Technology and Behaviour in the Use of Electricity

Mats Bladh
Dept. of Thematic Studies—Technology and social change
Linköping University, Sweden
mats.bladh@liu.se

In the literature on the potential of reducing householder's consumption of electrical energy, two interpretations can be discerned. On the one hand a technologist's view that technological change will do the work; on the other a sociologist's view that practice is at the heart of the matter. I argue that both views are important for our understanding, but at the same time reductionist. In this article I will discuss this based on studies of the use of electrical equipment among households in Sweden.

Two views on energy consumption

One and the same graph can be interpreted quite differently. Figure 1 on the next page shows individual differences in electricity consumption for lighting among single person households in multi-dwelling houses in Sweden 2005–2008. According to a technologist's view individual differences indicate differences in lamps and fittings. According to a sociologist's view individual differences indicate differences in habits and routines. These interpretations are part of two separate masses of concepts and way of reasoning taking place in different journals and scientific departments. To be sure, within each of these discourses there are considerable differences too. I will disregard internal discrepancies in order to cultivate two positions. Thus, the positions presented here exist among real researchers, but not necessarily the whole argument among any of them. In that sense the positions are my constructions.

There is always a technical solution

It came as a surprise to me, attending a hearing on electricity consumption, to see the same database I had used myself be presented as a kind of index of degrees of energy efficient equipment. There was no talk of use, behaviour or people at all, just the matter of the matter. The database I am referring to is the result of the monitoring study of nearly 400 households in Sweden organized by the Swedish Energy Agency, and performed during the 2005–2008 period. Electricity consumption was studied in detail—basically electricity used for each lamp, computer etc. was registered six times per hour for a month or a year. Also, information about the brands of the refrigerators etc. was noted, and so was information about the households: the number of persons, their age and income level, type of dwelling, and so on.

The graph presented at the hearing showed "cold appliances", short for fridges and freezers put together. The graph had the same message as the one shown here in Figure 1, namely the large individual differences. But there were also something else. A red horizontal line was drawn a bit above the X-axis indicating the best available cold appliances in store at the time. The conclusion was that households with staples above the red line, primarily those with the highest staples, had some replacements to do. If households with a high level of electricity consumption changed to cold appliances of better energy efficient classification according to labelling, a whole lot of gigawatt-hours would be saved in the totality of Swedish household's use of such appliances.

Deep down in the mind of the technologist we find a conviction that the world can be improved by technological change. This leads to an interventionist attitude, where the result of behaviour can be altered by way of, for example, switching from old white goods of a household to new energy efficient ones. In this view we see a stock of refrigerators, for example, distributed among millions of dwellings, demanding such and such amount of energy. Starting out with needs of households as given, and energy production as associated with environmental problems, the solution is focused on improvements in energy efficiency of this stock. It is possible to get the same amount of utility with less energy from an efficient refrigerator than an inefficient one. When the technologist confronts a sociological interpretation, he may be interested in how residual differences can be explained, or if acceptance among households of new items can be found. However, he is sometimes deplored by the lack of knowledge of fundamental physical properties.

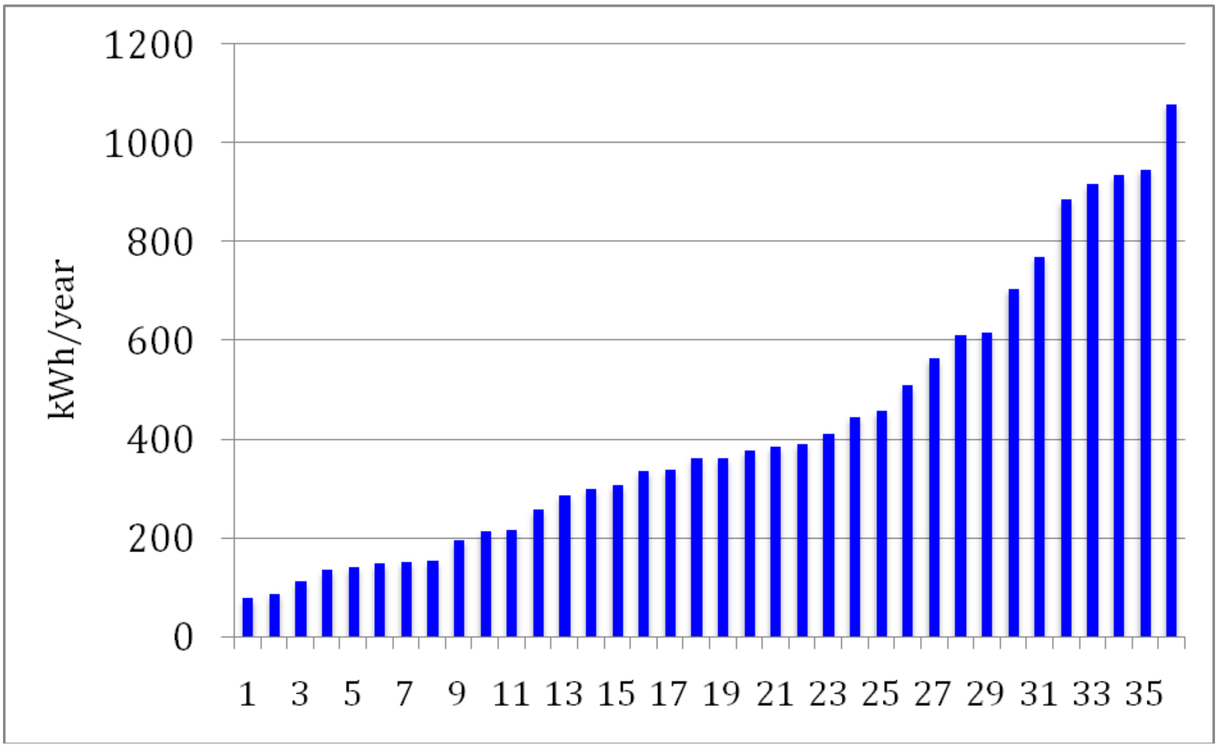

Figure 1. Consumption of electricity among singles living in multi-dwelling houses participating in the 2005–2008 monitoring study. KWh per year. Source: Data from the Swedish Energy Agency.

The social embraces the technical

It came as a surprise to me, reading an article on householder's electricity consumption in another country, to learn a lot of social differences and differences in use patterns among households, but nothing at all of differences in efficiency of their technical equipment. Attention was drawn to lifestyles, manifested in such things as income level, dwelling size, age, education, gender, ethnicity and income. Correlations were sought between levels of consumption in terms of kWh on one hand and the social categories just mentioned on the other. No or weak correlations were found. The number of electrical items in possession was mentioned only in passing, and the quality of these items was totally disregarded.

It was stated that people do not really consume energy instead they consume services such as heating, lighting, cooking etc. The consumer can satisfy her needs for these services in different ways, with different devices. At the centre we find routines. Routines may originate from childhood, and they are influenced by, or rather co-evolve with, cultural norms and physical infrastructures. The number and quality of energy consuming lamps and appliances is seen as the result of in-grained attitudes of the users. Even the electrical system is seen as malleable, with reference to historically different technologies for heating, lighting, cooking etc.

Deep down in the mind of the sociologist we find a conviction that people make the difference. Technology cannot just be taken as given; it must be seen as one component of the social, the result of a choice somewhere, someplace. The world is made up of social relationships, directly or indirectly so, in the latter case mediated by infrastructures and technologies. If change is to occur we must understand what people do—in the case of electricity consumption, what people do in everyday life. This life is filled with apparently boring activities like sleeping, reading, cooking, transporting etc. Understanding is something qualitative that cannot be reduced to numbers. When it comes to solutions recommendations are less clear compared to that of the technologist. One general recommendation is that the way of life must change, and in that view technology is part of the problem, not of the solution. When the sociologist is confronted with a technical interpretation, she would consider it as being technocratic and manipulative of ordinary and innocent people.

Both sides now

Whenever a story is presented in this way, with two positions presented far apart, the reader is directed to a middle position—a combination of both sides. This goes for this story too, even though the positions presented here are simplified. Individual differences on both sides are countless and cannot possibly be covered in this paper. Nevertheless, there is an effect of specialization turning some researcher's attention to the artefacts and other researcher's attention to "the social". An example of a focus on technical change is the idea of potential energy efficiency: First, we have level actually used; second, the level of the best available purchase; third, a techno-economic level including future cost effectiveness; fourth, the technical level representing the best available technology demonstrated; fifth, the theoretical potential limited only by the law of thermodynamics (Neij & Öfverholm, 2001). Such a focus is often followed by questions on "acceptance" of new technologies, and on "drivers" and "barriers" for the introduction of them by way of campaigns, information, regulation, subsidies and pricing. The technological solution is already, or will soon be, available, while obstacles connected with prices and information can be overcome by political intervention.

The social focus is radically different from the outset: "Start with service, not device!" Cooling, heating, cooking, lighting etc. can be accomplished in many ways. The dominant technology for any of these services today is just one of many solutions, and some of these other options are less dependent on technology than the current dominant mode of satisfying the service in question. When we look at differences in electricity consumption, for example, we look at the result (in energy terms) of different ways of solving a service problem. A device focus is an example of technological optimism, a kind of self-deception, as the number and/or size of energy demanding devices increases. It is impossible to make such a device more than 100% efficient. Increasing dependence on energy consuming solutions, and its social normalizations through adaptive habits and routines, point at a problem with much broader scope than just technical changes (Wilhite & Norgard, 2004; Shove, 2004; Gram-Hanssen, Kofod & Nærvig Petersen, 2004).

> I've looked at clouds from both sides now
> From up and down, and still somehow
> It's cloud illusions I recall
> I really don't know clouds at all (Mitchell, 1969)

I believe that technologists and sociologists can learn from each other, and thus that interdisciplinary collaboration is welcome. However, as I believe that a socio-technical perspective is something more than just an adding up of two perspectives I will below discuss an overlap of technology and behaviour. The idea of "script" has been developed theoretically (for example Akrich, 1992 and Wilhite, 2007), but I will propose an empirical generalization inspired by the general of idea of "script", not its theoretical detail. Another area where both sides can meet is around the issue of "the rebound effect". A rebound effect means that some or all reductions in energy consumption, made possible by improvements in energy efficiency, are offset by an increasing demand for energy. It implies a critique of the naïve position of technology optimism presented above, but we cannot assume the rebound effect to be so strong as to make efficiency measures worthless. I will discuss energy efficiency using the results from my studies on use of domestic electric appliances in Sweden. Beside my empirical findings I will also interpret the rebound effect as composed of a tendency and a counter-tendency. This will take the rebound effect closer to a critique of economic growth and consumerism, which I think is the strong point on the part of the sociologists.

Four types of "script"

Returning now to the technologist's interpretation of his graph on cold appliances presented at the beginning of this paper, I would say that his choice of appliance was no accident. Energy consumption of some appliances is more technologically determined than others. Appliances can be grouped according the degree of automaticity, namely whether the machine is always on, or turned on and off automatically or manually. Some things are on all the time, and thus beyond "behaviour". In this group we find clock radio, answering machine, aquarium, transformer, and stand by functions on other appliances. In the second group we find appliances that are turned on and off automatically. In this group we find refrigerator and freezer, regulated as they are by a thermostat controlling starts and stops. In the third group the appliance is turned on manually, but stops running due to a program. Washing machine and dishwasher belong to this group. Lastly, in the last group the appliance is turned both on and off manually. In this group we find many kitchen utensils, but most prominently lamps.

This grouping of appliances is modified sometimes and in some cases. Stand by functions can be interrupted using a separate socket with a switch. Freezers are sometimes turned off for defrosting. Washing machines can be pre-programmed to start at a certain point of time. Lamps can be turned on and off by timers. However, individual or temporary modifications do not change the general division in groups.

The point with this classification, in relation to the technological and sociological views, is that technology and behaviour are more or less important depending on the type of appliance we are studying. However, even in the first and second groups the user can make a difference, albeit to a limited degree. Electricity consumed by a refrigerator, for example, depends on the user's adjustment of temperature, defrosting and the frequency and duration of opening the fridge door. For the class of manual appliances routines play a prominent role, but (for lighting) also the natural light, the design of the dwelling and adherence to a lighting culture matter.

Getting deeper into the question of the role of technology and behaviour, it becomes increasingly hard to distinguish between the two. Agency on the part of the user is not strictly non-technological. Separate sockets, timers, interrupted programs etc. are technical gadgets or functions consciously used by the user, sometimes to overcome expected use ingrained in the design of the technology. Lighting experts, for example, spend a lot of effort in measuring the spectral field of a particular light. However, the user's experience of that same light source may be fundamentally different when a lampshade is put on. Technology and behaviour overlap here because people learn how to use appliances, and in this learning internalize expected use from the designer, but also overcome expectations by unintended use.

Three estimations of energy efficiency improvements

I have investigated this problem on the case of cold appliances in Sweden for the period 1980–2000. One tendency is increasingly energy efficient fridges and freezers: A new one in 1980 would require more electricity than a new one in 2000. Another tendency is a growing number of cold appliances, because of growing number of households, and/or a larger mean size of fridge and freezer.

The investigation was made in five steps. First, data on electricity consumption for all the brands of cold appliances for the years 1965, 1980 and 2002 was collected from "Market overview" published by the Swedish Consumer Agency. Second, data on household's possession of refrigerators and freezers was collected from censuses and other studies, including the share owning more than one unit of fridge or freezer. Third, the number of units based on housing statistics. Fourth, the distribution on six different types of cold appliances was estimated using industrial and trade statistics 1965–2000 (domestic manufacturing + import – export). Sums of yearly data 1966–1980 were used as the base for the distribution in 1980, and 1981–2000 for 2000. Fifth, applying efficiency data from step one on the six types from step four, assuming that efficiency in the stock of cold appliances in 1980 was the average of that of new units in 1965+1980, and for 2000 that of 1980+2002 (for details see Bladh, 2005).

The result of these estimations was that the total number of cold appliances had increased from 7.2 million in 1980 to 9.7 million in 2000. The average volume, in litres, had increased during the period for all types except chest freezers and absorption fridges. Fridges, fridge-coolers and fridge-freezers had increased in number and in average size. Despite these increases in number and volume, the total consumption of electrical energy had decreased, from 4.8 to 4.5 TWh. Counterfactually, if average volume had not increased but had been the same as in 1980 (while the number had grown as it did), then energy consumption would have been 3.6 TWh. On the other hand, had energy efficiency improvements not taken place, total energy consumption would have been 8.8 TWh.

The conclusion from this study is that the tendency towards increasing energy efficiency was stronger than the opposing tendency of growing number and growing volume. It is possible to make real gains in energy saving despite growing consumption.

I made a similar investigation of washing machines, drying cupboards and tumble dryers used by Swedish households. For information on energy efficiency I used data sources partially the same as those mentioned above for cold appliances. Added to this were results from questionnaires where people were asked whether they had access to washing and drying machines (it is common in Sweden that households in multi-dwelling houses use a collective laundry), how often they used them, and at what temperature. For the number of machines housing statistics were used 1975–2002 (for details see Bladh, 2005).

The result showed that access to washing machines and tumble dryers had increased, while drying cupboards had decreased (being replaced by tumble dryers). There was a significant rise in the average size of both washing machines and tumble dryers in the 1990's. Despite this the estimated total energy consumption had decreased from 2.4 TWh in 1980 to 1.4 in 2000. However, in this case behavioural change was important—washing frequency had decreased (but data quality on this is weak), and so had average water temperature used when washing. Increased energy efficiency also contributed to the lowering of energy consumption, and so did the replacement of drying cupboards.

The conclusion is that householder's behaviour can be just as important as energy efficiency improvements. Even though reliability of data on frequency of washing and drying is poor, it is reasonable considering that both machine types used have become larger. If the volume of clothes to be washed and dried is constant, using a 5-kilo machine instead of a 3,5-kilo means washing fewer times (if the machine is loaded full).

Together with Helena Krantz I made a third investigation, this time on lighting. This was different from the other two in that only nine households were studied and no long-term change explored. Instead data was very rich in detail, based as it was on measurement data from the monitoring study mentioned in the beginning (Bladh & Krantz, 2008; Bladh, 2008). To this material, interviews with nine of those metered households were added. We collected electricity consumption data on all lamps six times per hour for one month, and installed power on each lamp. One aspect analysed was the saving potential: Keeping the number of lamps and burning hours as they had been registered, a simulated replacement of all incandescent lamps with the equivalent compact fluorescent lamps would show how much electrical energy would be saved. The result is illustrated in Figure 2.

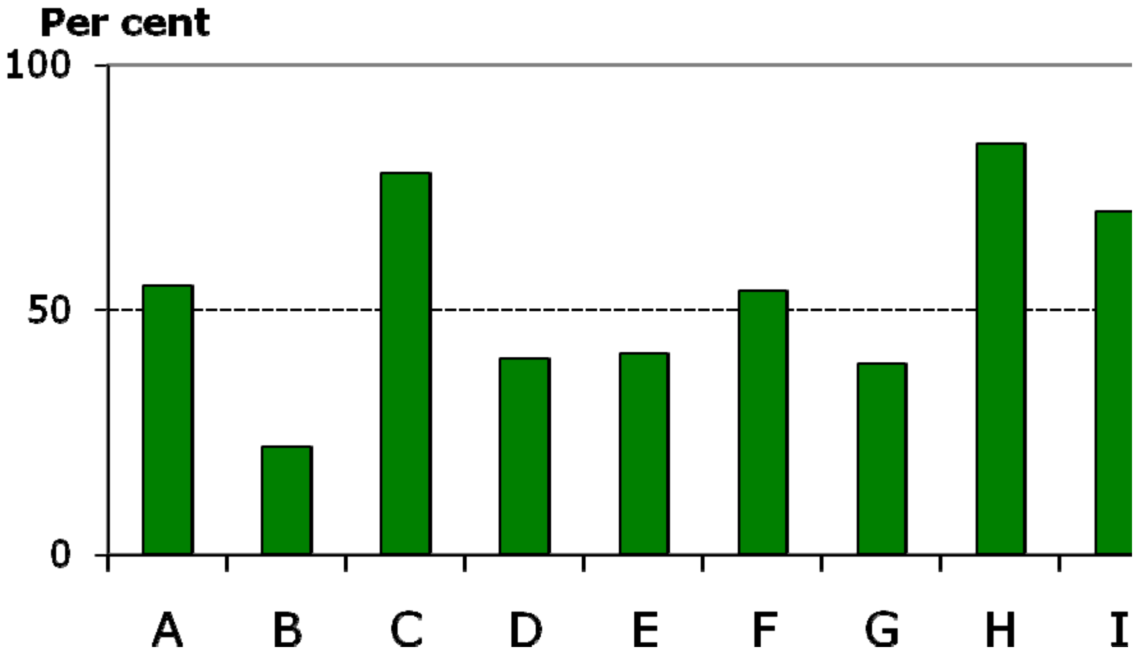

Figure 2. Realistic saving potentials on lighting among nine households in Sweden. Source: Data from Swedish Energy Agency and visits.

The staples show the amount of simulated electricity consumed for lighting in relation to actual consumption, in per cent. Differences between households depend on the share of incandescent lamps that can be replaced and their share of total burning hours. The result is very realistic as actual possession and behaviour is kept constant, but it is hard to generalize from only nine individual cases. Nevertheless, judging by the result from the nine, a reduction by half seems reasonable.

What makes this judgement seem probable is the recent development in regulations and in lighting technology. On the 18 of March 2009 the European Commission adopted the eco-design directive on lighting (EU, 2009). This means that inefficient lighting, in fact incandescent lamps, will be phased out stepwise 2009–2012. The consequence will be a successively reduced level of consumed electricity for lighting (and for other appliances as well, as eco-design regulates all domestic appliances), if the number of lamps does not increase per household and the number of households is constant. Secondly, light-emitting diodes are developing fast and will probably appear on the market during this transition period. LEDs are even more energy efficient, in terms of lumen per Watt, than CFLs, and probably have a much longer lifetime.

Rebound effects

If eco-design is effective, does that mean that technical solutions are sufficient? Will soft (labelling) or hard (phase-outs), energy efficient measures do the work? I would like to turn this question around: Is it preferable to regulate behaviour—a law banning the use of stand by, perhaps? Compared to that, an eco-design regulation seems both more humane and effective. A weak point in the critique of technical change, which is part of a broader critique known as technological determinism, is the lack of suggested political measures. However, I will argue that societal, social and behavioural aspects are important in the long run and in the big picture. In the long run all technologies are malleable and replaceable (perhaps with the exception of nuclear waste), and in the big picture other tendencies are at work that cannot be discovered at the micro-level. One way to discuss this is the “rebound effect”.

The rebound effect is a paradox: Improving efficiency tends to lead to an increase in consumption. Improvements in efficiency reduce consumption when ceteris paribus (other things being equal). However, other things do not stay the same. When James Watt improved the efficiency of Newcomen’s steam engine, less coal was needed for each engine performing a certain amount of “work”. This meant that costs were reduced, thus more people became interested in getting an engine. So, when the number of steam engines increased, more coal in the aggregate was used, eventually out-doing the saving from the original improvement. This is called “The Jevons paradox” after Stanley Jevons who wrote about this already in 1865 (Rebound, 2000, 2009).

Two aspects must be added to this. The examples I have presented above, that of cold appliances and that of washing and drying machines, tested just that. One tendency was improved efficiency; another was an increasing number and use of the machines in question. The result was that the former was stronger than the latter. In those cases the rebound effect was limited. Secondly, behaviour (or “practice”) can be as important as pure technical change. This means that behaviour is part of the improvements in efficiency.

The second aspect is that energy efficiency is a sub-class of general efficiency, or productivity. This, in turn, touches upon the very foundation of how growth and wealth has been accomplished, often to the detriment of the environment. The rebound effect discussed above is limited to cases where energy efficiency improvements are partially or wholly offset by increasing use and demand for the energy consuming service in question. However, it is relevant to broaden the picture so as to include external counter tendencies (external in the meaning not emanating from energy efficiency improvements). One example is the case of set-top boxes. Many Swedish households obtained set-top boxes a few years ago. They had to do so because of a political decision to introduce digital TV and closing down analogue broadcasting. This affected electricity consumption, especially stand by-consumption, as these boxes could not be turned off. Now, the eco-design directive says that there should be a power limit on boxes. Thus, first electricity consumption is raised, and then measures are taken to reduce it.

In the literature the rebound effect is often analysed as composed of three types of effect: a direct effect (increasing demand for the same service), an indirect effect (increasing demand for other services), and an economy-wide effect (affecting the whole economy) effect (Ruzzenenti & Basosi, 2008). There are several problems with this division, one is the unclear difference between the second and the third, and another is that we lose sight of some of the mechanisms at work. I will try to show this below using the example of lighting.

Analysis of the rebound effect on lighting

A direct rebound effect would appear at the household level as longer burning time for a relatively efficient kind of lamp, and on the aggregate level as a general increase in the use of that product. Furthermore, the Jevons’ example hide the distinctiveness of cases where improvements require purchase of new products, for which decorative design and fashion is important. A rebound effect of this kind would be extended use. Thirdly, there is the mechanism of indirect effects, effects on other products and services. Here we can distinguish between a technical and an economic mechanism. The technical has to do with the inefficiency of incandescent lamps, namely that a lot of the energy put in comes out as heat. This waste heat contributes to the heating of the dwelling, so in case of substitution heating demand will rise. This can be called heat compensation effect. Fourthly, the economic indirect effect has to do with money saved when energy consumption is reduced. This money will be spent somehow, something we can call re-spending.

Another result from the close study of nine households mentioned above was that burning hours for CFLs (4.2 hours) were double that of fluorescents (2.1) and incandescent and halogen lamps (1.8). Does this indicate a direct rebound effect at the micro-level? Not necessarily. A possible, and probable, interpretation is that CFLs were placed in those fittings that would have had many hours-of-use regardless of the kind of lamp used. Sweden belongs to the “cosy” lighting culture in which background lighting is common. Lamps placed on the windowsill or other places are considered to create a pleasant atmosphere typical of the Nordic lighting culture. These lamps are used for several hours per day (depending on the season). Fluorescent tubes are avoided for such purposes, and therefore used only for functional reasons, exclusively in the kitchen ceiling, in the bathroom, in the garage, the washing room or the basement. A typical Swedish household, following the Nordic lighting pattern, would turn on the tubes when preparing a meal in the kitchen, and turn them off when it is time to eat.

Even if this interpretation is wrong and the longer hours-of-use really was a direct rebound effect, the reduction in energy consumption switching from incandescent lamps to CFLs (only 20% of power needed) is so big that a doubling of the time cannot out-do the saving (Bladh & Krantz, 2008).

The next type of rebound effect becomes relevant in the case of LEDs. Using only 10% of the power required for an incandescent lamp, and at least 20 times longer life, LEDs will lower user costs significantly. However, this does not mean that incandescent or halogen lamps will be replaced. Now, the banning of incandescent lamps is taken care of by the eco-design directive, but we cannot be sure that LEDs will replace remaining lamps. In fact, many of the LEDs existing today are designed for new functions, in the form of bendable tubes or in the shape of a stone to be used around banisters or in the garden. It is possible that LEDs will extend the use of lighting to functions not used before.

The third type of rebound effect—that the heating system is compensating for the heat loss when inefficient lighting is replaced by efficient—is small. Studies from Britain and Sweden say that the maximum rebound effect would amount to the equivalence of 2.7 and 3.4 % respectively (MTP, 2006; Fahlén & Sikander, 1998). It is highly probable that it is less than that, because during summer time the heating system is off and cannot compensate at all. Furthermore, compensation depends on how fast the heating system reacts on changes in temperature. However, heat from lighting is accentuated by the new extremely heat efficient houses built now, the so-called passive houses heated solely from sunshine, bodies and electric equipment. A study of a household living in such a house showed that people had decided to reinstall incandescent lamps precisely because they wanted to gain the heat from them (Isaksson, 2009:110).

The last type of rebound effect, re-spending, is the most general. Is there such a thing as environmentally sound consumption? Let us imagine a person consuming a certain basket of goods and services determined by his or her preferences, socially accepted practices, actual prices and available income. Let us, secondly, imagine that the total cost for this basket is reduced by energy efficient measures so that an unused margin of the income appears. On what will this be spent? If it is saved in the bank or in stocks, it will be used for productive purposes (assuming an efficient financial system). If it is spent directly it will be spent on products of lower priority and higher income elasticity. This could mean anything from investment in parking lots, to the buying of ecological wine (Nässén & Holmberg, 2009; Barker, Dagoumas & Rubin, 2009).

According to Nässén and Holmberg income elasticity of demand in Sweden is highest for “purchase of vehicles” and for “consumption of transport fuels” (the financial crisis 2008–2009 is a proof in the negative of this). This means that car traffic will increase when disposable income increases, and the authors estimates show a high rebound effect when preferences include a change from a small to a big car: nearly 50% take-back. However, we should not rely too much on these estimates now considering the attention given to global warming and citizen's willingness to pay for this. Extending electricity use can be defended in some cases, but complicates our view on energy saving.

It can be said that the main problem with electricity is its advantages: It is silent, secure and flexible. It can be used for many purposes, and historically electricity has won battles with other types of engines in manufacturing industry, with other types of lighting, and other types of cooking, cooling etc. in the homes. However, it has won one battle too many (electric heating), and it has lost one battle that could have delayed global warming (electric cars). It is wasteful too use such a useful energy carrier as electricity for heating purposes. Energy of lower quality—waste heat, ground heat, etc.—should be used first. On the other the electric car is much more energy efficient than the ordinary car: About 70% is converted to useful work, while the petrol car converts only about 15%. Even if electricity is produced using fossil fuels, a replacement of the combustion engine still offers a radical reduction in greenhouse gases. Where electricity production is based on hydropower and nuclear power, and where a considerable part of consumption is used for electric heating, as it is in Sweden, the contribution to global warming mitigation is quite big. A conversion from electricity to energy of lower quality for heating purposes would save 15% of Sweden's total electricity consumption. Further savings, with take-back taken into account, would add to this. Then, if production capacity is constant, some of that capacity could be used for charging batteries in hybrid and electric cars.

Now, let us not forget the sociologist's warning about technological optimism. Car driving is not only a matter of the car and its motor, but also of infrastructures, routines and cultures built around it. Furthermore, batteries are associated with environmental problems too, and make the car heavier. Replacing the whole car fleet of a nation will take considerable time, and as Nathan Rosenberg (Rosenberg, 1976:205) has taught us, an old technology improves fast in a period of technical competition—increasingly fuel efficient cars can delay or even divert the transformation of the car.

Conclusions

Someone trained in economic history and working at an inter-disciplinary department will perhaps always feel somewhat uncomfortable with a typical technological and a typical sociological view. Inter-disciplinarity contains a struggle for preferential right of interpretation beneath the openness and politeness of the seminar and conference. This paper is no exception.

In my mind energy efficiency is not only a matter of devices, but also a matter of use of given technologies. It seems to me to be a mistake to associate efficiency solely with improvements of devices. However, I believe technical efficiency not only to be more important but also more humane. Exerting control of householder's use of their electric equipment must somewhere get in conflict with individual freedom. The eco design-directive will phase out several inefficient types and brands. For lighting this means that lamps of 60W, 40W and 25W will disappear, and must be replaced by lamps of only a fifth (or less depending on the future of LEDs) of the power for approximately the same lighting service in terms of lumen. The result of this replacement will not mean an end to huge differences between household's uses of electricity for lighting, but it can lower the overall level.

It seems to me that sociologists are trapped in their own critique of "technological determinism", making it impossible for them to see anything sustainably good coming out of technical change. The suggested solutions presented by sociologists are not realistic from a social point of view: regenerating the siesta in Southern Europe, wearing a waist coat in Britain, returning to natural ventilation or cold storage without refrigerators (Wilhite &

Norgard, 2004:996; Shove, 2004:1058). You can save on electricity for lighting by using candles, tea lights and kerosene lamps, but you increase the use of other sources of energy instead and raise the risk of causing fires. It is hard to ban the Nordic lighting culture or excessive use of decorative lighting. The service a refrigerator provides is not only cold storage, but also a uniform temperature for the storage. For that service putting your food on the balcony or in the larder (if there is one) is not an alternative, because the temperature is influenced by the surrounding milieu, while the fridge is isolated from such variation.

The rebound effect has reminded the naïve technical optimist of other matters than the pure technical efficiency improvement measures. What would happen when people learn that twenty yards of LED stripes consume no more than an ordinary Edison-lamp? It is still possible that without the assistance of the buyer and the user, improvements in energy efficiency will turn out as a go ahead-signal for extended use. It cannot be ruled out today (October 2009), without the participation of the intelligent switch, the user, that light-emitting diodes will open for massive façade decoration with glowing tubes of all colours. On the other hand, the attention given to the problem of global warming, offers an unprecedented opportunity to change user practices. It is difficult to see a revolution from close range, but the concerted attention given to energy saving, a peak load, so to speak, of environmental consciousness, is the window of opportunity many scientists talk about.

While a technological focus—technology without people—has its strong point in energy efficiency, but it has no recipe for the rebound effect. Especially re-spending is troublesome in the long run. A sociological focus—people without technology—can question consumer culture but has difficulties in formulating feasible solutions. If energy efficiency is not enough, well, then I see no other solution than a significant reduction in average income, the ultimate solution to the problem of "re-spending". A substantial reduction of working hours can get us out of the growing spiral.

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