A dynamic structuration approach to information for end-user energy conservation

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Abstract

Levels and patterns of energy consumption in industrialized countries are multiply determined by past and present choices on personal, social, technological, and institutional levels. Assuming that the ecological reform of Northern societies' consumption trajectory requires change on all of these levels, energy information approaches and tools oriented around householders should include both bottom-up (individual) and top-down (structural) dimensions. This paper describes the experience of deploying an energy information tool for householders based on this rationale in an interview setting. Quantitative comparisons and discussion of the relative impacts showed in each case where it pays to initiate personal conservation measures and where rather the emphasis should be placed on the greening of energy-relevant technologies, social practices, and consumption infrastructures. Overall, people's experiences in the sessions slightly reduced their view of the efficacy of individual conservation measures compared to top-down technological interventions. However, direct energy consumption in sectors like diet and air transport was seen to be highly personally determined. The three groups of subjects that emerged from the data showed themselves to be clearly differentiated in their use of energy-consuming devices and services, in their direct reduction potential, in their recognition of the role of factors higher up on production-consumption chains and networks, and in their possible willingness to participate in the greening of these networks and social practices. These experiments in bringing technological and social systems into a dynamic interplay with householders' individual behaviours set out a novel information approach to the energy consumption problem.

Introduction: The role of knowledge in direct energy-relevant behaviour and the conventional end-user energy information approach

Information provision is one of the standard policy tools for influencing end-users' energy demand and their energy- and environment-relevant behaviour in general. Information, knowledge, and motivation are examples of what environmental psychologists term psychological determinants of "ecological" behaviour. Environmental knowledge types include declarative, procedural, effectiveness, and social. But it is well recognized that knowledge is a "distal predictor of behaviour that is conveyed by more behaviour-proximal mediators." These intervening variables may include incentives, intentions, attitudes, values, and other factors (Kaiser in press). A unit of knowledge must converge with other types of knowledge and often a wide array of other factors, both concurrent and more proximal, to exert a behavioural influence, and it is the proper convergence and not the quantity of knowledge that determines its effectiveness in promoting ecological behaviour.

Knowledge is enmeshed in complex psychological and situational variables and communicative issues. Emotional

factors may be important in how knowledge is used. For example, if environmental fatalism is widespread or culturally endemic, it seems to act as a potent inhibiting mediator for (declarative) knowledge's conversion to proactive responses of any kind, except perhaps the collection of more of this knowledge (see Meijnders 1998, Finger 1994). For climate change, this would lock in adaptation as the only course of action.

The complexities of knowledge's connection to ecological behaviour show the weaknesses of the conventional policy assumption of a straightforward link that can be exploited by public information campaigns and educational efforts. Although information has long been one of the standard American energy conservation policy tools, affecting home energy use by providing information has been mostly ineffective; problems have involved credibility, behavioural commitments, and failure actively to involve the energy users. Informational programs often make the erroneous assumption, based on psychological or economic rational actor theories, that people will act on information about what steps they can take to save energy and money. Among other things, such programs fail to concentrate on the attractiveness, clarity, simplicity, or relevance of the message and/or the credibility of the sources (Stern 1987, 1992).

Among conventional energy information tools, the lack of a social message and focus on micro-efficiency may defeat the macro aim. For example, efficiency labels that implicitly encourage purchasing larger, or larger numbers of, electronic items, or using them more freely, may not serve the efficiency goals of the larger socio-technical system. Without a broader message, labels may validate symbolic or even counter-productive actions of purchasing relatively more efficient models and provide psychological salves instead of actually contributing to reduced overall environmental insults (Moezzi 1998). By including an aggregate national component, as well as user functions that allow scaling up individuals' profiles to the Swiss aggregate, the software this paper introduces makes potential scale and technological rebound effects explicit.

Theory and analysis for a broadened consumption-based, structuration information approach

This section develops the rationale and theory behind a broadened, structuralist information-knowledge approach for end-user conservation that addresses some of the problems just described. It also positions the approach within contending schools of energy analysis. Later sections discuss the approach's empirical application in a software tool and interviews.

Psychological and behavioural studies examining the connection between Western Europeans' resource consumption and environmental awareness find that householders display a combination of unwillingness and inability to change their behaviour patterns (Gatersleben 1998).

Looking more closely at the notion of *inability* in energy consumption, Dholakia et. al. (1983) presented a macro-micro model of energy consumption behaviour as a series of nested and interlocking choices, in which "macro choices delimit and define the scope of micro choices… In other words, energy use and energy conservation behaviours must be seen within the context of a broader *consumption pattern* which is socially determined" (emphasis in the original). Dholakia et. al. used the term *discretionary* to characterize the individual's scope in making micro choices; the implied term for the constraining macro consumption pattern, as it relates to the individual, would be *non-discretionary* or *less discretionary*. A host of factors – economic, technological, sociological, and so on – shape the macro-imposed portion of this non-discretionary consumption.

On the level of personal preferences, the threshold in the range (or continuum) of discretion, that is the point at which discretionary becomes non-discretionary for any single person, is murky and requires the use of psychological, sociological, or ethical devices to characterize. A combination of influences – especially psychological, situational, and economic – shape what an individual can and wants to control in her household (energy or resource) consumption as well as what she regards as achievable and desirable conservation measures. For example, a person's income and class affect which types of constraints (non-discretionary) are most relevant to his energy use profile: lower-income earners are more often constrained by a lack of technological alternatives, infrastructure, and institutions (car use in the US comes to mind). The upper class' energy use may be hemmed in on the other end by the high consumption norms and imperatives of the consumer society.

In sociology, Giddens' structuration theory seems to come closest to this framework (Giddens 1984). When knowledgeable and capable individuals act in a social context, they draw on a virtual set of social rules and resources, but in doing so they *instantaneously* reproduce (perpetuate, or "instantiate") these rules and resources. Social (and socio-technical) structures are both enabling and constraining of individuals. Some part of a person's energy consumption, and savings possibilities, is more highly discretionary, but just how much depends on a mutual interaction and dependence between the individual and the socio-technical structure.

Sociological notions of the ecological modernisation of consumption, based heavily on Gidden's structuration theory, entail shifting the border toward the discretionary by involving consumers in both individual action and the process of institutional ecological reform. Figure 1 depicts this actor-structure concept as applied to the ecological modernization of household (energy) consumption. Spaargaren (2000) summarizes: "On the left side of the model, human actors – aiming at a reduction of the environmental impacts of their lifestyles – are dependent on the environmental innovations made available to them through the systems of provision. On the right side of the model … agencies involved in the development of more sustainable goods and services are dependent on human actors. They have to recognise environmental innovations as relevant 'tools' that fit their lifestyles and their internal domestic organisation as well as their specific standards of comfort, cleanliness, and convenience".

Figure 2 offers a graphical representation of the lower portion of a sample person's discretion continuum for "mobility", with intervention types also indicated. The order is highly personally idiosyncratic: another person's graph

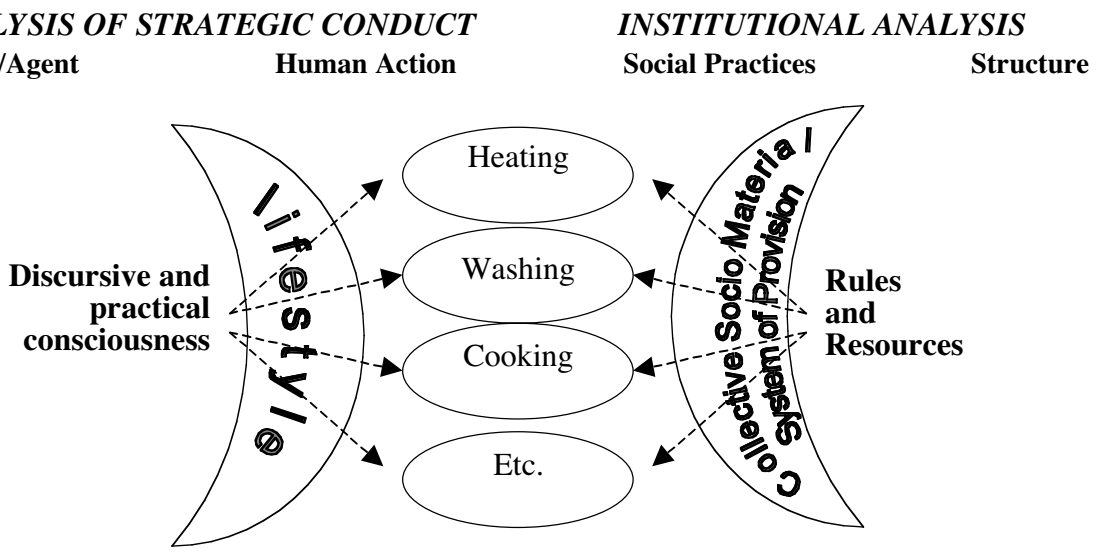

Figure 1. *A Conceptual Model for Studying Consumption Practices (van Vliet 2002), (Spaargaren 2000).*

would look different. Direct behavioural household measures may appear at both the bottom and top end of the y-axis of personal discretion: for example, since this individual, for whatever combination of circumstances and preferences, places a high value on owning his own car (albeit a relatively fuel efficient one), foregoing ownership and renting when needed is a much less discretionary option for him.

A *collectives* or society's "room to manoeuvre" may be best revealed through historical study (Spaargaren 2000). As a thought experiment, we can imagine a discretionary continuum for society based on hypothesized requisites for sustainable consumption,[1] using what it has achieved thus far as a measure of the minimum the collective deems currently possible or discretionary. We know that current potential for end-use energy efficiency development, for example, far exceeds what prevails in the marketplace, and we can hope that actual social and economic potential also exceeds past and current achievements. Figure 3 portrays Northern society's current discretionary range vis-à-vis resource and energy use, with examples of institutions arrayed on both sides of the discretionary/non-discretionary threshold (those above represent institutional or technological innovations it does not or cannot yet achieve). The vertical lines to the right sketch possible directions for future trajectories.

Returning to the level of the individual, the discretionary/non-discretionary constructs are related to the distinction between two schools of energy analysis that we have dubbed Energy-Revealing and Social-Revealing, and which we have described at length in (Goldblatt 2002). The Energy-Revealing (/Social-Concealing) approach applies a conventional individualistic, behavioural focus and often uses environmental/energy impacts exclusively as the unit of analysis and presentation. Energy-Revealing tends to concentrate on individual actors and the possibilities for influencing their direct energy consumption; thus it tends either implicitly to assume most end-user energy consumption is discretionary, or it limits its focus to the direct part that is.

The alternative Social-Revealing approach permits exploration of less directly discretionary factors that work to constrain or prescribe individuals' energy consumption. A Social-Revealing treatment recognizes that "... energy use is shaped in complex systems that often submerge energy and other environmental concerns..." (Wilhite et al. 2000, p. 123). Rather, it is the social, cultural, socio-technical, or institutional that may need revealing. The full Social-Revealing approach recognizes the determining decisions of institutional actors like building contractors and developers, manufacturers and retailers that frame or limit the choice for end-use energy decisions (e.g. Stern 1992). In addition, it examines "cultural and socio-technical embedding of energy-related practices"; the continuous growth of demand and energy-intensive lifestyles and their normalization at higher levels; the co-evolution of norms, practices, and ways of life with energy-technologies; and the role of institutions and the historical development of infrastructures (Shove et al. 1998, Wilhite and Shove 1998, Wilhite et al. 2000).

Policy Rationale

One of the aims of the study this paper grew out of was to expand opportunities for the public's involvement and participation in environmental decision making, public deliberation, and possibly resource provision. Environmental decision making is understood here not as the province of a few key environmental agencies or polluting companies but

1. E.g. decoupling consumption and welfare (Jackson et. al. 1999), restoring feedback to decision-makers by reducing systematic obscuring and distancing of costs (Princen 1997) (Princen 1998); shifting the market/non-market border in favor of non-market consumption (Cogoy 1995); breaking the work-and-spend cycle (Schor 1991, 1995, 1998); combating systemic planned obsolescence, full-cost pricing, eliminating resource subsidies, ecological tax shifts, and so on.

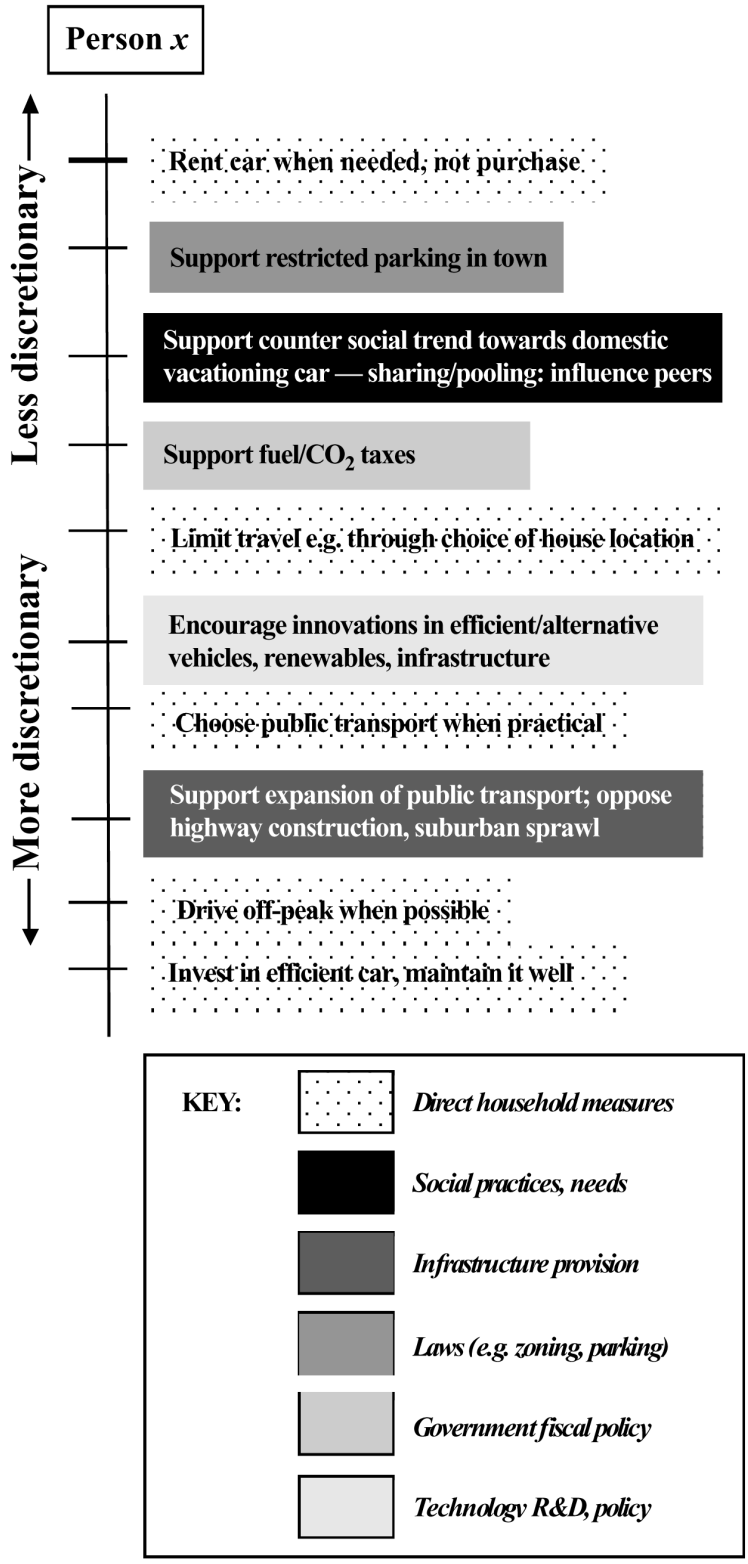

Figure 2. *Excerpt from a hypothetical individual's discretionary continuum for the "mobility" activity, with intervention type (pattern key).*

in a broad sense as pertaining to a wide spectrum of technological, social, and economic conditions and developments that impact environmental sustainability. Ecological modernization theory as well as risk society and reflexive modernization theory argue that a broader range of actors at different levels – including companies, consumers, social groups, and communities – should have a larger role in spurring changes for environmental protection and reform (Mol 2000).

To put this in an energy policy context, noting the small economic potential for energy efficiency improvements in a world of low energy prices, and the increasing tendency (es-

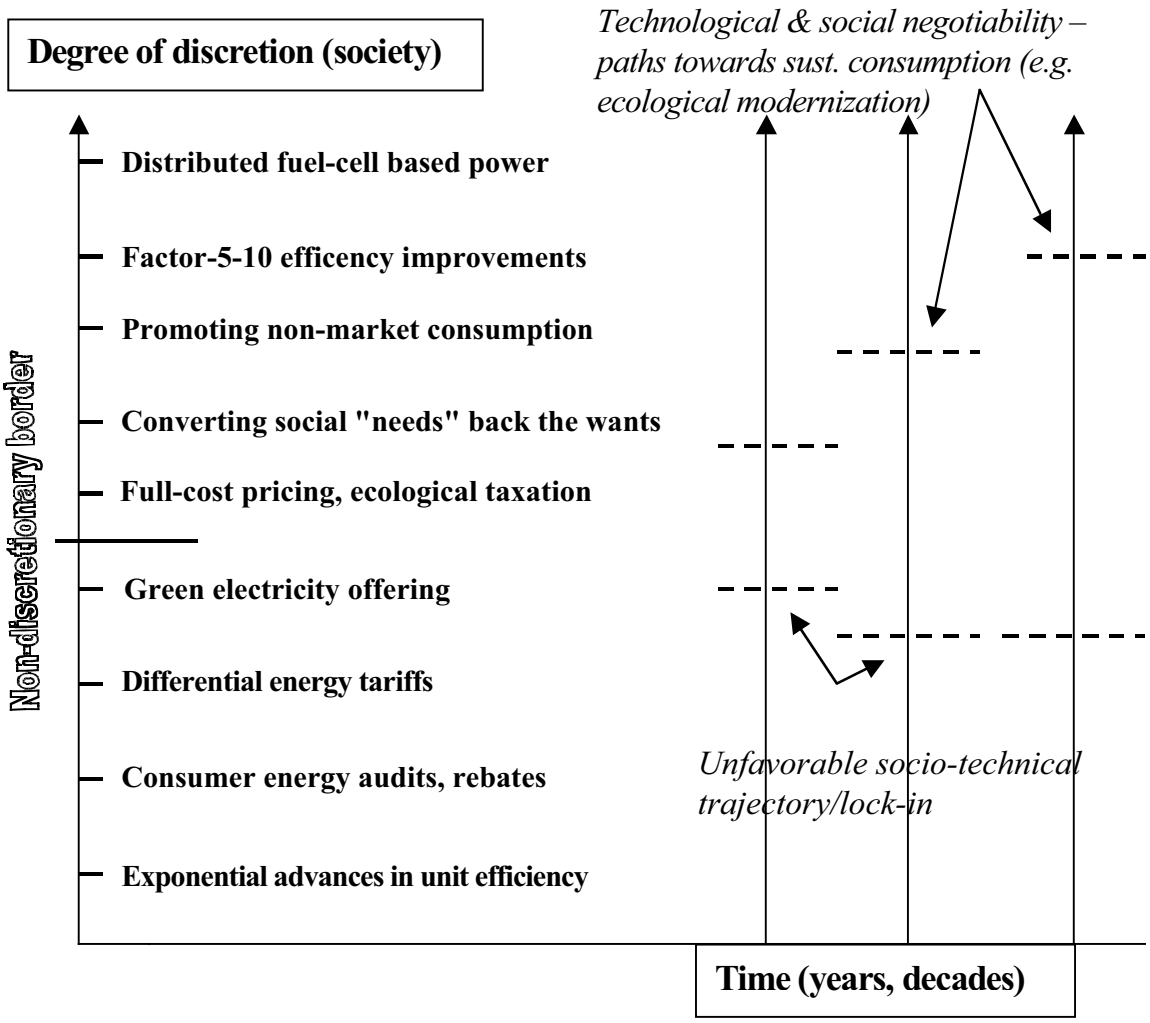

Figure 3. *Depiction of industrial society's current discretionary continuum for resource or energy consumption, with future alternative.*

pecially in the United States) to leave decisions concerning energy technology and emissions reductions up to businesses and energy companies under a regime of voluntary standards, we propose that the end-user takes a greater and necessary compensatory role in pressing companies and governments for environmental reforms. At the same time, despite the current absence of economic signals and social mechanisms inducing personal restraint, the user should also look to his own home and practices for reduction potentials. How much of the one and how much of the other? Providing or generating information and knowledge may help people find the appropriate balance and further lay involvement.

It is proposed here that laypeople need better information on the array of factors and their interactions that influence energy consumption and by extension environmental sustainability. This aim requires different approaches to the provision of knowledge than conventional information approaches; and, as a testable hypothesis, it benefits from different communication tools. In contrast to the conventional provision of energy information, then, it is helpful to (let the end-user) confront the duality of, and examine the shifting border between, the discretionary and non-discretionary, e.g. between the behavioural and structural, in energy consumption. A comprehensive, dual approach to social practices allows end-users to make both a left-approaching "analysis of strategic conduct" (according to Figure 1) as well as a right-approaching "institutional analysis." (It is especially interesting to focus on people's actions on the left side in light of their greater knowledge of the right side.)

An increasing number of studies of direct and indirect household energy consumption in the Energy-Revealing vein purport to enhance environmental awareness by providing information on the energy and emissions consequences of consumer behaviour. Voluntary informational and educational efforts are one of the most obvious means of stimulating greater consumer-citizen involvement. But what sorts of end-user knowledge sets (presumably comprising both expert and personal elements) are most important for achieving meaningful energy savings? And what might be useful and effective means of encapsulating and communicating the needed expert knowledge – and stimulating the necessary personal reflection – for the end-user?

The Social-Revealing approach to energy analysis described above takes embedded energy consumption in products, services, and systems for granted and instead tries

to shed light on its socio-technical drivers and causes the better to define and manage services and practices that consume energy. This applies to both policy makers and, according to theories of the ecological modernization of consumption, consumer-citizens as well: If end-users are to have a role in managing and shaping their own energy-consuming practices, services, and devices, they require a broader accounting (i.e. *knowledge* and understanding) of the determining factors than provided by the individual-oriented Energy-Revealing approach alone.[2] A broader accounting of the factors influencing end-users' energy-consuming devices, services, and practices may help facilitate their role in managing and shaping them. In the first place, it may induce personal or household conservation measures. In the second, it may encourage end-users' contributions at positions higher up in the production-consumption chain. For example, a broader accounting may enhance citizen-consumers' input into governmental and corporate technology policy choices or their support of environmentally favorable changes in social practices or norms. Expert modeling, in combination with explanatory discussion and interviews, is one way of providing such an accounting.

In addition, showing what is legitimately outside one's direct control highlights by contrast what is under one's control, although environmental psychologists insist this is very much a matter of personal characteristics vis-à-vis society and random influences that require a specific situational context for any coherent analysis. Balancing this approach with elements from the conventional Energy-Revealing economics-engineering approach – those that explicate end-users' direct contributions to energy consumption and attendant environmental insults – helps certain people to take personal responsibility where appropriate while peaking their interest in less discretionary social and technical issues as well.

Software development and empirical application

This section describes the reconfiguration of an energy accounting model and software tool based on the theory and rationale of the preceding sections. The software was tested in a series of in-depth, structured pilot interviews. The interviews and selected results are thematically presented here.

SOFTWARE DEVELOPMENT

Focusing on the discretionary/non-discretionary dialectic with respect to consumption and energy use, how could one encapsulate it in a communicative framework to enhance the public's ability to support environmentally favourable institutional, technological, or social changes? Cutting-edge integrated assessment-based models would be a logical starting point, since they expose some of the deeper social, institutional, and technological connections to energy and environmental trends. Would a reconfiguration of a pre-existing personal and regional energy calculator, a program based on such a model, be useful in pointing in this direction, at least as a springboard for discussions and questions in interviews or focus groups?

Two scientists at the ETH, Gregor Dürrenberger and Christoph Hartmann, had developed a program that incorporated both the householder and Swiss levels but largely separated them into personal and regional modules, respectively.[3] Collaborating to produce the current reworked version, we combined elements from the two modules in such a way as to allow the user to pose and at least partly answer the following questions: ((Goldblatt 2002) and (Goldblatt et. al. 2003) present a more detailed description of the model and software developed.)

1. Which personal or direct household variables (e.g. behaviours, practices, appliance purchases and use in heating, travelling, leisure time, etc.) do I think I could rather easily change? In what time frame? Which am I unable to change?
2. Of those I am able to change, which would I be willing to change in a direction of lower consumption; which not, and why?
3. What are the most important factors beyond my direct, immediate control constraining my energy use (in housing, travel, diet, etc.)?
4. What is the nature of the factors beyond my direct control? Technological (e.g. prescribing or constraining availability of options, efficiency levels)? Demographic? Social (e.g. prescribing types of consumption/activity levels)? Economic/institutional (e.g. establishing patterns of business and commerce that inflate the embodied energy of goods or set incentives for trends in the development of the other variables listed here)?
5. How significant would be the effects of changes in broad-scale social or technological variables on my energy consumption in comparison with the effect of independent personal changes I might be willing to make? I.e. How does the impact of "bottom-up" personal change compare with that of socio-technical change from the "top-down"?
6. What combinations of technological and social choices keep down future (Swiss) national energy use?
7. What would national energy use be if everyone consumed as much as I do now or in the short- or mid-term? In combination with other broad-scale technological changes?

The redesigned version would bring less-discretionary elements from the regional model, originally designed primarily for policy makers and planners, into a close interaction with the end-users' familiar household variables (which are variably discretionary depending on the householder's means, preferences, and situation). In order to answer the posed questions and other descriptive questions more fully

2. The developed software shows the comprehensiveness and synergies possible when the two approaches are combined.
3. Gregor Dürrenberger and Christoph Hartmann, Der persönliche ECO_2 Rechner, Interview-version 2.0, 2001, Zurich: Swiss Federal Institute of Technology.

Table 1. Subjects' biographical profile.

GENDER	16 male, 5 female
AGE	Avg. 32.3, s.d. 11.7
RESIDENCE	Zurich (16), Aarau (1), Bruettisellen (1), Trimmis (1), , Lausanne (1), Prilly (1)
EDUCATIONAL LEVEL	University (undergraduate or higher) 18; trade-school or equivalent: 3.
PROFESSION	13 7th / 8th semester ETH students, doctoral students, or recent graduates*: 8 professionals: private banker (2), bank clerk (1), national bank president (1), commodity trader (1), travel agent-owner (1), biomedical scientist/entrepreneur (1), clergyman (1)
HOUSEHOLD SIZE	Avg. 2.70, s.d. 1.08
HOUSEHOLD INCOME (MONTHLY)	Avg. CHF 7 994.74, s.d. 3 516.70
PERSONAL INCOME (MONTHLY)**	Avg. CHF 3 235.00, s.d. 2 251.34
HOUSING	18 apartments, one double-apt., two houses
AUTO USE (CAR OR MOTORCYCLE)	10 autos, 2 motorcycles (with autos)
ENVIRONMENTALISM***	Avg. 0.79 (neutral to somewhat green), s.d. 1.04
ENGAGEMENT WITH ENERGY ISSUES	Avg. 67.5%, s.d.29.36%

* Students' fields of study: physics (1), food sciences (2), environmental engineering (4), electrical engineering (1), survey engineering (1), biology (1), computer science (1), architecture (1), process engineering (doctoral- 1).

** Household income/household size

*** Numerical interpretation: 2-very green; 1-somewhat green; 0-neutral; -1 somewhat anti-green ('pro-growth', etc); -2 very anti-green

and to gauge the program's usefulness as a tool for communication and education, it was clear it should be tested in an interview or focus group setting. Although focus groups would have added an element of social dynamism, the novelty and pioneering character of this effort, as well as constraints on time and manpower, argued for beginning with a set of pilot structured interview sessions.

PILOT INTERVIEWS

As an experimental pilot test study, 21 subjects were interviewed from a pool of candidates ranging in age, income, education, profession (or students' field of study), housing, car use, environmental leanings, and other variables. (Due to the length and complexity of the interviews and staff limits, it was not feasible to conduct a sufficient number of interviews to reach a statistically generalisable sample size.) Table 1 presents interviewees' biographical characteristics. Close to half of the subjects were university student, who were generally more available and in need of the compensation offered. Student interview sessions lasted an average of three and one-half hours, including data entry; most interviews were done in single days, with a break at the midpoint. Later interviews with businesspeople were streamlined to approximately three hours.

The following abstracted description of the interview session also summarizes the software interfaces and capabilities: The subject enters information to generate a status quo energy profile, comprising direct and embodied (grey) sector components like heating, living, diet, and transport (see profile 1 in Figure 4); she compares herself to average and household types. The subject then generates conservation profiles (profiles 2 and 3 in Figure 4). In the long-term screen, the subject chooses levels for various technological parameters (e.g. industrial, commercial, residential, and transport efficiencies, modal split for goods transport, and electric power generation mix), notes effects on profiles (profiles 4, 5, and 6 corresponding to profiles 1, 2, and 3 respectively), and compares her conservation profiles with her status quo profile under the influence of technological changes (e.g. profile 3 vs. profile 4). The subject chooses levels for demographic and social parameters in Switzerland, including population, household size, consumption, driving and flying levels, auto occupancy rates, and living space; she assesses the differential effect of combined variables on long-term Swiss energy use. Finally, the subject has the option to scale up personal profiles to Swiss national levels.

DATA ANALYSIS

During the interview sessions, data were recorded through a combination of selective cassette recording, pre-prepared worksheets filled out by the interviewer or the subject, on-site hand-written notes, and Excel data generated by the software and saved for each subject at the interview's conclusion. Portions of the audio recordings were transcribed or their data otherwise extracted into a Zoot 3.1 program database.[4] Zoot and subsequently Excel 2000 served as the main data storage, manipulation, and analysis tools.

One analytical feature built into the interviews was a cluster of $time_1/time_2$ (before/after) questions designed to measure the subjects' degree of learning or opinion change over the course of the interview. As another part of the analysis, correlations were calculated between the quantitative data results (including the before/after questions) and the variables age, household size, personal income, green-ness, and energy-engagement.

4. http://www.zootsoftware.com/

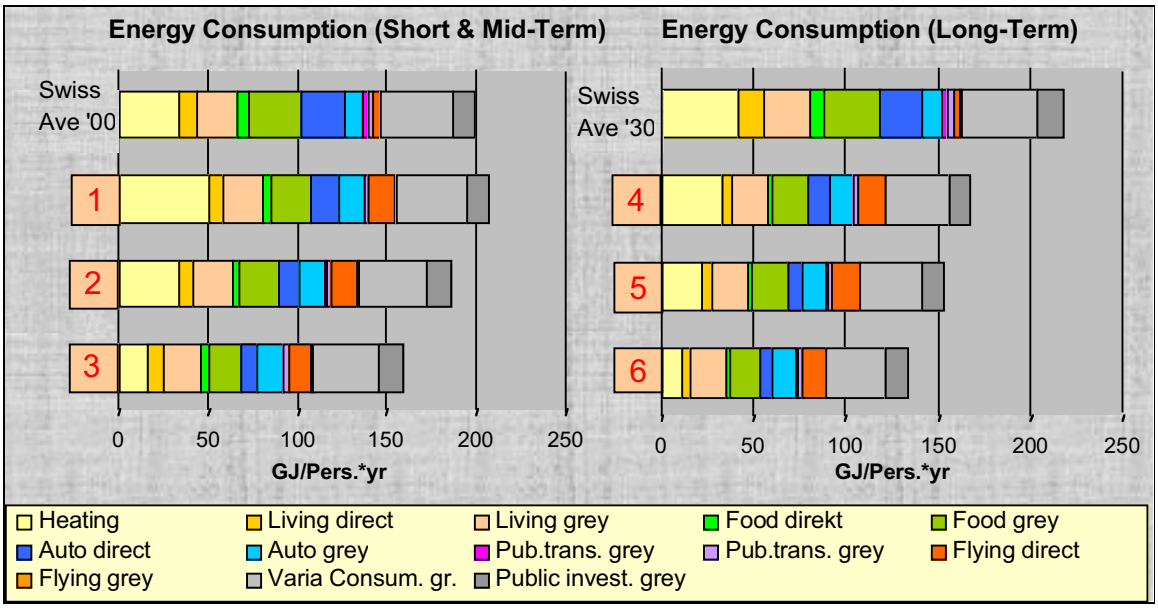

Figure 4. *Close-up of individual user output from long-term screen, with key for color-coded categories.*

Table 2. Groups of subjects in simple contrast

	Age	Energy use	Household size	μ Pers vs. Tech
Group I	↓	↓	↑	Both
Group II	–	↑	↓	Pers
Group III	↑	–	↑	Tech

(– = average; ↑ = above average; ↓ = below average)

Selected results

SUBJECT GROUPS

On the basis of their status quo energy use, willingness to reduce, and several other criteria, we categorized subjects into three groups (roughly, student-types (I: 14), young professionals (II: 4), and family professionals (III: 3)). Other data were analyzed with reference to these groups and to the subjects as a whole. Often strong group consistency was maintained across a range of themes.

Table 2 shows a simple summary of some of the groups' differentiating characteristics. (The last column, "μ Pers vs. Tech" (a dependent variable), conveys which type of intervention, personal or top-down technological measures, is most effective on average for that group, and is recognized as such (see next section).)

DISCRETIONARY VS. NON-DISCRETIONARY

As a result of the interview session, subjects in all groups tended to rate non-discretionary (especially technological) factors as somewhat stronger determinants of their energy consumption levels than personal factors. That is, after experience with the program, on average subjects had a slightly diminished view of the efficacy or capability of personal interventions to reduce consumption. Technological interventions were such steps as changes in industrial production efficiency, power mix, and/or efficiency or modal split of the freight transportation fleet; while personal changes included any household behavioural or investment decision like leaving the windows open less frequently in winter, replacing an old refrigerator or washing machine, or eating slightly less meat. This finding was only generally true of total energy profiles. Individual sectors sometimes showed the contrary. Direct electricity consumption in living, diet, and public transportation and especially direct fuel use for flying provided such counter-examples. Flying was seen to be strongly dependent on personal circumstances, behaviour, and choices and – per passenger-km through 2030 – only weakly influenced by technology. For reducing energy consumption from these activities, at least for Group I, short to mid-term personal steps were on average more effective than broad-scale technological improvements like higher efficiencies. Most subjects, especially Group II young professionals, expressed a willingness to make modest efforts to conserve electricity for living and diet-related activities.

The above conclusions are based on the distillation of several devices and tests built into the interviews. For example, one of the $time_1$/$time_2$ question sets gauged the change, over the course of the interview and interaction with the software, in interviewees' perception of the importance of behavioral/personal factors in influencing their (status quo) energy use. The average across all groups was -5%, i.e. an ex-post downward revision of their original assessment of per-

sonal factors' influence on their current energy use (evidently in favour of macro-technological or other less discretionary factors) by about 5%. Group I members showed an average of -7%, while Group II members show no change or an increase in the weight given to personal factors, as might be expected of a high-consuming group of professionals who have gone through the exercise of examining their household energy budgets in detail.

TECHNOLOGICAL VS. SOCIAL LEVERS

Another finding is that after experience with the program, a strong majority of subjects identified social and demographic factors as more important than technological factors for affecting future *national* energy use. As a learning process this reflected a moderate increase in social/demographic parameters' importance (+13% total average) and a slight downward revision for technological parameters (-6%). Subjects' judgment between the two sometimes clearly depended on their reference point, the goal they favoured for future national energy levels (specifically whether actually reducing or just holding down growth to stabilize at current levels).

In addition, by shifting the focus from the individual to the aggregate level, this question implicitly brought out the distinction between efficiency and conservation: it highlighted the difference between smaller scale efficiency increases and societal-scale increases in activity that defeat conservation aims. For example, one subject from Group III, a sworn "technologist" going into the interview, examined the effects of simulating simultaneous high technological advancement and high demographic and utilization rates (setting the respective parameters to their highest programmed levels). Looking at the results of the joint maximization, he saw that the demographic and social parameters completely overwhelmed the gains from improvements in technological factors, leaving total energy use roughly unchanged from current levels. Household size, he noted, was much more important than the other variable he had previously singled out, auto efficiency: Moving from over 9 liters/100 km to 2-4 liters/100 km for the private vehicle fleet has less of a dampening influence on overall national energy consumption than strong reductions, e.g. from 30% to 25%, in single-person households. The interviewee was amazed at this discovery: here the software provided a revelatory learning experience.

LONG-TERM CHANGE

The model showed that future (2030) Swiss per capita energy consumption will in all likelihood be much larger than 2000 watts, the ETH's designated ecological-energy threshold, even with optimistic assumptions about the energy efficiency of technologies and reductions in activity levels. Although at least one subject challenged the model's extrapolations here, most subjects accepted this projection as plausible, and on prompting they offered various explanations for this development, many of which accord with the current social-scientific understanding of the drivers: perverse economic incentives for extensive transport of materials and components in goods manufacture as an inflator of grey energies; problematic lifestyles of luxury, availability, and convenience; lifestyle normalization at ever-higher levels and difficulty of reversal; far-flung leisure travel; shrinking household size; low public awareness; transformation of wants into needs; and so on. A majority of subjects felt that Swiss society has the ability to make a collective choice of its energy consumption levels and that trend level increases are not the inevitable result of "automatic" socio-economic processes. This does not imply they think that ability will be exercised.

CONSUMER-CITIZEN INVOLVEMENT

Viewing all groups together, 12 subjects said indicated they had no means of contributing to the "greening" of structural elements surrounding energy consumption. Three could not answer definitively. The remainder believed they had, or might have in the future, some individual influence, but mostly not as individual consumers. Several of the students of environmental engineering or architecture viewed themselves as potential future decision-makers in their career capacities. A few subjects specifically invoked their roles as consumers or citizens who participate in or support the activities of NGOs.

SUBJECTS' ASSESSMENT OF THE SOFTWARE

A large majority felt the program was instructive and useful for themselves. Most subjects felt the program would be useful for informational and educational purposes with the general public, perhaps given certain changes or simplifications, or with older students and/or in a suitable educational environment. Some felt the screen with long-term variables was too complicated (for such use). Later versions of the separate personal and regional (national/long-term) modules have already been developed for the Internet[5]; with appropriate modifications and accompanying explanatory material, the combined version here may also be suitable for a web-based application, although the subtleties involved argue for a live or even group session.

Conclusions

The energy accounting model and software described here brought a modelled and simulated accounting of technological and social systems into a dynamic interplay with householders' individual preferences and behaviours as brought out through interaction with the program and interviews. It let users discover for themselves how nuanced and changeable is the discretionary border, in different individual life situations and at different levels of aggregation. The pilot interviews confirmed that a combination of technical and social factors is useful in this sort of model and tool; and that a presentation of these elements can work together well with familiar household behavioural and investment decisions. The program also helped people think more holistically about the personal, social, and technological dimensions of energy conservation currently and over different time scales. Subjects could ask themselves, what should be changed to

5. See www.novatlantis.ch

make a difference in the home, and for the nation as a whole, presently and in the future?

The interviews were also especially useful in stimulating thought on what can be changed, and how (especially who might exert the impetus). A small majority of subjects seemed on average to put somewhat more emphasis on top-down changes; however, by the interview's end, subjects could not in good faith entirely "pass the buck" in terms of personal effectiveness and responsibility.

The preliminary success in expanding the set of determinants in an end-user consumption information tool beyond the usual discretionary household variables like lighting and thermostat control should encourage energy analysts of the associated Social-Revealing school. Extensions of the software and interviews could be used to stimulate discussion in both public and policy circles of problematic trends for energy consumption like technological lock-in and perpetual demand escalation in private transportation, for example. According to SCOT theorists, this may be the start of the process by which the perceived "non-discretionary" becomes open to the possibility of collective change.

The inclusion of embodied energies was one of the innovative features of the household energy model and software program. The interview sessions showed participants how large a proportion of the current and future overshoot of Switzerland's designated sustainability threshold of 2000 watts per capita could be attributed to grey energies, even with considerable technological progress and conservation-favouring social changes. Including embodied energies helped meld the program's presentation and interface to the larger consumption perspective and social science framework that lay behind the interview sessions.

The three subject groups showed themselves to be clearly differentiated in their use of utility products and services, in their direct reduction potential, in their recognition of the role of factors higher up on production-consumption chains and networks, and in their possible willingness to participate in the greening of these chains and systems.

The implication is that different lifestyle groups might use or support different consumption interventions or "reduction strategies" differentially over other strategies, although preferences here may not consistently map to other fixed lifestyle group characteristics. The interviews only started near their end to assess participants' views on possibilities for consumer involvement in the ecological modernisation of infrastructures of consumption (e.g. collective consumption practices and/or those of providers or producers). Systematically exploring this issue is important for any future work of this sort. Concrete political applications also lend themselves to more social and participatory settings like focus groups (Dürrenberger 1999). The influence of different values, especially among cultural sub-groups, could also be investigated.

The interview sessions showed the software has considerable pedagogical value, even though it was designed for experimental purposes to point the way to future full-fledged packages that might incorporate those innovative features of the approach that proved themselves successful. Discussions are underway on how the program could be used in high school environmental curricula in Zurich.

Current research in similar but more ambitious sustainability tools shows that not only is it possible to stimulate dynamic interplay between the user and expert knowledge embedded in the tools, but that put in action at schools and homes, the tools can help people move from education and knowledge to participation in social change. Quest, a computer simulation game developed by University of British Columbia's Sustainable Development Research Institute, generates scenarios of sustainable futures based on users' choices of a wide variety of social and technological parameters and assumptions. Quest's underlying conceptual framework is built around the conventional triple sustainability imperatives and uses the strategies of dematerialization and resocialization. Applications and similar projects are in development or planned for cities around the world.

Open questions for future development of our tool and kindred efforts include the following (see also (Spaargaren in press)):

1. Does the "greening" of activity sectors and social practices like transport or diet favour expert knowledge over the participation in and influence of laypeople on providers, producers, infrastructure, and technology development? We want to stimulate lay involvement, but in our interviews we went about it in a partially expert manner.
2. How much lay involvement, participation, or co-provision of energy-related systems, artefacts, and other structural elements can actually be expected or encouraged? How much can even such enhanced voluntary consumer information approaches be relied upon? And, if consumer-citizen involvement can be confidently anticipated in a certain sector, what sort of arrangements or institutions can be looked towards to encourage an environmentally favorable outcome?

References

Cogoy M. (1995), "*Market and Non-Market Determinants of Private Consumption and their Impacts on the Environment*", Ecological Economics, 13, 3,169-180.

Dholakia R., Dholakia N. (1983), "*From Social Psychology to Political Economy: A Model of Energy Use Behavior*", Journal of Economic Psychology, 3, 231-247.

Dürrenberger G. et al. (1999), *Focus Groups in Integrated Assessment: a Manual for a Participatory tool*. ULYSSES Working Paper WP-97-2, Darmstadt University of Technology: Center for Interdisciplinary Studies in Technology.

Dürrenberger G., Hartmann C. (2002), "*Regional Energy and CO_2 Scenarios: A Decision Support Tool for Policy Makers*", Environmental Impact Assessment Review, *22*, 5, 449-461.

Finger M. (1994), "*From Knowledge to Action? Exploring the Relationships between Environmental Experiences, Learning, and Behavior*", Journal of Social Issues, 50, 3, 141-160.

Gatersleben B., Vlek C.A.J. (1998), "*Household Consumption, Quality of Life, and Environmental Impacts: A Psychological Perspective and Empirical Study*", in: Noorman K.J., Schoot Uiterkamp A.J.M (eds.), Green Households?

Domestic Consumers, Environment, & Sustainability, London: Earthscan.
Giddens A. (1984), *The Constitution of Society, Berkeley*: University of California Press.
Goldblatt D. (2002), *Personal vs. Socio-Technical Change: Informing and Involving Householders for Sustainable Energy Consumption*, Zurich: ETH Dissertation No. 14758.
Goldblatt D., Hartmann C., Dürrenberger G. (2003), *"Combining Interviewing and Modeling for End-user Energy Conservation"*, Energy Policy (forthcoming).
Jackson T., Marks N. (1999), *"Consumption, Sustainable Welfare and Human Needs – with Reference to UK Expenditure Patterns between 1954 and 1994"*, Ecological Economics, 28, 3, 421-441.
Kaiser F., Wolfing S., Fuhrer U. (1999), *"Environmental Attitude and Ecological Behaviour"*, Journal of Environmental Psychology, 19, 1-19.
Kaiser F. Fuhrer U. (in press), *"Ecological Behavior's Dependency on Different Forms of Knowledge"*, Applied Psychology: An International Review.
Meijnders A. (1998), *Climate Change and Changing Attitudes: Effect of Negative Emotion on Information Processing*, Eindhoven: Eindhoven University of Technology.
Moezzi M. (1998), *"The Predicament of Efficiency"*, ACEEE 1998 Summer Study Proceedings, Washington D.C.: American Council for an Energy-Efficient Economy.
Mol A.P.J., Spaargaren G. (2000), *"Ecological Modernisation Theory in Debate: A Review"*, Environmental Politics, vol. 9, no.1.
Princen T. (1997), *"The Shading and Distancing of Commerce: When Internalization is not Enough"*, Ecological Economics, 20, 3, 235-253.
Princen T. (1998), *"Consumption, Ecological Constraint, and the Nature of Work"*, Annual convention of the International Studies Association, March 18-21, 1998, http://www.lancs.ac.uk/users/scistud/esf/princht.htm
Schor J. (1991), *The Overworked American: The Unexpected Decline of Leisure*, New York: Basic Books.
Schor J. (1995), *"Can the North Stop Consumption Growth? Escaping the Cycle of Work and Spend"*, in: Bhasker V., Glyn A. (eds.), The North, the South, and the Environment: Ecological Constraints and the Global Economy, New York: St. Martin's Press.
Schor J. (1998), *The Overspent American: Upscaling, Downshifting and the New Consumer*, New York: Basic Books.
Shove E., Lutzenhiser L., Guy S., Hackett B., Wilhite H. (1998), *"Energy and Social Systems"*, in: Steve Rayner and Elizabeth L. Malone (eds.), Human Choice and Climate Change, vol. II, Columbus: Battelle Press.
Spaargaren G. (2000), *"Ecological Modernization Theory and the Changing Discourse on Environment and Modernity"*, in: Gert Spaargaren, Arthur P.J. Mol, Frederick H. Buttel (eds.), Environment and Global Modernity, London: Sage.
Spaargaren G. (in press), *"Sustainable Consumption: A Theoretical and Environmental Policy Perspective"*, Journal of Society and Natural Resources.
Stern P.C. et. al. (1987), *"Managing Scarce Environmental Resources"*, in: Daniel Stokols (ed.), Handbook of Environmental Psychology, New York: Wiley.
Stern P.C. (1992), *"What Psychology Knows About Energy Conservation"*, American Psychologist, 47, 10, 1224-1232.
Wilhite H., Shove E. (1998), *"Understanding Energy Consumption: Beyond Technology and Economics"*, ACEEE 1998 Summer Study Proceedings, Washington D.C.: American Council for an Energy-Efficient Economy.
Wilhite Harold, Shove E., Lutzenhiser L., Kempton W. (2000), *"The Legacy of Twenty Years of Energy Demand Management: We Know More about Individual Behaviour but Next to Nothing about Demand"*, in: Eberhard Jochem, Jayant Satheye, Daniel Bouille (eds.), Society, Behaviour, and Climate Change Mitigation, Dordrecht: Kluwer Academic Publishers.

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