# The Engineering Approach and Social Aspects of Energy Use: Mind the Gap, but Can It Be Closed?

*Jaap Jelsma, Univ. of Twente, Centre for Studies of Science, Technology and Society, and Energy Research Centre—Netherlands, Dept. Renewable Energy for the Built Environment*

**ABSTRACT**

After a temporary decrease in the mid-eighties, energy consumption by households has resumed its gradual increase over the recent years. In current approaches of this problem, there is an unproductive gap between the engineering approach seeking technical innovations to save energy, and its critics pleading for social factors to be included in analyses of (over)consumption by households. Within science and technology studies (STS), there is a growing awareness, supported by a growing body of theory, that the technological culture we live in can more fruitfully be understood using analytical approaches in which the technical and the social are integrated. Especially on topics of design and use of technology, there has been considerable progress in theoretical development and in development of tools for making technology that is more socially informed. The paper explores the knowledge-landscape with respect to energy use in households with the aim of identifying promising areas for conceptually connecting the various disciplines, especially for linking relevant approaches within the social sciences on the one hand, and technical engineering on the other. On behalf of this linkage operation we capitalise on the new insight STS offers. The hope is that we, progressing in this way, can overcome the unfruitful split and lay the ground for a new comprehensive paradigm.

## Introduction

Despite much policy effort aiming at the opposite, the trend in energy consumption of households persists in going up. This rising trend applies to energy requiring activities within the home as well as to outdoor activities, especially forms of private transport. Attempts to slake this growing thirst for energy seem to be channelled into a dual policy approach of which both tracks are largely independent.

One track has been described as the 'engineering approach' (Lutzenhiser 1993), i.e. technological innovation directed at the development and deliverance of energy efficient goods such as low or zero energy dwellings, A-label household appliances, efficient cars etc. The implementation of this approach is delegated to heavily sponsored engineers in technical research centres who indulge in conceiving, developing and testing all kinds of installations, systems and appliances, which in the artificial environment of the laboratory –as measured by calculations and simulations- generally show excellent energy saving performance. As soon as these advanced product have been introduced in the rough worlds of consumers outside however, they often show shortcomings and do not realise the predicted savings.

The other track is governmental support of different kinds of social science research to track down the incentives of consumers for behaving as they do in handling energy, and to reveal the 'behavioural' (psychological, social and cultural factors) that can explain these incentives. For many years, questionnaires, focus groups, interviews, laboratory experiments and intercultural comparisons have been deployed widely to gather data and to develop insights useful for influencing consumer behaviour. The dominant strategy in this effort is trying to change consumer attitudes toward energy use by offering information on energy consumption and price signals. In the meantime, energy consumption by citizens continues to rise.

Among policymakers this state of affairs leads to frustration. At least Dutch policy makers are disappointed about the contribution of the social sciences to control the energy problem. According to civil servants in the Ministry of the Environment, more than twenty voluminous social studies on aspects of the energy problem in households this ministry commissioned during the nineties, failed to deliver any productive lesson for policy (personal communication, JJ).

Probably, the engineers are better than their social science colleagues in creating promises that their approach will help. Their figures seem harder and their funds are bigger. However, the abundance of technical novelty that comes out of the laboratories conceals the fact that only a tiny fraction of research money is spent on monitoring of whether the new energy technology is as productive in practice as laboratory measurements suggest. For that reason there is little feedback to designers, and learning remains limited.

On occasion even policy makers, especially those who have to sell energy policy and therefore have to radiate optimism, step into this two-track frame. For instance in 1996, the Dutch former Minister of the Environment announced that 20% of the Dutch Kyoto targets had to be realised by changes in human behaviour. The remaining 80% should come from new technology (see Achterhuis 1996). Notice that in the Minister's conception of the world, technology and behaviour are completely separated phenomena.

This split in the practical approach of the energy problem is reflected in the underlying theoretical discourse. The scientific debate about energy consumption by households is parcelled out between the respective disciplines whereby the technical and the social sciences reside each at one side of a kind of Latourian Great Divide. I call this divide Latourian because it reminds us of the Great Divide between science and politics Latour postulated in his book ´We have never been modern´ (Latour 1993). The book describes the historical process in which the realm of humans (politics) has become -conceptually and institutionally- separated from the realm of nonhumans (things) studied by natural science and manipulated in technology. In my view, the split in conceptual and practical approaches of the energy problem is a special case of this divide, which is thus deeply rooted in history. In the present situation, this historically grown condition induces a practice in which engineers, at their side of the divide, continue to invest in technical solutions seen as politically neutral, whereas social scientists, from the other side, shout back that the (political) problem is laying elsewhere (Wilhite et al. 2000).

In this article, I will first map out in broad outline the knowledge-landscape on both sides of the divide in which problems and solutions of energy consumption in households have conceptually and methodologically been shaped in different vocabularies. In doing so, I will explore this landscape to identify locations between which conceptual bridges can be built, to connect the archipelago of disciplinary islands and to span the Great Divide. I will especially look at the fringes of existing paradigms, the peninsulas, since it is there that we expect the innovative developments to go on. For the connective work I will capitalise on recent work within the field of science and technology studies (STS). It offers good opportunities for a redefinition of the energy problem in terms of social processes of the design and use of technical goods, in which the technical and the social are conceptualised symmetrically, i.e. as actors in processes of exchange. A redefinition of this kind holds the promise of creating energy technologies that are more sensitive to problems and chances of practical use.

## The Engineering Approach

How is the definition of the energy problem in circles of engineering? Which strategies and solutions do engineers believe in? And how do they cope with the social aspects of their work, i.e. with the awareness that their technical creations have to function socially to save energy?

A popular doctrine within the Dutch engineering community in the domain of energy is the '*trias energetica*', which functions as a kind of guiding principle for the sponsoring of R&D: (i) lower energy demand by increasing efficiency of use, (ii) apply renewables as much as possible and (iii) cover the remaining demand with clean technology using fossil resources. Defining the energy problem in these terms can be characterised as not political but technical.[1] A more sustainable future is defined as a goal that can be reached by different types of related technical means, i.e. by the development of energy efficient machines, appliances and installations that are able to use renewable resources and are low in emissions. The characteristics of such artefacts are conceived as 'functional', in line with mainstream thinking in engineering. According to this paradigm, a primary requirement of all devices and systems designed by engineers is 'functionality', i.e. the design should technically guarantee that the intended functions are performed properly under specified circumstances: technology should 'work' according to functional (i.e technical) specifications. In the current conception, functionality is thought to be located in the specific layout ('design') that connects the different material entities that form together the device or system. In this sense, 'functions' are juxtaposed to 'intentions', which are supposed to reside exclusively in humans.

Though the functionality doctrine makes humans (those who live in and with the creations of engineers) rather invisible, it does not mean that they are completely absent from design activities in the engineering world. Engineers do deal with humans, made up as consumers (i.e. as hoped-for buyers of the novelties they produce) and as users, mostly end-users (those who must be able to properly handle the products that come out of engineering). Engineers construct both types of humans in different ways. In the discourse of engineers popular myths are created who consumers and users are supposed to be. In the technical design work proper, users have to be represented is some way to model and predict their influence on the functionality of the technology under design.

The dominant myth about consumers is that generally they are not interested in the energy saving properties of new goods; only the freaks are. Consumers are seen as wanting more comfort in their homes, or at least as not tolerating a decrease of the existing level of comfort. This myth implies that new energy efficient products or systems that utilise renewable resources such as solar heating systems should deliver at least the same level of comfort as their unsustainable competitors, and preferably a higher one to make introduction in the market easier. This line of reasoning has consequences for design. It means that the systems developed are thought to be socially robust only if they are equipped with storage capacity, peak burners, back up provisions and the like, i.e. technical features that prevent any need for adaptations in the behaviour of users.

[1] Such a technical definition is not self-evident. One could ask engineers the question –as I did at several occasions- whether energy efficiency is of any help since it makes energy use cheaper and so sets free capital that can be spent on new desires, which have to be made sustainable in turn. Engineers use to answer this question by saying that this is a political question, i.e. not a question for them to bother about.

Regarding users, my impression is that they are not very popular among engineers. During discourses in design team meetings I recorded, engineers regularly demonstrated a sceptical attitude toward users as exemplified by remarks such as: 'I am against giving users too much influence on the design', 'Users cannot want this', and: 'I don't like users, they spoil a carefully figured design'. Thus users are a nuisance in a purified technical world. On the other hand, engineers can not exclude users completely. For the sake of functionality, the influence of end-users on a technical design (e.g., as producers of heat and gases in buildings) has to be taken into account. This is difficult to realise, for users are a heterogeneous and capricious creed. Therefore, users are seldom incorporated directly as real persons but are represented in design work by different approaches, such as standardisation or rather 'parametrisation' (heterogeneous users are reduced to standardised or (re)settable parameters to fit an experimental setting)[2] and representation by experts or by the designers themselves ('I-methodology', see Oudshoorn and Pinch 2003). In substituting the user, the designer fails to realise that his relation to the product under design is completely different from the way end-users perceive it from their own context.

In conclusion we can say that for the engineering domain I am most familiar with (energy research for the housing sector) their seems to exist - on the level of normal science, i.e current conceptualisation and methodology- the kind of divide suggested earlier. Engineers define the energy problem in this sector as a technical problem, that is, a problem of technical means. They try to keep political questions at a distance, as well as any deeper analysis of the social worlds to which their technology has to relate for becoming really 'functional'. About consumers they think in stereotypes. Users are conceptually moulded so as to fit in the normal design practice. But there are seeds of change.

**Fringes of Interest: Requirement Elicitation, Contextual Design, Participatory Design, Forgiving Technology**

In dealing with users in design, the engineering literature offers seeds of change toward a more social attitude. Especially in systems engineering, anthropological methods have been imported in the early 90s to improve design specifications for development of new hardware and software products. Under the heading of 'requirement engineering' or 'requirement elicitation', specific pre-design activities – based on ethnomethodology and discourse analysis- were advocated to identify 'what the user really needs' (Goguen and Linde 1993). Contextual design is a related, recently developed but more radical approach that puts users in the role of experts on use practice (Beyer and Holtzblatt 1998). User behaviour and logic behind work patterns should be first carefully mapped and tapped by designers before they start to re-design the user environment by introducing new devices and new software. Contextual design has a further elaborated and better-structured philosophy and methodology than requirement elicitation. For this reason, it may be more successful. In the following I will show that contextual design offers good opportunities for contributing to a comprehensive approach with promising capacities for boundary spanning. Participatory design also puts user needs on the engineers' design agenda but has a more explicit commitment to workplace democracy (Schuler and Namoika 1993).

When we focus on energy technology, we see also struggles that revolve around the role of users. For instance, in the domain of cooling there are two schools of thought. One advocates active or mechanical cooling (air conditioning), which results in a completely controllable

---

[2] The pervasive application of Fanger's doctrine in the design of climate control systems for buildings is a telling example of the parametrisation of users (Fanger 1970).

building climate, its proponents say. Cooling is delegated to machinery, and windows stay closed. At the cost of high energy consumption and disciplining users, the propagators of the other school -passive or summer night ventilation- state. It is natural- though maybe irrational- that users want to open windows on hot days. Let them have their way. If the building is designed such that it acts as a buffer (its high mass accumulates cold during the night when it is spooled with cold air let in through valves), it stays cool in the daytime despite the 'irrational' behaviour of its users, the reasoning goes. In other words, the irresponsible behaviour of users during the daytime is corrected at low cost by the behaviour of the building. The latter approach can be conceived as a form of 'forgiving technology' , which includes a view of user and environmental interests that is fundamentally different form the paradigm of mechanical cooling. This approach has moved interests of users toward the centre of making choices in technical design without neglecting the saving of energy. The struggle described here is not recognisable only in local design processes (see Jelsma 2002), but also in the engineering literature.

## Psychology

In psychological studies of energy use in households, behaviour of individuals and its underlying mechanisms are the main objects of study. The dominant paradigm invoked is cognitive psychology, which assumes that humans think before they act. That is, use-actions are conceived as cognitive actions. According to this basic assumption, the main drivers of behaviour are conceived to be

(1) Intentions, which are considered to come from attitudes, normative beliefs and anticipated consequences of actions. These drivers are linked in behavioural models, in which technology is absent or only acting as a background factor (Fishbein and Aitzen 1975; Gatersleben and Vlek 1998). Such models underpin policy strategies to change the attitude of citizens by communicating values and moral appeals (using slogans as: 'a good environment begins with you!'), and by campaigns to increase awareness of energy scarcity and what to do about it in one's own private life.

(2) Information, which can be used to give feedback, that is: relating actions and outcomes so that learning can occur leading to changes in behaviour resulting in larger savings of energy (see Stern 1992). Fostering feedback has become a major policy strategy to save energy in households. Feedback can be given through different kinds of material information carriers, e.g. user interfaces of appliances such as washing machines and dishwashers (product-integrated feedback). In this domain there has been considerable theoretical development, especially by integrating feedback intervention theory with goal setting theory (see McCalley 2003) Practical effects have been measured in laboratory experiments where different types of information are communicated to users by interfaces simulated on computer screens (McCalley and Midden 1998).

### Fringes of Interest

Two domains at psychology's outer verge are of special interest for our endeavour. First, *environmental psychology* takes the role of the physical environment in influencing human behaviour much more serious than mainstream psychology does (Stokols and Altman 1987). It could be interesting to analyse whether the insights gained in this field about the interrelation between human and nonhuman elements in the construction of behaviour, might contribute to a more integrated approach to understanding energy use in households.

Second, efforts in *research on routine behaviour* promise to become an extremely relevant contribution to understanding a type of behaviour that seems to underlie many everyday life practices. Indeed the predictive power of the mainstream attitude models is rather limited (estimates do not go beyond 30%, cf. Ester 1984). This weakness may have to do with the assumption that the majority of behavioural actions is not of a cognitive nature but is embedded in routines, especially in relation to familiar, frequently occurring every day life situations. Especially the fact that models of routine behaviour seek to integrate the guiding role of material elements (called *cues*) in supporting this automated type of behaviour (Heijs 1999) makes this approach interesting for further study within the framework proposed here. Insights in the mechanisms underlying routine behaviour could lead to the development of strategies for breaking routines that neglect environmental consequences, and replace them by more eco-efficient practice based on the introduction of new material infrastructure.

## Economics

Within the framework of this paper, microeconomics –dealing with behaviour of producers and consumers- is of interest. Here again, the level of understanding is the individual. Much micro-economic research has been carried out on the effects of different kinds of financial instruments that have been developed for and practised in policy to foster the saving of energy by consumers. The outcomes induce serious doubts about the predictive power of the basic assumptions about human behaviour that microeconomics maintains. It appears that:

- it is often difficult to pinpoint the behavioural effects of financial incentives such as prices, tariffs, and taxes
- there is little rational choice among consumers in calculations relating to energy use (and much irrational choice, at least compared with the standards of economists)
- information about energy consumption and saving is bounded and often incomprehensible to consumers
- in purchasing energy saving equipment, consumers put much more trust in familiar persons (relatives, friends) than in numbers.

Such outcomes make DuPont and Lord to conclude that ‘consumers are no rational choice actors’ (DuPont and Lord 1996). A more precise conclusion might be that consumers have their own logic that is often different from the logic economists practice.

### Fringes of Interest

**Folk logic.** For a further exploration of the ‘irrationalities’ of the consumer, the concept of folk logic is interesting. Anthropologic research shows that for consumers, their own logic and methods are cognitively efficient to quantify energy For examples, see (Kempton and Montgomery 1982). The crucial question is whether folk logic leads to higher energy use, and this is unfortunately the case. Especially return-on-investment kinds of calculations (when will my A-label refrigerator start to pay me back?) lead to more pessimistic outcomes if done by laymen (Fitzgerald 1996). Thus the challenge here is to develop effective strategies for saving energy by taking folk logic as a starting point (e.g. in giving feedback), but by avoiding its weaknesses. To a certain extent, this is a design question. For instance, it appears that a layout based on bar diagrams communicates quantitative relationships with respect to energy use much easier to consumers than graphs (Egon et al. 1996).

**Anthropological marketing research.** Further relevant developments are going on in anthropologic market research, especially in relation with shopping behaviour. In this kind of research, shopping people are tracked by camera's and anthropologists who record clients' behaviour. Underhill has collected the results of such research in a fascinating book ('Why we buy', Underhill 1999). On the basis of this knowledge, Underhill advises supermarkets about the physical layout of their shops. High-selling articles have to be placed in the back of the shop to lead people along other goods that might attract their attention; where impulse-buying is to be stimulated the aisles have to be wider, etceteras. When confronted with the outcomes of such observational studies, consumers appear to be totally unaware of their buying behaviour.

Two lessons are to be drawn here: (i) there is a strong interaction between physical infrastructure and human behaviour, and (ii) behaviour is less cognitive than mainstream psychology assumes.

## Sociology/Anthropology

Here we are on the analytical level of groups, communities and cultures. For our discussion, the most relevant point to make is that in sociological studies about energy consumption in households, research uses to stop where the physical world begins (Lutzenhiser 1993). Although the importance of technology for influencing social behaviour such as energy consumption is often acknowledged, this influence is not studied systematically. Further, mainstream sociological research is quantitative. Large data sets gathered by questionnaires are processed by sophisticated methods to calculate statistical significance of findings that aim to relate behaviour in households to class, educational level, household size etc. This static type of research is neither very promising for providing insight in mechanisms that bring more and more technology into households and lead to rising levels of energy consumption, nor for generating ideas and strategies on what to do about it. Qualitative, observational and dynamic approaches seem to fit in with this purpose better, especially if they are keen to include the role of artefacts as anthropology traditionally does.

### Fringes of Interest

**Subcultures or lifestyles.** Lifestyle is one of those notions being ill-defined despite their frequent use by energy researchers. If this concept, as in marketing, is merely used to describe market segments of consumers, it is of little value for understanding dynamics of energy consumption. Used in a more dynamic way à la Bourdieu however, it offers one possible explanation for the on-going dynamic behind the increasing mechanisation of the household. Bourdieu assumes that people have a propensity to compare their own status to that of relevant others by the level of affluence in terms of goods (Bourdieu 1984). This type of analysis links production and consumption phenomena by assuming a co-evolution to occur between technological innovation (creation of novelty) and the development of lifestyles (moving toward higher levels of comfort).

**Cultural studies.** Cross-cultural studies based on observations and interviews demonstrate that lifestyles and consumer behaviour differ very much between cultures and countries. They also indicate that differences in practice have an underlying logic connected with specific material settings and artefacts. For instance, Japanese people prefer to do the dishes under a running tap, an unsustainable practice that they justify by referring to the small sinks in their kitchens (Wilhite and Nakagami 1996). This type of studies also reveals how lifestyles change by broader socio-cultural developments such as the emancipation of women. In many households both parents have paid jobs now which leads to increased delegation of household work to machines and a changing time management (Erickson 1996). By using machines, certain jobs can be shifted to other parts of the day or night when they can be done easier or cheaper. The fact that many studies show that the use of appliances in households is patterned in time (e.g., see CIEL Final Report) demonstrates that such time management is a socio-cultural phenomenon. The underlying logic of such patterned practice (of which we do not know much yet) links lifestyles and the use of household technology. Since the availability of renewable energy sources such as solar and wind power is also time dependent, better knowledge of the aforementioned logic may be crucial for matching household practices with the availability of renewable energy, either by shifting household practices in time or by making appliances programmable in time by applying smart technology (Kets et al 2002).

## Summing Up

Let me now sum up life in the knowledge-landscape overseen so far. As shown above, the paradigms that guide studies about energy consumption in households within the relevant disciplines differ in concepts, in levels and scales of analysis, in methodology and in the strategies they advocate as far as these are present. In my view, these differences are not the primary obstacles for formulating a common ground for understanding energy use, and for developing productive strategies for saving energy. In all the mainstream paradigms explored, the real hurdle is the conceptual break between physical (material) objects on the one hand, and mental and social phenomena on the other, that is: the conceptual distinction that is maintained between the world of humans and that of nonhumans. Whereas on the engineering side, especially in large firms and design studio's, more integrated approaches start to be developed and tried out, social science scholars in energy research use to stick to their core business, i.e. the study of humans. This happens despite the fact that social science studies in this domain acquire more strategic potential if they start to include material entities as in studies on feedback and on routines. An exception has to be made for anthropology, which is traditionally involved with artefacts. In studies of energy use in households, however, this involvement appears to be of little practical significance yet.

In sum, on the level of mainstream thinking about the factors that influence energy use in households, there seems to be a kind of conceptual divide indeed between the behavioural sciences on the one hand and engineering science on the other. However, an argument like mine that criticises conceptual discontinuity in the study of humans and nonhumans can only convince others by demonstrating the new potentialities that arise by giving up this divide. To do so, we have to switch our attention towards the domain of science and technology studies. This field has potential for linking up fringes of the other paradigms I discussed, and by this connective capacity make a promising contribution to building conceptual bridges over the divide.

## Science and Technology Studies (STS)

The social nature of technology has been at the core of studies in this field from the very beginning. Such studies have generated breakthroughs, which have been elaborated within a number of programmes and theories. These enable us now to begin with bridging the gap between the world of technology and the world of politics and the social in our field under study, energy use in households. For this purpose we best focus on a specific subfield at the border of the STS domain, the field of design and use studies (see Oudshoorn and Pinch 2003 for a survey of this field). Here are specific developments going on that are of special interest for our undertaking.

**Fringe of Interest: Design/Use Studies**

Within this fringe domain, I restrict myself to the microlevel of analysis, of interaction between humans and artefacts, though this type of analysis might be extended to higher levels of infrastructure (see De Laat 1996). The core concept here is *technical mediation* of human action. Mediation means that human action directed at realising needs and desires can only be made effective by collaborating with material tools and infrastructures. In this view, tools and infrastructures are to be conceived as material (sets of) actors that exert a guiding and translating force on actions of their human users. That is, artefacts and infrastructures afford and constrain, forbid and prescribe human action. They can channel human action toward the outcomes that were originally intended, but also deflect (translate) that action towards unintended effects (Latour 1994).

Intentions and values (such as protecting the environment) can be inscribed in products by actions of designers. The results of such inscriptions are called scripts meant to lead users toward such protective actions. *Script*s are those properties based on specific structural features of an artefact or infrastructure that encourage or force certain user actions while counteracting others (a curve in a corridor forces you to deflect your course or otherwise you bang your body against the wall). That is, a script of an artefact has a *prescriptive* force on user action.

In other words, products contain a materialised political message telling the user what to to (e.g, save energy, drive safely by doing this or that) that is carried from the designer to the user by the product. The 'wording' of this message can be dosed depending on the inscriptions made. For instance, the script of a safety belt that contains technical features hampering the engine to start if the belt is not fastened, has more behavioural force than one that only makes a signal blink. In general, if a script is too weak, the user can escape the message or 'morality' of the product, or appropriate it opportunistically (energy saving light bulbs that shine all night to illuminate gardens). In such case, we speak of unintended de-inscription (Akrich and Latour 1992) or decoding by the user, what is often indicated by the notion of *domestication* of the artefact in question (Lie and SØrensen 1996). If the script is too strong, users may rebel, i.e. behavioural 'antiprogrammes' (Latour 1992) against the artefact may be activated (e.g, hanging caps over camera's in public places). If the script is incomprehensible to users, it may be neglected, pushed aside or damaged (the packing of goods offers many examples).

Answering the question how to dose the force of the script of a product and how to make it attractive to follow, forces technical designers to become reflexive on use practice in today's society, i.e. to become social. In particular, they have to anticipate how scripts of the machine under design –especially those relating to energy saving- relate to the logic of users. Here the concept of *use logic* may be of use. Use logic is the mental driver of use actions. In most cases the user will be able to explain why he uses an entity as he does: there is a mental rationale, a story behind practice that can be tapped and reconstructed. In routine forms of use, the user is unaware of the reasons behind his/her actions. This does not mean, however, that he does not know these reasons. The latter can be digged up by special research methods (see below). Such kind of research can also make clear to what extent a particular use logic is shared among users.

A reconstructed use logic can be compared with the logic behind the design of the product, i.e. with *design logic*. Design logic is the logic behind inscription. As such, it is the mental driver of a local design process. The notion of design logic is meant to cover the consistent whole of ideas, views, beliefs, values, intentions, estimations etc. that become inscribed into a specific artefact, building or infrastructure during the process of its design. Design logic gives the reasons why a design is as it is (Jelsma 2002). A good design logic is reflexive and informed about use logic, but in practice mismatches between the two often become visible only after the product has entered the market, by the appearance of unintended effects. As we argued in section 2, in technical design of environmentally friendly and energy saving features of machines and installations, formalised anticipations of user reactions are more exception than rule. This omission results in scripts that do not work or work in the wrong direction (see below), or in the realisation that users need scripts to be added to a machine to let them do the right job (in terms of environmental protection). For instance, in researching the use logic behind dish washing we found that many users stuck to the inefficient practice of rinsing the dishes by hot water from a running tap before placing them in the machine, because they did not know that the machine rinses the dishes before washing. Here a cleverly designed script –a technical feature to correct this behaviour- might save a lot of energy.

Finally, *delegation* is about the division of labour between human and nonhuman actors in carrying out tasks. Government can urge citizens to close curtains in the evening to save energy, but it can also subsidise insolation glass to do the job. By deliberately re-organising the tasks between humans and non-humans, designers may strike a better balance between the demands of users and the needs of the environment (as in the concept of 'forgiving technology', see section 2). Thus analysing delegation is asking who is doing what and where for whom in a certain design, and for what reasons (the latter are specified in the underlying design logic). By making these questions explicit in a design project, the distribution of tasks, responsibilities and trust between humans and non-humans can be discussed, swapped and decided upon. By blurring the boundary between the technical and the social in this way, design choices become more symmetrical and flexible.

## Towards a Common Ground Holding Promises for Practice

Having sketched the different landscapes, I now come to my final synthesis.

The foregoing analysis clinches the point that, in analyses of energy use in households, there is a conceptual break between considering the role of physical (material) objects on the one hand, and mental and social phenomena on the other. Social scientists use to restrict their studies to the latter. On the other side, engineers deal with the former. However, on both sides I have identified interests and insights mostly emerging at the fringes of the mainstream developments that offer opportunities for building a common ground for doing future studies in a more integrated way. In my view, the emergent framework within STS which seeks to connect design and use of technology as sketched, is a prime candidate to be used for conceptual boundary spanning between the social and the technical side of the landscape I have mapped. It is the awareness of the technical mediation of human behaviour that gives this framework its connective quality. As soon as one starts to conceive human action as inextricably moulded by technical devices and infrastructures, the conceptual and political duality between behaviour and technology crumbles away. A new perspective opens up, i.e. thinking about human behaviour in terms of the design and use of technology. Or: technology shapes human behaviour but is being re-shaped by humans in the practice of use. The notions introduced (script, delegation, domestication, design and use logic) seem to be well equipped to analyse this duality in a symmetrical way, and to open it up for development of more adequate policy than we have seen in the past. On the other hand, my excursions demonstrate that in other parts of the landscape similar notions (under different names) already exist, which are sometimes further developed or add new insights to the phenomena under study. At such overlaps conceptual bridges are possible over which mutual enrichment and learning can take place (see examples below).

**Linking Psychology, STS and Engineering**

The most obvious example of convergent theoretical developments in different parts of the knowledge-landscape is the development of the concept of *cue* in psychology (Heijs 1999, see section 3) and that of *script* within STS. Thus here is a case of mutual enrichment. Psychology fills in the mental mechanism that makes technical mediation work, whereas STS couples design and use processes by capitalising on the idea of mediation, and so creates a link towards engineering. In this way we span a kind of conceptual pontoon-bridge from on side of the kowledge-landscape to the other, over the social/technical divide. What does this bridge deliver for practice?

Let me give one example. Behavioural studies tell us that people take their habits and routines to new situations and environments. Such routines are often wasteful in terms of handling resources such as water and electricity. Technical design, informed by the above-mentioned insights, may help to break such routines and shift them to more sustainable ones. I elaborated this strategy for a comparative study of the scripts (expressed through the user interface) of two water saving cisterns. One design hardly saved any water in practice because its script allowed users to stick to their old routines (i.e. to push the button routinely and leave). The other did better, since the script of this interface forced users before flushing to make a choice between using a small or a large amount of water. That is, the latter script intended to force users out of their old routine behaviour toward making a conscious choice (Jelsma 2004). Work of Norman on '*affordance*' (Norman 1998), another concept in psychology with similarity to the notion of script in STS, gives other examples of application in technical design.

**Linking Economics and STS**

Here we best depart from the role of economic instruments for influencing human behaviour such as tariffs, energy labels and bills. As we have seen, outcomes of the application of such instruments are often rather unpredictable. A deficient match of design and use logic behind these instruments might explain this unpredictability. Framing this problem in terms of design and use might help to understand the outcomes better and improve them by a better design of the instruments. For instance, we may conceive 'folk logic' about economic matters as a form of use logic that is often at odds with the (academic) design logic behind the economic instruments applied. This discrepancy has also a material side, in the sense that the communication of the economic message of such instruments to users is technically mediated in the form of energy bills, energy labels etceteras. Energy bills and labels can be fruitfully conceived as artefacts, of which the design should be improved by anticipating the user logic that guides understanding of these artefacts in the use setting, and so influences energy use behaviour. If a user cannot read his energy bill because it is ill-designed (i.e., at odds with user logic), we cannot expect that the bill will enhance the user's awareness about his energy consumption and change his behaviour accordingly.

Thus two conceptual extensions are proposed here: economic behavioural stimuli are seen as technically mediated, and consumers are conceived as users of such economically motivated mediators. Making these extensions offers practical advantages: by turning to the

STS-approach, economic instruments can be tailored better to the practice of use as soon as one starts to conceive them as technical designs to be embedded in user contexts which have to mapped.

**Linking Engineering and STS**

Replacing 'functionality' by 'design logic' has the advantages that it makes clear that functionality is not an objective property of a design but only one of more possible ensembles under construction. Moreover, design logic is fluid in the sense that it depends on the logics of the design team members. If the team is changed –e.g., a environmental advisor is added, or users- the design logic, and thus the inscribed values will change. Another advantage is that design logics, as soon as they have been mapped, can be compared for inconsistencies. For instance, in a recent test project we found –by comparing the design logic of a smart system for climate control with the logic of the test building- that both logics defined completely different users (Jelsma 2001). This inconsistency turned out to be very confusing for the real test-users in the building (Jelsma 2002). A final asset of design logic is that it can be checked for the quantity and quality of the user logic that it incorporates (ranging from I-methodology to extended mapping of user practice). The hypothesis here would be that the less user logic a design logic includes, the less functional –e.g., in saving energy- the resulting design will be. Ergonomics and 'usability' (see Mackay et al. 2000) goes a long way in including user logic, but still departs from concepts that stem from the minds of designers only. Contextual design is the most radical approach in this respect, since it proclaims that extensive mapping of user practice should precede any technical and organisational (re)design activities.

In another project, carried out for the Dutch energy agency Novem, I imported this idea of user practice mapping and included it in an experimental design methodology. The basic idea was to redesign the scripts of household appliances such that they would support and guide user behaviour more effectively in the direction of energy efficient interaction with the appliance. We took 'contextual interviews' (a tool borrowed from contextual design) with users while operating certain appliances at home, and reconstructed how their logic of use interacted with the scripts of the machines. From this reconstruction we detected clues for improving the scripts with respect to support of energy saving in use practice (Jelsma 2004, forthcoming). On the basis of these studies we improved the methodology which can now be re-imported and enrich the engineering approach. Thus here we have an example that borrowed concepts and tools from two sides (STS and a fringe domain within engineering) and connected them into an integrated methodology for the (re)design of energy efficient household appliances.

## References

Achterhuis, H. 1996. Samenleving moet leren om moderne technologie te moraliseren, NRC Handelsblad. 23 April.

Akrich, M. and B. Latour. 1992. 'A summary of a convenient vocabulary for the semiotics of human and nonhuman assemblies'. In: *Shaping Technology, Building Society*. Cambridge Mass.: The MIT Press.

Berg, M. 1998. 'The politics of technology: On bringing social theory into technical design'. *Science, Technology and Human Values* 23 (4): 456-490.

Beyer, H. and K. Holtzblad. 1998. *Contextual Design: Defining Customer-Centered Research*. San Francisco: Morgan Kaufmann.

Bourdieu, P. 1984. *Distinction, A Social Critique of the Judgement of Taste*. Cambridge Mass.: Harvard University Press.

-----. CIEL, *A domestic end-use measurement campaign in France*, Final Report, EU Programme SAVE contract no. 4.1031/93.58.

De Laat (1996), *Scripts for the future*, Thesis, University of Amsterdam.

DuPont, P.T. and D. Lord. 1996. Reality Check: 'Comparing policymaker perceptions with consumer energy behaviour'. In *Proceedings of the ACEEE Summer Study 1996,* 8.27-31. ACEEE Press, Washington DC: American Council for an Energy Efficient Economy.

Egon, C.W., W. Kempton. 1996. 'How customers interpret and use comparative graphics and their energy use', *ibid*., 8.39-47.

Erikson, R.J. 1996. Energy and environmental awareness in Swedish and American households, *ibid*., 8.61-8.69.

Ester, P. 1984. Consumer Behaviour and Energy Conservation. Ph. D. Thesis. Rotterdam: Erasmus University.

Fizgerald, K.B. 1996. 'Consumer choice of energy using durables – competing interpretations'. In *Proceedings of the ACEEE Summer Study 1996,* 8.71-8.81. ACEEE Press, Washington DC: American Council for an Energy Efficient Economy.

Fanger, P. O. 1970. *Thermal comfort*. New York: McGraw-Hill Book Company.

Fishbein, M. and I. Aitzen. 1975. *Beliefs, Attitudes, Intention and Behaviour: An Introduction to Theory and Research*. Reading Mass.: Addison-Wesley.

Gatersleben, B. and C. Vlek .1998. 'Household consumption, quality of life and environmental impacts: A psychological perspective and empirical study'. In *Green Households? Domestic Consumers, Environment and Sustainability*. London: Earthscan Publicatons Ltd.

Goguen, J.A. and C. Linde. 1993. 'Techniques for Requirements Elicitation'. In *Proceedings of the IEEE International Symposium on Requirements Engineering*, 152163. Los Alamitos, CA: IEEE Computer Society Press.

Heijs, W. 1999. *Huishoudelijk energiegebruik: Gewoontegedrag en interventiemogelijkheden***.** Eindhoven: Faculteit Technologie Management TUE.

Jelsma, J. 2001. *Smart work package 4.1 final report: The Smart system and its test building: matching design logics*, ECN-C—02—008. Petten: Energy research Centre of the Netherlands.

Jelsma, J. 2002. *Smart work package 4.2: Smart field test: experince of users and technical aspects*. ECN-C—02-094. Petten: Energy research Centre of the Netherlands.

Jelsma, J. 2004. ‘Designing ‘moralised’ products: theory and practice’. In *Technology, Behaviour and the Environment, a Multidisciplinary Approach*. Dordrecht: Kluwer Academic Publishers. In press.

Kets, A. , P.G.M. Boonekamp and J.Jelsma. 2002. ‘Script-induced shifting of user behaviour in time’. Paper presented at the EASST Conference, York, 31 July-3 August.

Latour. 1992. ‘Where are the missing masses? The sociology of a few mundane artefacts’. In: *Shaping Technology, Building Society*. Cambridge Mass.: The MIT Press.

Latour, B. 1993. *We have never been modern*. Cambridge Mass.: Harvard University Press.

Latour, B. 1994. ‘On technical mediation – Philosophy, sociology, genealogy’. *Common Knowledge*: 29-64.

Lie, M. and K. H. Sørensen. 1996. *Making Technology our Own? Domesticating Technology in Every Day Life.* Oslo: Scandinavian University Press.

Lutzenhiser, L. 1993. ‘Social and behavioural aspect of energy use’. *Annual Review of Energy & Environment* 18: 247-289.

McCalley, T. and C. Midden. 1998. *Computer-based systems in household appliances: The study of eco-feedback as a tool for increasing conservation behaviour.* Eindhoven: Department of Technology Management, Technical University of Eindhoven.

McCalley, T. 2003. ‘From motivation and cognition theories to everyday applications and back again: the case of product-integrated information and feedback’. In *Proceedings of the ECEEE 2003 Summer Study*, 6: 1151-1157. Stockholm: European Council for an Energy Efficient Economy.

Mackay, H., C.Carne, P. Beynon-Davies and D.Tudhope. 2000. ‘Reconfiguring the user: Using rapid application development’. *Social Studies of Science* 30 (5): 737-57.

Norman, D.A. (1998), *The design of everyday things*. Cambridge Mass.: The MIT press.

Oudshoorn, N. and T. Pinch. 2003. *How users matter*. Cambridge Mass.: The MIT Press.

Schuler. D. and A. Namoika. 1993. *Participatory Design: Principles and Practice*. Hilsdale N.J.: Erlbaum.

Stern, P. 1992. ‘What psychology knows about energy conservaton’ *American Psychologist* 47 (10):1224-1232.

Underhill, P. 1999. *Why We Buy, The Science of Shopping.* New York: Simon and Schuster.

Wilhite, H. and K. Nakagami. 1996). ‘A cross-cultural analysis of household energy use behaviour in Japan and Norway’. *Energy Policy* 24 (9): 795-803.

Wilhite, H., E. Shove, L. Lutzenhiser, L. and W. Kempton. 2000. ‘The Legacy of Twenty Years of Demand Side Management: We Know More of Individual Behavior But Next to Nothing about Demand. In *Society, Behaviour and Climate Change Mitigation*. Dordrecht: Kluwer Academic Publishers.