.
The directive on energy services (COM 2006/32/EC) suggests that smart meters should be introduced on the market, when it is technically feasible and cost-effective in regard of the energy savings that smart meters could foster. In a liberalised market, different actors are indeed interested by smart meters: energy providers, energy distributor, distribution system operators, retail energy sales companies, providers of energy efficiency improvement measures, public authorities, users, and all their representatives. All actors interested by demand side management are virtually interested by smart meters for different reasons. For instance, smart meters could be tools to modify the demand of households. This demand can be modified in shape or/and in global amount. Smart meters with two-way communication system could also reduce fraud. Smart meters could accelerate the allocation process, important for the industry since it is the exact redistribution of the amount of electricity sold/bought by the different suppliers on a liberalized market. New ways to pay for the users can be proposed. Finally and more importantly for our project, these meters could change the behaviour of the users, by giving them various kinds of information. Smart meters could give information on the price of electricity at a given time: the energy could be more expensive at peak hours and cheaper at valley hours, and this is supposed to make the household consumer change its behaviour, buying the electricity when it is cheap.
Smart meters are being introduced in EU countries, and it seems that a standard has been chosen for Belgium. However, as far as we know, this introduction does not focus on the users, though smart meters could help to raise awareness about energy consumption. In making energy visible for households, they could take part in the new culture of energy. In our survey of 2005, we noticed that 69% of Belgian people state that they would pay attention to energy consumption if their appliances displayed this consumption. 57% find that a software managing their energy consumption from their computer would be useful. The question is how to balance the economic and ecologic costs of constructing and using a smart meter with the supposed benefits. Under which conditions is the saved energy bigger than the amount used for make the

smart meter functioning? Is it environmentally worth? To answer to these questions, academic literature gives an idea of the scale of energy consumption reduction one can expect. Most of the literature concludes that it is possible to reduce the energy consumption, but the numbers and figures vary greatly (Darby 2006).
Protocols of smart metering experiments can indeed 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 rather unclear. Some conclude that information alone is enough for a behavioural change, some 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 and 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. This turns around the value of 10 to 15%, with maximums at 30 on the level of some practices.
If we consider that meters work very well when they provide direct feedback info, then on what kind of appliances would it be interesting to put meters? Clearly it would be pertinent only on machines with certain malleability in energy use; if the appliance has constant energy consumption or a limited variability in energy consumption (for example only on/off mode) then a meter would not be pertinent. The use of a general meter for the household can also be asked. Most of the texts on smart meters give information on a general reduction of energy consumption, but they do not mention on what appliances or practices the reduction has been done. We have then made a simple calculation in order to assess under which conditions a smart meter could interest a household. We assume that:

- the meter has a power of 5 Watts (1 to 3W for the screen, 2 or 3W for the electronics);
- the meter costs 50€
- the meter allows for 10% reduction
- electricity costs 0,15€/kWh

Then, if we want a payback time of 3 years, the yearly consumption should not exceed 1549 kWh. For a payback time of 10 years, the maximum consumption of the appliance is 771 kWh/year. Knowing that the mean global electricity consumption of a Belgian household being around 3500kWh/year, a smart meter is interesting only for the whole household (except perhaps for electrical water heater). We did not found figures for the embedded energy of this kind of meter, making the calculation of the ecological benefit impossible.
It might be possible to reduce standby consumption, but we have not yet considered other important cost: the installation of the meter. By that, we mean the physical installation, but above all the 'teaching' of the appliance. Households need indeed to learn how to use this new appliance, and that entails several visits and more hours to spend with the household-as-experimenter. This is probably the main barrier to the introduction to smart meters in all households. Yet, on the other end, the benefits of introducing smart meters are not limited to a direct reduction of energy consumption (and money spend for it). The smart meters introduced in households would also have an effect on the culture of energy as such. This effect is neither estimable in terms of saved kWh nor in terms of money. We can hypothesise that a factor of success of smart metering will be to move away this appliance from the rational ontology, in order to give space for appropriation by a diversity of users. A large-scale implementation of smart metering could take part in the change the culture of energy for citizens, and it is difficult to predict what the social change could be. These experiments always take some limited group of people, but what would happen if a whole country received smart meters? What would be the interactions of people about this change in their daily life, and what would be the impacts on energy consumptions are questions that are left unanswered.

Collaboratories: Eco-conscious artefacts and smart energy meters

The eco-conscious principle (cf. section on computers, above) suggests that computers can be

an interface for energy management of any household subject to the analysis of a smart meter. This principle assumes that energy metering enables households to change their behaviours.
Despite the efforts of communication about energy consumption, the energy flux supplied to the home is not inherently motivating for users. It is part of the infrastructure of the habitat and, except to have to optimize a growing bill, it is not of interest in itself. More precisely, the structure of gross consumption by appliances is fragmented and does not seem significant to a household that would analyze and change its practices: the heating and lighting are presented separately while they contribute to domestic comfort. To mean something to the users, it is necessary to develop indicators related to practices: according to housekeeping functions (maintenance of laundry, meal preparation, etc.) and to space (living room, bedrooms, bathroom, etc.), and reported to daily, weekly and monthly distribution average. Then users may think, compare and decide to act on the basis of an analysis of the perceived value of their consumption.
Beyond the static presentation, the interface can provide a dynamic mode to monitor and optimize its consumption. Again, management of energy consumption is more a management concern than a matter of spontaneous interest, and must be considered on the basis of an eco-conscious principle limiting the cognitive overload of users and facilitating their daily management. To do this, the interface should provide a dynamic management by objectives: households establish a threshold of consumption for some critical uses, which they want to monitor or control, and work then in adjusting their practices according to the margin of energy left.

9. 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. Smart meters are currently a market in expansion, betting on the meeting of rational and experimental ontologies. 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	Smart meter
Conceptual question	Trade-offs	Delegation of decision	Scripting and appropriation	Standardisation and practices	Rationalisation of practices
Buy/use	Buy	Use	Buy	Use	Use
Action	Discrete	Discrete	Continuous	Discrete	Discrete or continuous
Function	Ambiance; basic need	Ambiance; basic need	Transforming interactions	Liberating women	Rising awareness
Gender	Man & woman	Conflicts	Man	Woman	Man
Standards & norms	Energy label; quality	Social norms	Constant upgrading	Cultural differences	Choosing one's standard (?)
Current trends	Innovative	Central heating	Increasing CPU power	Optimisation (breakthrough?)	New market in fast expansion
% energy household Consumption	±14% of electricity	70% of total energy	±2% of electricity	±12% of electricity	/

Poor representation of users

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. These representations are part of the process of negotiating a new energy-using product. While these representations are an important stake, we can conclude that for the moment they are relatively poor. It seems that producers can only represent users through an average behaviour.

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 (Kauffman 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.

Engineering practices

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 (rational ontology) 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 could be an interesting starting point.

10. The interest of collaboratories

The realisation of collaboraties has been instrumental in reminding us several important points.
1. 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. The ecodesign directive is mainly concern with product redesign, while collaboratories inviting to see the product in its system lead 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.
2. 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).
3. The lack of relationship to users prevents to examine the meaning of energy-using practices. The case of computers is conspicuous: what people are doing is linked to the development of new social practices. And this question can be generalised to the big variety of tasks required by a specific practice (Shove 2003, Gram-Hanssen 2008).
4. The question of aesthetics, in the broad sense of the word, is not asked, as the case of lighting shows. And in general, the reduction to energy efficiency prevents to ask the question of attractiveness of some objects.
5. Experimental ontology is transient. The desire to play with new objects can last only a little time. It is nevertheless the process by which new ideas and new practices can emerge and stabilise.

6. CONCLUSIONS AND PROSPECTS

The practices related to energy consumption are going to change. 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. incandescent bulbs). How could practices be transformed without calling to the "good will" of users (e.g. through information instruments)? Users are mainly addressed in a rational ontology that mobilises information about energy efficiency of appliances (e.g. through labels), while they are currently described in a hedonistic ontology (e.g. search for comfort). When left with these two ontologies, 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 ontologies 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 (Shove & al 2007). An experimental ontology, 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 ontology would be experimental, i.e. allowing redistribution within practices of the relationships between objects and users. The exploration of this experimental ontology — which already exists but is not thematized as such — is the following step of our research.

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. For instance, energy labelling shapes appliances, sometimes to the detriment of consumers (e.g. washing machines).

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. To cope with a systemic approach, installation standards should be considered. End of life is not examined either. Why not to implement standards for lifespan about 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).

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. The better example is all the services provided by the different EuPs! 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 degrowth 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.

Second phase of our project

Rationalities of energy consumption are diverse and distributed through home sectors, but these rationalities held by households 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 are black boxes for users, users practices are black boxes for manufacturers. An objective of the research in its second phase (2009-20) is to get in-depth understanding of user's practices, and notably to develop the knowledge about the gaps and barriers between attitudes and practices. 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. We will therefore explore the following questions:

- What is the current households' culture of energy related to specific objects?
- What are the different uses of an appliance? An appliance can be used by one or several persons; it can be at a central or peripheral place; it can be used at different times; gender and age of the users are also important.
- Routines and habits are difficult to change. They however change each time a new object is introduced. What are the dynamics of change and appropriation for the different objects? What is the use of handbook? Hypothesis: resistances to objects can be due to misunderstanding between the user and the object. What are the "resistances" to some objects?
- How have energy-using objects created new modes of existence and new space-time frameworks and transformed their users? How they transform routine patterns? Through energy-using objects, the housewife has been progressively transformed: from cleanliness and tidiness activities, she has now engineer practices in which rationalisation and efficiency have become keywords.
- What kind of standards could be developed about systems? We have gathered a huge amount of information about standards and standardisation process, that we are not able to show here.

Based on the present report, we will introduce smart meters in some households and make surveys in order to understand what they learn with such an object. In 2010 we plan to organise several conferences about the results of our research.

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The independent organisation ECEEE summarises the implementation of the ecodesign directive: http://www.eceee.org/Eco_design/

A complete access to the preparatory studies for the ecodesign directive: http://www.cfsd.org.uk/seeba/EuP/eup.htm

Standardisation and environment at the EU level: http://ec.europa.eu/environment/standardisation/index_en.htm

The environmental strategy of CENELEC (standardisation body for electrical appliances): http://www.cenelec.eu/Cenelec/CENELEC+in+action/Horizontal+areas/Environment/default.htm

ANEC: http://www.anec.org/anec.asp

ECOS: http://www.ecostandard.org/

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