The Internet: the most important driver for future electricity demand in households

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1. SYNOPSIS

Electricity demand in Swiss households may increase up to 30% over the next twenty years due to internet-induced interconnection of appliances and installations alone.

2. ABSTRACT

Electricity demand in Swiss households may increase up to 30% over the next twenty years due to interconnection of appliances and installations alone induced primarily by the use of the Internet. At least a quarter of this additional electricity use could accrue when the appliances are not even in use but in standby- or off-mode. This waste of energy runs counter to the goals of (Swiss) energy efficiency policy and makes it more difficult to reach the CO_2-emission reduction targets. Appliance manufacturers and the installation industry must therefore work to avoid such waste. The (Swiss) government can also accelerate and strengthen efforts of the industry to reduce standby-energy use by creating favourable political conditions together with other European countries, the European Union and the International Energy Agency.

3. INTRODUCTION: INFORMATION TECHNOLOGIES, THE INTERNET AND ENERGY USE

The undisputed fact that technology influences society is an almost daily topic in the media, where terms like Internet, Digital Economy, e-business, Information Society and Globalisation abound. The question if and to what extent society influences and directs technology is hardly asked anymore. By discussing the uses of technology in this context (where? what for? how? how much?), some first elements of an answer can be found.

Spreng and Hediger examined the effects of information technologies on energy use and concluded that they would lead to a clear increase in electric energy use, unless they were specifically employed to improve energy efficiency (Spr 87). This latter possibility was quantified in the EGES-papers[2] in the “Communication Society” scenario (Aeb 88), (Lut 88): Despite average economic growth of 1.3% per year, fossil energy and electricity use in the year 2025 would remain below the 1985 starting-point levels. Today, however, Information Technologies (IT) are overwhelmingly applied for entertainment, increasing productivity, and gaining access to new markets. A significant increase in energy use is expected, though the degree of the anticipated increase is debated.

The scientific and political controversy over the Internet’s energy consumption is very vivid in the US. In fact, the US House of Representatives held a hearing on February 2nd, 2000, on “Kyoto and the Internet: The Energy Implications of the Digital Economy”-, where divergent opinions on the Internet’s energy use clashed.

On one side, Mark Mills (Mil 99)- posited that Internet energy use accounted for 8% of total electricity use in the US for 1999 and would rise to 50% of the total in ten years’ time. Mills concluded that “ No energy policy, including and perhaps especially the anti-electricity aspects of the Kyoto Protocol, should be considered without passing it first through a Digital sanity test. The integrity, reliability and low cost of the national electric infrastructure will be more, not less important in the future. (…). Clearly energy policy and the Digital Economy are tightly linked”.
Joseph Romm (Rom 99) took the other side in the debate by arguing that the estimates of Internet energy use are greatly exaggerated. In his view, the indirect effects of the Internet - such as structural changes and improved

energy efficiency - will compensate for increased Internet use, with the exception of the household sector and, possibly, of the transportation sector. In sum: “Also, although it is not a major factor today, we believe that in the very near future the Internet will itself be used to save energy directly. (…) We know one major service company that is pursuing the installation of digital Energy Management and Control Systems please write outin the building they manage (…). Similarly, many utilities begun exploring Internet-based home energy management systems, which could give individual homeowners more control and feedback over their home energy use, or the ability to have an outside energy company or expert software optimise their energy consumption. This could lead to significant energy savings in homes”.

This scientific and political discussion about the increase or reduction of Internet energy use will certainly continue, and indeed it is much more complex than just looking at the direct and indirect electricity demand of computers and entertainment electronics. The motto of the information- and communications industry is no longer “a computer on every desk and in every home”, but rather “Internet anywhere, anytime, from any device” (NZZ 00/2). One can no longer overlook those 85% of microprocessors that are not installed in computers or comparable appliances. This paper on interconnection in households aims to contribute - in one small area - to the larger discussion about the effects of IT and the Internet on energy use.

4. RESEARCH QUESTIONS AND METHODOLOGY

Internet use in the home is on the rise and multimedia technology is developing manifold new applications. It is thus to be expected that in the near future those electronic household components that were hitherto used separately will be interconnected and/or that the different media will be used on a common platform. The old idea of an “intelligent house” might even be realised through this development. The computer- and telecommunications industries, together with the relevant service providers, have been making intensive efforts at development and marketing in this area, and a vast literature on the subject is already available. The effects of such developments on energy consumption, which have rarely been addressed, are the topic of this paper. It will contribute to the discussion on *whether the State should become active in this area* and, if so, *which measures it could institute to promote energy efficiency in the household and by interconnections there*.

The “potential area” for increased electricity consumption ascribable to interconnection in the household is assessed by *simulation- and scenario-calculations* extending to the year 2020. The upper limit of this area is a fully interconnected household, whose energy consumption is transferred - where applicable - to the whole of Switzerland. The “inductive” effects of interconnection, such as additional components and higher use of household appliances and equipment, are also considered.

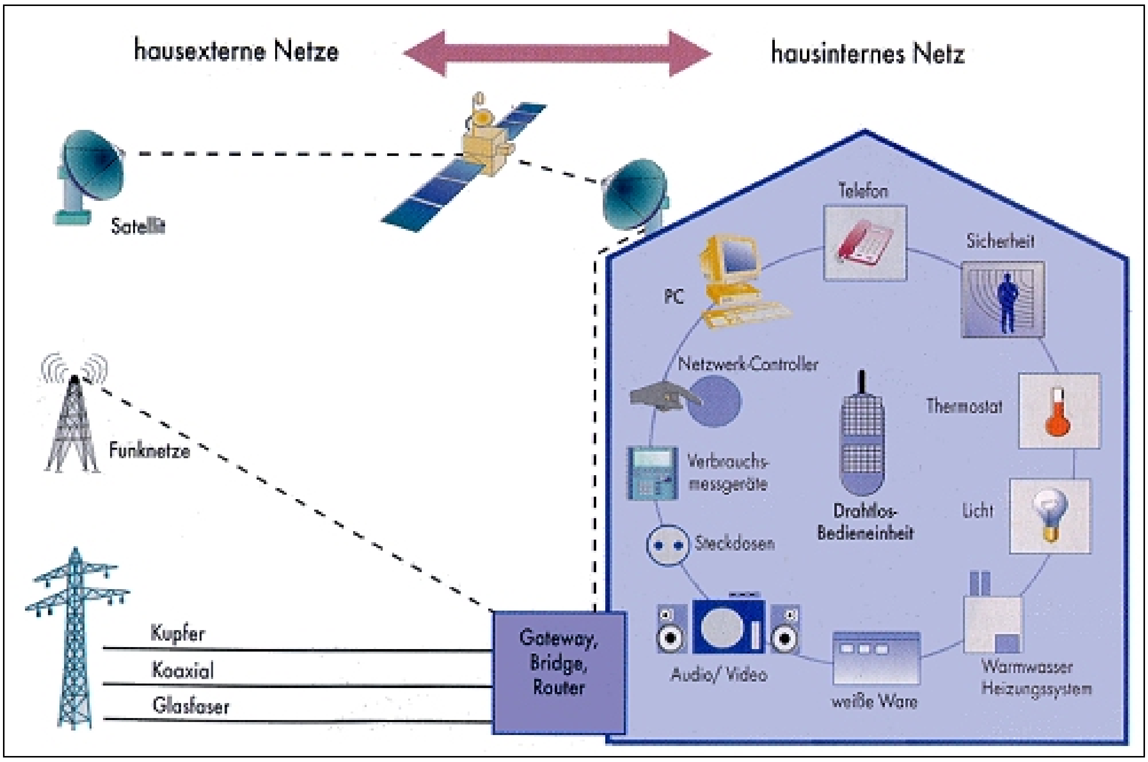
5. CURRENT INTERCONNECTION IN HOUSEHOLDS

Many households in Switzerland are already equipped with IT-installations (telecommunications, entertainment electronics, office appliances). Nearly every home has at least one telephone, one radio and one television set. PCs are installed in 50% of Swiss households (Wei 00) and the percentage of homes with Internet connections has risen from 1.2% in 1994 to 30% in 2000 (Gas 00). With a few exceptions, however, these IT-applications in the home are *not* interconnected.

Today, multimedia applications are the driving force behind interconnection, the fusion of various media being the catalyst and the first sign of this development. User-friendly people-machine-interfaces, new services, and especially the ability to access and control household components at any time from anywhere will also foster the interconnection of white goods and the intelligent regulation of house technologies (figure 1).

In several countries houses have been interconnected as a demonstration of the newest technology, e.g. in Switzerland the newly opened “house of the future” in Hünenberg (www.futurelife.ch). And even in regular houses networking starts to get more popular. There, the main focus is on multimedia services (telephone, Internet, computers, television, video, audio) and on regulating building installations (lighting, heating, security). In most cases a number of networks are installed parallel to each other: building installation-bus and ethernet or coaxial cable as broadband-transmission net. The manufacturers of white goods do not yet offer serialised solutions for interconnection (remote control, remote servicing and documentation), but that is sure to change over the coming years.

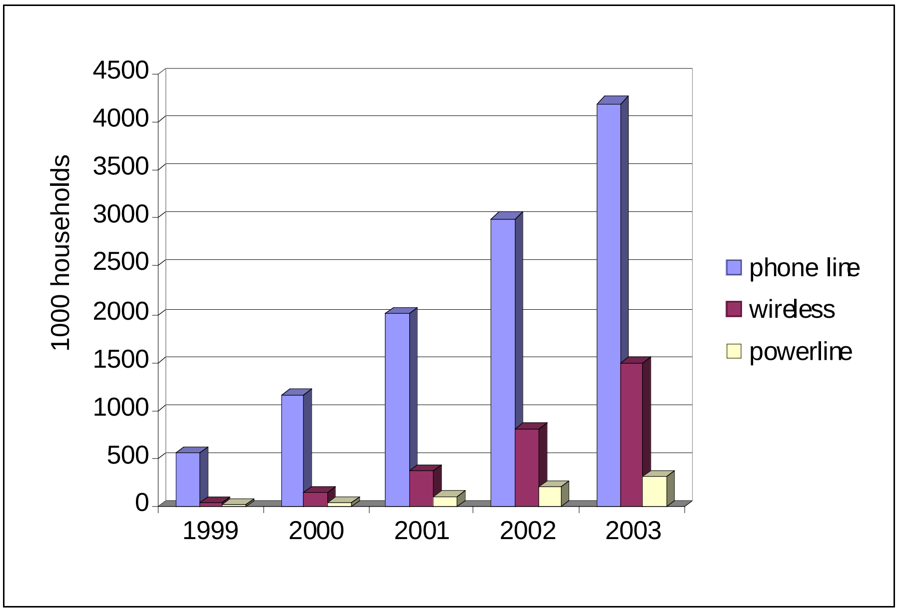
Figure 1. House with external and internal networks



(source: Fraunhofer Gesellschaft – Projekt inHaus-NRW; www.inhaus-nrw.de)

Household interconnection in the US is expected to increase greatly in the near future (figure 2). One can assume that at least in the first few years, the various transmission means and technologies (telephone wires, twisted pair, coaxial cable, wireless, infrared, electric grid, lightwave-conductor) will coexist.

Figure 2. Number of interconnected households in the US



Source (Ami 99)

British market researchers expect 15% of European households to have private wireless networks by 2005. By this estimate, there would be 2.5 interconnected components in the average household (Met 00).
According to various experts, interconnection in the home will develop more slowly in Switzerland than in other countries such as the US, England or Italy. The reasons for this are the following:

- Durable building materials and therefore longer cycles of renovation and new construction than for example in the US;
- High percentage of rentals;
- Large share of institutional investors in the real estate market.

The market chances of many products and services probably depend heavily on developments in transmission technologies based on the electricity grid (powerline) and on wireless solutions.

Besides these structural and technical-economic barriers to the rapid development and diffusion of interconnected houses, we also have to take greater account of psychological and sociological aspects. In fact, not everyone subscribes to Bill Gate's vision of an "intelligent home", in part because interconnection in the family house could also mean more social control and less privacy. Thus, the individual and collective acceptability of the new technological devices of the Information Society - now explicitly defined as a political program in the US and Europe - is still to be evaluated (and to be integrated in the simulation- and scenario-calculations).

6. MAXIMUM INCREASE IN ELECTRICITY CONSUMPTION DUE TO INTERCONNECTION

In this short paper, the results of interconnection in the home are not examined in every aspect, but rather by using three examples:

- Multimedia/Internet,
- White goods and
- Lighting control.

Only a long-term analysis can ascertain whether there is a need for action, since the potential effects of such actions become visible only after a longer time period. In addition, any measure also requires time to be developed and fully implemented. But, even over a period of a few years, it is difficult to make moderately accurate predictions on the diffusion of household interconnection. All predictions up to date have proven to be much too optimistic, with the exception of those sceptics who negated a market for such applications even in the very long term.

Instead of a "definite" perspective we therefore posit a "perspective area": Its *lower boundary* is "no interconnection in the household takes place", while its *upper boundary* is defined as "maximum diffusion in multimedia applications within twenty years." While this differentiated presentation of potential increases in energy demand cannot comprehensively answer the question about the need for action and the appropriate policy measures, it does allow political decision-makers to assess the expediency of interventions. Furthermore, it enables them to propose a strategy based on "no-regret" measures.

The *upper boundary* is determined as follows: In a first step (*simulation*), the interconnection-induced increase in electricity demand is evaluated for one household. In a second step (*scenario*), that increase is calculated for the Swiss household sector.

Simulation

The simulation of the increase in electricity demand is undertaken separately in the three categories multimedia, white goods and lighting control (as an example for building-control technologies) and extend over a time period of 2000 - 2020. To this end, we analyse the two possibilities of interconnection in each category: *Version 1* is a typical interconnected household today, *version 2* is a maximally-interconnected household in the future. These variants differ not only in the number of interconnected components, but also in their use. Similar to different IT-applications, where one has observed for many years that the power demand remains the same (Aeb 00/2), we expect the power reduction due to technical innovation to be compensated by the growing number of available services.

The increase in electricity demand in an interconnected household is measured relative to a *reference household*. This reference household is equivalent to one which contains all the relevant appliances and applications of today, but without interconnections between the components. We simulate the development of the energy demand increase between 2000 and 2020 in an average interconnected home with the following model:

- In the starting year (2000), the average interconnected household is described by version 1
- For the year 2020, the interconnection level equals today's vision of a maximally interconnected household (version 2).
- The market shares of both versions change in a linear fashion between 2000 and 2020, i.e. the market share of version 1 falls from 100% in 2000 to 0% in 2020, while the market share of version 2 rises from 0% in 2000 to 100% in the year 2020.

This development reflects today's technical possibilities. From an economic and sociological perspective, however, it is hardly realistic: Not every interconnected household can afford version 2, and not every interconnected household will want to use all the technical options available (whatever the reason for this under-utilisation). The average interconnected household simulated here therefore represents the upper boundary of the interconnection-induced increase in electricity demand.

The study of Aebischer and Huser (Aeb 00) provides a detailed documentation of both versions. The underlying theses and some of the technological assumptions used for defining versions 1 and 2 in the multimedia/Internet sector are summarised in the frame below.

In the multimedia/internet domain, we are guided by the following hypotheses in framing the two versions in the multimedia/Internet application sector:

- Multimedia- and Internet applications are the most important factors for interconnection within and outside of the household.
- As soon as there are two PCs in a household, their interconnection is desired. Similarly, if the household is internally interconnected, more than one PC (or similar component) is also desired.
- The fusion of PC and television: The PC is used as a TV and the TV is used for surfing. One can envisage identical basic equipment with additional modules, for example a large screen, and further software and computing capacity which can be accessed via a central house computer or via the net.
- Increased Internet use does not lead to a reduction in television use (NZZ 00), (Sti 00).
- A powerful broadband gateway (the connecting element between internal and external household nets, see figure 1) allows for optimum communication to the outside.

Explanations for version 1:

- PC with LCD screen: 100 W
- The PC-use duration of 1.2 hours per day, 5% in 2000, is slightly lower than the 2 hours per day spent surfing by frequent Internet users in the US (NZZ 00), (Sti 00). Today's average Swiss Internet use at home is 4.6. hours per week (Bul 00). One can assume a very rapid increase (based on the average three person-household) to 3.6 hours per day by 2010. In the years between 2010 and 2020, version 1 will quickly be replaced by version 2.
- Longer daily use is also expected for digital televisions with built-in video over the 2000-2020 time period, from 2.4 to 4.8 hours (for three persons). This reflects the assumption that Switzerland will approach current US levels of use and takes the combined use of PC and TV, as observed in the US (Sti 00), into account.
- A potential overestimate of use duration would lead to an overestimate of total electricity demand, but to an underestimate of electricity demand in standby- and off-mode. This would result in underestimating the potential for energy savings that could be achieved by lowering the standby energy requirements.
- We calculate an average 2.5 W of power per component for connection to the network.

Explanations for version 2:

- Multimedia components (PC/television/game console) in every room, where screens also serve decorative purposes as pictures on the wall.
- The powerful broadband gateway has high standby power (25 W). It can be used immediately and anytime for transmission.
- The number of appliances and their cumulative use duration are twice as high as in version 1; the wattage in on-mode (standby/off-mode) is about 60% (160%) higher than in version 1.

The upper boundary of the induced energy increase in an interconnected household with all three simulated applications is somewhat lower than the sum of the separate energy increases for the three applications. This is explained by the fact that certain components of the interconnection, e.g. people-machine-interface and gateway, are used jointly by different applications. Although only selected applications were taken into account, the upper boundary for the energy increase in the interconnected household in the year 2000 lies almost 1000 kWh/year or 20%-25% above today's energy consumption in the reference household. By 2020, the difference will increase to over 2000 kWh/year (table 1).

Table 1. Increase in electricity demand in an interconnected household (hh) versus a reference household

	total	on-mode		standby-/off-mode	
	kWh/hh.a	kWh/hh.a	fraction	kWh/hh.a	fraction
2000	926	342	37%	584	63%
2005	1242	577	46%	665	54%
2010	1555	836	54%	719	46%
2015	1866	1120	60%	746	40%
2020	2175	1429	66%	746	34%

This estimate of the upper boundary does not constitute an absolute value, since the following factors, among others, were not considered:

- Increased demand due to additional applications of interconnection (e.g. interconnection of small appliances, surveillance/security, or control of further elements of building technology);
- Increased demand due to interconnection via the electricity grid (powerline) or wireless instead of wire connections;
- Increased demand by employing mobile units for using the household interconnection.

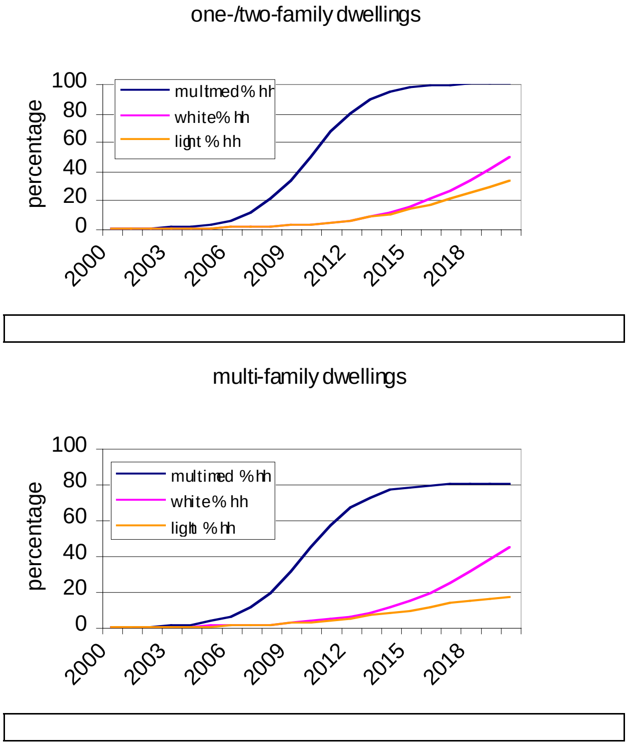
The electricity increase in table 1 is based on the growing number of interconnected appliances/components and their increased use. The latter is responsible for the steadily growing share of electricity demand in on-mode. Electricity demand in standby- and off-mode, on the other hand, increases only very little in this version depicting maximum interconnection; its share of the overall energy demand falls from 2/3 to 1/3. Assuming, however, that the average use duration of the various appliances remains on the year 2000 level – not an implausible assumption in view of the growing number of components and installations – the increase in electricity use in 2020 drops to only 1500 kWh/household and year. The wattage in standby- and off-mode would then rise to 900 kWh/household and year, i.e. its share would hardly decrease and even by 2020 it would still constitute 60% of overall power use.

Scenario calculation

As in the simulation of the average electricity increase in an interconnected household, in this chapter we will only determine an upper boundary for the increase in the Swiss household-sector. This boundary thus defines the upper limit for the potential area of expected development, while zero-growth circumscribes it as the bottom limit.

Multimedia and Internet applications ("multimed") are expected to be completely interconnected within twenty years in single- and two-family-dwellings; the interconnection of white goods („white") will take about twice as long due to their longer lifecycles. Households in multiple-family-dwellings are expected to have a lower saturation rate. Lighting control ("light") serves as an example for all other interconnections of building technology. Its lobby is weaker than the other two categories', and since lighting control is more in demand in living rooms than in kitchens and bedrooms, it is assumed to be significantly less widespread (figure 3).

Figure 3. Share of interconnected households in single-/two-family dwellings and in multi-family dwellings

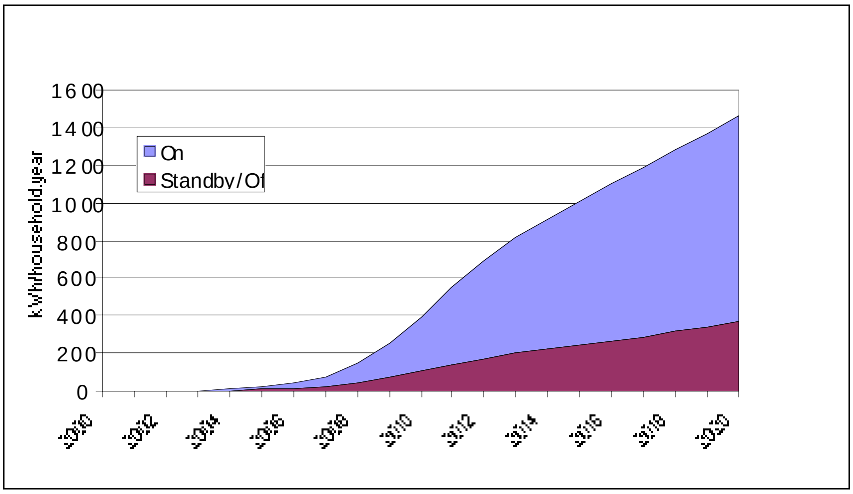


The resulting increase in electricity demand in Switzerland's household sector is minimal in the first few years. It then rises to 1500 GWh/year by 2010 (around 10% of today's electricity demand in the household sector) and reaches 5000 GWh/year in 2020. The average growth rate over the coming twenty years is *1.3%* per year relative to current electricity consumption. Energy use in standby-and off-mode contributes a *25%* share to this figure.

Assuming a constant use duration of the components, induced energy increase in 2020 will still amount to 3000 GWh/year. In this case the share of consumption in standby- and off-mode would rise to *55%.*

In the average household in Switzerland (and similarly in other industrialised countries) these additional demand due to networking in households amounts to 400 kWh/household and year in 2010 and almost 1500 kWh/household and year in 2020 (figure 4). Without increase in intensity of use of the equipment, the additional demand in 2020 would be of the order of 900 kWh/household and year. The additional losses in standby- and off-mode lie between 400 and 500 kWh/household and year, independent of the intensity of use.

Figure 4. Upper boundary for increases in the average Swiss household of electricity demand attributable to interconnection



7. CHALLENGES OF POLICY DESIGN

The effects of interconnection on energy consumption within and outside the home are manifold and uncertain. A significant increase in electricity use is certainly foreseeable – the simulation and scenario calculations give an increase of 1.3% per year as the upper boundary of this growth over the next twenty years. This number could be much smaller under the following conditions:

- There are significantly fewer interconnected appliances/components in an average interconnected household, and they are used less than the simulation assumed;
- Interconnection spreads more slowly across Swiss households than expected and reaches a lower saturation point than in the scenario;
- The wattage of appliances/components in the on- as well as in the standby- and off-mode is reduced;
- An effective power management is instituted.

The potentially dramatic increase in household electricity demand due to interconnection in the household runs counter to the goals of the (Swiss) energy efficiency policy and makes it more difficult to reduce CO_2 emissions.

The first need is to reduce the scientific and political *uncertainty* regarding future developments of technologies and the social acceptability of these devices. Further studies on economic, social and cultural aspects should be undertaken to this end. For example, policy advisers and policy makers need some information on the R&D strategies of appliances/components manufacturers and the installation industry, on the real home Internet use (e.g. business-to-consumer e-commerce, substitution of Internet-surfing for television-watching)-, on public utilities' promotion of Internet-based home energy management systems, etc.

Second, measures should be taken immediately to optimise the increased future electricity demand in *standby- and off-mode*. A large fraction of the evaluated maximal increase of electricity demand in the standby- and off-mode (400-500 kWh/household and year) can be avoided by use of existing technologies. Supporting R&D for innovative solutions is recommended.

A large proportion of the power losses in standby- and off-mode are caused by converting 230AC to lower DC levels. Several solutions to this problem are possible:

- Employ as few network components as possible, because a central electricity supply via communication-bus lowers the standby wattage (EIB-bus, USB-bus).
- Use separate and adapted network components in large household appliances and entertainment electronics which supply only those communication components necessary for the interconnection.
- Utilise high-frequency instead of conventional circuits, as the electronic circuit components are highly efficient and lose less standby power (0.25 W).

Since this equipment is developed and produced for the world markets, internationally co-ordinated measures seem to be essential- (e.g. rules according to international trade agreement; testing and measuring energy efficiency consistently across national markets). Related technologies such as office appliances and entertainment electronics already boast labelling programs (e.g. US Energy Star Label). Extending these to appliances and components crucial for household interconnection should not pose great technical difficulties and should help to avoid confusion among producers and retailers, service providers and consumers.

Above all, the involved governments and agencies must be convinced of the need for such measures. Convincing them will not be an easy task because energy efficiency is (still) a minor aspect in the whole IT and Internet industry (it may be even less important than it has been for individual household appliances and office equipment!). Furthermore, the (energy efficiency) policy problem is not obvious to everyone (see for example the US debate presented in the introduction of this paper). Thus, policy designers will be confronted with the difficult task of developing a strong coordination with the actors in economic, technology and information policies who are - in the mind of the policymakers at least - more directly concerned with the Internet, the Digital Economy and the Information Society. It is also important to involve the new actors in the telecommunications and appliances industries (also service providers) and to motivate them to implement new measures. In the case of white goods, standby wattage could be made part of the energy declaration. This would provide manufacturers with an incentive to integrate future interconnection components in their appliances in such a manner as to avoid unnecessary standby losses.

8. BIBLIOGRAPHY

(Aeb 00) Bernard Aebischer and Alois Huser. Networking in private households. Impacts on electricity consumption. Swiss Federal Office of Energy, Berne, November 2000 (http://www.electricity-research.ch/SB/haushaltsvernetzung-00-english.PDF)

(Aeb 00/2) Bernard Aebischer, Harald Bradke and Hubert Kaeslin. Energie und Informationstechnik. Energiesparer oder Energiefresser? Bulletin (Magazin of the ETH Zürich) Nr. 276, January 2000 (http://www.fmpro.ethz.ch/FMPro?-db=bulletin.fp3&-format=bulletin%2fbulletin%5fdetail.html&-lay=html&-op=cn&AutorIn=Aebischer&-recid=120&-find=%20)

(Aeb 88) B. Aebischer et al. Perspectives de la demande d'énergie en Suisse, 1985-2025. Groupe d'experts scénarios énergétiques. Série de publications no 18. Bern, 1988 (EDMZ no 805.818)

(Ami 99) Amitava Dutta-Roy: Networks for Homes, IEEE Spectrums, December, 1999

(Bul 00) Nutzung- und Reichweitendaten für Internet. Bulletin SEV/VSE 1/00 (ausführlicher auf http://www.wemf.ch/de/produkte/internet.html)

(For 99) Dig more coal – the PCs are coming. Forbes Magazine, 31 May 1999 (reproduced in German in the journal c't (Gro 00))

(Gas 99) Rolf Gasenzer. E-Commerce als Träger gesellschaftlicher Veränderungen. „Junge“ und „doppeler-werbstätige“ Haushalte schon heute mit anderen Bedürfnissen. NZZ, Nr. 219, 21 September 1999

(Gro 00) Andreas Grote. Vielfrass Internet. Das Netz als Energiemoloch. c't 2000, issue no 5.

(Kra 98) Robert Kraut et al., Internet paradox. A social technology that reduces social involvement and psycho-logical well-being?, American Psychologist, 53 (9), 10171-031. (http://www.apa.org/journals/amp/amp5391017.html)

(Lut 88) C. Lutz et al. Neue gesellschaftliche Prioritäten und Energiepolitik. Groupe d'experts scénarios énergétiques. Série de publications no 15. Bern, 1988

(Met 00) D. Metzger: Jeder Haushalt wird zu einer Mobilfunkzelle, Tages-Anzeiger, 18 January 2000, Zürich

(Mil 99) Mark Mills. The Internet Begins With Coal: A Preliminary Exploration of the Impact of the Internet on Electricity Consumption. 1999

(NZZ 00) Bedrängt das Internet wirklich das Fernsehen? NZZ Nr. 99, 28 April 2000

(NZZ 00/2) Welche Microsoft? Ein Rückblick auf das PC-Zeitalter. NZZ, Nr. 138, 16. June 2000

(Rom 99) Joseph Romm, Art Rosenfeld and Susan Hermann. The Internet Economy and Global Warming: A Scenario of the Impact of E-commerce on Energy and the Environment. December 1999 (http://www.cool-companies.org/ecom/index.cfm)

(Sch 96) Jürg Schwarz and Daniel Spreng. Einfache Modellierung der Entwicklung des Energieverbrauchs von Energieanwendungen. Materialien zur Schriftenreihe RAVEL-Industrie, Bern, 1996

(Spr 87) Daniel Spreng and Werner Hediger. Energiebedarf der Informationsgesellschaft, Verlag der Fachvereine Zürich, 1987

(Sti 00) Horst Stipp. Nutzung alter und neuer Medien in den USA. Media Perspektiven 4/2000

(Var 01) Frédéric Varone and Bernard Aebischer, Energy efficiency: the challenges of policy design, Energy Policy (to be published in Spring 2001).

(Wei 00) Robert Weiss: Weissbuch 2000 – PC-Marktreport Schweiz, Robert Weiss Consulting, January 2000

9. END NOTES

1. Centre for Energy Policy and Economics (www.cepe.ethz.ch)
2. Experts Group for Energy Scenarios which evaluated on behalf of the Swiss government the prerequisite requirements and the impacts of a phase-out from nuclear energy in a number of scenarios.
3. See http://www.house.gov/reform/neg/hearings/index.htm
4. A discussion of Mill's article can be found on http://enduse.lbl.gov/Projects/InfoTech.html. A shorter version of the article was published in Forbes magazine (For 99) and appeared in German in the journal c't (Gro 00).
5. As far as they can be foreseen, innovation leaps have been explicitly considered. LCD and related display technologies are regarded as standard. Due to its high cost, laptop technology (energy-optimised chips) will only be used in mobile components/applications.
6. Many scholars, technologists and social critics believe that the Internet is deeply transforming economic and social life. But they often disagree as to the nature of the changes and whether the changes are for the better or the worse. For example, Kraut *et al.* (Kra 98) examined the social and psychological impacts of the Internet on 169 people in 73 households during their first 1 to 2 years on-line. The conclusion of their experimental research is that greater use of the Internet was associated with declines in people communication with the family members in the household, declines in the size of their social circle, and increases in their depression and loneliness. Such findings certainly have implications for the design of technology and for public policy.
7. This international harmonization of policy instruments (e.g. at EU level or through the IEA) does not mean that different countries should not go beyond this intervention level and try their own policy instruments. We suggested elsewhere (Var 01) that it seems advantageous to keep a certain diversity of policy instruments in different countries. This allows the testing of new instruments and of new policy mix.